

Severe Tooth Wear: European Consensus Statement on Management Guidelines

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Summary: This paper presents European expert consensus guidelines on the management of severe tooth wear. It focuses on the definition of physiological vs pathological tooth wear and recommends diagnosis, prevention, counseling, and monitoring aimed at elucidating the etiology, nature, rate and means of controlling pathological tooth wear. Management decisions are multifactorial, depending principally on the severity and effects of the wear and the wishes of the patient. Restorative intervention is typically best delayed as long as possible. When such intervention is indicated and agreed upon with the patient, a conservative, minimally invasive approach is recommended, complemented by supportive preventive measures. Examples of adhesive, minimum-intervention management protocols are presented.

Keywords: tooth wear, decision making, restorative treatment, direct, indirect.

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Tooth wear and its management currently pose new challenges in dentistry.²² As predicted, tooth wear is increasingly common, especially among children and adolescents.^{7,35} Epidemiological studies have reported the estimated prevalence of erosive wear of permanent teeth in children and adolescents to be 30%.^{6,38} “Severe tooth wear”, a condition variously defined in the literature,⁴⁷ has been found to be present in 25% of a population of 15-year-

old adolescents.¹² Another report on severe tooth wear reported the prevalence to be 3% of 20-year-olds with dentin exposure and 15% of 70-year-old patients.⁴⁶ A recent survey among the Dutch adult population revealed that mild to moderate tooth wear is a common condition with prevalence and extent increasing with age.⁴⁸ Some patients exhibiting severe tooth wear may belong to a special risk group, for instance, those who exhibit reflux-related symp-

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toms.³⁹ The etiology of the wear is normally multifactorial, comprising effects of erosion, abrasion, and attrition.^{22,40}

Patients with severe tooth wear may need complex restorative care, possibly consisting of full rehabilitation at an increased vertical dimension of occlusion.^{24-26,44} The nature and extent of these treatment options and the phasing of the care plan for the patient is normally challenging and time consuming. In general terms, there is a shift in restorative treatment protocols for the management of tooth wear towards minimum-intervention approaches. Although less invasive, such approaches tend to be as complex and demanding as conventional treatments. However, the need for conventional approaches remains in some cases, but minimum-intervention approaches should be considered first.

The purpose of this paper is to critically appraise different views and restorative options for the care of patients with severe tooth wear, with the intention of developing best-available-evidence guidelines on criteria that help determine when to embark on a program of care, together with guidance on the most effective, state-of-the-art approaches to managing various forms of this complex, multifactorial condition. Furthermore, this paper aims to identify the gaps in existing knowledge and understanding, and make suggestions for further research on this topic.

PHYSIOLOGICAL OR PATHOLOGICAL? THAT'S THE QUESTION!

Tooth wear is an age-related phenomenon.⁴ As teeth continue to function throughout life and suffer erosive, attritive, and abrasive challenges, both highly variable degrees of tooth surface loss and changes in the surfaces of teeth will occur. Data on the typical (physiological) wear of enamel of the occlusal surfaces of permanent teeth is scarce, but has been reported to be around 15 μm per year for premolars and 29 μm per year for molars.¹⁹ Others have reported a decrease of the mean crown length for maxillary incisors from about 12 mm at the age of 10 years to about 11 mm at the age of 70 years, yielding a mean decrease of about 1 mm (1000 μm) in six decades.³⁶ For mandibular incisors, the mean crown length in the youngest age group was about 9.5 mm, which decreased by an average of about 1.5 mm (1500 μm) in the oldest age group, resulting in a mean crown length of 8 mm at the age of 70 years.³⁶ Merging the results of these studies reveals that over a time span of 60 years, molars show the most wear (1740 μm), followed by mandibular incisors (1460 μm), maxillary incisors (1010 μm), and premolars (900 μm). In the study by Ray et al,³⁶ females and males showed similar rates of tooth wear in incisors, while in most studies, gender differences are found,¹⁸ with males showing more advanced tooth wear than females.

