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# Monitoring Tooth Wear

**Abstract:** Tooth wear is a multifactorial condition leading to the irreversible loss of dental hard tissues. Although tooth wear is mainly a physiological process, it can become pathological if the wear process is accelerated for various reasons. Since this process is not linear, but can sometimes be inactive and sometimes active, a careful monitoring policy is necessary. The possible monitoring tools are described in this article, and a proposal is made with regard to the frequency of the systematic and periodic collection of information.

**CPD/Clinical Relevance:** The prevalence of tooth wear is increasing and it now carries the third highest risk (after caries and periodontitis) for maintaining the natural dentition.

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Tooth wear is a multifactorial condition leading to the irreversible loss of dental hard tissues. Tooth wear can be divided in four subtypes: mechanical–intrinsic (attrition), mechanical–extrinsic (abrasion), chemical–intrinsic (erosion), and chemical–extrinsic (erosion).<sup>1</sup> The terminology relating to tooth wear has evolved and there are variations in the meaning of a single term, and sometimes different terms are used to describe the same condition. Use of a common terminology will facilitate less ambiguous communication between researchers, clinicians and their patients. It will also enable better documentation and interpretation of research findings and clinical observations.<sup>2,3</sup>

For many years, tooth wear was a condition of little interest in daily clinical practice; however, this has changed. Tooth wear is becoming increasingly significant in maintaining the long-term health of the dentition.<sup>4</sup> It becomes especially important when the dentition is kept relatively intact in the contemporary ageing population, where edentulism is decreasing, but the prevalence of tooth wear is increasing.<sup>5,6</sup>

The damage done through tooth wear is irreversible, and will thus compromise the dentition for the total lifetime, which can many be many decades, and may require repeated and increasingly complex and expensive restorations. Therefore, it is important that the diagnosis of tooth wear is made early, and adequate preventive measures are taken. To that end, dentists should explore the numerous factors that play a role in the onset, severity and progression of tooth wear.<sup>7</sup>

In general, the dental clinician has two options: counselling and monitoring; and restorative treatment accompanied by counselling. The challenge is to determine the right time to move from monitoring to restorative treatment.

## Diagnostic process

The first important step in the diagnostic process is the quantification of the observed tooth wear, in other words to grade intra-orally the severity of the tooth wear, and assess its spread. There are many methods for the quantification of tooth wear. The

European Consensus Statement<sup>8</sup> describes the use of three systems: the Tooth Wear Index (TWI),<sup>9</sup> the Basic Erosive Wear Examination (BEWE)<sup>10</sup> and the Tooth Wear Evaluation System (TWES) (Table 1).<sup>1,11</sup> For the same reasons as described concerning terminology, the use of one universally accepted and used assessment system is also desirable.<sup>12,13</sup>

The second step in the diagnostic process is to determine possible pathology. In the European Consensus Statement,<sup>8</sup> it was made clear that severity alone is not indicative for the measurements to be made by the clinician. It was stated that to differentiate between physiological and pathological tooth wear is an important task for the clinician. In the definition produced by the authors of the European Consensus Statement, pathological tooth wear is described as atypical for the age of the patient, causing pain or discomfort, functional problems, or deterioration of aesthetic appearance, which, if it progresses, may give rise to undesirable complications of increasing complexity.<sup>8</sup> So, it is not only the severity, but also the negative consequences experienced by the patient that are of importance. This fits with the concept of 'shared decision making' whereby the practitioner and the patient jointly decide what is best for the patient in a given situation. The concept has long been adopted in medicine, but not yet fully in dentistry.<sup>14–16</sup>

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Component	To be carried out	Instruments
<b>TWES-Screening</b>	Quantification per sextant	5-point ordinal scale for occlusal/incisal grading per sextant
		5-point ordinal scale for non-occlusal/non-incisal grading per sextant
<b>TWES-Status-obligatory</b>	Quantification per tooth	5-point ordinal scale for occlusal/incisal grading per tooth
		Optional: 8-point ordinal scale for occlusal/incisal grading per tooth
		5-point ordinal scale for non-occlusal/non-incisal grading per tooth
	Detection of pathological signs and symptoms	Five objective signs (according to the practitioner)
		Five subjective symptoms (according to the patient)
	Qualification	Clinical signs indicating the influence of chemical factors
Clinical signs indicating the influence of mechanical factors		
<b>TWES-Status-optional</b>	Quantification of clinical crown length of sextants 2 and 5	Ruler in mm
	Structured oral history taking, use of relevant questionnaires	Both medical and dental questionnaires regarding aetiology and consequences
	Recording of tooth wear	Intra-oral photographs, dental casts, intra-oral scanner
<b>TWES-Status-management</b>	Assessment of the level of difficulty of a restorative treatment	General and specific complicating factors

