TOPICS OF INTEREST

Analyzing the Etiology of an Extremely Worn Dentition

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Patients requiring extensive restorative care frequently exhibit significant loss of tooth structure. Specific clinical findings in an extremely worn dentition may vary widely and are often confusing. Severe wear can result from a mechanical cause, a chemical cause, or a combination of causes. The location of the wear, the accompanying symptoms and signs, and information gained from the patient interview are essential components in determining the etiology. A diagnostic decision tree facilitates a systematic analysis and diagnosis of dental wear.


**INDEX WORDS:** tooth wear, diagnosis, abrasion, attrition, erosion

**Initial Assessment**

The initial interview should include a thorough review of the patient’s health history, an evaluation of the wear history, a discussion of the patient’s dietary patterns, and an assessment of potential occupational factors and/or habits. The clinical examination should include an evaluation of the patient’s dental status, observation of specific wear patterns, and, if possible, determination of the rate at which tooth structure has been lost. Serial bite-wing or other radiographs, made in earlier years, may provide objective evidence of the rate of tooth surface loss. Casts made in earlier years may also prove useful in determining the progression of tooth wear.

Observing the patient’s facial appearance provides information such as an apparent decrease in occlusal vertical dimension. With the teeth in occlusion, the patient may exhibit a diminished facial contour, thin lips with narrow vermilion borders, and drooping commissures (Fig 1). Interocclusal space may appear excessive at the rest vertical dimension. Vertical dimension should be carefully evaluated using one of several techniques previously described.

**Terminology**

Four types of surface loss have been identified, distinguished by the differing causes of loss. **Attrition** describes mechanical wear resulting from mastication or parafunction, and is limited to the contacting surfaces of teeth. **Abrasion** denotes the wearing away of structure through some unusual or abnormal mechanical process other than tooth-to-
tooth contact.\textsuperscript{10} Erosion indicates the progressive loss of tooth structure through chemical processes that do not involve bacterial action.\textsuperscript{11} Abfraction connotes the pathologic loss of tooth structure attributed to mechanical loading and resulting in wedge-shaped defects in the cervical areas.\textsuperscript{12,13}

Surface loss can be differentiated into 3 general causal categories: mechanical loss, which includes attrition and abrasion; chemical loss, which includes erosion; and finally, a proposed biomechanical category, described as abfraction by Grippo.\textsuperscript{12} Abfraction lesions, in theory attributed to tooth flexure, remain controversial\textsuperscript{12-14} and will not receive further attention in this article. Although categorization as mechanical or chemical constitutes a useful beginning toward understanding enamel wear, further exploration is necessary to determine specific etiologies.

\section*{Determining Etiology}

The diagnosis of severe wear is frequently clouded by the presence of multiple etiologic agents. The diagnostic challenge is to first correctly identify the signs of a severely worn dentition and then, using an orderly evaluation process, to arrive at an understanding of the etiology. It will be useful to begin the discussion of this process with a review of the general kinds of surface loss, including the developmental dysplasias that may contribute to the process.

First, it is important to distinguish between mechanical and chemical wear. Each has distinctive characteristics. Mechanical wear occurs between 2 or more moving surfaces. This type of surface loss occurs as teeth contact each other, or are abraded by another source (Fig 2). With mechanical wear, restorations tend to wear at the same rate as adjacent enamel; asymptomatic teeth; and histories that include parafunctional habits.

Chemical erosion occurs when tooth surfaces experience prolonged exposure to acidic solutions (Fig 3), resulting in loss of structure and restorations that appear elevated, often termed “amalgam islands.” Occlusal surfaces display cupping and cra-
tering with rounded margins. Such findings are pathognomonic for erosion. The teeth are frequently hypersensitive and, in most instances, are not stained. The cupping and cratering from erosion cannot be matched on opposing articulated diagnostic casts. The causative acid may come from within the body, from the diet, or from the environment, and a detailed history will often reveal the source.

Many reports have confirmed a multifactorial etiology associated with tooth surface loss. When considered as a single factor, location has not been shown to reliably indicate the cause of surface loss. Limited population studies have attempted to identify factors associated with high-wear groups. Johansson and co-workers examined 59 high-wear patients and found that men showed significantly more wear than women. Increased bite force was also positively correlated with increased wear. Analysis of saliva showed that a low buffering capacity and a diminished rate of secretion also were related to high wear rates.

An efficient diagnostic approach involves determining whether the cause of the surface loss is chemical or mechanical or a combination of both. The location of the loss and an interpretation of the accompanying signs and symptoms may then be used to guide the differential diagnostic process.