Pathological tooth wear is difficult to quantify and define. The term has been used to describe unacceptable levels of progressive wear.^{10,42,43} It is usually interpreted as meaning a degree of ongoing tooth wear that is so severe it may result in sensitivity, compromise dental attractiveness or give rise to functional problems. As such, pathological tooth wear may

present in many different forms caused by different combinations of wear processes, with diverse signs, symptoms, and consequences. Longitudinal (≤ 12 months) data from a cohort of 70 participants with severe tooth wear demonstrated that in most cases, the rate of progression was below 15 μm , but for some, particularly those with reflux-related symptoms, the wear exceeded 100 μm in six months.³⁷ This study suggests that the activity of tooth wear is phasic, with periods of progression and remission, and implies that prevention of tooth wear is appropriate in any stage of the condition. Therefore, it is of paramount importance that a state-of-the-art diagnostic procedure is followed.⁴⁷

Several indices have been devised as an aid to determining the extent and severity of tooth wear.^{5,43,47} These indices may also serve as indicators of treatment need, particularly if a series of index scores or grades, obtained at successive recalls, confirm that the wear is progressive. A single index score or grade may help to quantify the nature, extent, and severity of wear, but is only a “snapshot” of what is typically a dynamic condition. A patient may be given a maximum index score or grade, but may not require or be a suitable candidate for restorative intervention at that time. For example, almost all studies on the prevalence of tooth wear report a relatively small proportion of mostly young patients (2%-10%) with relatively high levels of tooth wear^{6,12,46} which could be qualified as ‘pathological’, but do not conclude that all such patients should immediately enter into a program of restorative management.

SEVERE TOOTH WEAR OR PATHOLOGICAL TOOTH WEAR?

To avoid confusion between the terms “severe tooth wear” and “pathological tooth wear” the two conditions must be clearly distinguished. The term “severe tooth wear” relates to the amount of tooth substance lost, and is defined by the highest grade of index scores, whereas the term “pathological tooth wear” relates to active wear of atypical rate and nature. As a result, a young patient may have pathological tooth wear, caused primarily by erosion, with cupping in dentin and increased sensitivity, while the severity of the wear may still be limited. In contrast, an 80-year-old may have severe tooth wear, but ongoing wear, if any, may not be atypical for a patient of that age.

Definition of severe tooth wear

Tooth wear with substantial loss of tooth structure, with dentin exposure and significant loss ($\geq 1/3$) of the clinical crown.

Definition of pathological tooth wear

Tooth wear which is atypical for the age of the patient, causing pain or discomfort, functional problems, or deterioration of esthetic appearance, which, if it progresses, may give rise to undesirable complications of increasing complexity.

RISK ASSESSMENT – THE KEY TO SUCCESSFUL MANAGEMENT

Risk assessment is an important aspect of evidenced-based, patient-centered decision making in modern healthcare provision. Patients with severe tooth wear should be risk-assessed for possible alternative forms of management, including further preventive measures and monitoring only, mindful of the potential for effects of further wear and the failure of restorations and prostheses. In this respect, it is important to assess the likelihood of further wear and what form this wear may take, knowing that episodes of wear may well have different etiologies and rates of progression. Mechanical wear, causing attrition or abrasion, is enhanced by the initial demineralization (softening) of dental hard tissue, as hardly any tooth substance loss can be measured when the surface is not softened. Therefore, tooth wear is often described as erosive tooth wear, although in all probability, abrasive/attritional processes contribute to tooth surface loss after chemical softening by erosion.^{22,40}

A prerequisite to successfully treating severe tooth wear is a state-of-the-art diagnostic procedure aimed at identifying the etiology of the wear, among other features, and as a consequence, determining those preventive measures which may be most effective. Hence, besides the previously mentioned quantification of the existing tooth wear, the next step is revealing the possible etiological factors by using an evaluation system. This can be achieved by qualification, taking a thorough oral history and using validated questionnaires. The OHIP-49 questionnaire may be used to test the Oral Health Related Quality of Life of patients with severe tooth wear.⁴¹ However, even with a thorough anamnesis and examination, the multifactorial origin of severe tooth wear often prevents a clear diagnosis of the etiological factors. Eliminating all the etiological factors, however, may be unrealistic when dealing with patients suffering from long-established, recalcitrant chronic reflux disease⁴⁹ or persistent bruxism,⁴⁵ for example. Persistent bruxism, both sleeping and waking,²⁰ may greatly limit the prognosis of restorations made of brittle materials, eg, ceramic onlays and crowns, while an oral environment which remains erosive may limit the longevity of partial coverage restorations. In such cases, as with severe tooth wear of multifactorial etiology, every treatment approach must be underpinned by a robust preventive regime. This may be complicated if long-term management includes wearing a protective, occlusal splint at night (when sleep bruxism is present), myofeedback therapy (when waking bruxism is present), or any medicinal therapy such as proton-pump inhibitors (PPI) when a gastric reflux disease is present.