**Table 1.** Components of the Tooth Wear Evaluation System (TWES 2.0).

In the European Consensus Statement, pathology was described in general terms,<sup>8</sup> while in the two versions of the Tooth Wear Evaluation System, there was an attempt to define it in more detail.<sup>2,11</sup> Along with dentine exposure, one out of five objective signs (according to the practitioner) and five subjective symptoms (according to the patient) are needed for tooth wear to be considered pathological (Table 2).<sup>11</sup>

The third step in the diagnostic process is qualification or phenotyping of the existing tooth wear. Many terms and descriptions have been used to indicate which subtypes of tooth wear are suspected on the basis of an oral examination. Gandara and Truelove<sup>17</sup> produced the first good and coherent list with later publications, which were bundled in the TWES 2.0.<sup>11</sup> However, the use of these clinical signs remains difficult. Various publications indicate that there is no evidence that the signs can be unequivocally linked to subtypes of tooth wear and the

presumed aetiological factors. For this reason, the subdivision into four subtypes (chemical/mechanical; intrinsic/extrinsic) was reduced and bundled to two subtypes, namely, clinical signs indicating the influence of chemical factors, and clinical signs indicating the influence of mechanical factors (Table 3).<sup>11,13</sup> The more signs that are found of one of the two subtypes of tooth wear, the more likely it is that this subtype is part of the complex picture. By determining which subtype contributed (most) to the wear process, one can try to identify the aetiological factors in a more targeted way, and thus start targeted counselling. The observed signs of tooth wear in the hard tissues are the sum of the wear over the years. It is not possible to deduce from this when these signs arose.

### Monitoring

As mentioned above, the diagnostic process consists of three steps:

quantification; determination of possible pathology; and qualification or phenotyping. The monitoring process should also consist of three steps. Although training can reduce the amount of time that is required to execute a proper diagnostic or monitoring procedure, during a standard recall appointment, there is often not enough time.

The different scales and indices use different methods for quantification. The TWI<sup>9</sup> grades all teeth and surfaces, BEWE<sup>10</sup> grades the six sextants on all surfaces, and TWES<sup>2</sup> grades the six sextants, but only on the surfaces that are involved in occlusion and articulation. These differences in methodology take different amounts of time to perform the grading. So, rather than a full mouth assessment, Martignon *et al* tested whether assessment of 'index teeth' was comparable, which was the case.<sup>18</sup> In this study, the index teeth were the buccal surfaces of the upper central

Five objective signs observed by the practitioner:	
1.	Rapidly progressing tooth wear
2.	Wear atypical for the age of the patient
3.	Crumbling of hard dental hard tissue and/or restorations that threatens the integrity of teeth
4.	Wear on surfaces involved in occlusion/articulation, leading to the loss of the vertical dimension of occlusion (VDO)
5.	Reduced condition of the saliva
Five subjective symptoms indicated by the patient:	
6.	Dissatisfaction with the aesthetic appearance
7.	Sensitivity and/or pain
8.	Experience with crumbling teeth and/or restorations
9.	Difficulty with chewing
10.	Difficulty with speaking

**Table 2.** Detection of pathological signs and symptoms. There should be at least wear into the dentine (TWES-grade 2, 3 or 4), i.e. moderate, severe or extreme tooth wear, and one or more of the 10 signs or symptoms listed.

Clinical signs for the influence of chemical factors
Occlusal 'cupping', incisal 'grooving', 'cratering', rounding of cusps and grooves
Wear on non-occluding surfaces, non-carious cervical lesions (NCCL)
'Raised' restorations
Broad concavities within smooth surface enamel, convex areas flatten, concavities become present, width exceeds depth
Increased incisal translucency
Clean, non-tarnished appearance of amalgams
Preservation of enamel 'cuff' in gingival crevice
No plaque, discolouration or tartar
Hypersensitivity
Smooth silky-shining, silky-glazed appearance, dull surface
Clinical signs for the influence of mechanical factors
Shiny facets, flat and glossy
Enamel and dentine wear at the same rate
Matching wear on occluding surfaces, corresponding features at the antagonistic teeth
Fracture of cusps or restorations
Cracks within the enamel
Cervical areas of premolars and cuspids are affected
Located at cervical areas of the teeth, NCCL
Buccal/cervical lesions more wide than deep, NCCL
Impressions in cheek, tongue and/or lip
Torus mandibulae