Finally, it must be noted that hereditary dysplasias, such as amelogenesis imperfecta and dentinogenesis imperfecta, compromise wear resistance and predispose teeth to accelerated surface loss from mechanical or chemical causes. Amelogenesis imperfecta, a local, systemic, or hereditary dysplasia affecting the quantity of enamel or the quality of calcification, results in enamel that is thinner and/or more friable, thus more susceptible to chemical erosion and mechanical wear.

Dentinogenesis imperfecta, a hereditary dysplasia of the dentin affecting both primary and permanent dentitions, results in teeth with a characteristic gray or brown opalescent appearance. A weak enamel-to-dentin bond results in the early loss of the enamel, rapid attrition, and increased susceptibility to caries.

**Determining the Cause of Mechanical Wear**

Once the mechanical nature of wear has been identified, the location or locations of surface loss should be analyzed. Several individual patterns of mechanical wear can be identified that tend to occur at predictable locations. In the first, wear occurs primarily on the anterior teeth. A second pattern displays occlusal wear throughout the arch, with progressively greater structural loss as one proceeds from the posterior teeth to the anterior teeth. A third wear pattern tends to occur on the facial surfaces of cuspids and premolars. Each of these patterns exhibits specific associated clinical signs and symptoms.

**Pattern: Anterior Tooth Wear Greater Than Posterior Tooth Wear**

Inadequate or unstable posterior support has been identified as a factor in severe anterior attrition and decreased occlusal vertical dimension. The loss of posterior teeth has been reported as a major factor in the development of a traumatic anterior occlusion. Posterior occlusal prematurities also may cause increased function on anterior teeth, resulting in increased wear (Fig 4).

**Pattern: Progressively Greater Wear on the Anterior Teeth**

Mechanical wear resulting from bruxism often results in progressively greater wear toward the anterior teeth (Fig 5). An exception to this finding occurs in individuals with anterior open bite. Variations in mandibular movement may result in a wide variety of wear patterns in bruxing patients. As might be expected, bruxism produces surface loss, which is related to the duration and force of parafunction. A definitive diagnosis may be made.

**Figure 4.** Mechanical wear affecting primarily the anterior teeth may result from posterior tooth loss, malposition, or interferences.
by hand articulating diagnostic casts and matching wear facets. Additional intraoral findings may include grooving of the lateral borders of the tongue, evidence of cheek biting, and the presence of fractured porcelain restorations. Cupping or cratering of the occlusal surfaces can occur once the enamel has been perforated.

**Pattern: Wear on Facial Surfaces of the Cuspids and Premolars**

Excessive tooth brushing may produce noticeable wear on the facial surfaces of the cuspids and premolars, sometimes resulting in a “sandblasted” appearance with reduced anatomic detail (Fig 6). Depending on the patient’s oral hygiene habits, tooth brushing abrasion also may result in bizarre patterns of wear with notching or grooving of the teeth. The amount of surface loss will be affected by the individual’s tooth brushing technique, the amount of time spent in brushing, the mechanical properties of the toothbrush, and the abrasiveness of the dentifrice. A definitive diagnosis may be made by asking the patient to demonstrate his or her brushing technique. This may confirm that the location of the wear correlates with the source of the abrasion.

**Pattern: Wear in Variable Locations, Primarily Occlusal and Incisal Surfaces**

Variable wear on occlusal and incisal surfaces suggests some type of parafunctional habit as a causal factor. Such habits may be related to job requirements, habitual behaviors, or stress. Case reports document the destructive effects of foreign objects such as pipe stems, pins, needles, paper clips, sunflower seeds, and soft drink cans. Wear is found primarily on the occlusal and incisal surfaces of the teeth (Fig 7).

**Diagnostic Algorithm for Mechanical Wear**

Mechanical wear can be unusual in appearance and difficult to diagnose. Using a 3-tier decision tree can assist in categorizing the wear (Fig 8). First, identify the character of the pathologic wear, then the location, then evaluate the clinical signs and symptoms and discuss habit possibilities with the patient.
Determining the Cause of Chemical Erosion

Pindborg described “erosion” as loss of tooth structure resulting from a chemical process and not mediated by bacteria. Chemical erosion has been identified as a major cause of tooth surface loss. In a study of 100 patients referred for evaluation of tooth wear, 89% were determined to have erosion as a contributing cause. Several population studies have shown an increasing prevalence of dental erosion in children. The largest of these studies, the United Kingdom Child Dental Health Survey of 1993, reported that 52% of the 5-year-olds surveyed showed evidence of significant erosion. Awareness of the problem of erosion has increased in both the dental profession and in the general population for the past 3 decades.

