Tooth Wear Guidelines for the BSRD

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Tooth Wear Guidelines for the BSRD Part 1: Aetiology, Diagnosis and Prevention

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Tooth wear (TW) is a common condition affecting patients who often require advice and treatment from dentists. Physiological TW is normal and accepted by most patients. Pathological TW, by virtue of symptoms or rapid wear, will prompt the need for dental care. It can range from mild sensitivity from an abrasion lesion to gross destruction of the dentition. Similarly, treatment can range from simple operative care to full mouth reconstruction with crowns or complex dentures. Too little or too much treatment can lead to tooth loss and patient complaints.

These guidelines are designed to help dentists manage tooth wear. A selected literature review covers three sections:

1. Aetiology, diagnosis and prevention of tooth wear;
2. Fixed management of tooth wear;
3. Removable management of tooth wear.

Each section is concluded with a summary of key points which can act as a quick reference checklist for the busy practitioner. It is hoped that effective treatment or advice given at the right time can reduce the amount of long-term maintenance care required in the future. However, it is acknowledged that some severe bruxist patients will always require regular repairs or replacement restorations.

Guidelines become out of date immediately they are published. The society will review and update these guidelines on a 3-yearly basis. The work that the authors have put in to draft these guidelines is gratefully received. The British Society of Restorative Dentistry (BSRD) Council and members of the society are also thanked for their comments in improving the document. Effective treatment does exist and it is most gratifying to make a dramatic difference to patients with tooth wear when guidance is provided.

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Definition

Tooth wear, or as it is also often referred to as non-carious tooth surface loss (TSL), can be described simply as 'the pathological non-carious loss of tooth tissue'.[1]

The distinction between pathological and physiological TW can be difficult to determine. Wearing of the teeth is a normal physiological process. The estimated normal vertical loss of enamel from physiological wear is thought to be approximately 20–38 µm per annum.[2] It is important to remember that just because a tooth has some element of wear this does not always necessitate treatment. Tooth wear may be regarded as pathological if the rate of wear is greater than that expected for the patient's age, the patient has concerns over the wear or the prognosis of the tooth is compromised due to the wear.

Tooth wear is often multifactorial in nature and can be difficult to distinguish between, but it is often subdivided into:

- Attrition;
- Erosion;
- Abrasion; and
- Abfraction (abfraction is often described but, as yet, is not universally accepted as a true form of tooth wear).

Attrition

'The loss of tooth substance or a restoration as a result of mastication or contact between occluding surfaces of approximal surfaces'.[1]

Erosion

'The loss of tooth tissue by chemical processes not involving bacterial action'.[3]

Abrasion

'The physical wear caused by materials other than tooth contact'.[4]

Abfraction

'Tooth wear located in the cervical area caused by flexural forces during function and parafunction'.[5]

Prevalence

Prevalence in children and adolescents

Epidemiological research across Europe has shown an increasing prevalence in tooth wear in children over the last ten years. An increased level of TW is found to be associated with increasing age, especially in the deciduous dentition.[6] Tooth wear was reported to be between 0% and 80% for children under seven years of age. This significant relationship of level of TW to increase in age found in the deciduous dentition did not appear to correspond to the permanent dentition.[6]

In the UK, the Child Dental Health Survey has been undertaken decennially since 1973. The most recent survey, in 2013, showed an increased incidence of tooth wear. In children aged five, 33% had some evidence of TW on the buccal surfaces, with 4% involving the dentine or pulp and 57% on the lingual, with 16% involving the dentine or pulp.[7] In the permanent dentition, 31% of 15-year-olds showed signs of TW on the occlusal surfaces of the first permanent molars and 44% on the palatal surfaces of the maxillary incisors.[8]

Prevalence in adults

In the UK, NHS Information Centre commission surveys are undertaken decennially to assess the dental health status of adults to capture trends over time. The most recent survey, in 2009, showed an increased incident of tooth wear from 66% to 76% since the 1998 survey. Tooth wear into dentine was found to be higher than previously, at 77% in the anterior teeth. Moderate TW (extensive into dentine) also showed an increase from 11% in 1998 to 15%. Severe wear (exposing secondary dentine) remained at 2%.[9]

Tooth wear in adults is a common clinical finding, with an increase in prevalence with increased age. A systematic review showed 3% of 20-year-olds and 17% of 70-year-olds exhibited severe tooth wear.[10] Furthermore, it has been suggested that males tend to experience greater TW than females, possibly due to increased tooth retention and greater occlusal forces in males.[11]

It is worth noting that prevalence studies are somewhat lacking for adults and stricter guidelines are required for quality control.[10] This may be attributed to the difficulties in recruiting participants and maintaining them, the varied study designs and terminology making comparisons difficult.

Aetiology

Clinical presentation and aetiology is usually subdivided into the previously mentioned terms of attrition, erosion, abrasion and abfraction. Diagnosis is often based on the clinical findings, which may suggest one causative factor. However, it is well known that the cause of tooth wear is multifactorial, making clinical diagnosis difficult. Thus it is suggested that these single terms, which can be useful when considering and describing the aetiology, may only describe the outcome of a number of underlying events rather than the cause or process involved in the wear.

It is important to acknowledge, even if one single contributing factor appears to be involved, that other damaging factors may be present. Failure to acknowledge this may lead to insufficient advice, failure of treatment and progression of the condition. A thorough patient history is essential to help aid understanding of the causative factors.

Occasionally, patients may have inherited dental conditions that may increase the severity of tooth wear, such as dentinogenesis imperfecta and dentine dysplasia, to name but two. It is important to inform these patients of their increased risk of wear.[12]

Attrition

Smith and Knight[13] found attrition to be the predominant pathological cause of tooth wear in 11% of cases and reckoned that it accounted for two-thirds of the combined aetiology of TW. It is important to acknowledge that a level of TW is normal, physiologically increasing with age, but may become pathologically secondary to a parafunctional habit.[14] The diagnosis of parafunctional activity is difficult and patients themselves are often not aware of the condition. In fact, it has been suggested that only half of the population of bruxists are aware of the condition.[15,16] Owing to this, the reported prevalence of bruxism varies between 5% and 96%.[3] Two popular theories have been proposed, but not confirmed, as the cause of bruxism, including parafunctional activity as a manifestation of stress[17] and as a result of premature contacts on mandibular movement.[18]

At present, there is little evidence to support the theory that a reduced number of occluding teeth leads to increased tooth wear. Studies have reported no significant correlation between the loss of posterior teeth and anterior TW, including the shortened dental arch.[19,20] It is suggested that the proprioceptive feedback mechanism and mutually protected occlusion contribute to this finding.[19,21]

Erosion

It has been well documented that demineralization of dental hard tissue leading to dental erosion occurs following the drop in pH of the oral cavity below critical pH, ie 5–5.5.[22] Smith and Knight[13] found an erosive aetiology as part of the cause in almost 89% of patients referred for severe wear. Erosion is often subcategorized into 'extrinsic' or 'intrinsic', depending on the nature of the acidic causative agent.[23]

A wide range of diseases and syndromes are associated with erosion:

- Various medications, such as the frequent use of asthma inhalers containing steroid or effervescent medication, which have a pH value ranging from 4.3 (Bricanyl, powder form) to 9.3 (Ventolin, aerosol form);[24]
- Reduced quantity and quality of saliva (including drug-induced, salivary gland agenesis, Sjögren's syndrome); and
- Reduced motor function (including cerebral palsy), affecting the clearing of acidic food and drink from the teeth, may

enhance intrinsic and extrinsic factors leading to erosion.[25]

It has been noted that, for children of all socio-economic backgrounds, tooth wear is most common on the palatal surfaces of the maxillary incisors. Furthermore, cross-sectional studies report a high prevalence of erosion, 53%[26] and 77%[27] in adolescents and adults, respectively, in the UK. The prevalence of dental erosion in children and adolescents is believed to be due to the increased susceptibility of demineralization of the newly formed dentition, the time taken for maturation and the reduced salivary buffering capacity at night.

Extrinsic erosion

Extrinsic sources of acid may include acidic food and drinks and medications, from the environment or industrial processes. Medications, such as Aspirin (a salicylic acid), iron tonics, chewable vitamin C and replacement hydrochloric acid, may lead to erosive tooth wear.[3]

Epidemiological studies have observed a correlation between acidic diets and the development of erosive TW.[28,29] Acidic food and drink intake has increased on a population level, furthermore, there has been an increase in population trends of leading a healthy lifestyle with increased consumption of diet drinks and 'juicing', leading to increased erosion. A strong link between the increased consumption of carbonated drinks, citrus fruits, fruit juices, herbal tea and erosion is well known.[23,28,30] Both carbonated and non-carbonated drinks exhibit a similar erosive potential.[31,32] The acids commonly found in these foods include phosphoric, citric and malic acid, however, there are many other acids with erosive potential in food. It has been accepted that titratable acidity, which is a measurement of the total acid content, is a more important indicator than actual pH value in determining erosive potential of beverages.[22]

Exposure to acid in the work place can lead to environmental erosion. It has been reported in those working in industries such as wine tasting[33] and manufacturing battery acid.[34] Leisure activities, such as swimming, may also be a causative agent due to low pH gas-chlorinated swimming pool water.[35] Due to this, improvements in health and safety have been developed, such as wearing protective airways masks, to reduce the effects of environmental erosion from the work place.[36]

Chronic alcoholism is a source of both extrinsic and intrinsic dental erosion, Extrinsically, the alcohol consumed has an acidic component, resulting in erosion alongside the effects of regurgitation, vomiting and gastritis.[4]

Intrinsic erosion

Intrinsic erosion results from the gastric content entering the oral cavity.[25] This can be from a variety of voluntary or involuntary habits and diseases. Vomiting can be both voluntary and involuntary as a result of pregnancy, as a side-effect of some medications, through alcoholism, alimentary tract disorders, as well as psychosomatic conditions including eating disorders.

Involuntary regurgitation of gastric acids may be a result of gastro-intestinal disturbances, such as during pregnancy, gastro-oesophageal reflux disease (GORD), vomiting, hiatus hernia or rumination.