**Table 3.** Clinical signs indicating the influence of chemical and mechanical factors.

incisors and the occlusal surfaces of lower first molars. These index teeth had already been suggested and tested in earlier studies (Table 4).<sup>19,20</sup>

Clinical photographs, intra-oral scans or study models can also be chosen for monitoring rather than scoring intra-orally during a recall appointment.<sup>2,7</sup> Dental clinicians can take the photographs, scans or casts or this task can be carried out by dental assistants, hygienists or technicians, saving time for the clinician. Indices can be used reliably on photographs, scans or casts.<sup>7,13</sup> Photographs and scans are not only suitable for quantification, but also partly for the determination of possible pathology, and qualification or phenotyping (Table 4). In modern daily dental practice, the use of photographs and scans is increasing, because their use is easier and cost effective. However, it is important to state that the use of these techniques supports the clinician, but the choices are made by the clinician and not by the techniques. Clear thinking and common sense are required.

Another difficult question is the interval for assessing tooth wear, especially when bearing in mind that the tooth wear process is not linear, but can have 'active' and 'inactive' periods. As mentioned earlier, for many years, tooth wear was a condition of little interest in daily clinical practice; however, the suggestion to assess tooth wear at every recall appointment was to change this dramatically.<sup>2</sup> This advice was not adequately followed, which was most likely to have been due to the fact that it is a time-consuming process. Therefore, a computer technique ('timed automata modelling') was used to calculate the best interval for monitoring.<sup>21</sup> The modelling technique showed that a yearly monitoring protocol yielded better outcome measures than a once-in-5-years monitoring protocol.<sup>21</sup> O'Toole and colleagues concluded that the intra-oral use of an index should be performed every 18 months.<sup>7</sup> Furthermore, they suggested a diagnostic interval for clinical photographs of 18 months, and for study casts, an interval of 3–5 years. For scans, visual changes would be expected to be seen at intervals of between 18 months and 2 years and that wear analysis can be performed between 6 months and 1 year (Table 4).<sup>7</sup> So at least, these days, there is an indication for assessing not too

a		
1.	<b>Quantification</b>	A. Intra-oral index/scale
		A1. Assess all teeth and grade: Per tooth, all teeth and surfaces (TWI) Per sextant, all surfaces (BEWE) Per sextant, only surfaces that are involved in occlusion/articulation (TWES)
		A2. Assess index teeth: Buccal surfaces of upper central incisors and occlusal surfaces of lower first molars (TWI, BEWE, TWES)
		B. Intra-oral photographs, intra-oral scans or study models: Taken by the dental clinician, dental assistant, dental hygienist or dental technician Asses later, if necessary, as mentioned (A)
2.	<b>Determination of possible pathology</b>	Chairside, partly on intra-oral photographs, intra-oral scans or study models
		Chairside by structured oral history taking or using proper questionnaires
3.	<b>Qualification or phenotyping</b>	Chairside, partly on intra-oral photographs, intra-oral scans or study models
b		
<b>At each recall, quantification using the TWES-Screening</b>		
If grading results in TWES grade 0 or 1 (no tooth wear or tooth wear restricted to enamel)	Continue to use the TWES-Screening	
If grading results in TWES grade 2 (moderate tooth wear with dentine exposure)	Choose to continue with TWES-Screening or change to TWES-Status	
If grading results in TWES grade 3 or 4 (dentine exposure with reduction of clinical crown height, 3 or 4 (severe or extreme tooth wear))	Use the TWES-Status	
c		
<b>Quantification</b>	<b>Interval</b>	
Index	1 year–18 months	
Intra-oral photographs	18 months	
Intra-oral scans	18 months–2 years	
Study models	3–5 years, or only when a restorative treatment is started	

**Table 4.** Monitoring and monitoring schedule: (a) assessment; (b) stepwise flowchart; and (c) assessment intervals.

often, but also not too infrequently, and by doing so, avoiding supervised neglect.<sup>22</sup> In different clinical settings and in different countries, the recall interval differs, from every 3–6 months to once a year or once every 2 years. Although it is perhaps difficult to determine what is desired, a person-centred approach is needed.<sup>23</sup>

Another option is a so-called stepwise approach. To smooth the clinical workflow as much as possible, the authors of the TWES 2.0<sup>11</sup> suggested assessing tooth wear via a stepwise approach, using the Tooth Wear Screening, the Tooth Wear Status-obligatory, and the Tooth Wear Status-optional. All the instruments that are part of the TWES 2.0 are used only when indicated (Table 1). The flowchart that was designed is for use only with the Tooth

Wear Screening (screening per sextant) during every recall and use should be continued when there is no observed tooth wear (TWES grade 0), or the assessed tooth wear is mild (TWES grade 1: tooth wear restricted to the enamel) in any or all sextants. If dentine is exposed (TWES grade 2), there is the choice to continue to the Tooth Wear Status. If there is, according to the TWES, severe or extreme tooth wear (TWES grade 3 or 4) in any or all sextants, the Tooth Wear Status should be performed.<sup>11</sup> The Tooth Wear Status consists of grading tooth wear per tooth rather than per sextant, determining possible pathology, and qualification or phenotyping (Table 4).