The risk of dental erosion has been shown to increase with certain dietary habits, with gastric regurgitation or reflux, and in individuals with chronic self-induced vomiting. Once the chemical cause of surface loss has been identified, the location should be assessed. Patterns of erosion with anterior tooth surface loss greater than posterior tooth surface loss or vice versa can occur.

**Pattern: Anterior Surface Loss Greater Than Posterior Surface Loss**

Chemically mediated surface loss has been observed to occur in stages. Lesions begin as smoothly glazed enamel and progress to concavities. As the erosion process continues, islands of restorative material become evident, and cupping of the enamel occurs. Chronic vomiting is the most common cause of severe erosion of the lingual surfaces of the maxillary anterior teeth, although hiatal hernia and gastric reflux are also possible causes. Chemical erosion of the maxillary anterior teeth has been correlated with self-induced vomiting since 1937. A diagnosis relating to chronic vomiting may be difficult to confirm because patients with eating disorders frequently deny such behavior.

Chronic regurgitation can be recognized by the very specific pattern of surface loss (Fig 9). As gastric contents, with a mean pH of 3.8, rush past the teeth, the lingual surfaces of the maxillary anterior teeth are most severely affected. There is progressively greater erosive damage from posterior to anterior. Eroded palatal surfaces are very smooth, with the defects beginning at the gingival margins. The maxillary molars and premolars may have chamfer-like defects on the lingual surfaces. Mandibular teeth tend to be minimally affected because of the protection afforded by the tongue and the buccal mucosa.

Gastric reflux has also been shown to cause erosion on the lingual surfaces of the maxillary anterior teeth. Erosion may occur as a localized phenomenon at other locations if the hydrochloric acid reflux solution is permitted to pool, as may happen, for example, when the patient is sleeping. Gastroesophageal reflux differs from vomiting both in the volume of acidic material to which the teeth are exposed, and in the lack of forceful expulsion, because muscular contraction of the diaphragm does not occur. Identification of gastroesophageal reflux disease, or GERD, is often suggested by the symptoms of belching, acidic tastes in the mouth, stomachaches on awakening, heartburn, and hyper-

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**Figure 8.** The etiology of pathologic wear resulting from mechanical causes can be determined by correlating the location of wear, other signs and symptoms, and information obtained during the patient interview.

**Figure 9.** Erosion occurring on the lingual surfaces of the maxillary teeth is evidence of chronic regurgitation. The lingual surfaces of the maxillary premolars and molars may display chamfer margins.
sensitivity of the affected teeth. However, many patients with this disorder report no subjective symptoms, and ambulatory pH monitoring may be required to confirm this diagnosis.

Alcoholism may lead to erosion resulting from chronic vomiting and regurgitation associated with gastritis. The lingual surfaces of the maxillary anterior teeth are primarily affected, with mandibular teeth minimally affected (Fig 10). Alcoholism is a relatively common condition in western countries, with an estimated incidence of as high as 10% in men. Robb and Smith found evidence of chemical erosion in 92% of a clinical sample of 37 inpatients admitted for the treatment of chronic alcoholism. They observed more severe wear in those who drank regularly as compared with binge drinkers (ie, heavy alcohol consumption for up to 2 weeks with intervals of sobriety).

Citrus fruit sucking results in erosion on the facial surfaces of the maxillary anterior teeth (Fig 11). Severe erosion related to a prolonged history of eating or sucking lemons has been reported. The location and severity of erosion is directly related to the manner in which the acidic food is consumed, the degree of its acidity, and the duration of exposure. In most instances, posterior teeth are spared the effects of the acid, and a marked transition from the eroded anterior teeth to the unaffected posterior teeth can be observed.

**Pattern: Posterior Surface Loss Greater Than Anterior Surface Loss**

The dietary causes of dental erosion have received widespread attention in case studies, population surveys, and in vitro testing. As acidic food and drinks are consumed, the occlusal surfaces of the posterior teeth tend to display greater wear than the anterior teeth. Erosion resulting from extrinsic causes has been correlated with excessive consumption of low-pH carbonated beverages as well as fruits and juices with high citric acid contents. A study of 106 patients referred for evaluation of erosion, indicated a significant risk of surface loss occurred in patients who consumed citrus fruits more than twice a day or soft drinks at least once a day.

