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DENTAL WEAR: HOW TO MEASURE, PREVENT AND TREAT

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ABSTRACT

The aim of this work is to have a complete picture of dental wear, defining it properly, understanding how it occurs and its consequences, as well as reviewing the different methods to measure it, the existing preventive measures and treatment options. The topic was considered relevant due to the high prevalence of the condition, especially increasing in children, and the lack of clear management protocol. For that purpose, a systematic literature review of scientific publications was carried out.

Dental wear is divided in three types: attrition, erosion and abrasion. Abfraction can be added but is not recognized universally as a different type. Each one has different causes including parafunctional disorders for attrition, intrinsic or extrinsic acid exposure for erosion, and foreign bodies, such as abrasive toothpastes, for abrasion. The consequences on dentition are therefore different for each, leading to different recognizable patterns. It explains the complexity of defining a uniform way to measure wear: many indexes have been developed and employed through time until this day, with the BEWE being the easiest one to use and the TWES offering good perspectives for the future. The latter seems to be the most complete until now. As for the management, it seems all the preventive measures developed until now lack evidence about their efficiency even though they are the preferred option. For now, counselling and monitoring seem to be the key to handle wear. As for restorative treatments, they should be delayed as long as possible but in advanced cases, they are the best alternative. Ceramic ones remain the first option, but composite resin has known improvements in its manufacturing and technique which makes it more used today than it was before. Further studies are still needed regarding its durability.

RESUMEN

El objetivo de este trabajo es obtener una visión completa del desgaste dental, abarcando su definición, causa y consecuencias, revisando los diferentes métodos, las medidas preventivas existentes y las opciones de tratamiento. El tema se considera relevante debido a la alta prevalencia de la condición, especialmente en los niños, y a la falta de un protocolo de manejo claro. Con este fin, se llevó a cabo una revisión sistemática de publicaciones científicas.

El desgaste dental se divide en tres tipos: atrición, erosión y abrasión. Abfracción se puede agregar, pero no se reconoce universalmente como un tipo diferente. Cada uno tiene diferentes causas: trastornos parafuncionales para la atrición, exposición intrínseca o extrínseca al ácido para la erosión, y cuerpos extraños, como pastas dentales abrasivas, para la abrasión. Por lo tanto, las consecuencias sobre la dentición son diferentes para cada uno, dando lugar a diferentes patrones reconocibles. Esto explica la complejidad de tener una medida universal del desgaste: muchos índices se han desarrollado y empleado a través de los años hasta nuestros días, con el BEWE que es el más sencillo de utilizar y el TWES que ofrece buenas perspectivas para el futuro. Este último parece ser el más completo hasta la fecha. En cuanto al manejo, las medidas preventivas siempre son la mejor opción a pesar de que exista poca evidencia científica sobre su eficacia. Por ahora, el asesoramiento y el seguimiento parecen ser la clave para manejar el desgaste. Y los tratamientos restauradores deben retrasarse tanto como sea posible, pero en casos avanzados, son la mejor alternativa. Las de cerámica siguen siendo la primera opción, pero la resina compuesta se ha mejorado en cuanto

a su fabricación y técnica; por eso, se utiliza más que antes, aunque más estudios sobre su durabilidad son necesarias.

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INTRODUCTION

In dentistry, many very different types of diseases are seen every day, but one has caught the attention in the past few years because of its growing rate in children and young patients: dental wear.

Dental Wear, also often referred to as Tooth Surface Loss (TSL), could be described as the non-carious loss of tooth tissue. It is the result of a multifactorial process engaging the loss of enamel and possibly dentine, which impacts the tooth survival and the patient's oral health. (1,2) It is actually difficult to draw the line between pathological and physiological dental wear as the process is supposed to be physiological. The accepted amount of vertical loss of enamel each year is from 20 to 38µm and it could be considered pathological if the wear rate is abnormally high for the patient's age or if it threatens the tooth prognosis. (1,3) Therefore, its prevalence increases with age and is normally more frequently found in elder patients. But when it becomes pathological, it has severe consequences no matter the age and there's an alarming situation that has been observed in the younger population, first in 1993 with the Children's Dental Health survey where children under 5 years old showed signs of abnormal erosion, especially in those who consumed carbonated drinks. Almost half of them had their primary dentition affected. (4)