Approximately half of patients with localized anterior tooth wear report having gastric reflux. GORD results in gastric content moving from the stomach into the oesophagus due to a laxity in the lower oesophageal sphincter.[37] It is now recognized as a more common condition for children/adolescents than previously thought. Stomach acid has a pH of approximately 2, which is highly erosive to the dentition. The effect can be particularly damaging to the dentition, especially the palatal surfaces, when continual episodes are involved.[38] Silent reflux can occur whereby patients are unaware of having longstanding, asymptomatic GORD leading to dental erosion. Referral to a general medical practitioner to assess this may be beneficial to the patient as repeated soft tissue harm can lead to strictures, ulceration of the oesophageal lining and, in some cases, malignant changes, in particular Barrett's oesophagus.[39]

Voluntary regurgitation is increasing due to increasing incidence of eating disorders, such as bulimia and anorexia nervosa. The most common sign of this condition is perimolysis lesions, which are erosive lesions on the palatal surfaces of maxillary incisors.[40] The effects of such disorders leading to self-induced vomiting in the development of dental erosion are well documented.[41,42] The incidence of bulimia has rapidly increased, with 14 per 100,000 affected and approximately 7 per 100,000 individuals in the population now thought to be affected by anorexia. This increase may be due to increased exposure to the media portraying the 'ideal' body shape and size.[43,44] It is worth noting that the male to female ratio is approximately 1:10. However, males are less likely to seek medical attention so may be at equal risk of eating disorders.[45]

Rumination predominately affects patients with mental disabilities. It involves GORD combined with voluntary or involuntary regurgitation of swallowed food into the oral cavity, which is then re-chewed and re-swallowed. Unfortunately, this condition is poorly understood and the prevalence of erosion associated is not fully known.[42]

Abrasion

The prevalence of abrasion is reported in a range from 5%–85%, depending on the inclusion criteria.[46] Abrasion can often result from over enthusiastic toothbrushing with abrasive toothpastes, improper use of interdental cleaning aids, or patient habits such as nail-biting, pen-chewing or having a tongue piercing. It is also suggested that there is an occupational hazard associated with some jobs, such as dress-making, glassblowers and musicians.[14] Dental treatment may cause attrition if improper materials are utilized, for example, unpolished ceramic restorations against a natural tooth.[1]

It has also been highlighted that the present day 'healthy diets' may be contributing to an increase in tooth wear,[1] especially if there is high erosive content from 'juicing', alongside an increase in abrasive foods such as nuts and seeds. It is important to take into consideration dietary, social and demographic patterns associated with time to determine what is acceptable for physiological wear.[47] This

makes the diagnosis between physiological and pathological a little more difficult to determine as it is ever changing.

Abfraction

Abfraction has caused much debate as to whether it is an accepted form of tooth wear. Much research has developed from finite element studies with little clinical evidence.[48,49,50] As TW is often multifactorial in nature, it is debated that abfraction is a manifestation of a combination of erosion, abrasion and attrition.[46] Erosive processes may lead to subsurface mineral loss, which leads to a softening of the tooth surface. Abrasion and attrition may lead to an acceleration of the tooth wear processes in the cervical region.

Clinical presentation

Due to the multifactorial aetiology tooth wear can present in a variety of clinical appearances, making a diagnosis may be difficult. Occasionally, one causative factor may be dominant and indicative of the main cause, but often the clinical appearance is the result of cumulative damage over a period of time. Tooth wear may present as localized or generalized loss off tooth substance, depending on the number of teeth affected.

Patients may be unaware of the presence of tooth wear, especially in the early stages of the process. However, often patients present complaining of reduced aesthetics. Occasionally, patients complain of the appearance of reduced lower facial height, however, due to alveolar compensation, this is not often a presenting feature. Dentists may note a reduced interocclusal space for restorations. Enamel may fracture and the teeth appear shorter.[23] Loss or thinning of the enamel may lead to shine through or exposure of the underlying dentine, changing the optical properties and colour of the teeth.[45] Patients may complain of symptoms of dentine sensitivity and impaired function.[51] Other reported symptoms of burning mouth syndrome, oral ulceration and parotid gland enlargement may be provided.[52]

Attrition

Attrition, as previously defined, results in loss of the cusp tips or incisal edges which generally interdigitate with the occluding dentition.[53] Initial presentation may involve localized occlusal cusp tips and the palatal surfaces of the maxillary anterior teeth showing loss of tooth structure. As the process progresses, dentine may become exposed, leading to flattening of incisal edges and cusp tips. The matching opposing surfaces wear at the same rate and so the teeth continue to interdigitate (Figure 1).

Figure 1. Tooth wear presenting as mainly attrition. The lack of posterior support may have contributed to this appearance.

Figure 2. Tooth wear mainly presenting as erosion from frequent vomiting in a patient with anorexia bulimia. Note how the crown has been spared from the erosive wear.

Figure 3. Tooth wear mainly presenting as abrasion with the prominent teeth being affected most.

Erosion

Often, early erosive lesions are not noticed by the patient. The cause of the erosion can determine, to some extent, the clinical presentation as the location and severity may differ.[5] If the erosive process is currently active, there is often no staining of the teeth. If dentine is exposed and stained, often the erosive element is no longer occurring.

In general, erosive lesions present clinically when in enamel only as rounded and smooth lesions with loss of surface contour. Once the enamel layer has been lost, exposed dentine is more susceptible to the acidic attack and the accumulation of tooth wear factors, leading to a more rapid loss of tooth substance. This can lead to cupping or dished out lesions. Teeth may appear translucent, due to thinning of the enamel anteriorly, or darker due to the exposed dentine. Anterior teeth may chip or fracture and restorations may stand proud from the teeth. A chamfer margin of enamel is often observed.[54]

In extrinsic erosion, for example from dietary intake, tooth wear is often observed on the buccal cervical surfaces of the maxillary teeth and the occlusal surfaces of the mandibular posterior dentition.[13] It has been suggested that erosive and abrasive TW can be differentiated, in the cervical region, as erosive wear tends to create broader dished-out shallow lesions in comparison to the sharply defined margins associated with abrasion.[55]

In intrinsic erosion, TW tends to present on the palatal surfaces of the maxillary dentition. The lingual surfaces and lower anterior teeth are often not affected due to the protective nature of the tongue covering them from exposure to the acid attack[41] (Figure 2).

Abrasion

Clinical presentation is dependent on the causative factor and will affect the severity and distribution of the wear. Localized lesions may be the result of a habit such as pen-chewing, nail-biting, pipe-smoking, or present as an occupational issue, such as builders holding screws between their teeth. The tooth wear pattern

will fit the shape of the object causing the wear.

Overenthusiastic toothbrushing often presents as rounded grooves in the cervical region of teeth; again this can present as a localized problem, often with the canines and premolars being most affected, or as a more generalized condition dependent on the patient's toothbrushing technique. Of note, right-handed individuals tend to create more wear on the left side and vice versa (Figure 3).

Abfraction

Abfraction lesions can present similarly to toothbrushing abrasion cavities, but tend to be more angular and undercut at the coronal aspect where enamel overhangs the defect.

Examination of the tooth wear patient

For patients presenting with tooth wear, the extra-oral examination should include an assessment of their temporomandibular joints and associated musculature. The presence of any clicking, crepitation, mandibular deviation on opening or closure, maximum jaw opening (less than 40 mm is considered restricted) and any associated muscle tenderness/aches/pain should be recorded.[56] It is also worth noting the presence of parotid gland enlargement, which is often seen in bulimic patients.

Severe tooth wear patients may present with a reduced lower facial height due to over closure from loss of vertical tooth height. Due to this, the facial vertical proportions should be noted. This can be examined by assessing the freeway space (FWS), by determining the patient's resting vertical dimension (RVD) and occlusal vertical dimension (OVD). Callipers or a Willis gauge can be used for this. Other simple techniques include the use of phonetic assessments (particularly the sibilant sounds) and facial soft tissue contour analysis.[57] The patient's smile aesthetics may also be examined looking at the smile line and lip line.

A full intra-oral examination should be undertaken including a detailed soft and hard tissue assessment. The level of oral hygiene should be recorded together with the undertaking of a Basic Periodontal Examination (BPE). An occlusal assessment may be required for moderate to severe wear.

Measuring and monitoring tooth wear

A large number of indices have been developed over the years, including the more popular Tooth Wear Index (TWI)[13] and the Basic Erosive Wear Examination (BEWE).[58] However, at present, a single universally accepted method of quantifying and recording tooth wear is yet to be adopted.[59] This can make recording and documenting TW difficult.

Some indices record wear based on the aetiology; however, the majority of indices that have been developed are based on the diagnosis and monitoring of the wear. These indices tend to distinguish severity of the wear and are often numerical in nature. Measuring wear *in vivo* is difficult for a clinician as indices can only provide the prevalence of wear at the point of time of recording as there is a lack of reliable natural reference points for continuity. The majority of indices rely subjectively on visual assessment of the wear severity, which can lead to a conflict of opinions from different clinicians. Furthermore, the vast number of indices available makes comparison and aggregation of data challenging.[6]

The Tooth Wear Index, developed by Smith and Knight,[13] is the most widely utilized. It was designed to be of use in research into the aetiology, prevention, management and monitoring of tooth wear and epidemiology. It was the first index of its kind to measure and monitor multifactorial tooth wear. It is a comprehensive index whereby the four surfaces of a tooth are scored according to clinical findings based on the level of enamel lost, level of dentine lost and change of the contour of the surface. Smith and Knight[13] proposed a distinction of pathological levels of wear based on a patient's age.

However, there are several limitations to this index.[11] The thresholds for each age group have been criticized with subsequent underestimation of pathological wear.[59] A number of suggestions have been proposed to improve the TWI, including modifying the threshold values for pathological wear, expanding the scoring criteria and creating another scoring level for secondary dentine and pulpal exposure. Millward *et al*[60] modified the TWI to study erosion in primary and secondary dentine by grouping TWI scores into categories of 'Mild', 'Moderate' and 'Severe'. Again, there is potential for overestimation of tooth wear. Fares *et al*[61] undertook the most recent modification of the TWI to produce the Exact Tooth Wear Index. This index scores wear for enamel and dentine separately. It has the potential for scores to be converted into the original TWI for research purposes for comparison and review.

