Occlusal wear of teeth and restorative materials

A review of classification, etiology, mechanisms of wear, and some aspects of restorative procedures

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This paper is a literature review of various aspects of the wear of occluding tooth surfaces. It presents classification and terminology of occlusal tooth wear, and discusses etiology and differential diagnosis. It may be difficult to differentiate among abrasion, attrition, and erosion because there is nearly always a combination of the various processes. These processes of wear are described, and the in vitro and in vivo wear of some restorative materials is discussed. Treatment of severe tooth wear is considered difficult; prophylactic measures are therefore important. Some guidelines for restorative treatment of patients with extensive occlusal tooth wear are given, with special emphasis on the type of treatment, the vertical dimension of occlusion, the space available, and choice of material for the restorations. □ *Dental attrition; dental materials; dental restoration; tooth abrasion; tooth erosion*

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Loss of hard tooth substance may be caused by factors other than caries and trauma, such as the wearing away of enamel and dentin on the occlusal surfaces of the teeth. In the literature terms like abrasion and attrition are commonly used and refer to tooth wear due to normal and abnormal chewing, oral parafunctions, especially bruxism, but also defects caused by oral hygiene procedures. Considering that various chemical processes can also affect the degree of tooth wear, it is apparent that a more 'neutral' terminology would be welcome.

In the American literature the terms 'occlusal' and 'dental wear' have been used, whereas in England the terms 'tooth wear' or 'tooth surface loss' are preferred. In this paper the term 'tooth wear' will be used to describe the loss of enamel and dentin.

Wear of approximal tooth surfaces has been observed mainly in aboriginal Australians and in skulls from earlier times (1, 2) and will not be considered in this paper.

Classification

Terminology

Several attempts at classifying the various types of tooth wear have been presented. Pindborg (2) produced the following classification:

Attrition: The gradual loss of hard tooth substance as a result of chewing activity. Various degrees, such as physiologic, intensified, and pathologic attrition, are given. The last one is defined as extreme wear of one or more teeth due to malfunction or malposition of the teeth.

Abrasion: Pathologic tooth wear caused by friction from a foreign body, independent of occlusion between the teeth. An example of this type of wear is that occasionally caused by tooth brushing.

Erosion: Defined as the loss of hard tooth substance due to a chemical process not involving bacteria.

A special type of erosion is termed *peri-*

mylolysis or, occasionally, *perimolysis* (American literature) and is thought to be caused by a low pH along the tongue border (due to reflux of gastric juices into the mouth) combined with muscle hyperactivity of the tongue. This gives a combined erosive and mechanical action against the palatal surfaces of the maxillary teeth in particular.

Ranking of tooth wear

There are several classifications of tooth wear (3). Most classifications or indices are based on quantification of the loss of tooth substance by evaluation of changes in the incisal and occlusal surfaces. This is often combined with an estimation of the degree of worn enamel, the size of the exposed dentin, and the reduction in length of the clinical crown, as already suggested by Broca in 1879 (4, 5).

Other classifications combine a qualitative evaluation with an estimation of the need for treatment (6, 7). This index was similar to the rating system suggested by Ryge and the California Dental Association (8). One obvious disadvantage of the existing classifications (indices) is that they all contain a certain amount of subjective evaluation and that they do not provide a complete classification of the corresponding wear of restorative materials.

Differential diagnosis

It is often difficult, if not impossible, to differentiate among loss of tooth substance due to abrasion, attrition, and erosion because there is nearly always a combination of the various processes simultaneously or over time (9, 10).

Etiologic factors

When extensively worn teeth are to be restored, the etiologic factors involved must be thoroughly considered. A mechanical action on the tooth substance is generally the basic factor, but salivary factors such as buffer capacity and the pH of the saliva must also be taken into consideration. The mechanical effect depends on various factors such as the type of contact between the teeth, the development of forces when teeth make contact, the time factor in relation to tooth contacts, and the presence of abrasive factors in the oral cavity. The presence of erosive factors is of importance also in the reduction of the hardness of the enamel, making it more susceptible to wear (11).

In aboriginals the degree of tooth wear was more generalized and strongly correlated to the age of the individual owing to their consumption of abrasive foods and the use of their teeth as tools (1, 2, 12).