With time, it has become a disease commonly seen in the dental office, particularly with the current lifestyle and diet adopted by society. However, it seems it is a condition too overlooked or unknown by patients, yet it often requires intervention from the dentist, either in terms of oral advice or invasive treatments. Moreover, patients often come to the dentist only when the aesthetics has been affected enough or when it has become symptomatic with

pain, hypersensitivity, functional issues or great loss of structure, which imply more aggressive treatments than if caught early.

It should be noted that wear can affect dental tissue but also the surface of restorative materials. (5) These latter can indeed be subject to the phenomenon but can actually cause it as well: some materials chosen for restorative purposes will be sensitive to factors causing wear while others can in fact cause damage themselves to natural dentition. It is of upmost relevance that the dentist accordingly makes the right material choice in those patients. Seghi *et al* suggest to choose a material that has a similar hardness to the natural enamel to obtain a prognosis that is as comparable as possible to natural dentition. (6)

Therefore, it is important to inform and educate the population on this matter so individuals can go consult their dentist as soon as possible and avoid potential complications in the future: it is then essential to give a proper training to the dentist so he can diagnose the condition early, even if the patient doesn't complain about anything in particular when arriving in the office.

Knowing the different ways to measure dental wear and which is best and more adapted to each patient will allow to establish the appropriate treatment plan; indeed, the guidelines for dealing with this phenomenon vary a lot according to many different criteria such as the patient's compliance, his age, the state of evolution of the disease, economics, the aetiology... and the evolution is very variable from a patient to another. The diagnosis is usually done thanks to the clinical findings but as tooth wear seems to be influenced by more than one factor, a simple visual exploration is not that accurate nor enough. It could also be added that the evaluation – hence also the related decision concerning the treatment – would be very

subjective according to the practitioner who performs it, based on one's personal and professional experience. Numerous studies have been made in order to come up with the best way to diagnose, grade and monitor dental wear but they are not all based on the same criteria; some focus on the aetiology while some omit it, some take the age into account and others don't. The existence of that many diagnostic methods without having an universally accepted one make it hard to gather clear information about the current status of the dental wear in the population; this complicates even more the finding of the most adapted preventive and therapeutic measures. (7) Many indicators and indexes have been developed through time to allow to score dental wear. One of the first notable one is Eccles, who first gave a broad classification according to the early, small or advanced stage of erosion without defined selection criteria for each category. He then included the notion of severity and location in 1979 and even if the classification had its drawbacks, he paved the way for others who based their indices on his. (7) An overview of the most acceptable ones could be an approach to reach the ideal guidelines.

Understanding the pathophysiology of dental wear enables the selection of the best dental materials and techniques for a possible restauration of the mouth's integrity and functionality. The treatment options can vary a lot from a simple care to full mouth rehabilitation with crowns so not correctly identifying the wear condition could worsen the initial situation and create mistrust from the patient towards his/her dentist. It is important to stay up to date about the current treatment strategies and the modern approach with the constant evolution of technologies and researches to offer the best options to the patient.

And identifying a patient potentially susceptible to suffer pathological dental wear can actually change the outcome and avoid future complications, by giving the proper advice about some bad habits or perform small dental procedures before the occurrence of a problem. (8)

Hence, dealing with dental wear is very complex and requires meticulous study and work. With better knowledge, the dentist would be able to give better information and advice to the patients, make early diagnoses and perform preventive treatments instead of invasive ones.

OBJECTIVES

The main objective:

1. Describe dental wear and its oral implications

Secondary objectives:

2. Examine its different aetiologies
3. Review the methods to measure it
4. Describe the management and treatment options for dental wear

METHODOLOGY

A systematic literature review was conducted out to select articles from scientific publications dealing with the theme of dental wear, how to measure, prevent and treat it.

