

**Basic Erosive Wear Examination - A Review**

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**Abstract**

Erosive tooth wear is a condition that affects the long-term health of the dentition and the overall well being of the patient. Problems and questions concerning erosive tooth wear now cover an ample area of research in dentistry and therefore, the need for an universally accepted index to measure dental erosion becomes vital. Many indices have been developed all over the world for the assessment of dental erosion. They vary considerably with respect to scale and grading as well as to the information provided, making comparison of recorded data difficult, if not impossible.

The Basic Erosive Wear Examination (BEWE) is a suitable index for classification, which links the grading of lesions with clinical management. The aim of the BEWE is to be a simple, reproducible and transferable scoring

system for recording clinical findings and for assisting in the decision-making process for the management of erosive tooth wear. This paper reviews the challenges in the clinical assessment of erosive tooth wear and describes the Basic Erosive Wear Examination index and its diagnostic criteria. It also reviews the various studies on the validity, reliability, sensitivity and specificity of this index as well as its potential of this index to be considered as the standard index for the assessment of dental erosion in research as well as clinical practice

**Keywords:** Basic Erosive Wear Examination, erosive tooth wear, dental erosion, dental erosion index, tooth wear index, BEWE.

**Introduction**

Dental erosion is an irreversible loss of dental hard tissue due to a chemical process of acid dissolution, but not

involving bacterial plaque acid and not directly associated with mechanical or traumatic factors or with dental caries[1]. It was for many years a condition of little interest to clinical dental practitioners or research professionals as tooth wear was rarely a major complaint of the dental patient. Diagnosis was seldom made, especially in the early stages, as the patients remained asymptomatic[2]. It was later understood that progression of dental erosion may lead to dentine and pulp exposure and may even result in tooth loss.

Erosive tooth wear is also of importance as it affects the long-term health of the dentition and the overall well-being of those who suffer its effects. It is important to define the magnitude of this problem of dental erosion so that effective preventive and curative strategies can be implemented in the earlier stages. Problems and questions concerning erosive tooth wear now cover an ample area of research in dentistry, and will undoubtedly expand in the future. The need for an universally accepted index to measure dental erosion, therefore, becomes vital[2].

The Basic Erosive Wear Examination (BEWE) is a suitable index for classification, which links the grading of lesions with clinical management[3]. For scoring, the dentition is divided into sextants and the most severe lesion in each sextant is recorded and an overall score for a patient is calculated by adding the scores of all sextants.

The BEWE was introduced by Bartlett, Ganss and Lussi in 2008.

### **Terms and Definitions**

The terms 'erosion', 'dental erosion' and 'erosive tooth wear' are often used interchangeably when referring to the effects of acids on the surfaces of teeth.

According to Terminology of Erosive Tooth Wear: Consensus Report of a Workshop Organized by the ORCA and the Cariology Research Group of the IADR[4], the terms related to dental erosion are defined as follows

## **Clinical Conditions and Processes [4]**

### **Conditions**

**Tooth wear:** The cumulative surface loss of mineralized tooth substance due to physical or chemophysical processes (dental erosion, attrition, abrasion). Tooth wear is not considered to be the result of dental caries, resorption, or trauma.

**Erosive tooth wear:** Erosive tooth wear is tooth wear with dental erosion as the primary etiological factor.

### **Processes**

**Dental erosion:** Dental erosion is the chemical loss of mineralized tooth substance caused by the exposure to acids not derived from oral bacteria.

**Dental attrition:** Dental attrition is the physical loss of mineralized tooth substance caused by tooth-to-tooth contact.

**Dental abrasion:** Dental abrasion is the physical loss of mineralized tooth substance caused by objects other than teeth.

### **Diagnosis of Dental Erosion**

Diagnosis of erosive tooth wear integrates findings from the patient history, assessment of risk factors and an oral examination. Typical early signs of erosive tooth wear include defects that are shallow; they mostly affect the smooth surfaces and the area coronal to the cemento-enamel junction with an intact band at the gingival margin. On the occlusal surfaces, cupping and flattening of the surface can be found. As erosive tooth wear progresses, the dentine colour becomes more visible and restorations may protrude from the surrounding dental hard tissue. Finally, the teeth can have a melted appearance losing the morphology of sound teeth[4].