DECISION MAKING: TO RESTORE OR NOT RESTORE

The amount of tooth wear as established by the application of an index should not be the major, let alone sole basis for

a decision to begin restorative treatment. For this, more information is needed. This information can be categorized as complaints of the patient and reasons for the clinician to start treatment.

Reasons for a patient seeking help may include: 1. sensitivity and/or pain; 2. difficulties chewing and eating; 3. impaired orofacial esthetics because of loss of dental hard tissue; and 4. “crumbling” of dental hard tissue and restorations, threatening the integrity of teeth. Alternatively, the patient may simply be worried about the condition and life expectancy of their dentition following a routine dental examination in which tooth wear was identified.

The reasons for the clinician to start the treatment and management process can be divided into primary factors and secondary factors.⁴⁷ Primary factors include: 1. the amount of tooth wear (grading); 2. the affected surfaces (involved in occlusion/articulation or not); and 3. the number of teeth affected (localized or generalized). Secondary factors include: 1. progression (speed) of the tooth surface loss; 2. age of the patient; and 3. etiological factors.⁴⁷ Regarding the progression of the wear process, this can be assessed from a series of casts or digital 3D datasets/scans of the teeth obtained over a period of several months or years. Casts or digital 3D datasets are a valuable aid for monitoring patients with tooth wear, and may help to elucidate the etiology of the process and explain the nature and severity of the condition to the patients. Figure 1 illustrates a case of monitoring tooth wear over 3.5 years, revealing no detectable (relevant) progression. If monitoring reveals that the wear process is progressive, it should signal the need for preventive measures, or a referral for examination for gastric reflux disease, for example. It may also help reinforce patient acceptance of the need for compliance with an agreed care plan to preserve, and, where clinically indicated, repair or possibly restore the damaged teeth. All relevant decision making should be made jointly with the patient. Individually or collectively, factors such as pain or discomfort, functional or esthetic problems may be reasons to embark on a program of care. When no demands, concerns, or symptoms are present, a targeted preventive approach may be all that is required. In such cases, arrangements should be made for further counseling and monitoring. In the event of a patient having suffered clinically insignificant amounts of wear for their age, and being found to be free of any active wear, the clinician should resist any pleading by the patient for restorative intervention. In all cases, the benefits of care must clearly outweigh any immediate or subsequent negative consequences. Above all else, patients must not be launched into an unnecessary “restorative death spiral”¹³ driven by failing restorations of ever-increasing complexity and cost.

The following protocol is suggested to aid decisions on how to best manage patients with severe tooth wear (Fig 2):

- Restorative treatment is not always indicated. Preventive measures should be advised and arrangements made for counseling and monitoring, irrespective of the severity of the tooth wear.