In modern man the factors contributing to tooth wear are many (13–15), and some of them are discussed here:

Time/age

Several studies have demonstrated that both the prevalence and the degree of tooth wear increase with age (1, 15–20). It is natural for the degree of tooth wear to be proportional to the time of exposure of the teeth to the oral cavity. In modern man, however, the development of tooth wear is not as regular as in aboriginals, owing to our different types of food.

Gender

The degree of tooth wear has been claimed to be more extensive in men than in women (15, 17, 19, 20). These findings are in contrast to those made by Dahl et al. (7). In animal studies, too, such differing findings have been reported. In one study (21) of rats the males presented more extensive wear than the females, but not in another (22).

Occlusal conditions

A reduced number of occluding teeth will lead to increased tooth wear (10, 15, 16). The effect of tooth and face morphology on the degree of tooth wear has also been discussed. Studies of ancient skulls have demonstrated a gradual transition from a normal horizontal overbite in the incisor region to an edge-to-edge relationship in those showing excessive tooth wear (23, 24).

Krogstad & Dahl (25) found a more horizontal mandible and a smaller jaw angle in a group of patients with advanced tooth wear than in the normal population. This was assumed to be the result of hyperfunction of the jaw muscles. No change in the horizontal overbite as compared with the normal population was found. A similar result has been reported more recently (26). Poor mineralization of the enamel has also been considered a factor leading to an increased degree of tooth wear (2, 27).

Hyperfunction

Reference to the correlation between bruxism and tooth wear has often been made (3, 28, 29). The prevalence of bruxism has been reported to be between 5% and 20% in a normal population (19, 30). Other parafunctional jaw activities such as chewing on foreign objects may also give rise to abnormal wear of the teeth (2). Mentally retarded people often demonstrate excessive tooth wear. This has usually been ascribed to bruxism (6, 31, 32).

The normal vertical loss of enamel due to natural wear has been estimated to be about 65 μm/year (33). Xhonga (34) found similar values in her study, but three to four times higher ones in bruxers.

An interesting question would be whether excessive wear of the primary dentition is predictive of the state of wear in the permanent one. In a longitudinal study (26) a weak but significant correlation between wear facets on incisors at the age of 5 years and the ages of 14 ($r = 0.44$) and 18 ($r = 0.39$) was found. On an individual basis, however, wear of the primary incisors had a low predictive value for incisal wear in the permanent dentition.

The time factor

It should be pointed out that the time factor—that is, the total time of contact between opposing tooth surfaces—is probably the most important one for the development of tooth wear (14, 35). Graf (36) has estimated 17.5 min/day as the average time necessary for teeth to be in contact during normal function such as chewing and swallowing. This value is no doubt vastly exceeded by most bruxers (37, 38).

Bite force

The importance of bite force in relation to tooth wear is not fully evaluated. The literature presents opposing views (14, 26, 39). It has been suggested, however, that increased bite force is part of the reason the prevalence and the severity of tooth wear are greater in men than in women (3).

Gastrointestinal disturbances

One reason for dental erosions may be perimylolysis—that is, the reflux of gastric juices into the oral cavity combined with hyperactivity of the tongue. This is a common feature in cases of hiatus hernia and occurs also in cases of gastritis in gastric ulcers (9, 13, 40). Other instances when gastric juices come in contact with the oral cavity are when the individual carries out forced vomiting, as in cases of anorexia and bulimia (13, 41–43). Anorexia is a psychosomatic disease with oral manifestations such as erosions of the teeth, reduced salivation, and sometimes an increased incidence of caries.

Several authors have found an increase in incidence of tooth wear in chronic alcoholics (13, 44, 45), although the mechanism is obscure. The substance loss may be due to erosion caused by 'subclinical regurgitation due to the chronic gastritis which is known to be produced by the ingestion of large amounts of alcohol' (46).

Nutrition

The importance of the food composition for the development of incisal/occlusal tooth wear has decreased in modern societies. Excessive intake of citrus fruits, apples, and beverages with a low pH, especially the colas, has in several case reports been ascribed the property of causing a substantial loss of hard tooth substance (2, 47).

The use of snuff and chewing tobacco has also been related to increased tooth wear (3), which has also been discovered in vegetarians (48). Animal experiments have demonstrated that the content of abrasive particles in the food is of greater importance for tooth wear than the hardness of the food (22).