The above indices tend to be quite comprehensive and often used for research. Bartlett *et al*[58] designed The Basic Erosive Wear Examination (BEWE). It is a simple index, based on the principles of the Basic Periodontal Examination (BPE) as a screening tool for tooth wear. The BEWE is a partial scoring system recording the most severely affected surface for each sextant. This can then be utilized to guide management of the condition, much like the BPE for periodontal disease. This index has been found to be easy to use by general dental practitioners and researchers alike. Studies have found the BEWE to be an acceptable method for scoring erosion with good inter-examiner reliability when scoring sound surfaces and TW into dentine, but more discrepancies were recorded when scoring enamel lesions.[62]

A new classification, proposed by Vailati and Belser,[63] the Anterior Clinical Erosive classification (ACE), aims to provide a tool that is easier to use than the BEWE for clinicians. Patients are grouped into six classes based on five parameters relevant to the treatment and the prognosis:

1. The dentine exposure in the contact areas;
2. The preservation of the incisal edges;
3. The length of the remaining clinical crown;
4. The presence of enamel on the vestibular surfaces; and
5. The pulp.

A dental treatment plan is suggested for each class.[63] Much like the aforementioned BEWE and the well-known Basic Periodontal Examination (BPE) utilized

for assessing periodontal disease, the most severely affected tooth is used to decide the classification. It is worth noting that the classification is specifically for the anterior maxillary dentition, however, assessment and treatment of the posterior dentition must also be planned as an integral part of the definitive oral rehabilitation, which is a limitation of this classification.

The difficulty with all the indices is that they are subjective and potentially insensitive to small changes. Some, such as the TWI, may be time consuming in a general dental practice setting when compared with the BEWE and ACE. However, both are good for assessing the level of tooth wear and how best to manage the condition. Alternative methods to measure TW include using intra-oral three-dimensional laser scanners; sequential photographs; periodic accurate study casts; sectional silicone index and radiographs, which have all been utilized in clinical settings with varying results. Furthermore, assessing the patient clinically and for changes in reported symptoms, ie the patient begins to notice increased tooth wear or sensitivity, should also be utilized for measuring TW.

Diagnosis

The difficulty in distinguishing between the clinical presentations and often multifactorial nature of tooth wear can make diagnosis difficult. It is important to take into consideration whether the wear is physiological or pathological. A detailed history of the chief complaint should be ascertained and documented. Alongside this, also record an accurate and up-to-date medical history assessment of the clinical signs and symptoms and the location of the wear (generalized or localized) when creating a diagnosis.

The diagnosis of a patient presenting with tooth wear should include a description of the type(s) of lesions observed, together with an account of the extent/location (localized, anterior/posterior or generalized) and severity (restricted to enamel only, into dentine or severely affecting the teeth involving the pulp) of the condition.

Prevention

The increase in incidence of tooth wear, especially in children, is concerning as, without appropriate prevention, this is likely to continue into adulthood.[64] The correct diagnosis is essential for successful prevention and management. Even though prevention is of utmost importance, there is little high quality evidence about the clinical effectiveness of most preventive measures.[65] Furthermore, it is difficult to predict which individuals will be affected by TW, making primary prevention difficult to achieve.

The decision to treat arises when the extent of the tooth wear and potential for progression may affect the prognosis of the tooth, or the patient expresses a want for treatment, or there is the presence of symptoms. In the absence of functional and aesthetic issues, monitoring and counselling may be the preferred treatment option.[66]

It is reported that, once TW has been diagnosed, wear progression appears to occur at a relatively slow rate whilst the enamel is still present, particularly in cases where preventive advice has been successfully implemented.[66,67] However, a change in lifestyle and personal circumstances, including an increase in stress, may be associated with sporadic bursts of wear activity amongst these patients, which may have the potential to produce severe wear. Therefore, early preventive advice is paramount to success in preventing ongoing wear leading to possible highly restored dentitions with long-term management requirements. Most research into the efficacy of preventive strategies has focused on the prevention of erosive wear. Preventive advice should be structured in relation to cause.

Preventive advice may be centred on medical management with referral to a medical practitioner or psychiatrist.[68] This is considered appropriate when an eating disorder or reflux disease is suspected. Medication, such as antacids, omeprazole and ranitidine can be used to reduce gastric reflux and acid production. Where xerostomia may have an underlying role, referral to a specialist in oral medicine may be considered; or discussing with the medical practitioner an alternative medication if xerostomia is a side-effect of a current medication regimen. For example, in cases of acid erosion, avoidance of further exposure of the tooth to acid is paramount.[66] A reduction in the quantity and frequency of the consumption of acidic food/drinks would be beneficial. Patients should also be advised to limit their consumption of acidic foods/drinks to meal times. A change of habit, so that when acidic drinks are consumed they are drunk through a wide bore straw, plus avoidance of swishing beverages in the mouth, will help to reduce the rate of dental erosion. It has been found that consuming dairy products, including hard cheese or chewing gum after the ingestion of an acidic substances, is beneficial in promoting the re-hardening of enamel, stimulating saliva flow and increasing the saliva pH and reducing the effects of the erosive source.[69]

Appropriate toothbrushing advice and habit avoidance or counselling will also be of benefit to the patient, including the avoidance of overzealous toothbrushing and the use of less abrasive toothpastes such as those marketed for tooth whitening. Toothbrushing shortly after acid exposure (commonly practised after vomiting or after drinking citrus juice in the morning) should be avoided. Studies have shown that remineralizing toothpastes increase the surface hardness of teeth exposed to acidic substances and have a greater effect than conventional fluoride-containing toothpastes alone.[70] However, topical fluoride application has been shown to protect against subsequent tooth wear following an acid challenge. A neutral sodium fluoride mouthrinse or gel should be recommended.

Furthermore, fluoride application can also aid in prevention of symptoms of sensitivity. Toothpastes containing potassium and *Tooth Mousse ACP* (GC) are also considered to be appropriate for the management of dentine sensitivity.[56] Such agents may be applied with the aid of a custom-fabricated tray (containing reservoirs akin to bleaching trays). For patients experiencing sensitivity this may be prevented by the application of dentine-bonding agents, and fissure sealant to erosive lesions may be of some benefit. However, studies have shown the longevity of dentine-bonding agents applied to teeth displaying severe wear to be relatively short lived.[71] Glass ionomer cements can also be readily applied to worn surfaces for

Figure 4. (a, b) Soft or bilaminar splints are cheap to provide but not as durable as a hard acrylic splint.

Figure 5. (a, b) A maxillary hard acrylic splint involves more clinical and laboratory time to make. It can be more durable and effective when treating severe tooth wear, TMJ dysfunction and reducing muscle dysfunction.

the purposes of sensitivity and tooth wear prevention.

Advising patients to change habits, such as that of pen/pencil-biting, nail-biting or holding or opening objects with the teeth, such as bottle tops, hair grips, sewing needles, pipes, will also help prevent ongoing wear.

In cases of tooth wear, splint therapy is beneficial in order to prevent the loss of tooth structure from attrition. The use of a night guard is recommended for nocturnal bruxists. This may be a soft splint, but this will not be durable in the long term. A bilaminar splint may be more cost-effective[72] (Figure 4). However, for an established bruxist patient, a full coverage hard acrylic occlusal splint should be constructed (ie a Michigan splint or a Tanner appliance). The splint should be fabricated to provide an 'ideal occlusion' (Figure 5). It is important to take precautions when providing splints to patients with an erosive factor, in the cause of the tooth wear, especially if night reflux is a causative factor. Advice should be given to the patient accordingly, as the acidic substances may accumulate within the splint and further exacerbate the rate of wear, and regular maintenance is required. Splints may be used to protect teeth during episodes of vomiting for the bulimic patient, which are worn during the vomiting period only and after vomiting should be removed and cleaned. Again precautions and instructions on wear/usage must be precise, so that the splint does not become a reservoir for the acid produced. In erosive tooth wear a soft vacuum-formed appliance modified to include reservoirs is beneficial. Neutral fluoride gels, desensitizing agents and also acid neutralizers, ie sodium bicarbonate solution, can be applied, respectively.[56]

Key points

1. Making a diagnosis in tooth wear is a fundamental starting point for managing TW. It should be expressed in terms of aetiology, severity, whether it is physiological or pathological, localized or generalized and compensated or non-compensated. This should be explained to patients in terms that they can understand.
2. Monitoring tooth wear is best carried out with study casts or photographs. In the future, digital scanning methods are likely to be available in daily practice. The most useful indices[58,63] have not gained universal acceptance as yet.
3. Tooth wear usually has a mixed aetiology of attrition, erosion and abrasion. Abfraction is not a universally accepted entity.
4. Patients' attitude will dictate whether prevention or treatment is advised. They may be aware or unaware of their tooth wear. If it is of concern and they have symptoms (pain, poor function or poor appearance) they may request treatment. If possible, the dentist should advise prevention or minimal intervention treatment to prevent symptoms from occurring.
5. The exposure of dentine and presentation of thin or unsupported enamel should prompt a discussion with the patient about the tooth wear. The rate of TW is likely to increase when dentine is exposed.
6. Preventive management of tooth wear may include any of the following:
(a) Dietary advice;
(b) Medical referral;
(c) Oral hygiene instruction and correction of damaging habits;
(d) Fluoride application;
(e) Alkaline solutions;
(f) Remineralizing solutions;
(g) Desensitizing agents;
(h) Occlusal splints;
(i) Composite or glass ionomer restorations to cover dentine.
7. In early or mild presentations of tooth wear, in the absence of symptoms, monitoring and prevention may be most appropriate.
8. Occlusal splints may be soft, bilaminar (hybrid) or hard and can be placed in either jaw. The selection will depend on the severity of tooth wear and cost involved. Hard acrylic splints are expensive but are more effective in managing severe TW, severe TMJ dysfunction and establishing a reproducible retruded contact position (RCP) in pre-restorative treatment.

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Tooth Wear Guidelines for the BSRD Part 2: Fixed Management of Tooth Wear

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The management of tooth wear (TW) may often present a dilemma to the clinician. The clinical decision-making process between monitoring and active management can be difficult. Thorough history-taking and clinical assessment are essential parts of gathering sufficient information to allow the clinician and the patient to make these treatment decisions.