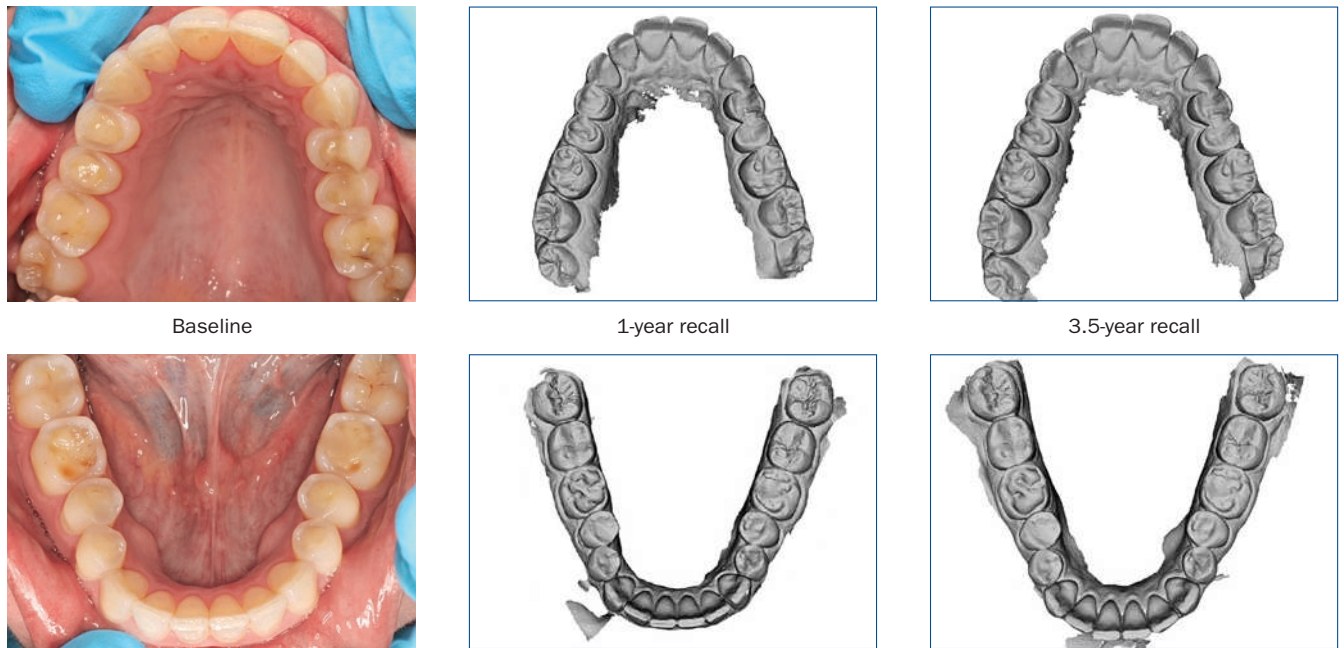


Fig 1 Patient with severe tooth wear, without a functional or esthetic problem. Patient was treated with counseling and monitoring over a follow-up period of 3.5 years. Patient from the Nijmegen Tooth Wear Project.

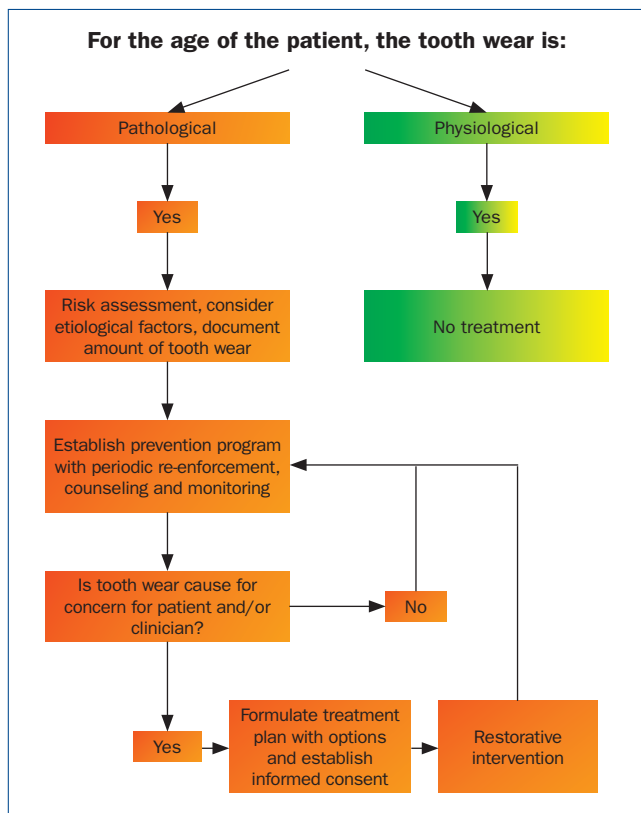


Fig 2 A flowchart that might help the clinician make the appropriate decision and give treatment advice, from counseling and monitoring towards restorative treatment.

- If the tooth wear is considered to be progressive, with a rate giving cause for concern, engage the patient in establishing the main etiological factors and instituting a mutually agreed-upon program of preventive measures:
 - If the patient has no complaints, monitor the efficacy of the preventive measures, preferably relying on (digital) casts, intraoral images, and an evaluation index. When satisfied that the wear is not progressive, discuss the need for restorative intervention with the patient. If the decision is made to continue monitoring, new evaluations can be made at intervals of 2 or 3 years.
 - If the patient is concerned about her/his appearance or has complaints, restorative options should be critically reviewed with the patient. Definitive forms of restorations should not be advised in the presence of active disease. Restorations, including composites and full veneer crowns, do not prevent wear processes, merely modify the rate, location, and nature of the wear. Moreover, most restorations that are considered “definitive” may prove to have a limited lifetime in patients with severe tooth wear due to bruxism and erosion.

Conservative, preventively oriented approaches to the management of wear may result in accusations of supervised neglect. Therefore, accurate record keeping of patient engagement, a description in the notes of the tooth wear severity, using indices such as BEWE, TWI, TWES, shared decision-making outcomes, the actions taken, and follow-up are crucial additions to clinical records.