- Online databases were used: PubMed, Medline, Wiley Online Library
- Key words used: *tooth wear, dental wear, diagnosis, measure, prevention, treatment, prevalence, erosion, attrition, abrasion, abfraction, diagnosis evolution, perimylolysis lesion, index, evaluation system, FDI criteria, USPHS criteria, intra-oral scanner, restoration, ceramic, zirconia, LDS, composite resin, direct, indirect*.
- The research was limited at a maximum of 15 years old publications.
- Based on the content of the abstract, an overlook of the construction of the discussion and the conclusion of numerous publications, 53 articles were considered inherent to the topic and were consequently saved to write the following discussion.

DISCUSSION

I. Dental Wear: Generalities

a. Classification of Dental Wear

It is usually subdivided in 3 types of processes: **Attrition, Abrasion** and **Erosion.** There's a fourth one, **abfraction**, which is debatable nowadays; some authors add it into the classification, but it is not yet universally accepted as a type of dental wear on its own. (1,2)

Attrition is defined as the "wear of dental hard tissue as a result of tooth-to-tooth contact with no foreign substance intervening". (2)

Erosion is characterized as the "loss of tooth tissue by chemical dissolution of enamel or dentine by the action of non-bacterial acids from dietary or gastric sources". (2)

Abrasion is described as the "mechanical wear of dental hard tissue not involving tooth-to-tooth contact" (2), caused by other materials.

Abfraction is known as "tooth wear located in the cervical area caused by flexural forces during function and parafunction". (1) In the literature, they can be referred as to "cervical stress lesions". (6)

Thus, trauma, bacteria and developmental disorders are not included in TSL. (3,6)

b. Aetiology

The cause of dental wear is frequently multifactorial, explaining how necessary it is to identify the main cause as all the contributing or damaging factors that are present to have a global apprehension of the situation. It is thought to be the result of the interactions of attrition, erosion and abrasion combined, often with a predominating one. (1,5) One of the most important interaction observed was the initiation of dental abrasion by erosive damage. (6)

1. Attrition

The presence of a physiological wear that worsens with age can actually turn into a pathological one, secondarily to a parafunctional habit for example. (1)

The diagnosis of a parafunction can in fact be complicated, as sometimes patients are not even aware of their predicament: it appears only half of these patients are aware of their condition. (1) The most common one is bruxism, being described as “the grinding or clenching of teeth at other times than for the mastication of food”, even though there is no universally accepted definition. (9) The occlusal loads produced by bruxism can be six times greater than the ones created during normal mastication (9), explaining the importance of trying to understand how it occurs.

a. Main Theories

There are actually a few main theories thought to explain attrition, like the functional theory saying dental wear is created by a prolonged teeth contact in patients with extensive envelope of function. (10) Kim *et al* compared groups of subjects with normal pattern of mastication versus subjects with a "grinding-chewing" pattern of mastication, finding the latter had a significant increase in dental wear. It also should be noted the study was made in young patients, so it could be expected that the difference would only increase with age. (10)

The other one relates to the central nervous system, being stimulated. It can manifest as awake bruxism and nocturnal bruxism. The origin of awake bruxism is not-well understood but anxiety and psychological stress are known to be risk factors. As for nocturnal bruxism, it has been classified as a sleep-related movement disorder caused by micro-arousals occurring in the brain stem. (10)

b. Influencing factors

There are also contributing factors, capable of increasing the TSL caused by attrition.