Environmental factors

Several investigations have studied the effect of an industrial environment on the severity of tooth wear. It has been demonstrated that a dusty environment adds to the wear of teeth—for instance, in iron works employees, miners, and quarry-men (17, 49–51). Workers exposed to acid vapors often present teeth with erosive lesions (52–54). A comparison of young adults in Sweden and Saudi Arabia showed a greater prevalence and severity of tooth wear in the Saudi sample. It was suggested that harsh environmental and climatic conditions probably account for the Saudi experience of high wear (55).

Salivary factors

Animal experiments have shown that if the salivary secretion is stopped, the degree of tooth wear increases (56). It is not known, however, which components of the saliva are responsible for its lubricating effect, but certain hypotheses have been presented (57, 58). In man it appears that the buffering capacity of the saliva and its contents of certain salts are the factors of greatest importance in this connection (3, 14, 55).

Table 1. Some factors of importance for excessive tooth wear

Time/age
Gender
Occlusal conditions
Muscle hyperfunction
Parafunction
Gastrointestinal disturbances
Environmental conditions
Saliva

Other factors

A reduced occlusal tactile sensitivity and a greater occlusal endurance time has been found to be associated with increased wear (55). This may be a cause or an effect relationship, or a combination.

In conclusion, it may be stated that tooth wear may be caused by several factors (Table 1) and that in most cases of advanced tooth wear a combination of several factors is almost always involved.

Mechanisms of wear

Tribology

Wear of materials is a complex phenomenon not always fully understood but studied in tribology, the science of interacting surfaces in relative motion, or simply 'the study of rubbing' (59). 'The most common characteristic of the wear process is its unpredictability' (60). Definitions applicable to tribologic studies are described in DIN 50320, 'Standard of wear' (59). The mechanism of wear is complex, including variables such as the properties of the two contacting substances and the surrounding and interfacial media (saliva, food).

Wear may occur in the following ways:

Adhesive wear. Formation and rupture and interfacial adhesive bonds (for example, 'cold-welded' junctions).

Abrasion. Removal of material by microcutting (ploughing).

Surface fatigue. Fatigue and crack formation in the subsurface layers by tribologic stress cycles resulting in the separation of material (spalling).

Tribochemical reaction. Development of reaction products as the result of chemical reactions taking place between the wear couple and the interfacial medium.

The wear process of dental materials can be described by the factors listed in Table 2.

All these factors are constantly varying intraorally. In addition, the physical properties of contacting materials, especially the resin or resin-based materials, will vary with changes in temperature and as a result of chemical influences from saliva and foods

Table 2. Factors affecting the wear process in the oral cavity

Properties of the contacting materials
Type of movement
Velocity
Load and duration of tooth contact
Diet
Saliva
The wear mechanism involved
Temperature

(60, 61). Another important factor is the difference between 'true' and 'apparent' contact area between two microscopically observed raw surfaces. On the microscopic level the true contact surface area is only 10^{-2} to 10^{-4} of the visible contact surface (60, 62). As a consequence, the local pressure will be extremely high in any single microcontact, causing elastic and plastic deformation of the two antagonizing materials.

Wear of different dental materials

The difficulties encountered in establishing the potential rate of wear of dental materials on the basis of in vitro studies are obvious. If valid in vivo values are to be obtained, a large number of test subjects must be examined. This would involve serious economic, practical, and ethical problems. When using small series of test subjects, only a ranking of the wear resistance of any material may be obtained.

In vitro studies

The wear of gold, ceramics, and polymers was studied in vitro in a two-body abrasion system (63, 64). The first group found that ceramics opposing ceramics produced the largest loss of substance (63), whereas the other group found that ceramics opposing gold produced the largest loss (64). In ceramic-to-ceramic contact a certain amount of self-polishing was observed. Reviews of the literature on wear studies of prosthodontic materials have discussed the theoretical models governing wear of dental materials using a somewhat different nomenclature (64–67). Several authors have studied the abrasive wear of various dental materials: ceramic, heat-cured resin, microfilled resin (Isosit), veneering material, gold, and cobolt–chromium. Used to grade the wear resistance of the various materials, the test may prove to be of clinical value.