Uncontrolled tooth wear can lead to poor aesthetics, dentine hypersensitivity and functional problems, ultimately resulting in a reduced quality of life. Significant tooth structure loss can also lead to difficulties with any potential rehabilitation.[1] Patients often only become aware of their TW when the appearance of their teeth begins to deteriorate or they become symptomatic. Enamel may appear thin or discoloured, begin to fracture and the teeth may appear shorter.[2] Exposure of dentine can lead to transient pain in response to chemical, thermal, tactile or osmotic stimuli. This is commonly known as dentine hypersensitivity and may occur following loss of enamel with dentinal exposure secondary to tooth wear.[3] This pain can often be unsettling for the patient and may lead to limitation of the types of food or beverage ingested.

Loss of tooth structure can have many restorative implications. The need to conserve tooth structure, in particular enamel, remains vital to the predictability of adhesive restorations which are indicated, where possible, to avoid removal of more tooth structure, as is required with conventional crown and bridge work.[4] Further restorative difficulties can be encountered as TW causes loss of interocclusal space, thereby leaving limited space for the restorative material.

Uncontrolled tooth wear may ultimately result in decreased quality of life, affecting patients' satisfaction with their dentition, in particular; aesthetics, oral comfort and/or mastication.[5] Correct diagnosis is therefore critical for successful management of TW. The predominant aetiology should be determined and the patient concerns identified.[6] Although the rehabilitation of worn teeth is common clinical practice, there appears to be a stark absence of documented outcomes. It has been identified in numerous reviews that there is no strong published evidence on management strategies.[6,7] To date, most recommendations are based on published, evidence-based, expert opinion or observational studies, with a lack of high quality research supporting individual restorative measures for the replacement of tooth tissue.[7]

The decision to treat arises when the patient's needs, severity of the wear and potential for progression are of concern. There is a lack of evidence to suggest that the presence of TW will predictably lead to severe wear.[6] In the absence of aesthetic or functional issues, monitoring of the TW and preventive advice, including diet counselling, may be preferable.[8,9]

The preservation of tooth

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structure is critical. In cases of intrinsic erosion, prevention of further exposure to the damaging gastric contents is of paramount importance.[10] The management strategy should be centred around medical management, and psychiatric evaluation if eating disorders are suspected.[11] Parafunctional habits may exert highly destructive forces and are difficult to prevent in comparison to erosive wear.[12] Despite prevention being the foundation for successful management, there is a lack of high quality evidence about the clinical effectiveness of most preventive measures.[13]

Indications for fixed management of tooth wear

Generalized/localized tooth wear in dentate patients with associated:

- Pain/discomfort;
- Aesthetic concern;
- Functional disturbance;
- Compromised structural integrity of tooth/teeth;
- Alveolar compensation with resulting lack of interocclusal space for restoration.

Contra-indications for fixed management of tooth wear

Contra-indications include:

- Worn teeth compromising periodontal disease and/or extensive caries;
- Unrestorable teeth – vertical root fractures, horizontal/oblique fractures to bone crest, caries to bone crest, failed endodontics;
- Concurrent soft tissue defects;
- The additional time and cost involved which may be prohibitive for some patients;
- Worn dentitions with extensive edentulous spans or insufficient posterior support and dental implants are not considered.

Aims of fixed management of tooth wear

Restorative management of tooth wear may be necessary in order to achieve the aims of restoring the appearance, function and/or speech of patients with worn dentitions, conserving remaining tooth structure and reducing sensitivity or pain associated with worn teeth. This may be by means of fixed, removable or a combined fixed and removable restorative approach. Disadvantages of restorative treatment revolve around the patient entering the restorative maintenance cycle, thus rendering both the restorations and the teeth susceptible to fracture or even failure. The consequences of failures and their subsequent management must all be taken into consideration prior to embarking on a restorative management strategy.

Preliminary investigations

The initial investigations should involve thorough assessment of the patient in order to identify the cause of wear, if possible, and correlate the clinical symptoms resulting from such wear. The relevant aesthetic, restorative, periodontal and endodontic examinations should be carried out along with any necessary radiographic investigations. This should be accompanied with a set of mounted study casts.

On conclusion of the assessments, the clinician will be able to draw conclusions on the overall state of the dentition, the complexity of the problem, individual and general prognosis and potential treatment options available.

Diagnostic phase

Mounted study casts

A set of articulated study casts can be used to assess the overall dentition, occlusal relationship, contacts and interferences, and restorative space available. The mounted casts can also be used to assess the effect of changing occlusal contacts (trial equilibration), diagnostic repositioning of teeth[14] and to create a diagnostic preview.

If it is determined that reconstruction is required, treatment should aim to restore the worn dentition to a determined occlusal vertical dimension needed to create space for restoration of lost tooth tissue, avoiding sound tooth destruction, whilst ensuring acceptable function and aesthetics. In most patients who are fully or mostly dentate, where restorations will be tooth borne, such changes are well tolerated. The occlusal vertical dimension should ideally be captured with a jaw registration at or close to the desired vertical dimension, which is then used to mount the casts. A diagnostic wax-up can be carried out at the desired vertical dimension. This diagnostic preview forms the foundation for future treatment and can be transferred to the patient in order to assess proposed changes in the vertical dimension and aesthetics and function.

Occlusal splints

A hard heat-cured full coverage acrylic splint can be used in the diagnostic phase. The ideal splint should provide even contact along the retruded arc of closure, with anterior guidance on anterior teeth with posterior disclusion and canine guidance in lateral excursions with no interferences from the posterior dentition.[15] They can provide the following benefits:

- Protect worn teeth from any further wear, especially if the original cause is attrition;
- Disrupt the habitual path of closure into intercuspal position (ICP) by separating the teeth;
- Testing tolerance to the planned changes in occlusal vertical dimension.[16-18] This is probably unnecessary, since proprioception makes tolerance highly likely when occlusal loads are directed through the periodontal ligament (PDL), as with fixed restorations;
- Pre-restorative stabilization to ensure a reproducible jaw relationship is established prior to embarking on a re-organized approach. This is thought to be achieved by breaking the proprioceptive feedback from periodontal mechanoreceptors, resulting in muscle relaxation that will facilitate the accurate recording of the retruded axis position (RAP);[17]
- Protection of new restorations from occlusal forces in parafunction;
- Management of temporomandibular dysfunction through a true therapeutic effect or potential placebo effect.[19,20]

Partial coverage splints should be avoided due to potential selective intrusion and extrusion of teeth. The resulting malocclusion can be difficult to correct and a potential source of medicolegal litigation.

Planning strategies

Management strategies will be influenced by the following factors that should all be considered during the

Figure 1. Adhesive metal backings and onlays are durable but can have poor aesthetics.

planning phase:

1. The aetiology and pattern of tooth wear;
2. Occlusal vertical dimension, dento-alveolar compensation and available restorative space;
3. The remaining available tooth tissue;
4. Space requirements of the proposed restorative materials;
5. The patient expectations

Aetiology and pattern of tooth wear

The aetiology of tooth wear and wear resistance of restored and natural teeth should be considered. Although some aetiologies can be controlled, some may be beyond the control of the patient or the clinician. It is essential to establish whether the restored dentition is likely to be exposed to such causes of wear prior to making material choices. Behaviour under normal and excessive loads will have an influence on decision-making, especially in parafunctional patients. Given the complex nature of the oral environment, both mechanical and biological failures are possible. Biological failures have been shown to be primary or secondary (often following a mechanical failure), and are more probable.[21] Laboratory-based trials have shown the wear resistance of gold and ceramic materials to be similar, whereas resin-based materials have demonstrated three to four times more material wear than gold or ceramics. In cases of high load conditions, traditionally, metal or metal-ceramic restorations have been recommended as the material of choice,[6] however, under extreme conditions there is no material that is likely to last. Nevertheless, survival of the restorative material is of far less importance by way of comparison to survival of the tooth and the dentino-pulpal complex.[13]

Modern resin-based restorative materials have risen in popularity due to their use being less destructive to the remaining tooth tissue whilst serving the functional requirements, bringing into question traditional fixed prosthodontic approaches.[9]

Localized tooth wear

The vast majority of studies are centred around management of localized tooth wear. Huge variations in outcomes exist in the reported success and survival of direct and indirect restorations. There has been a gradual evolution in restorative methods when it comes to the management of TW. Traditional methods revolved around full coverage cast restorations. Rochette's introduction of a method for cementation of metal alloy castings to enamel without relying primarily on macromechanical resistance and retention resulted in significant advances within restorative dentistry.[22] The adhesive techniques proposed allowed for a more conservative approach to be adopted, whereby individual cast-metal veneers cemented to the palatal surfaces of anterior maxillary teeth. Further advances in the physical properties of resin-based restorations have resulted in a further development of management techniques involving the sole use of composite resin-based restorations.

The success and survival rates of the newer adhesive techniques have gradually improved with the evolution of materials. Nohl et al, reported an overall success rate of 89% in a retrospective survey of 48 patients treated with 210 metal palatal veneers for anterior palatal TW for periods of up to 5 years.[23] They recommended the combination of metal palatal veneers with resin composite luting agent restoring the functional surfaces of maxillary anterior teeth affected by acid erosion (Figure 1).

Direct composite resin restorations have been extensively studied and vary significantly in annual failure rates from 0.7%[24] to 26.3%.[25] Variations in material properties have been suggested as contributory factors to this wide variation. Microhybrid composite resins have been shown to perform better than the older microfilled resins.

In a series of studies assessing direct and indirect composite resin restorations in predominantly erosive cases, Gow and Hemmings found an annual failure rate of 6.9% in a relatively short follow-up of two years for indirect palatal ceromer veneers.[26] The indirect restorations did not offer any advantages over direct composites. Gulamali *et al* found a similar annual failure rate when assessing indirect and direct hybrid composites in the management of localized TW, with median survival times of 7 years for major failures and 5.8 years when assessing all failures.[27] Despite more than 50% of all restorations suffering some form of failure, the authors concluded that composite resin restorations offer a viable medium-term management strategy for TW, in view of the fact that they are non-destructive of tooth tissue when compared with conventional indirect restorations and treatment can be repeated. Despite the huge variation in clinical situations posed and the variety of approaches used to rehabilitate dentitions, which limits comparison among different studies, annual failure rates of composite resin restorations appear to be within an acceptable range.