### **Classification**

**Mild erosive tooth wear (BEWE 1):** Initial loss of surface texture

**Moderate erosive tooth wear (BEWE 2):** Distinct

defect: hard tissue loss involving less than 50% of the surface area.

Severe erosive tooth wear (BEWE 3): Hard tissue loss involving more than 50% of the surface area. Moderate and severe levels may involve dentine exposure.[4]

Physiological tooth wear : Some degree of tooth wear expected over a lifetime. The rate of progression varies between individuals and not all tooth wear needs treatment.

Pathological tooth wear : Tooth wear can be defined as pathological if it is beyond the physiological level relative to the individual's age and interferes with the self-perception of well-being[4].

Erosive tooth wear is, in part, a normal wear process occurring over lifetime. For management of the condition, it is therefore necessary to distinguish between pathological and physiological loss of tooth tissues[5] . According to Smith and Knight, "Tooth wear can be regarded as pathological if the teeth become so worn that they do not function effectively or seriously mar the appearance before they are lost for other causes or the patient dies. The distinction of acceptable and pathological wear at a given age is based upon the prediction of whether the tooth will survive the rate of wear

### **Morphology and Differential Diagnosis of Erosive Tooth Wear**

The early signs of erosive tooth wear appear as a smooth silky-shining, sometimes dull surface. In the more advanced stages, changes in the original morphology occur. On smooth surfaces, the convex areas flatten or concavities become present, the width of which clearly exceed the depth. Undulating borders of the lesion are possible. Initial lesions are located coronal from the enamel-cementum junction with an intact border of enamel along the gingival margin. The reason for the preserved enamel band could be due to some plaque

remnants, which act as a diffusion barrier for acids or due to an acid-neutralizing effect of the sulcular fluid, which is slightly alkaline[6].

Erosion can be distinguished from wedge shaped defects, which are located at or apical to the enamel-cementum junction. The coronal part of wedge-shaped defects ideally has a sharp margin and cuts at right angles into the enamel surface, whereas the apical part bottoms out to the root surface. The depth of the defect clearly exceeds its width. The initial features of erosion on occlusal and incisal surfaces are the same as described above[6].

Further progression leads to a rounding of the cusps, grooves on the cusps and incisal edges, and restorations rising above the level of the adjacent tooth surfaces. In severe cases the whole occlusal morphology disappears . Erosive lesions have to be distinguished from attrition. The latter are often flat and have glossy areas with distinct margins and corresponding features at the antagonistic teeth. Whenever possible, the clinical examination should be accomplished by a thorough history taking with respect to general health, diet and habits and by the assessment of saliva flow rates [6].

### **Challenges in Clinical Assessment of Erosive Tooth wear**

#### **Validity**

Validity of an instrument reflects to what extent it measures what it is supposed to measure. Although there are different types of validity, if an erosion index displays a high level of content and construct validity, significant methodological issues will have been adequately addressed.

Content validity describes whether all aspects that are relevant to grasp the construct of interest have been considered at the highest possible level. Regarding an erosive wear index, the erosion of surfaces of all teeth has to be considered; therefore partial recording indicates low

content validity. Although the inclusion of all teeth appears to increase the content validity of an erosion index, lack of consensus between investigators regarding the clinical features of erosion may significantly affect the content validity of an instrument.

On the other hand, construct validity is established by relating the instrument to a general theoretical framework and is subdivided into discriminate and convergent validity. Regarding erosion assessment, convergent validity is very difficult to confirm. The results obtained by the new instrument cannot be correlated with the results of an established instrument that measures similar aspects and specifically erosive wear, as this established instrument simply does not yet exist. On the other hand, an instrument possesses discriminant validity if the results of this instrument are not too highly correlated with the results of an established instrument that measures a different construct – for example, abrasive wear. With regard to erosive wear, a potentially high correlation between tooth erosion and wedge-shaped defects might indicate insufficient discriminant validity. Therefore, an ideal erosion index should include specific instead of general clinical criteria [7].