Ecstasy is a very popular drug – with almost 1.5% of users – and one of its side effect is bruxism, associated to xerostomia, lasting around six to eight hours. In a study done by Milosevic *et al*, 60% of users showed TSL versus 11% in non-users and 89% of users reported tooth grinding. (10) Selective 5-hydroxytryptamine Reuptake Inhibitors (SSRIs) are the most commonly used antidepressants for anxiety and depression and it has been suggested recently that they could cause bruxism, especially in patients who begin treatment. (10)

Another theory was mentioned stating that a decreased number of occluding teeth, especially posterior ones, could increase the risk of dental wear but until now, to the studies conducted have shown too much discrepancies and contradictory results, so there is not enough valid data to include it in one of the possible reason of dental attrition. (1,10)

2. Erosion

Erosion takes place when the oral cavity pH has reached the critical threshold of 5-5.5 and dental hard tissue starts being demineralized. (1)

Erosion is often differentiated according to the aetiological agent, being intrinsic or extrinsic.

a. Extrinsic Erosion

Acidic foods and drinks participate in erosive wear such as fresh fruits – containing citric acid or malic acid especially –, carbonated drinks, juices, pickles, vinegar and herbal tea, proven to have a strong link with erosion. (1,2,4) To determine the erosive potential of beverages, the measurement of the total acidity of the drink is a better indicator than its pH. Some medications as salicylic acid, iron tonics or chewable vitamin C are a source of erosion as well. (1)

It has also been observed in some jobs due exposure at work, as employees in the wine testing field or in the manufacturing of battery acid, where people are exposed to corrosive or acidic fumes. (1,3) Erosion induced by industrial acids was shown to lead to severe dental attrition.

(6) It was suggested that swimmers in pools with low pH could also be victim of erosive wear, because of the presence of chlorine. (3,4)

As for chronic alcoholism, it can actually be both extrinsic and intrinsic but extrinsically, it is an acid being consumed. (1)

b. Intrinsic Erosion

Intrinsic erosion occurs when the gastric content reaches the mouth, which is a result of voluntary or involuntary actions. (1)

Vomiting can come from both in cases of pregnancy, side effect from medications, alcoholism creating regurgitation, vomiting and gastritis, alimentary tract disorders and psychosomatic disorders, such as eating ones. (1)

The involuntary regurgitation can come from pregnancy, gastro-intestinal disorders, gastro-oesophageal reflux disease (GORD), rumination or vomiting hiatus hernia.

The GORD comes from the weakening of the lower oesophageal sphincter causing the stomach gastric content to go back up to the oesophagus and on patients presenting localized anterior tooth wear, 50% declared experiencing gastric reflux. It is nowadays considered a condition more commonly found in children and adolescents. The acid content is actually highly erosive to teeth, with its pH being 2 and the palatal surfaces can be particularly affected when continuously exposed to this gastric content. (1) The case of rumination is particular as it affects mainly patients with mental disabilities. It relates GORD with the regurgitated food

being chewed and swallowed again. But this condition is not well-comprehended and the association with erosion has not been exactly established. (1)

The voluntary regurgitation has been a more observed condition recently because of the increase of eating disorders including bulimia and anorexia nervosa, with 14 per 100,000 and 7 per 100,000 individuals in the population respectively. (1)

c. Influencing factors

The impact of the erosive factors can be influenced by different parameters such as the physiological soft tissue movements, the quality and quantity of the patient's saliva or the tooth anatomy and its position regarding the soft tissues. (2) Patients affected by diseases or syndromes can be more prone to erosive wear too, especially if they take medications, like asthma inhalers containing steroids. They also could also have a reduced quantity and quality of saliva due to salivary glands problems or drugs that decrease salivary flow or reduced motor function creating a worse elimination and cleaning of acidic drinks and foods from the oral cavity. (1) The behavioural determinant also has a great influence, including style and frequency of eating and drinking. For example, if a person has a tendency to keep drinks that are acidic a long time in the mouth before swallowing, there's a longer contact between the erosive agent and the teeth, giving more time to start damaging the dental structure. And an increased frequency of intakes, even in small quantities, will participate in wearing teeth. (2)

Recreational drugs such as ecstasy and LSD have proven to be associated to erosive dental wear as well. (4)

3. Abrasion

It appears it can result from the improper dental care at home, related mainly to the toothbrushing, implicating a strong force applied combined with the time spent on the tooth surface. (1,3) *In vitro* studies have proven that it was more related to the abrasiveness of the toothpaste and that the toothbrush was merely the carrier, which acts as a modifying factor but is not a cause of abrasion *per se*. The force used and the bristles stiffness seem can more or less worsen the wear. (11) But *in vivo* studies are lacking on the matter to give more accurate data.