Generalized tooth wear

Traditional treatment methods for patients with severe generalized tooth wear involved full mouth rehabilitation with cast indirect restorations, However, there is a lack of well-designed clinical studies assessing performance and outcomes for this method.[6,7] This, combined with high cost and an invasive technique, rendered this approach less favourable when compared to the newer more conservative treatment strategies. Despite rehabilitation of severely worn teeth being common practice, there appear to be deficiencies in the evidence in support of specific techniques or materials.[28]

The limited data shows that rehabilitation of TW with direct composite resin can offer good clinical results, whilst being less invasive than preparations for an indirect approach. Direct hybrid composite restorations have been reported to perform well, even in larger posterior restorations. A number of studies have suggested that

a

b

c

Figure 2. (a, b) Full mouth reconstruction with conventional crowns and bridges at fit and at 14 year review. The long span bridge has failed and the UR3 abutment is unrestorable. **(c)** Lower arch at 14 years with no failures.

material properties may not be as relevant as originally thought when considering longevity of the restorations.[29,30] A retrospective case series by Hamburger *et al* assessed the use of direct composite resin in the management of severe TW caused by erosion, bruxism or a combination of the two.[12] A total of 332 restorations were placed in 18 patients over a period of 6 months to 12 years following completion of treatment. Findings were again descriptive, with a total of 23 failures, predominantly in the maxilla, 8 of which were major failures. The authors concluded that the direct hybrid composites offer good clinical performance in cases of severe TW.

In a prospective study assessing 1010 restorations in 164 patients, Milosevic and Burnside suggested that direct hybrid composite resin restorations offer a predictable option in the management of generalized TW, with relatively low failure rates.[31] The study highlighted the detrimental impact of attrition and the lack of posterior support on survival outcomes.

Within the current literature, very few studies are available assessing the management of generalized TW, with even fewer comparing the use of direct and indirect restorative techniques.

Vailati assessed the management of severely eroded dentitions with a combination of indirect palatal composite restorations and labial porcelain veneers.[32] The study concentrated upon observations on the restored anterior teeth, whilst the posterior teeth were restored but not assessed. The authors used USPHS assessment criteria, with most restorations receiving alpha or bravo scores, however, no statistical analysis of the results were carried out, with findings being purely descriptive. Despite positive findings in the use of ceramic in erosive cases, the risk of chipping under heavy load, coupled with difficulty in repairing ceramic restorations, may prove to be a significant deterrent for its use in wear cases when aetiology might involve some form of parafunction.[33]

Only one study compared the use of composite resin restorations and traditional metal-ceramic and gold restorations in the severely worn dentitions.[34] This study found cumulative survival estimates of 74.5% for indirect restorations and 62% for direct restorations, over 10 years. Over the study period the authors found a strong trend for lower survival of the composite resin restorations in comparison to the indirect restoration. However, these results were not statistically significant. The least failures were noticed with full gold crowns, whilst the metal-ceramic crowns experienced 25.2% failures. Modes of failure with indirect restorations were mostly biological complications. Composite resin restoration, in comparison, suffered more fractures, the management of which was identified as being straightforward (Figure 2).

The aetiology of wear can have a significant impact on the subsequent management. Incorrect diagnosis can prove to have a confounding effect on results. Parafunctional activity can result in devastating forces resulting in the increased risk of mechanical failure at both the restoration and tooth level. Numerous clinical studies on the management of severe TW exclude high risk subjects such as bruxists.[28] As such, interpretations of these studies should be carried out with caution. Research into the use of composite resin in such cases have shown mixed results. A few studies have shown good outcomes supporting its use,[31,34] however, these were over a relatively short observational period, whilst others have shown poorer outcomes.[25,35] It is clear that further high-quality research is required to aide material choice in such cases.

Assessing the occlusal vertical dimension and available restorative space

In the absence of tooth wear the free-way space remains constant due to the continued growth and increase in anterior facial height into middle age.[36,37] Localized TW often presents with the occlusal vertical dimension within normal limits.

Generalized tooth wear can often present one of two distinct outcomes:

1. Compensated TW: Tooth wear with continued eruption of teeth, allowing free-way space and facial proportions to remain constant without loss of occlusal vertical dimension.[38,39]

2. Non-compensated TW: Tooth wear when the rate of the TW exceeds that of the physiological mechanisms of tooth eruption.[40] This will result in an increased free-way space and loss of occlusal vertical dimension.

The list below can be used in combination to determine the correct OVD:

1. The point of first contact along the retruded arc of closure (RAP) if there are unworn teeth posterior to the worn anterior teeth. This will be the retruded contact position (RCP) and may provide the required space to restore the worn anterior dentition;

2. Ideal tooth dimensions;

3. Occlusal plane and tooth display at rest and on smiling;

4. Amount of posterior

Figure 3. (a) Anterior erosive tooth wear. **(b)** Metal Dahl appliance in place. **(c)** Dahl appliance removed after 4 months of use. **(d)** Conventional crowns in place. Case completed in 1993. Adhesive restorations would be considered more appropriate today.

Figure 4. (a, b) Anterior tooth wear showing loss of incisal height and palatal erosion in a male patient with excessive intake of carbonated drinks. **(c, d)** Post-operative view of first documented case of composite 'Dahl' approach.[49] **(e, f)** Posterior disclusion at time of placement of composite 'Dahl' restorations. Posterior occlusion restored in 4 months.

prosthetic space required for restoration of teeth;

5. Assessing phonetics;

6. Photographs of the patient's teeth prior to being worn.

Generally, dentate patients will be able to tolerate even significant changes in the occlusal vertical dimension. The ability of the dentate patient to adapt to changes in the vertical dimension is thought to be down to the the nature of the dento-alveolar structures and associated neuro-musculature proprioception through the supporting periodontal ligament.

The occlusal vertical dimension can theoretically be increased to anywhere along the retruded arc of closure in a dentate patient. Dahl *et al* used a removable appliances to increase the vertical dimension from 1.8 mm to 4.7 mm (mean of 2.84 mm).[41] Hemmings *et al*[25] and Gow and Hemmings[26] placed anterior restorations at an increased vertical dimension allowing for separation of posterior teeth of up to 4 mm.

Assessing severely worn teeth for remaining available tooth tissue

Severely worn teeth can still be restored by means of traditional or adhesive techniques. The tooth must be assessed by the following normal parameters in order to determine its restorability. Additionally, the following factors have an impact on restorative material choice:

- Remaining enamel and dentine – Despite improvements in dentine bonding the presence of a complete 'ring' of enamel may influence the clinician towards adhesive restorations;
- Remaining clinical crown height – If sufficient tooth structure is remaining to provide sufficient resistance form for conventional restorations. For conventional restorations, tooth restorability should be assessed without any existing restorations allowing evaluation of the amount and contribution of remaining coronal dentine to resistance and retention form.[42] Less critical for adhesive restorations.
- Pulpal status of tooth – Reducing a tooth will expose more dentinal tubules and less calcified dentine, making the pulp more vulnerable to cariogenic bacteria.[43,44] The physical and thermal insult of conventional preparation techniques can result in

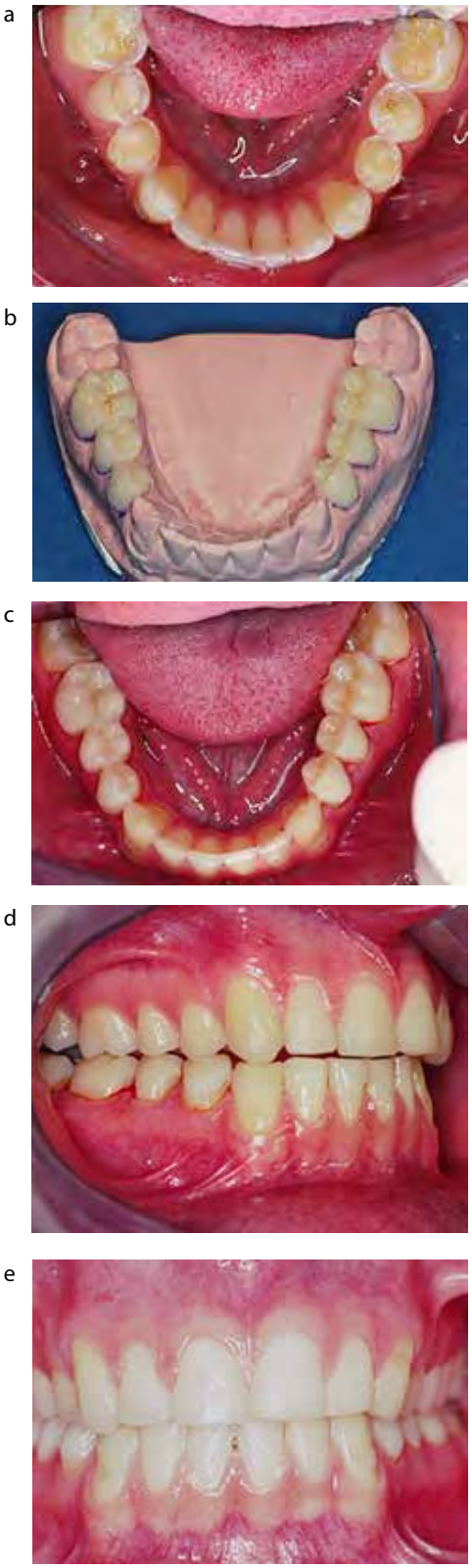

Figure 5. (a) Posterior occlusal wear. **(b)** Posterior composite onlays. **(c)** Posterior onlays *in situ*. **(d)** Anterior and posterior disclusion created. **(e)** Occlusion re-established at 6 months.