RESTORATIVE TREATMENT OF SEVERE TOOTH-WEAR PATIENTS

It is likely that some patients with severe tooth wear suffer premature restoration failure caused by bruxism, resulting in restoration fracture, or erosion and bruxism, causing progressive wear that results in the need for new restorations. This might speed up the restorative cycle, with restorations of ever-increasing size, increased risk of restorative complications, and the eventual possibility of tooth loss.¹³ It is particularly important to bear this in mind with younger patients, in whom the application of conservative, minimum-intervention approaches may make the difference between a functional, non-functional, or even nonexistent dentition in old age.

GENERAL PRINCIPLES FOR RESTORATIVE TREATMENT

- Try to postpone initial restorative interventions, as “once a restorative patient, always a restorative patient”. Effective counseling and monitoring will provide valuable information on the effects of preventive measures and the need to refine them, the nature and rate of any ongoing wear, and patient engagement and compliance.
- Spend enough time to systematically collect and analyze all the information necessary to obtain robust, informed consent.
- Before giving consent, the patient must understand the risks and benefits of the possible restorative options and have realistic expectations of the alternative clinical outcomes. The process of obtaining informed consent should be carefully documented in the patient’s dental records.
- When indicated clinically, restorative treatment should wherever possible be “additive” rather than “subtractive”, as the latter involves the removal of yet more tooth tissue. To protect tooth structure and the pulp, minimum-intervention approaches involving direct, indirect, or hybrid techniques should be favored over approaches comprising very invasive, traditional indirect restorations, which require extensive preparations that sacrifice sound tooth tissue.

RESTORATIVE TREATMENT OPTIONS

Direct and indirect materials and techniques should be included in options to restore severely worn teeth.²⁷ The management of severe tooth wear should be minimally invasive wherever possible, thereby keeping as many as possible future restorative options open. This is described as the dynamic restorative concept.⁸ In keeping with this concept, this paper focuses on modern additive rather than traditional subtractive approaches.

Traditionally, patients with severe tooth wear were treated by means of interventional full and partial crowns,^{23,29} but such restorations, apart from being costly, carried a high risk of complications, some of which even compromised the prog-

nosis of teeth. However, such classic prosthodontic techniques may continue to have a certain place in the management of severe wear, eg, often where restorations of composites have been shown to fail, but mainly as a last resort. For instance, the judicious application of traditional approaches may offer a favorable clinical outcome in cases where composite restorations regularly fail, or in some older patients with cumulative effects of disease, aging, and previous operative interventions. However, careful judgment must be exercised in such cases.

MATERIALS SELECTION

A recently published systematic review concluded that there is no strong evidence to suggest that any one material is better than another for constructing restorations to manage severe tooth wear.²⁷ Assuming that an additive, minimum-intervention approach is adopted, the selection and appropriate application of adhesive techniques is critical to success in the restorative management of severe tooth wear. When direct composites are used, the use of appropriate adhesives is recommended.^{21,32} As the worn tooth substrate usually consists of both dentin and enamel, selective phosphoric acid etching is indicated to optimize adhesion. The relatively few clinical studies and case reports available indicate that modern adhesives and hybrid composites have the potential to perform adequately in the management of severe tooth-wear patients;^{2,14,16,28} in contrast, restorations made of microfilled composites have been found to suffer high failure rates in such situations.³ With a few notable exceptions, some of which are extended controlled case reports² or retrospective, uncontrolled studies,¹⁶ there is a paucity of clinical studies on the use of indirect ceramic and composite restorations in the management of severe tooth wear.

Nevertheless, it is recognized that restoration of the worn dentition with composites can result in a need for interventional maintenance care, including the repair of fractures and chipping, especially when the patient is a bruxist. The patient should be informed of this possibility in the process of obtaining consent for care.

Furthermore, it is remarkable that high risk patients, for example bruxists, were excluded in the available clinical studies on the suitability and clinical performance of crowns and inlays.⁴⁵ As a consequence, it is impossible to say whether ceramic or indirect composite restorations, which may be found to have an annual failure rate of ca 1% to 2% in highly controlled studies, are a valid restorative treatment option in the management of severe tooth wear.