DeLong et al. (68, 69) studied in vitro the wear of tooth enamel against various ceramic systems such as Cerestore, Dicor, and metal ceramics. Wear against Dicor showed the least loss of enamel from the test specimens. Different wear mechanisms were found to occur from one material to another.

In vitro tests of denture teeth demonstrated high resistance of resin teeth opposing the same material (70). New brands of teeth made from cross-linked polymers or from composite materials demonstrated better resistance against wear than the conventional resin denture teeth (71–76).

The introduction of posterior composites in dental restorative techniques has initiated a large increase in wear testing research. Several in vitro testing machines have been introduced for either two-body abrasion (77, 78) or three-body abrasion (60, 79). It is concluded that there is no in vitro system that can simulate the complex oral environment.

In vivo studies

Several problems are connected with the study and measurement of wear in vivo. In one of the systems most used, the USPHS (United States Public Health Service) system, wear is quantified by a subjective evaluation of the anatomic form of the teeth and/or restorations (8). The discriminating power of such systems is limited (60, 80).

Bergman et al. (81) used a modified CDA system to evaluate wear of two different veneering materials (Isosit and Dentacolor) used on the occlusal or incisal surface of full crowns with a titanium substructure.

An improvement of the CDA system has been presented to evaluate wear of posterior composites (82). Several methods, including three-dimensional computer systems, have been introduced in the wear testing of class-II composites (for a review, see Ref. 3).

Both the number and the extent of in vivo research projects on the wear resistance of restorative materials are limited. In studies of the clinical wear of denture teeth the wear of resin teeth was approximately 0.1 mm/year, and that of teeth made from ceramic material even less (73, 82).

Denture resin teeth made from cross-linked polymer (IPN) showed better wear resistance than conventional resin teeth in a clinical study (84), but even these showed a modest degree of wear.

Comparisons of the clinical wear of bridges made from heat-cured polymethyl methacrylate and two microfilled resin materials showed that the heat-cured material displayed a vertical wear resistance value between those of the two microfills (85).

Ekfeldt & Øilo (86, 87) presented two clinical studies on the occlusal wear of some restorative materials, using telescopic crowns. The importance of different opposing materials for the wear process was also studied. The conclusions, based on a limited number of test subjects, may be summarized as follows: 1) All materials tested showed a maximum substance loss when the opposing material was ceramic. 2) Gold (Sjöding's type III and IV) and porcelain (Vita VMK) demonstrated almost equal and high wear resistance when opposing ceramic. 3) Gold-to-gold contact seemed to give less wear than ceramic-to-ceramic contact. 4) Microfilled resin materials (Isosit and Dentacolor) showed at least three to four times higher occlusal contact wear rates than gold and ceramic. 5) Polymethyl methacrylate (Biodent K + B) was found to be the least wear-resistant material tested. 6) Gold showed a combined abrasive and fatigue type of occlusal contact wear, and in ceramic materials mainly a fatigue type of wear was observed. The resin-based materials showed a fatigue type of wear, sometimes in combination with a tribochemical reaction.

Management

Examination

Treatment of a severely worn dentition can be very demanding. Careful evaluation and treatment planning together with an adequate standard of clinical management is necessary.

The following general factors should be considered during treatment planning (88): 1) Not all patients with severe tooth wear need complete oral rehabilitation. 2) Even in cases of extreme tooth wear the occlusal face height may not be significantly reduced as a compensatory occlusal tooth migration usually takes place. 3) No increase in the occlusal face height is necessary if the chewing ability is satisfactory, the cosmetic value is acceptable, and there are no functional complaints. In such cases single crowns or small fixed bridges made at the existing occlusal face height are the treatment of choice. 4) If a complete rehabilitation is necessary, there is plenty of time to plan the most appropriate type of treatment. Wear of teeth is usually a long-term process. Except in a few cases the development of tooth wear into a state of pathologic attrition has taken years to accomplish.

Case history

Identification and elimination of all causative factors is desirable before prosthodontic rehabilitation. Wear of teeth seems to take place intermittently; that is, there are active and inactive periods (14, 35, 89). Therefore, when taking the case history, it is important to consider the time factor in relation to the development of the wear (3). The prognosis for the whole dentition should also be evaluated before extensive oral rehabilitations.