It is clear that improvements in our knowledge have been made, but

clinical challenges and doubts remain. In the recently published preliminary beta version of the Diagnostic Criteria for Tooth Wear, the above-mentioned clinical challenges are described and various proposals are made.<sup>13</sup>

### Risk assessment

In order to perform the appropriate assessment with an appropriate interval, risk assessment can facilitate the dental clinician. Attempts have been made to develop criteria for risk assessment in tooth wear patients. In 2005, Young<sup>24</sup> warned about the 'emerging epidemic of tooth wear' and indicated the importance of a healthy lifestyle and diet strategy that conserves the teeth by natural means

of salivary stimulation, and to address the specific needs of patients' oral and medical conditions. An individualized, patient-empowering erosion WATCH strategy (Water, Acid, Taste, Calcium and Health) was discussed.<sup>24</sup> Lussi and co-authors also proposed an individually tailored preventive programme for each patient that comprised dietary advice, optimization of fluoride regimens, stimulation of salivary flow rate, use of buffering medicaments and motivation for non-destructive tooth brushing habits.<sup>25</sup> Additionally, Slater and co-authors mentioned in their paper, 'Warning: Tooth Wear Ahead', the growing importance of early identification of patients who may be at risk of pathological tooth wear. They proposed a so-called 'wearogram', with physical, medical and social markers of tooth wear, making possible early identification of patients at risk.<sup>26</sup> In a multicentre study, a new proposal was formulated, the erosive wear assessment of risk (EWAR), which is a combination of a clinical index, a questionnaire, and saliva secretion evaluation.<sup>27</sup> More recently, Oudkerk and co-authors published their study on risk assessment.<sup>28</sup> In this review, nine domains were determined from the literature: socio-demographic factors; medical history; drinking habits; eating habits; oral hygiene habits; dental factors; bruxism and temporomandibular disorders; behavioural factors; and stress. Results related to chemical tooth wear risk factors underline the importance of eating disorders, gastro-oesophageal reflux and lifestyle, particularly drinking and eating behaviours, which supports the development of public health information campaigns and other interventions. This review also identified evidence of several mechanical tooth wear risk factors, such as toothbrushing and bruxism.<sup>28</sup> Additionally, the preliminary beta version of the Diagnostic Criteria for Tooth Wear determined, described and made proposals regarding risk assessment.<sup>23</sup> Further research is needed to reveal which combination of all the above-mentioned assessment tools is optimum.

## Restorative treatment

The main goal of counselling and monitoring is the attempt to detect signs of progressive wear in order to avoid the further loss of hard dental tissues as much as possible. By doing this, the

start of a restorative treatment can be postponed or even avoided.<sup>8</sup> Advantages of a restorative treatment can be the reduction of sensitivity and/or pain, the improvement of function and mastication, the improvement of orofacial aesthetics and the prevention of further loss of hard dental tissues and/or restorations. Disadvantages of restorative procedures are often overlooked and include the failure and/or fracture of the restorations and/or of the teeth itself. As soon as the restorative cycle is started, it will always be necessary to continue to re-restore the dentition, because restorations do not last for decades.<sup>29</sup> Therefore, it is important to postpone the start for as long as possible. If a restorative treatment cannot be avoided, it should preferably be performed minimally invasively.<sup>8</sup> Various evaluation studies have been carried out to determine which treatment methods are preferable.<sup>30–32</sup> The heterogeneity of treatment options and treatment situations makes an unequivocal conclusion, as might be expected, impossible.

## Conclusion

This article describes several aspects of monitoring tooth wear. Since tooth wear is an irreversible multifactorial condition, monitoring is of importance and requires attention in daily oral healthcare. Based on the available evidence, several suggestions have been made for carrying out the monitoring process on a routine basis.

## Compliance with Ethical Standards

**Conflict of Interest:** The authors declare that they have no conflict of interest.

**Informed Consent:** Informed consent was obtained from all individual participants included in the article.

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