Acidic beverages are widely consumed in our society. Larsen and Nyvad studied the erosive potential of 18 acidic beverages and observed 3 distinct groupings: carbonated flavored soft drinks including colas; orange juices; and mineral water drinks. In general, enamel erosion was found to increase logarithmically as the pH decreased. Carbonated mineral waters were found to increase in pH by almost a half unit as they were poured, and the erosive effects on enamel were found to be minimal.

Chemical erosion in which posterior tooth surface loss is greatest at mandibular first molar and second premolar areas has been associated with holding carbonated soft drinks in the mouth and/or swishing (Fig 12). Erosion resulting from holding carbonated soft drinks in the mouth until the carbon dioxide bubbles have dissipated has been described. Holding a low pH solution in the mandibular posterior area tends to produce a specific pattern of tooth surface loss. The buccal mucosa and the lateral borders of the tongue tend to limit
the effects to the occlusal surfaces with the result that amalgam restorations on mandibular molars may appear as elevated islands. Cupping or cratering of the occlusal surface also may be present and may be severe. Maxillary teeth and mandibular anterior teeth are usually not affected.

Chemical erosion with surface loss evenly distributed on the occlusal surfaces of the maxillary and mandibular posterior teeth has been associated with chewing the pulp of citrus fruits (Fig 13). Eating citrus fruits more than twice a day has been observed to increase the risk of erosion 37-fold, producing a specific pattern of wear similar to that resulting from habitually holding a carbonated soft drink in the mandibular posterior area. As the acidic citrus fruit pulp is mulled between the teeth, surface loss tends to occur on both maxillary and mandibular occlusal surfaces. Cupping and cratering with smooth and rounded enamel edges is observed. This type of dental erosion has been associated with the increased intake of fruits in health-conscious individuals such as vegetarians.

**Pattern: Variable Locations, Miscellaneous Causes**

Any medication that has an acidic pH and that is in frequent contact with tooth surfaces can cause erosion. Chewable vitamin C tablets, chewable aspirin tablets, and aspirin powders have been associated with erosion on the occlusal surfaces of posterior teeth. Abuse of the illicit amphetamine drug, Ecstasy (3,4-methylenedioxymethamphetamine), has been associated with significant wear of the posterior occlusal surfaces when compared with age-matched, non-drug users. In addition, the application of cocaine to the oral mucosa has been reported to produce cervical erosion on the facial surfaces of maxillary anterior and first premolar teeth.

It should be noted that saliva plays an essential role in minimizing tooth surface loss from chemical erosion. Saliva dilutes, buffers, and neutralizes ingested acids and aids in remineralization by providing calcium and phosphate. Therefore, xerostomia should be considered in evaluating the factors contributing to dental erosion.

Case reports and epidemiologic studies document erosion in factory workers related to occupational exposure to acidic fumes and aerosols. Severe erosion affecting the facial surfaces of the
anterior teeth has also been reported in professional wine tasters\cite{61} and competitive swimmers.\cite{62,63}

Because erosion lesions present a wide variety of appearances, a decision tree can be helpful in identifying chemically mediated surface loss patterns (Fig 14).

**Conclusion**

Organizing the evaluation of a severely worn dentition involves determining whether the character of the surface loss is chemical, mechanical, or both. In turn, identification of surface loss locations should be made and accompanying clinical signs and symptoms identified. These observations, along with information gained from the patient interview, can then be combined to guide the diagnostic process.

It is important to remember that surface loss may result from a combination of chemical and mechanical factors. Attrition from bruxism often can be identified in association with other causes. Patients may remain secretive about eating disorders and dietary habits. Establishing a diagnosis represents a challenge, but analysis and identification become more manageable if an orderly system of information gathering and analysis (Fig 15) is used to guide the process.