The following factors should be considered:

- Case history
  - General health
  - Oral parafunctions
  - Nutritional habits
  - Environmental factors
  - The development of wear over time
- Status
  - Clinical examination, including oral function
  - Radiographs
  - Mounted study models

Intraoral photographs
Special examinations, such as salivary conditions.

Treatment planning

Prevention

Observe/expect/follow up. Except in certain diseases such as anorexia/bulimia, tooth wear is a slow process. Often it is enough to advise the patient as to nutritive precautions and point out the importance of breaking parafunctional habits. In some cases an occlusal splint in combination with counseling is the treatment of choice.

Change of important etiologic factors. Prophylactic measures aiming at disruption of any condition leading to excessive wear should be carried out. As a reduced number of teeth is correlated to increased degree of tooth wear, it is important to maintain good oral health and to preserve as many teeth as possible. Replacement of lost teeth should be evaluated and carried out on an individual basis. Not all lost teeth need replacement even in patients showing extensive tooth wear.

Diet. Nutritional conditions suspected of contributing to tooth wear or other types of tooth substance loss should be altered. In modern societies abrasive foods are rare, but the use of fruit juices and other acid beverages has increased dramatically. Vegetarians should be informed about a possible increase in tooth wear as a result of their nutritional habits.

Illnesses. Patients in whom anorexia and/or bulimia is suspected or has been diagnosed often need special medical or psychologic treatment. To reduce the erosive effect maximally, the use of daily NaF rinses, the use of tooth pastes with a low content of abrasives, and at least nightly use of an occlusal splint should be recommended. A maxillary occlusal splint will protect the palatal surfaces against tongue parafunctions.

For patients with gastrointestinal disturbances the dentist should collaborate with the patient's physician in trying to reduce the oral effects caused by the reflux of gastric contents. In cases of xerostomia, too, close co-operation with medical expertise is necessary, as reduced salivation may result in extra tooth wear with time. If reduced salivation is due to general medication, the use of a different drug should be considered.

Parafunctions. One important factor in most types of tooth wear seems to be muscle hyperactivity, which may be claimed to be an absolute prerequisite for the definition of pathologic attrition (35). Bruxism—that is, clenching and grinding of the teeth—is probably the commonest parafunction leading to excessive tooth wear. There are also other parafunctions involving foreign objects which may cause tooth wear.

Parafunctional activities may be reduced by counseling, muscle exercises, or biofeedback. Some parafunctions, especially nocturnal bruxism, take place unconsciously and can seldom be influenced by psychologic means. In such cases an occlusal splint is necessary. Patients with pathologic attrition due to bruxism demonstrated limited continued wear after long-term occlusal splint therapy (14).

Interocclusal appliances. Several different removable devices made of hard acrylic resin, often called occlusal splints, have been recommended to reduce the ill effects of bruxism (90). The simplest and most reliable one seems to be the full-arch stabilization splint for one of the jaws, usually the maxillary one. In extreme bruxers it has sometimes been necessary to provide splints for both jaws or even metal ones as the acrylic splints have fractured.

Restorative treatment

Restorative treatment may be semi-irreversible or irreversible. The first includes composite resins, partial removable dentures, and overdentures. The irreversible types include various fixed restorations. This paper will also discuss matters such as increasing the occlusal vertical dimension, retention of cast restorations, and other problems encountered when restoring heavily worn teeth.

Indications for treatment

It is most important that treatment is individualized. Initially, this involves control of the etiologic factors. The patient's age must be considered, as must his own wishes with regard to dental treatment.

The patient may request treatment for cosmetic reasons, out of fear for the future development of the wear process, for functional reasons, or because of increased hypersensitivity of the teeth.

Type of treatment

It is impossible to give general recommendations as to which type of treatment to choose in any single case. The use of composite resins may be considered in young individuals presenting with wear of the palatal surfaces of the maxillary incisors due to erosive factors and in old people displaying mandibular wear, in whom economic limitations may preclude the use of crowns (91). However, composite resins possess poor resistance against contact wear and may also be unretentive. Their value in restoring extensive tooth wear is therefore limited, particularly on occluding surfaces.

Removable partial dentures or overdentures are comparatively economical and easy to produce. The occluding surfaces are usually made from acrylic resin, however, and in heavily worn dentitions the retention by means of clasps can be difficult owing to the short clinical crowns. It may be helpful to use precision attachments to improve retention, but then the treatment will no longer be either simple or cheap. When using partial dentures with free-end saddles, it should be stressed that any increase in the occlusal vertical dimension should be made on remaining teeth and not on the free-end saddles only.