Figure 6. (a) Anterior tooth wear pre-operative appearance. **(b)** Appearance after crown lengthening surgery. **(c)** Post-operative appearance with composite restorations.

an increased risk of pulpal pathology.[45]

Space requirements of the proposed restorative materials

The survival and success of restorations is heavily influenced by the physical properties of what material the techniques use and the environment within which it is placed. Conventional cast metal ceramic restorations have the largest footprint, requiring up to 2 mm occlusal reduction and can result in up to 72% loss of tooth tissue (by weight).[46] All-ceramic monoblock crowns can be less destructive, with the reduction guides for newer full contour zirconia crowns being comparable to conventional full metal crown preparations. Space requirements for adhesive restorations vary depending on the material properties and function. Adhesive metal onlays require a minimum of 1 mm occlusal clearance, whilst adhesive metal palatal veneers require a minimum thickness of 0.7 mm. Composite resin restorations require a minimum thickness of 1–2 mm, depending on manufacturer guidelines and functional load.

Methods of achieving space for restorative materials

- Occlusal reduction of those teeth to be restored – This can be particularly destructive to compromised teeth with short clinical crowns and reduced amount of tooth tissue.
- Reduction of opposing teeth – An option if opposing teeth are unaffected but preservation of dental tissue is vital in cases of tooth wear.
- Occlusal equilibration – If there is a significant horizontal discrepancy between retruded contact position (RCP) and intercuspal position (ICP) space may be generated. This alone rarely provides a solution in cases of advanced wear, since it is difficult to establish a definite ICP in a more distal relationship. It is difficult to achieve and involves preparation of already compromised teeth which warrants a careful assessment and execution. It is more often used as a pre-restorative measure before extensive restoration.[47]
- Conventional orthodontics – This provides a controlled and predictable method of creating localized interocclusal clearance. Conventional orthodontic appliances are indicated when tooth movements in addition to minor axial movements are required.
- Localized minor axial tooth movement ('Dahl' approach) – There is a variety of methods that combine differential intrusion and eruption of teeth to create interocclusal space, as originally described by Anderson[48] and subsequently Dahl[41] (Figures 3–5). This well-described approach can be adapted to modern adhesive materials and techniques.
- Crown lengthening surgery – Although this does not create space in itself, increased axial wall height aids in retention and resistance form for restoration. Gingival re-contouring may also modify the gingival architecture and improve aesthetics (Figure 6).
- Elective devitalization of pulps in order to utilize the root canal for retention of cast retention – A destructive option that worsens the prognosis for the tooth as compared with other methods of restoration described.

Figure 7. (a) Generalized tooth wear with erosion predominating. **(b, c)** Occlusal views of maxillary and mandibular arches. **(d)** Full arch reconstruction with composite restorations. There are no long-term studies on the survival of this type of management of tooth wear. **(e, f)** Occlusal views of dental arches. **(g)** Review at 6 years. Composite repairs have been carried out on LL3 and UL7.

- Increasing the OVD, re-organizing the occlusal scheme in retruded axis position (RAP) at a pre-determined vertical relation – This may involve fixed, removable, or a combination of these options to reconstruct one or both dental arches. This entails a complex, expensive and extensive treatment with long-term maintenance (Figure 7).
- A combination of the above.

Material choice

Material options available:

- Cast metal restorations;
- Cast metal ceramic restorations;
- All-ceramic restorations;
- Cast metal palatal veneers;
- Indirect ceramic veneers;
- Indirect resin restorations;
- Direct resin restorations;
- Combination.

The choice of material to be used for the restoration is critical. Unfortunately, the vast majority of research on the physical properties of restorative materials are laboratory-based trials. Extrapolation of results to the variable clinical environment is fraught with difficulty.[50] With such uncertainty concerning the likely prognosis of different treatment options, it is reasonable to delay treatment for as long as possible and provide a conservative approach initially.

With careful planning following a 'tooth by tooth' assessment, a combination of technologies may provide an extensive but conservative treatment plan (Figure 8).

Managing patient expectations

It is important for patients to have realistic expectations of any future reconstruction. They must be informed of their limitations and potential clinical and financial implications of failure from the outset so that they do not attribute this to inadequate clinical work. The patient will need to be motivated and have a positive outlook if treatment is to provide a successful outcome.

Key points

1. Consider adhesive methods of repair first when treating tooth wear. Good moisture control and attention to detail with bonding procedures are required.
2. The prognosis for teeth can be difficult to ascertain. In severe wear and in teeth which have been heavily restored the prognosis may be poor. When investigating such teeth, the patient should be told of the risk of removal if the prognosis becomes clear that they are uneconomic to repair or hopeless.
3. If space exists and restorations conform to the current occlusion, treatment may be relatively straightforward.
4. If a re-organized approach is undertaken and the occlusion is to be changed, careful planning is required. Mounted study casts are required to produce a diagnostic wax-up or wax try-in. An aesthetic composite or acrylic mock try-in can be tried in the patient's mouth for approval. Digital simulations are also possible.
5. Fixed adhesive or conventional repair with crowns are usually possible if there is at least 50% of the original tooth structure remaining. If more tooth tissue is missing, repair will be more difficult and may require crown lengthening surgery.
6. Interocclusal space for restoration can be generated in the following ways:
(a) Tooth reduction;
(b) Orthodontic movement including the use of Dahl appliances;

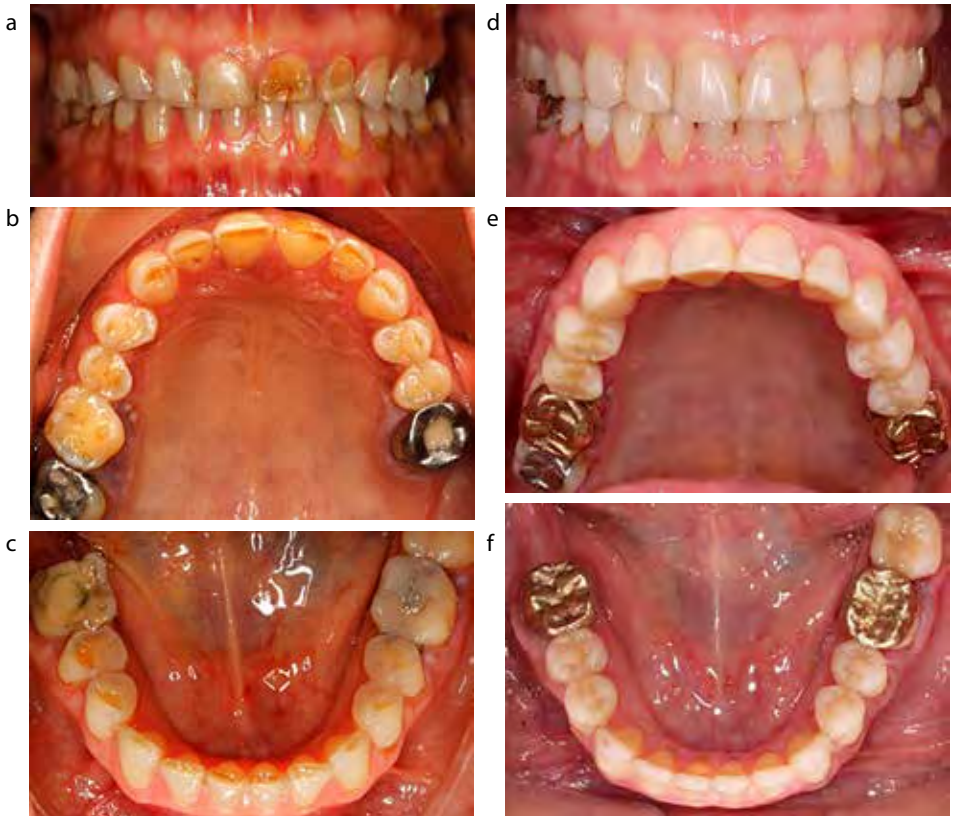

Figure 8. (a) Generalized tooth wear. **(b, c)** Occlusal views showing anterior teeth with significant wear and more heavily restored posterior teeth. **(d)** Anterior teeth and premolars have been restored with composite restorations. The heavily restored posterior teeth have been restored with adhesive and conventional cast restorations. **(e, f)** Occlusal views. The composite restorations would be expected to have a median survival of 6–7 years and the conventional crowns of 10–15 years.

(c) Crown lengthening surgery (followed by further tooth reduction);
(d) Increase in occlusal vertical dimension;
(e) Occlusal adjustment;
(f) Subapical osteotomy (only for severe malocclusions).

7. There is not an ideal material to treat tooth wear. There is a compromise between aesthetic considerations and durability. Composite and porcelain are brittle materials and metals are unaesthetic. Composite, acrylic and type III gold alloys do not worsen tooth wear on opposing teeth whereas other materials do. Similar materials should be used if opposing restorations are provided.
8. Composite restorations used to treat localized anterior tooth wear, the 'Composite Dahl' technique, have been shown to be effective over a 10-year period with some maintenance. At present this cannot be confirmed for full mouth reconstructions.
9. Conventional crowns have a high biological and financial cost for the patient. They are destructive of tooth tissue, but are successful if planned and provided carefully. The principles of preservation of tooth structure, retention and resistance form, marginal integrity and structural durability should be observed.

Core materials should be viewed as 'space fillers' rather than adding strength to the tooth.

10. Full mouth reconstructions whereby one or both dental arches are restored are particularly demanding of the patient and the operator and require postgraduate training.
11. The maintenance requirements and uncertain survival of extensive treatment should be explained to patients.

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Tooth Wear Guidelines for the BSRD Part 3: Removable Management of Tooth Wear

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Removable prostheses can be used alone or in combination with fixed prosthodontic treatment to manage tooth wear (TW). It is an accepted mode of treatment that can fulfill the aims of restoring the appearance, function and/or speech of patients with worn dentitions.[1,2]

The lack of coronal tooth tissue in cases of severe tooth surface loss can make fixed prosthodontic treatment more challenging and less predictable. Removable prosthodontic treatment may be more appropriate in these cases, especially when the additional time and cost associated with fixed prosthodontic treatment is taken into account. The remaining coronal tooth tissue can be used to support, retain and/or stabilize a removable prosthesis. A partially dentate patient with advanced tooth wear may add more credence to this form of treatment.

Patients will need to be made aware of the limitations associated with removable appliances, the added maintenance and potential risks to the remaining dentition. Patient compliance, adaptation and managing expectations will also be key to providing a successful outcome.