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**References**


![Decision Tree](Figure 15. The chemical and mechanical branches of the diagnostic decision tree can be combined to provide a methodical framework for analyzing an extremely worn dentition.)
33. Bargen JA, Austin LT: Decalcification of teeth as a result of 
29. Smith BGN, Knight JK: A comparison of patterns of tooth 
28. Pindborg JJ: Pathology of the Hard Dental Tissues. Phila-
27. Ehrlich J, Hochman N, Yaffe A: Contribution of oral habits 
24. Akerly WB: Prosthodontic treatment of traumatic overlap of 
23. Turner KA, Missirlian DM: Restoration of the extremely 
20. Milosevic A, Lennon MA, Fear SC: Risk factors associated with occlusal tooth wear in a se-
18. Johansson A, Fareed K, Omar R: Analysis of possible factors 
16. Jarvinen V, Ryto¨maa I, Meurman JH: Location of dental 
15. Lussi A: Dental erosion. Clinical diagnosis and case history 
14. Levitch LC, Bader JD, Shugars DA, et al: Non-carious cer-
8. Wright WH: Use of intra-oral jaw relation wax records in 
7. Turner KA, Misirlian DM: Restoration of the extremely 
6:278-285 
1. Milosevic A: Toothwear—Aetiology and presentation. Dent 
46. Al-Dhaifan YH, Shaw I, Smith A: Dental erosion in a group 
45. Asher C, Read MJF: Early enamel erosion in children asso-
42. Fahey C, Read MJF: Early enamel erosion in children asso-
41. Allan DN: Enamel erosion with lemon juice. Br Dent J 
40. Robb ND, Smith BGN: Prevalence of pathological tooth 
34. Milosevic A, Brodie DA, Slade PD: Dental erosion, oral 
33. Milosevic A, Brodie DA, Slade PD: Dental erosion, oral 
32. Smith BGN, Robb ND: The prevalence of toothwear in 1007 
30. Robb ND, Smith BGN: Prevalence of pathological tooth 
29. Smith BGN, Knight JK: A comparison of patterns of tooth 
28. Pindborg JJ: Pathology of the Hard Dental Tissues. Phila-
27. Ehrlich J, Hochman N, Yaffe A: Contribution of oral habits 
25. Meurman JH, Frank RM: Progression and surface ultra-
24. Akerly WB: Prosthodontic treatment of traumatic overlap of 
23. Turner KA, Missirlian DM: Restoration of the extremely 
18. Johansson A, Fareed K, Omar R: Analysis of possible factors 
17. Jarvinen VK, Ryto¨maa I, Meurman JH: Location of dental 
16. Jarvinen V, Ryto¨maa I, Meurman JH: Location of dental 
15. Lussi A: Dental erosion. Clinical diagnosis and case history 
14. Levitch LC, Bader JD, Shugars DA, et al: Non-carious cer-
9. Pound E: Applying harmony in selecting and arranging 
8. Wright WH: Use of intra-oral jaw relation wax records in 
7. Turner KA, Misirlian DM: Restoration of the extremely 
6:278-285 
1. Milosevic A: Toothwear—Aetiology and presentation. Dent 
46. Al-Dhaifan YH, Shaw I, Smith A: Dental erosion in a group 
45. Asher C, Read MJF: Early enamel erosion in children asso-
42. Fahey C, Read MJF: Early enamel erosion in children asso-
41. Allan DN: Enamel erosion with lemon juice. Br Dent J 
40. Robb ND, Smith BGN: Prevalence of pathological tooth 
34. Milosevic A, Brodie DA, Slade PD: Dental erosion, oral 
33. Milosevic A, Brodie DA, Slade PD: Dental erosion, oral 
32. Smith BGN, Robb ND: The prevalence of toothwear in 1007 
30. Robb ND, Smith BGN: Prevalence of pathological tooth 
29. Smith BGN, Knight JK: A comparison of patterns of tooth 
28. Pindborg JJ: Pathology of the Hard Dental Tissues. Phila-
27. Ehrlich J, Hochman N, Yaffe A: Contribution of oral habits 
25. Meurman JH, Frank RM: Progression and surface ultra-
23. Turner KA, Missirlian DM: Restoration of the extremely long 
18. Johansson A, Fareed K, Omar R: Analysis of possible factors 
17. Jarvinen VK, Ryto¨maa I, Meurman JH: Location of dental 
16. Jarvinen V, Ryto¨maa I, Meurman JH: Location of dental 
15. Lussi A: Dental erosion. Clinical diagnosis and case history 
14. Levitch LC, Bader JD, Shugars DA, et al: Non-carious cer-
9. Pound E: Applying harmony in selecting and arranging 
8. Wright WH: Use of intra-oral jaw relation wax records in 
7. Turner KA, Misirlian DM: Restoration of the extremely 
6:278-285 
1. Milosevic A: Toothwear—Aetiology and presentation. Dent
57. Redfearn PJ, Agrawal N, Mair LH: An association between the regular use of 3,4 methylenedioxy-methamphetatamine (Ecstasy) and excessive wear of the teeth. Addiction 1998; 93:745-748
60. Petersen PE, Gormsen C: Oral conditions among German battery factory workers Community Dent Oral Epidemiol 1991;19:104-106