### **Sensitivity and Specificity**

The sensitivity of this index indicates its ability to detect dental erosion lesions. In contrast, an erosion instrument with high specificity is able to indicate the absence of dental erosion if dental erosion is not present. Assessment of both sensitivity and specificity requires the comparison with a gold standard, which, as mentioned earlier does not exist. Therefore, an attainable way to accomplish this comparison is the one described to confirm face validity [7].

### **Reliability**

Reliability reflects the extent to which an instrument contains errors that appear between observations –

measured either for one observer at different times (intra-examiner reliability) or between multiple examiners at points in time (inter-examiner reliability). Reliability can be relatively easily addressed if there is appropriate training and calibration of all potential examiners prior to the assessments, focusing on specific clinical criteria that must be applied in given circumstances [7].

### **Diagnostic Criteria Challenges**

Specific and internationally accepted diagnostic criteria are necessary for the development of a valid and reliable erosion index. Shallow defects located coronal from the cemento-enamel junction may predominantly occur as an effect of chronic acid exposure and most probably might be pathognomonic for dental erosion. On the contrary, grooving of incisal surfaces and cupping of cusps are the most uncertain criteria because they can be an effect of various chemical and physical factors. Therefore, experts in the field should reach an agreement as to what clinical criteria would be included in an index to exclusively record erosive wear. In order to successfully differentiate clinical diagnosis of dental erosion, having the patient's reports about acid exposure may be helpful and could support the diagnosis 'erosion'. However, in many cases the acid exposure lies in the past, or the patient is not aware of or does not report an acid exposure. Therefore, any potential aetiological factors/criteria obtained by a thorough history should be validated and standardized in more epidemiological studies, using modern epidemiological approaches.

The use of exposed dentine as a diagnostic criterion is under debate. The main benefit of using this criterion is that it is generally interpreted as a relatively severe finding and therefore it may be useful for the assessment of the progression rate and for therapeutic purposes. However, studies indicate that the visual diagnosis of exposed dentine may be challenging, particularly in the cervical

area; thus this criterion should be avoided whenever possible, especially in epidemiological studies.

Another significant challenge regarding erosive diagnostic criteria is the definition of pathological and age-related erosion; thus the use of the same erosion index for all ages could be problematic. Tooth wear of the permanent dentition, including attrition and abrasion, is expected to be more obvious at older ages. Furthermore, erosive wear as a result of chemical dissolution could become more severe at older ages because of the coexistence of other types of tooth wear. This observation emphasizes the need to integrate aetiological/pathognomonic criteria in a clinical erosion index in order to reduce the false positive cases as much as possible[7].

#### **Evolution of Indices Measuring Tooth wear**

Many indices which more or less fulfil the described requirements have been developed all over the world. They vary considerably with respect to scale and grading as well as to the information provided, making comparison of recorded data difficult, if not impossible.

Two main contrasting strategies have been identified. The first approach was intended to present a way of quantifying tooth wear, irrespective of the cause. Indices in this category stem mainly from the Tooth Wear Index (TWI) of Smith and Knight (1984). Essentially, the TWI provides a comprehensive system whereby buccal, cervical, lingual and occlusal/incisal surfaces of all teeth present are scored for wear, irrespective of how it occurred. Several modifications of the TWI have been published by Al-Malik et al., 2001; Chadwick et al., 2004; Donachie and Walls, 1996; Oilo et al., 1987 that mainly use criteria for quantifying the amount of tissue loss expressed as the proportion of the sound tooth surface and as the degree of dentin exposure[8].

Other approaches intend to focus on subforms of tooth wear diagnosed by defined clinical criteria. Specific

indices combine quantitative criteria (severity scores) with qualitative criteria for diagnosis. These erosion indices mainly originate from the index published by Eccles and Jenkins in 1979. This index was presented as a comprehensive qualitative index, grading both site of erosion and severity. In essence it includes three classes, the latter with four subclasses with respect to the location of the lesion. The index has been refined or modified mainly with respect to the scoring component, whilst the clinical criteria have remained more or less unchanged. Erosion indices were for instance published by Fares et al. (2009), Larsen et al. (2000), Linkosalo and Markkanen, (1985), Lussi et al. (1991), and O'Sullivan (2000). Another approach has been to use the TWI in combination with the diagnostic criteria for erosion by Nunn et al., 2003. A specific index for abrasion or attrition has not yet been published[8].