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Indications for removable management of tooth surface loss

- Severe generalized tooth surface loss;
- Severe generalized tooth surface loss in a partially dentate patient with long edentulous spans and/or distal extensions;
- Tooth surface loss in a patient well adapted to wearing removable prostheses;
- Patients who may not be suitable for fixed prosthodontic treatment due to the following reasons:

- Worn teeth compromised by periodontal disease and/or extensive caries;
- Unrestorable teeth – vertical root fractures, horizontal/oblique fractures to bone crest, caries to bone crest, failed endodontics;
- Concurrent soft tissue defects;
- The additional time and cost involved.

Contra-indications for removable management of tooth surface loss

Patients unable to tolerate a removable prosthesis.

Aims of removable management

- Restore appearance;
- Restore function;
- Protect the remaining dentition;
- Re-establish the occlusal vertical dimension if this has been reduced.

Definitions

The following terms will be used to describe the various removable appliances:

1. Overdenture: a denture that replaces the worn or missing teeth with prosthetic teeth and an acrylic flange[3] (Figure 1).

Figure 1. (a, b) Overdenture abutments can be vital or non-vital teeth. Ideally, they should be 2mm supra-gingival. Re-inforced acrylic has been used. Often a metal strengthener is needed for durability.

Figure 2. (a, b) Onlay provisional denture to test an increase in the OVD. The onlays have to be refined in the mouth for an accurate fit. A low lip line made this appearance acceptable for this patient.

Figure 3. (a, b) Anterior overlays on a metal framework partial denture. Refinement in the mouth is usually necessary for accuracy of fit and a good appearance.

2. Overlay denture: a denture that covers the worn teeth with a full labial veneer facing[3] (Figure 2).

3. Onlay denture: a denture that covers the occlusal or incisal surfaces of the abutment teeth[3] (Figure 3).

Combinations of the above can be used on the same prosthesis.

Removable management

Severely worn teeth cannot always be restored through fixed prosthodontic means. They may be present in combination with long edentulous spans that also require soft tissue replacement. Removable prostheses can help to replace soft tissues and provide lip support. They can also be designed to have further teeth added to them in the future.

Not all teeth necessarily require replacing. Patients can function well with 10 pairs of occluding units or a second premolar to second premolar occlusion.[4,5] Patients presenting with severe tooth wear often do so because it affects their anterior teeth. Compliance with removable prostheses has been shown to be better when they replace and/or restore the anterior dentition.[6]

Despite the benefits of removable prostheses, they can lead to increased levels of plaque accumulation when oral hygiene is inadequate.[7] It is therefore even more critical that patients are given clear instructions on maintaining excellent oral hygiene and advised to leave their removable prostheses out at night. Failure to do so may quickly lead to failure of strategic abutment teeth and further challenges for the patient and clinician.

Managing patient expectations

It is important for patients to have realistic expectations of removable prostheses. They must be informed of their limitations from the outset so that they do not attribute this to inadequate clinical work.

Treatment options

Extracting the remaining teeth and providing complete dentures

Patients are retaining more teeth for a longer period of time due to the increase in life expectancy, fluoride availability and improved oral hygiene practices.[8] The increase in age, together with increasing expectations, means that patients often have a lower adaptive capacity and ability to manage complete dentures at an advanced age. Extracting the remaining teeth, no matter how heavily restored or worn, has therefore become a less frequently practised option. It can, however, still be a pragmatic option if there are only a few teeth remaining that are beyond saving, and if the patient is not suitable for complex treatment. Anecdotally, it is thought that many bruxist patients transform into maladaptive denture-wearing patients. The high occlusal loads lead to early mucosal trauma and ridge resorption. Careful planning and care at every stage during the process of making complete dentures will be required. An implant-supported mandibular overdenture can be considered as a further treatment option in this cohort of patients to facilitate and improve this transition.[9,10] These will still be subjected to high occlusal load in bruxist patients.

Complete or partial overdentures

It can be more appropriate to reduce the teeth further when they are severely worn and provide either complete or partial overdentures. These appliances replace the worn teeth with prosthetic teeth and an acrylic flange. The following advantages can be gained from doing this:

- Provide the psychological benefit of

tooth retention, creating a more positive attitude to dentures;[11]
- Maintain continued proprioceptive feedback with the preservation of periodontal mechanoreceptors;[12,13]
- Decrease the rate of residual ridge resorption and therefore maintain added support and stability.[14,15] They can also provide lip support if located anteriorly;
- Can provide added retention, improved masticatory efficiency and better control of mandibular movements;[16]
- Further retention can be gained from the addition of precision attachments such as magnets or stud attachments;
- Replace soft tissue through the use of a flange;
- Improve the crown-root ratio and therefore limit damaging lateral forces.

There are, however, disadvantages associated with this treatment option that include:
- A reduction in the space available for the prosthetic teeth and denture base. This reduction can lead to weakness and the increased likelihood of developing a fatigue fracture;[17]
- Caries affecting the overdenture abutments can be a problem due to plaque accumulation under the denture base if the patient does not have a good preventive regimen;[11,18-21]
- Similarly, poor plaque control can lead to periodontal breakdown;[18]
- Severely worn teeth do not always require root canal treatment due to the continued deposition of secondary dentine. However, there is always a risk of pulp exposure when reducing teeth.

Complete or partial onlay or overlay dentures

The occlusal or incisal surfaces of worn teeth can be restored with an onlay or overlay type appliance without a flange. Onlay type appliances can be useful for moderately worn posterior teeth to restore the surfaces of these teeth and re-establish the correct occlusal vertical dimension. The occlusal surfaces can be made of a cobalt-chromium alloy and can be made to be an integral part of the denture framework to increase their durability.

The choice between an onlay or overlay design for anterior teeth will depend on the following factors:
- The height of the upper lip in function and when smiling. An onlay type design will not be aesthetic if the butt joint is visible in function and on smiling. An acrylic veneer terminating at the gingival margin will be more attractive in these situations.
- The path of insertion of the denture. Gaining a favourable path of insertion for acrylic veneer facings may eliminate favourable undercuts for clasping posteriorly and needs to be considered when designing the denture.

Partial dentures in combination with adhesive or conventional fixed prosthodontics

Teeth that have not been affected by wear can be modified so that they can help to retain, support and stabilize a removable prosthesis. The following features can be considered when designing the denture:
- Preparation of guide planes on abutment teeth to limit the ways in which the denture can be displaced and provide added stability;
- Additions can be made to teeth with composite resin to alter their contour and provide favourable undercuts for clasping;
- Consider restoring teeth that have large plastic restorations with milled extra-coronal restorations that have guide planes, ledges and/or rest seats.

Damaging occlusal forces on worn anterior teeth restored with adhesive or conventional crowns should be considered if the partial dentures only replace posterior teeth. Compliance with wearing dentures is reduced in this cohort of patients.[22,23]

Preliminary investigations

The following should be investigated in relation to providing removable prostheses for tooth wear.

Assessing the occlusal vertical dimension

Restoring the worn dentition to the correct occlusal vertical dimension will form the basis of treatment. In the absence of tooth wear the free-way space remains constant due to the continued growth and increase in anterior facial height into middle age.[24,25] Tooth wear, however, leads to the continued eruption of teeth so that the free-way space remains constant and so do the proportions of the face. This is commonly known as compensated tooth wear.[26,27] Non-compensated tooth wear occurs when the rate of the tooth wear is too fast for the physiological mechanisms of tooth eruption to keep up. There is therefore a resultant increase in free-way space and loss of occlusal vertical dimension.

Patients with compensated tooth wear will usually have a complete dentition and treatment with removable prostheses will rarely be indicated.[1] Partially dentate patients with loss of the posterior dentition and wear affecting the anterior teeth will usually present with non-compensated tooth wear and a loss of OVD, making it necessary to provide treatment with removable prostheses. These patients will often have an unacceptable occlusal plane and the following can be used to determine the correct occlusal vertical dimension:

1. The point of first contact along the retruded arc of closure (RAP) if there are unworn teeth posterior to the worn anterior teeth. This will be the retruded contact position (RCP) and may provide the required space to restore the worn anterior dentition;
2. Photographs of the patient's teeth prior to being worn;
3. Tooth display at rest and on smiling;
4. Amount of posterior prosthetic space required, if necessary;
5. Phonetics;
6. Use of a provisional denture for between 6 weeks and 6 months.

The recording of the OVD is usually carried out using occlusal registration rims. Edentulous patients will be less tolerant to changes in the occlusal vertical dimension than dentate patients (Figure 4).

Assessing severely worn abutment teeth

As mentioned earlier, a severely worn tooth does not necessarily need to be condemned. It can be retained as an overdenture abutment. The following factors need to be considered if a tooth is to be retained as an overdenture abutment:
- The periodontal health of the abutment tooth. At least five millimetres of alveolar bone support has been recommended,[28,29] together with an adequate band off

Figure 4. (a, b) Non-compensated tooth wear in a depleted dentition. Clinical appearance reproduced in mounted study casts. **(c, d)** Increase in OVD determined in the laboratory. Upper and lower wax try-ins made. **(e, f)** Provisional upper and lower partial overdentures in place for patient approval.

attached gingival tissues.[30]

- The height of the overdenture abutment should be one and a half to two millimetres above the gingival margin and dome-shaped.[31] The reduction in crown root ratio will reduce the mobility of the tooth.[32]
- Reducing a tooth will expose more dentinal tubules and less calcified dentine, making the pulp more vulnerable to cariogenic bacteria.[33,34] A good level of oral hygiene is therefore paramount. It has been shown that overdenture abutments can be maintained in older patients with a history of primary dental disease by four to five recall visits per year.[35]

Assessing spaces

Spaces should be assessed in three dimensions that should include inter-occlusal, mesio-distal and bucco-palatal measurements. The following should be considered when making an assessment of the space:

- The site and extent of spaces. Are the spaces bounded or free end saddles?;
- Have any teeth drifted, tilted or over-erupted into the resulted space? This can be more readily assessed on a set of accurately mounted casts;
- What is the condition of the soft tissues overlying the ridge?