Clinical experience has shown that the use of telescopic crowns for the retention of superstructures does not represent any advantage in heavily worn dentitions. Most people with extensive tooth wear have all or most of their teeth. Then the telescopic crown is contraindicated for both hygienic and cosmetic reasons.

Vertical dimension of occlusion

Many colleagues appear to be apprehensive that wearing away of occlusal tooth substance may lead to a reduction in the occlusal vertical dimension. However, there is no such simple correlation (92, 93).

First, nothing is known about the initial vertical dimension of occlusion of the patient, and, secondly, the bite is not necessarily reduced due to a general wearing away of occlusal tooth substance. There appears to be a potential for continuous occlusal migration of teeth and alveolar processes maintaining the occlusal vertical dimension even in cases of extreme tooth wear (94). Therefore, an increase in the occlusal vertical dimension is primarily used to obtain space for the restorations required by the patient. Clinical experience has demonstrated that increases in the occlusal vertical dimension necessary to accommodate for material thicknesses of 1.5–2 mm in either jaw are well tolerated. A dentate patient's ability to adapt to changes in the vertical dimension of occlusion appears to be considerable (95, 96). There is no reason to fear that moderate changes in the occlusal vertical dimension should cause muscle dysfunction problems provided the occlusion is correctly managed.

To evaluate a new vertical dimension of occlusion by using long-term provisional restorations does not appear to be generally necessary. Ordinary, well-functioning provisional restorations during the laboratory phase of the treatment should be enough.

Space for the restorations

Space for the restorative material may be obtained in several ways: 1) a general increase in the occlusal vertical dimension by means of crowns or other types of restoration on all or most of the teeth in one or both jaws; 2) orthodontically induced intrusion and eruption to obtain space to restore the teeth most heavily worn; and 3) exploitation of the difference between retruded contact position (RCP) and intercuspal position (ICP).

In case the teeth of both jaws are so worn that alternative 1 is chosen, it is often discussed whether the maxillary or mandibular teeth should be restored first. There is no scientific documentation of this, but we would recommended that restoration of the mandibular teeth should be carried out first as far as the trial stage. Then the maxillary teeth should be treated and both arches finished, so that all restorations may finally be cemented after a reasonable trial period.

After preparation of the teeth and impression-taking, the vertical and horizontal relations between the two jaws are recorded using the preferred technique with the mandible in the retruded position (RP). If using an average articulator of normal size and the casts mounted with an RP recording, it is then possible to make small adjustments of the vertical dimension of occlusion in the dental laboratory to achieve the right amount of space for the restorative materials without exceeding what is acceptable for the patient.

When only the anterior teeth need restoring, it is important to avoid grinding more than is absolutely necessary. Space for the restorative material may then be obtained by means of a partial cobalt/chromium splint placed on the palatial surfaces of the maxillary incisors and canines and retained by means of clasps. To have effect, the splint must be worn 24 h a day and only be removed for hygienic purposes. After a period of wear a space develops between the anterior teeth due to their intrusion and eruption of the posteriors (for further information, see Refs. 97, 98).

Accompanying the wearing away of occlusal tooth tissue there is also a flattening of the posterior occlusal surfaces. This may create a more anteriorly adopted intercuspal position, leading to an increase in the horizontal distance between RCP and ICP. This difference should be exploited when space for restorative materials is needed to restore heavily worn anterior teeth. Again an index of jaw relations is obtained with the mandible in the retruded position, providing space for the restorative material equivalent to the distance between RCP and ICP, which again means that an increase in the occlusal vertical dimension may be avoided if desired (99).

Type of restoration

The type of restoration to be chosen should depend on both the degree of tooth wear and the main reason for the wear. In patients with anorexia/bulimia, in whom the wear is limited mainly to the palatal surfaces of the maxillary incisors (and a rim of enamel is still left gingivally), composite resins or palatal ceramic laminates should be chosen (100). As a result, full coverage may be postponed if not avoided altogether.