#### **Requirements of an Erosion Index**

A simple and standardized index that is suitable for assessment of erosion should ideally be (1) easily applicable in general dental practice, (2) adaptable for epidemiological prevalence studies, (3) suitable for monitoring erosive lesion activities such as progression or arrestment of lesions, (4) easily reproducible under varying conditions for examination such as with/without magnification devices, ambient light, and hydration state of the tooth surface (dry/ wet), (5) capable of reflecting net exposure of an affected individual to the erosive challenge, (6) capable of indicating the need for treatment, and (7) should serve for both children and adult as well as permanent and primary teeth[9].

#### **Basic Erosive Wear Examination**

The Basic Erosive Wear Examination (BEWE) has therefore been designed to provide a simple scoring system that can be used with the diagnostic criteria of all existing indices aiming to transfer their results into one

unit which is the BEWE score sum. The aim of the BEWE is to be a simple, reproducible and transferable scoring system for recording clinical findings and for assisting in the decision-making process for the management of erosive tooth wear [3].

The Basic Periodontal Examination (BPE) or the Periodontal Screening Index adopted from the Community Periodontal Index was developed to allow a convenient, repeatable method of recording periodontal diseases. Development of these indices allows dentists not only to screen for periodontal diseases in a simple and effective manner but also to improve awareness and understanding of the disease. The same objectives are now needed for erosive tooth wear [3].

Erosive tooth wear from a clinical viewpoint is a surface phenomenon, occurring on areas accessible to visual diagnosis. The diagnostic procedure is therefore a visual rather than an instrumental approach. The BEWE was designed to avoid grading lesions according to weather and to what extent dentine is exposed. It is a simple scoring system quantifying the size of a given lesion as the percentage of the surface affected. All teeth (vestibular, occlusal and palatal surfaces) except third molars are graded. The dentition is divided into sextants; the most severe score in a sextant is recorded and a cumulative score from all sextants is calculated and represents the index value. The index is not only directed to epidemiological studies but is also intended to help clinicians with managing the condition[6].

### **Basic Erosive Wear Examination (BEWE) scoring system [3]**

The BEWE is a partial scoring system recording the most severely affected surface in a sextant and the cumulative score guides the management of the condition for the practitioner. The four level score grades the appearance or severity of wear on the teeth from no surface loss (0),

initial loss of enamel surface texture (1), distinct defect, hard tissue loss (dentine) less than 50% of the surface area (2) or hard tissue loss more than 50% of the surface area (3). The differentiation between lesions restricted to enamel and dentine can be difficult particularly in the cervical area. Buccal/facial, occlusal, and lingual/palatal surfaces are examined with the highest score recorded. The examination is repeated for all teeth in a sextant but only the surface with the highest score is recorded for each sextant. Once all the sextants have been assessed, the sum of the scores is calculated as indicated on a grid[3].

The result of the BEWE is not only a measure of the severity of the condition for scientific purposes but, when transferred into risk levels, also a possible guide towards management [3]. The management would include identification and elimination of the main aetiological factor(s), prevention and monitoring, as well as symptomatic and operative intervention where appropriate. Repetition of the BEWE will vary according to the severity and the relative importance of aetiological and risk factors. For patients particularly exposed to intrinsic or extrinsic acids, the procedure should be repeated at 6-month intervals, but for most other cases, annually is acceptable.

### **Guidelines for use of BEWE [10]**

Ideally, the teeth should be cleaned before a clinical examination and then the buccal, occlusal and/or incisal and lingual/palatal surfaces should be assessed in each sextant under good lighting. Third permanent molars are generally excluded but should be considered if they replace a second permanent molar.

### **BEWE score 0**

A score 0 is given when no tooth wear signs are present. Enamel developmental defects, opacities, fluorosis and amelogenesis are scored 0 when they do not involve changes to the shape of teeth due to wear. Anatomical



defects can be present but, provided they show no signs of wear, they can be scored as 0.