INCREASING VERTICAL DIMENSION OF OCCLUSION

To ensure appropriate function and esthetics, provide enough space for restorations, and prevent sound tooth-tissue removal, an increase of the vertical dimension of



Fig 3 Treatment of patient with partial severe tooth wear. A Dahl plateau was placed with direct composite resin restorations. Immediately after treatment, the posterior teeth were in disclusion. After six months, extrusion of posterior teeth and intrusion of anterior occurred and all teeth were in occlusion again. Patient treated by Dr. Ulla Pallensen.

occlusion (VDO) may be required. Splints are rarely needed to test the effects and acceptance of an increase in VDO.¹ In some restorative concepts, a temporary splint may assist in planning and treatment.^{11,14} Given temporomandibular disorders, their use may also be advisable.

Notwithstanding an absence of high-level scientific evidence, the authors recommend the following general principles for the management of severe tooth wear:

1. Restorative treatments should be as conservative as possible, involving the minimum number of teeth necessary to achieve a satisfactory clinical outcome.
2. Wherever possible, preparations should be restricted to the creation of necessary features, including seats, bevels, or chamfers, to particularly facilitate restoration placement.
3. Assuming good oral hygiene maintenance, the selection of materials and technique should take into account the expectations, esthetic demands and risk profile of the patient, operator familiarity and skills, patient availability for recall, and any budgetary constraints.

TECHNIQUES FOR RESTORATIVE MANAGEMENT OF SEVERE TOOTH-WEAR PATIENTS

There are several techniques that can be considered to meet the suggested requirements and can be used to treat tooth-wear patients restoratively.

Localized severe tooth wear

A localized increase in VDO is often required. The “Dahl concept” refers to the axial tooth movement that is observed when an appliance or restorations are placed in su-

pra-occlusion and full arch contacts are re-established over a period of time.⁹ The technique is well described in several other papers.^{14,33} A clinical example is shown in Fig 3. It typically involves the placement of restorations on the palatal surfaces of anterior teeth to create an increase in VDO and, in time, space for additive restorations.

Occlusion is re-established over a period of several months, possibly involving condylar repositioning and compensatory eruption of the posterior teeth, together with some intrusion of the anterior teeth and remodeling of the alveolar bone. This allows the posterior occlusion to re-establish at a new intercuspal position, stabilizing the increased interocclusal space.

Generalized severe tooth wear

Direct composite restorations

Direct composite restorations may be placed using different placement techniques that help create the required anatomy and occlusal relation. The DSO technique^{17,31} uses silicon stops for establishing increased VDO and places the composite directly, while the mold² and stamp³⁴ techniques use a wax-up reconstruction on dental casts from which a mold matrix is obtained to place the composite restoration. An example of a full-arch direct reconstruction using a direct composite restoration technique is shown in Fig 4.

Indirect restorations

For indirect techniques, several options are available, such as composite, ceramic, or the recently developed polymerceramic CAD-CAM restorations, all ranging from classic impression taking and laboratory-constructed restorations to a fully digital workflow.¹⁵ In a minimally invasive approach, it is an option to leave qualitatively good direct restorations in place, and indirect restorations are used for the occlusal part in a technique related to margin elevation.³⁰ A minimally invasive indirect rehabilitation of a patient with tooth wear is shown in Fig 5.



Fig 4 Patient with severe tooth wear treated with direct composite resin restorations. Before treatment, at 1- and 5-year recall. Patient treated by Dr. Bas Loomans.



Fig 5 Patient with severe tooth wear treated with indirect composite resin restorations. Before treatment and after treatment. Operator: Prof. Dr. Daniel Edelhoff.

CONCLUSION

From the present paper, it is clear that the restorative management of severe tooth wear lacks a robust body of high-level evidence. Specific patient characteristics and increased risks of restoration failure preclude existing data on restoration performance being used to guide clinicians and patients in choosing which approach to use in the management of severe tooth wear.

The following guidelines are suggested to help practitioners best manage severe tooth wear:

Guidelines for the treatment of patients with severe tooth wear

- Priority should be given to the diagnosis of the etiology of the wear and instigating appropriate preventive measures.
- Patients with moderate or severe tooth wear but without (functional or esthetical) complaints should be advised to monitor the situation first to determine whether the tooth wear is progressive or not.
- Restorative treatment should be as conservative as possible, employing minimally invasive treatment strategies according to a dynamic restorative treatment concept.
- Direct and indirect minimally invasive techniques can be employed using adhesive materials. Traditional, invasive restorations remain an option in selected cases and under certain circumstances.
- Explanation of the possible treatment options and expected complications should be included in the informed consent.

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