The choice with regard to the type of complete crown depends also on etiologic factors and degree of tooth wear. When the teeth have a reasonable clinical crown height and the wear is mainly of an erosive nature, ceramic crowns may be chosen anteriorly. If the wear is mainly due to attrition the use of ceramometal or gold restorations is advisable. There is one region, however, where gold and acrylic veneers should be avoided, and that is the mandibular anterior region except in Angle class-III cases.

Retention

In many cases the degree of wear has progressed so far that the retention of restorations will present problems owing to the very short clinical crowns to be restored, at least until new and better mechanisms for adhesion to dentin have been developed. At present cast metal restorations and conventional luting media must be resorted to. Excellent retention may be obtained, however, even in heavily worn teeth, if the preparation is furnished with boxes and grooves. Thereby both the resistance and the retention form of the preparations are increased. The length and the surface area of the preparation can also be increased by carrying the preparation to the bottom of the gingival sulcus, if necessary after a gingivectomy. Further increase in the clinical crown length can be obtained by an alveoplasty followed by healing before the preparation is carried out. Devitalization of the pulp and endodontic treatment for retentive purposes should not be resorted to except under extreme circumstances (35, 88).

It should be stressed that it is the retention of each single retainer which is important. No extra retention is obtained by splinting crowns that have poor individual retention. Some of the advantages of single crowns are that the independent mobility of the teeth is maintained, individual parallel preparations are more easily performed, and repairs more easily carried out. Heavily worn teeth should therefore be restored by using single crowns and as small bridges as possible. Only when the teeth are periodontally reduced, which is unusual in cases of pathologic attrition (101), should the teeth be splinted by soldering the individual retainers together.

Choice of restorative material

Wear of materials may reduce the longevity of dental restorations. The choice of materials is difficult and must often be made on the basis of common sense, as adequate scientific data are lacking.

The conclusions and recommendations that can be given on the basis of a review of the literature are as follows:

Composites and acrylic resins should not be used to restore the occlusal surfaces of patients displaying severe tooth wear. Restorations made from gold with resin veneers seem to have good resistance against wear. If this choice of material combination is made, even the incisal edges must be made from gold to resist the wear. Disadvantages of gold and acrylic veneer restorations are poor cosmetic value and the risk of discoloration and wear of the veneers with time.

If cosmetic considerations must be given priority, metal ceramics should be chosen, especially in the mandibular incisor region. This material combination displays good wear resistance, but there is always the danger of chipping and fracturing of the ceramic, making replacement of the whole restoration necessary in some cases. This risk may be minimized if optimal conditions for dimensioning are provided to the dental technician through adequate tooth preparation and proper handling of the materials. Absolute recommendations with regard to the dimensions of the metal framework are difficult to give. In bruxers especially, a rigid metal substructure is essential. This should support the covering ceramic, following the surface outline of the restoration, giving an even layer of ceramic material of 1.0–1.5 mm. In cases of severe wear it is recommended that the crown margin be metal all the way round.

Fractures at the interface between metal and ceramic should never occur if the technician uses good working routines. In extreme bruxers fracturing within the ceramic layer seems to be unavoidable in certain cases. If remaking of the whole restoration becomes necessary, the use of gold and acrylic resin should be considered.

There does not seem to be any general reasons to avoid the use of different opposing materials, such as gold against ceramics. In vivo wear research has shown that these two materials wear approximately the same amount (3). Ceramics should be glazed or highly polished on delivery, however, and any chipping or fractures should be repaired if necessary and if possible, or at least well polished in accordance with recommended procedures. Stepwise polishing of the ceramic material will provide a surface similar to that obtained by glazing (102–104). An unglazed ceramic surface may represent a risk of extra wear of the opposing material—for instance, enamel, gold, or composite resin. Ceramic opposing ceramic appears to have a self-glazing effect (86, 87).

Heavy bruxers should be clearly informed that restoring their teeth will not lead to cessation of the bruxism. Diurnal bruxism will not only lead to direct wear of the incisal/occlusal surfaces of the restorations but most probably also cause fatigue in the various materials involved—that is, the metal framework, the veneering material, not to mention the abutment itself. Therefore, the patients have to accept that their new teeth will also be subjected to wear and that they cannot be expected to last for the rest of their lives.

After a careful rehabilitation, therefore, it is recommended to supply the patient with an occlusal splint to be worn as much as possible, and to establish a regimen of regular controls so that any untoward development is quickly registered and repairs can be made.

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