### **BEWE Score 1**

First signs of tooth wear with rounding of the cusps and grooves are scored as 1. Concavities on cusps (cupping) with diameter  $\leq 0.5$  mm (use the WHO probe to assess its diameter since its tip has a greater size) are given Score 1. More than one cupping may be found on a single surface. In incisors, initial loss of surface texture (brightness loss, opaque surface or 'frosted glass' appearance) but with a discrete area on the buccal (facial) surface and minimal loss of the incisal edge is scored as 1.

### **BEWE Score 2**

A distinct defect with tooth wear less than 50% of the whole surface area is given this score. Dentine is often involved. Concave wear on cusps (cupping) has a diameter  $\geq 0.5$  mm (it is possible to use the WHO probe to assess its diameter since its tip fits perfectly into the defect) and overall covers  $< 50\%$  of area. On restored teeth, the tooth wear is not related to the restoration marginal interface. In incisors, if there is loss of clinical crown height less than 50% from the buccal aspect, a score of 2 is given.

### **BEWE Score 3**

Hard tissue loss signs are seen on more than 50% of the surface area and dentine is often involved in score 3 cases. Concavities merging (cupping) can be visible but the total or near-total loss of the occlusal surface covers more than 50%. On restored teeth, if tooth wear is seen adjacent to a proud restoration and affects  $> 50\%$  of the surface, it is a BEWE 3; however, if the restoration covers more than 50% of the surface, it cannot be scored.

### **Studies on BEWE**

Vered et al[11] investigated erosive tooth wear and related variables among adolescents and adults in Israel, utilizing the basic erosive wear examination (BEWE) scoring

system, in an attempt to contribute to the ongoing review, evaluation, and further development of an international standardized index. They conducted a cross-sectional, descriptive, and analytic survey among 500 subjects of five age groups. Dental erosion was measured according to the new BEWE scoring system. It was found that the BEWE index was straightforward, easy to conduct, and comfortably accepted by the examinees [11].

### **Validity and Reliability of BEWE**

Mulic et al[12] evaluated and compared two dental erosive wear scoring systems, the Visual Erosion Dental Examination (VEDE) and Basic Erosive Wear Examination (BEWE). Seventy-four tooth surfaces (photographs) and 562 surfaces (in participants) were scored by clinicians using both scoring systems. Inter- and intraexaminer agreement showed small variations between the examiners for both systems when scoring the photographs. The reliability of the two scoring systems proved acceptable for scoring the severity of dental erosive wear and for recording such lesions in prevalence studies. The greatest difficulties were found when scoring enamel lesions, especially initial lesions, while good agreement was observed when examining sound surfaces (score 0) and dentine lesions (score 3) [12].

Olley et al[13] conducted a study to assess the validity of the BEWE score by comparing the BEWE sextant cumulative score to a percentage score from all tooth surfaces and a highest BEWE per subject. A total of 350 subjects were recruited from hospital and general practice in southeast England. Buccal, occlusal and lingual/palatal BEWE scores were collected and percentages calculated based on scores 1, 1 and above, 2 and above and 3. BEWE sextant cumulative scores and highest BEWE scores were also recorded per subject. Spearman's correlation coefficients (p values) assessed the relationship between BEWE sextant cumulative scores, BEWE percentages and

BEWE highest score per subject. It was found that the BEWE sextant cumulative score correlates significantly to a BEWE score taken as a percentage score from all tooth surfaces (Spearman's  $r > 0.5$ ,  $p < 0.001$ ) and especially to BEWE surface scores of 1 and above and 2 and above ( $r > 0.8$ ,  $p < 0.001$ ) and the highest surface score per subject ( $r > 0.8$ ,  $p < 0.001$ ). BEWE sextant score provides a representation of tooth wear on all tooth surfaces. This study validates this tooth wear index, which provides clinicians with risk indicators of a patient's level of tooth wear and may help to guide clinical management[13].