Diagnostic phase

Occlusal splints

An upper, hard, heat-cured, full coverage acrylic splint with (provisional denture) or without teeth can be used in the diagnostic phase. They should provide even contact along the retruded arc of closure with anterior guidance on anterior teeth with posterior disclusion and canine guidance in lateral excursions.[36] They can provide the following benefits:

- Protect worn teeth from any further wear, especially if the original cause is attrition;
- Break the proprioceptive feedback from periodontal mechanoreceptors resulting in muscle relaxation that will facilitate the accurate recording of the retruded axis position;[37]
- Useful for testing tolerance to the planned changes in occlusal vertical dimension.[38,39]

Partial coverage splints should be avoided due to selective intrusion and extrusion of teeth. The resulting malocclusion can be difficult to correct.

Provisional appliances

Fully acrylic provisional appliances that have an overdenture, onlay and/or overlay design can be provided to test changes in occlusal vertical dimension, aesthetics, phonetics and function. They can also be used to test the patient's tolerance and adaptive capacity to removable appliances. They should be designed and made with the same care as a definitive denture. They can be modified, ie relined or adjusted, whilst abutment teeth are being prepared to receive extracoronal restorations or being built-up with composite resin prior to making the definitive dentures.

Definitive dentures

The ideal features of the provisional appliance should be carried forward to the definitive denture. These include the proposed changes to the occlusal vertical dimension and aesthetics. A wax try-in will be required if any further changes are proposed.

The definitive denture should fulfil the following aims:

- Increased durability;
- Reduced bulk;
- Improved cleansability;
- Decreased maintenance.

The definitive denture should be designed prior to considering any irreversible changes to the abutment teeth. The changes to the abutment teeth can then be made taking into account the materials to be used to construct the definitive denture.

The stability of dentures and patients'

a

b

Figure 5. (a) Macromechanical and micromechanical retention needs to be applied to the partial denture design, in this case with beads and struts to retain anterior overlay veneers. **(b)** Further protection of acrylic components with palatal backings, in this case extended up to the incisal edge.

adaptation to them will be increased if guidance in excursions is maintained on the natural teeth. In the depleted dentition it is more likely that a bilateral balanced occlusion should be provided.

Materials

Denture base

The retention of teeth as overdenture abutments will limit the amount of space available for the denture base and prosthetic teeth. This can therefore pose challenges when managing patients with wear.

The ideal denture base should meet the following requirements:[40]

- Accuracy of adaptation to the tissues with minimal volume change;
- Dense, non-irritating surface capable of receiving and maintaining a good finish;
- Thermal conductivity;
- Low specific gravity;
- Lightweight in the mouth;
- Sufficient strength;
- Easily kept clean;
- Aesthetic acceptability;
- Potential for future relining;
- Low initial cost.

Denture bases can be metal- or resin-based

Acrylic resin bases need be at least two to three millimetres thick, can be aesthetic and easily adjusted and relined. They can, however, release internal strains that may lead to distortions and can be more prone to accumulate deposits, be bulky and less abrasion resistant.[40] If this is not possible, some form of strengthening of the denture base should be considered.

Metal-based dentures that can be cast in either gold, chrome or titanium alloys are more difficult to reline and adjust. They do, however, have the following advantages:

- Can be cast more accurately than acrylic resins, resulting in better adaptation to the underlying tissues;
- Are more abrasion resistant;
- Cleanliness, due to the bacteriostatic nature of metal bases;
- Transmission of temperature changes to the underlying tissues;
- Can be cast in thin section, limiting their bulk without compromising on strength and rigidity.

Prosthetic teeth

The material used for replacing missing tooth tissue will be influenced by the following factors:

- The amount of prosthetic space available;
- The material used for the denture base;
- The presence of parafunctional habits;
- Aesthetics, ie is the material visible on smiling and in function;
- The position of the tooth in the arch, ie anterior or posterior;
- The surface of the tooth to be covered, ie occlusal, labial, palatal;
- The opposing material.

Materials

Materials commonly available include:

- Acrylic resin;
- Chrome alloy;
- Gold alloy;
- Ceramic.

Acrylic resin

Acrylic resin prosthetic teeth need to be provided in sufficient bulk without thin or sharp edges and can be chemically bonded to the acrylic resin base or attached to a metal base through mechanical retention or chemical bonding. An adhesive containing 4-methacryloxyethyltrimellitic anhydride (4-meta) can be used to bond acrylic resin to metal-based dentures. A chemical union can make the junction more hygienic. The low abrasion resistance can make this material easy to adjust but prone to accelerated wear in patients with parafunctional habits. Acrylic resin prosthetic teeth can provide a natural appearance and are the kindest material for opposing teeth.

Chrome alloy

Chrome alloy prosthetic teeth can be cast in thin section and are therefore useful when space is limited. They still provide good strength and rigidity in thin section. They can be cast as part of the overall framework but their appearance will limit their use to posterior sections of mouth and as palatal backings on anterior teeth. They can, however, be difficult to adjust and also abrasive to opposing natural teeth when they lose their surface polish. Chrome alloy prosthetic teeth can be useful for covering the worn occlusal surfaces of posterior teeth with an onlay type design in patients with parafunctional habits.

Gold alloy

Gold alloy prosthetic teeth will cause the least abrasion to natural teeth and can be more easily adjusted. Cast gold occlusal surfaces can be attached to acrylic resin teeth and can be useful in patients who parafunction.

Ceramic

Tooth-coloured veneering materials can be the weak link in the durability of partial and complete dentures made for patients with tooth wear. Macromechanical and micromechanical retention needs to be applied to the denture design. Retentive beads, 'nail heads' and struts can be combined with palatal metal backings to protect acrylic, composite or porcelain components. On occasion, these backings or onlays need to be extended up to the incisal edge or occlusal contacting surfaces (Figure 5).

a

b

Figure 6. (a) Failure of an acrylic complete overdenture. **(b)** Failure in a partial metal framework denture. A more robust design could avoid early failure in the future.

a

b

Figure 7. (a, b) A precision retainer complete overdenture requiring considerable clinical and laboratory skill. An enthusiastic patient following a strict maintenance regimen will be required to prevent early failure.

Maintenance

The cohort of patients treated with removable prostheses for worn teeth are usually older and have a number of other missing teeth. These have often been lost as a result of plaque-associated disease and so these patients are often at high risk of caries and periodontal disease. This is often compounded by diminished fine motor skills so that cleaning may still be ineffective, even if patients are motivated. Plaque accumulation will also tend to increase in the presence of removable prostheses.[7] These patients must therefore be managed similarly to patients with a high caries risk.[41]

It is therefore of utmost importance that patients change their behaviours to prolong the survival of their abutment teeth. Patients should be instructed to do the following:

- Brushing the abutment teeth including overdenture abutments with a high fluoride concentration toothpaste;
- Use a daily fluoride mouthrinse at a different time from brushing;
- Leave the dentures out at night and soak these in a denture-cleansing solution;
- Apply a high fluoride concentration gel to the fit surface of the denture corresponding to the overdenture abutment in the morning.[42] The patient should not eat for 30 minutes following this to maximize effectiveness;[43]
- Clean the dentures after meals.

An occlusal splint with or without replacement teeth can be made for the patient to be worn at night to protect the abutment teeth from parafunction. If the denture design has not been robust, early failures should be expected (Figure 6). All of the above should be supplemented with regular recall as appropriate to review the abutment teeth, soft tissues and removable prostheses (Figure 7).

Maintenance care

By definition patients treated for tooth wear are heavily restored and need more frequent review and maintenance care. Dental caries and periodontal disease can be worsened by the placement of multiple restorations or by using an overdenture. Preventive and periodontal care with a reliable recall system will help with preventing primary disease.

Biomechanical failures should also be expected and the patient informed of this. If their teeth have been worn down or fractured, patients will exert the same forces on their restorations. If a patient is prepared to use an occlusal splint on a regular basis adverse events can be reduced. Furthermore, well designed and executed prosthodontics can give these patients a welcome break from the restorative spiral downwards with the loss of restorations and teeth.

Concluding remarks

Dentists will be treating more patients with tooth wear as the population ages. There are many challenges ahead for the dental team in providing high quality dentistry for these patients. There have been many technological improvements over the years to help with providing care. As a profession we will need to continue to develop new techniques to deliver cost-effective and successful treatments for our patients.

Key points

1. Removable or fixed and removable management of tooth wear may be indicated in the following circumstances:
(a) Severe wear;
(b) Multiple missing teeth and tooth wear;
(c) Soft tissue defects;
(d) Long spans or distal extension;
(f) Primary disease or uncertainty with the prognosis of some teeth;
(g) Cost.
2. If a re-organized approach is undertaken and the occlusion is to be changed, careful planning is required. Mounted study casts are required to produce a diagnostic wax-up or wax try-in. An aesthetic composite or acrylic mock try-in can be tried into the patient's mouth for approval. Digital simulations are also possible.
3. A diagnosis of compensated or non-compensated wear should be made early in treatment planning.
4. Planning follows conventional prosthodontic protocols with consideration for:
(a) Saddles;
(b) Support;
(c) Retention;
(d) Bracing and reciprocation;
(e) Major connectors;

(f) Indirect retention.
5. Partial or complete dentures for tooth wear patients may have one or more special components:
(a) Overdenture;
(b) Onlay;
(c) Overlay.
6. An increase in the occlusal vertical dimension (OVD) can often be guided by:
(a) The former appearance;
(b) Mandibular rest position and assessment of the free-way space;
(c) Former crown height;
(d) OVD at the RCP;
(e) Acceptance using a provisional denture for 1–6 months.
7. A diagnostic or provisional appliance should make an assessment of:
(a) Appearance;
(b) Lip support;
(c) Occlusion;
(d) Patient tolerance;
(e) Durability.
8. There is not an ideal denture material to treat tooth wear. There is a compromise between aesthetic considerations and durability. Acrylic is most commonly used for denture teeth. It needs to be protected by good denture design and be used in thick section of at least 2 mm to be durable. Cobalt chrome is strong in thin section. Advances in metal primers and treatments have increased the bond between these materials. Composite, porcelain, gold alloys and flexible rubbers are alternative materials.
9. Frequent failure of denture components in tooth wear patients will be attributable to:
(a) Occlusal factors;
(b)Design factors;
(c) Incorrect choice of material;

Endnotes

The British Society for Restorative Dentistry hopes that these guidelines will act as a practical reminder of the standards that the BSRD tries to achieve. Any comments you may have will be gratefully received and should be addressed to the Honorary Secretary.

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