A study assessed the reliability of the BEWE index on 3D models by comparing the 3D-assessed erosive tooth wear scores with clinically detected scores. The study concluded that the BEWE index is reliable for recording erosive tooth wear on 3D models. 3D models seem to be especially sensitive in detecting initial erosive wear. Additionally, it seems that erosive wear may be underscored in the upper posterior sextants when assessed clinically. Due to the nature of 3D models, the assessment of erosive wear clinically and on 3D models may not be entirely comparable. 3D models can serve as an additional tool to detect and document erosive wear, especially during the early stages of the condition and in assessing the progression of wear[14].

#### **Sensitivity and Specificity of BEWE**

Dixon et al[15] conducted a study in UK to test the validity and reliability of the BEWE. By screening patients with the BEWE and comparing the results to the established tooth wear index (TWI) the sensitivity and specificity of the BEWE was established. The BEWE predicted moderate to severe wear with a sensitivity of 48.6% and a specificity of 96.1%, and predicted severe wear with a sensitivity of 90.9% and a specificity of 91.5%. Inter- and intra-examiner reliability for the BEWE were both moderate ( $\kappa_w = 0.43$  and  $0.57$  respectively). It

was concluded that BEWE scores show a similar distribution to TWI scores and the examination is an effective screening test for severe tooth wear. The moderate levels of examiner reliability suggests the BEWE scores should be interpreted with some caution [15].

#### **Diagnostic Value of BEWE**

Holbrook et al[16] conducted a study to evaluate the Basic Erosive Wear Examination (BEWE) scoring method, using data previously collected from two studies and applying the BEWE retrospectively to these two studies. In a national survey of erosion in children and adolescents, a representative, 20 % nationwide sample of 2,251 children, aged 6, 12 and 15 years, was examined. Erosion, recorded for all surfaces of permanent teeth, was converted to a BEWE score. The value of scoring with the BEWE methodology was clearly demonstrated in the study, as scoring using BEWE highlighted the increasing severity of erosion between 12 and 15 years and brought out the gender differences in erosion severity. Intrinsic acid erosion clearly caused an increased BEWE score[16]. A study by Wohlrab et al[17] investigated the diagnostic value of the basic erosive wear examination (BEWE) in clinical use, on dental photographs, and on dental casts over a two-year follow-up period (2013-2015), and concluded that in longitudinal clinical monitoring, the assessment of the BEWE on patients and dental photographs yielded comparable results. In addition, based on these findings, the assessment of the BEWE on dental casts showed moderate reproducibility. Therefore, dental casts may be better used for laboratory assessment techniques[17].

Bartlett et al suggested that examination for erosive toothwear should be part of a routine oral health assessment. Until this becomes routine, and part of the clinical examination, there is a risk that patients will



continue to develop severe tooth wear, on occasion so damaging that the longevity of otherwise sound teeth is compromised. It was suggested that BEWE was a convenient way to record the severity of erosive tooth wear, had the greatest adoption and should therefore be the index of choice. It was designed specifically for clinicians working within the general practice environment as a means to record the erosive tooth wear severity in the clinical notes[18].

#### Use of modified versions of BEWE

A study on the prevalence of toothwear in 12 and 15 year old adolescents in Central China used a modified BEWE for clinical assessment of toothwear. In addition to the four scores of BEWE, the modified BEWE included a score for wearing orthodontic appliances, caries or restoration on more than 25 % of the surface area, partial eruption, trauma, and crowns that cannot be assessed, as well as another score for missing teeth. In addition, two scores were used to assess the prevalence of dentin exposure. The buccal, cervical, occlusal/incisal and lingual surfaces of all of the teeth, except for the third molar, were examined for lesions[19].

#### Conclusion

The structure of the BEWE is designed to allow fulfilling of most formal requirements generally formulated for indices. The grading includes four levels which is neither too precise nor too crude, and the threshold values should be easy to learn and to calibrate[3]. It will not only evade diagnostic uncertainties but will open a broad applicability in a clinical situation for the general practitioner as well as beyond it. It will further allow a more reliable estimation of the severity of tooth surface loss on an individual basis. The BEWE is also ideal for screening studies, but a longer version is required for a more detailed investigation. The BEWE, therefore, is an index that can be used for the clinical assessment of erosive tooth wear, and which has

the potential characteristics be universally considered as the standard index for use, in future research and clinical practice.

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