Inadequate techniques for interproximal cleaning with brushes or toothpicks also participates in interproximal surfaces abrasion. (1,3) The presence of bad habits, as nail-biting, pen-chewing, pipe-smoking or tongue piercings are abrasive agents as well. (1) It has been suggested that it could be associated with some jobs like dressmaking, glassblowers, musicians, where people tend to hold objects with their teeth or because of the daily exposure to particles, grit and dust in some working areas. (1,3) It appears that some foods, like nuts and seeds that are included in current healthier diets, could have an abrasive effect, but dietary abrasion is being obsolete nowadays because of the soft diet adopted by our modern society, in opposite to older times. (1,6)

It could be also influenced by dental treatments; TSL can be worsened and have an increased rate with materials such as ceramic, if unpolished and antagonist to a natural tooth. (1,6) Feldspathic porcelain has been used because of its aesthetics for decades, but it actually causes excessive abrasion to natural dental structures. An *in vitro* study has shown zirconia could cause a lot of wear as well but only if not well-polished. (6,12)

4. Abfraction

Being the centre of numerous debates about whether it is a form of dental wear or not, the studies are not being highly conclusive about its whole mechanism. Some authors like Barlett and Shah say it is the clinical manifestation of erosion, abrasion and attrition combined: the erosion would lead to mineral loss, making the tooth surface softer and abrasion and attrition help in stimulating dental wear in the cervical area. (1,3) The most commonly accepted reason is that abfraction is related to abnormal occlusal loading, with eccentric forces being applied. It would cause cusp flexure, which leads to tensile stress and the formation of cracks in the tooth structure, especially in the area where the stress is concentrated. (3) Nonetheless, it appears all the evidence gathered until now doesn't seem to be enough to state abfraction can be a major aetiology of dental wear *per se*. (6)

c. Oral Manifestations

Because of its multifactorial origin, dental wear can have various clinical manifestations. Although one factor could be the main cause, the clinical appearance is generally the result of years of deterioration making the diagnosis unclear. (1)

Generally, dentine sensitivity and impaired function are described. Dentine sensitivity refers to the "transient pain in response to chemical, thermal, tactile or osmotic stimuli" and generally appears after enamel loss with dentinal exposure (13). They can also present oral ulceration, burning mouth syndrome and parotid gland enlargement. (1)

As a first approach, the dentist can observe reduced occlusal space, enamel that easily fractures and teeth that appear shorter. The enamel fragility makes it thinner, showing the underlying dentine and changing the teeth optical properties. (1)

1. Attrition

The most affected surfaces are the occlusal and incisal ones, where the opposing occluding surfaces of antagonist teeth interrelate. (2) In general, the first ones that are altered are cusp tips in a localized pattern and the palatal surfaces of the maxillary anterior teeth presenting structural loss and with time, a more generalized flattening is observed. (1) Then the lesions look flat, glossy with distinct margins and are hard. (1,3) [Figure 1]

Figure 1: Moderate to severe TSL due to attrition, with flattened incisal surfaces (6)

There's actually a clinical correspondence between where and how patients brux their teeth. (2) Indeed, if the patient tends to brux in anterior/posterior direction, the lesions will be seen in the anterior teeth and if he bruxes laterally, the lesions are generally on the canines. But if he has a group function occlusion, lesions on the premolars and molars can be observed. (10) The antagonists surfaces that are in contact wear at the same rate, displaying a certain

symmetry – although the contacts causing attrition are often in one of the border positions, so usually not the ones in occlusion. (1,2) Once the occlusal dentine is exposed and no protection is being established from the bruxism, the tooth wear rate accelerates as dentine tends to be removed two to five times quicker than enamel. (10)

In bruxist patients, there will often be complain of jaw fatigue or muscular pain. (10)

2. Erosion

The initial lesions are generally not noticed by patients. According to the cause of this type of wear, the location and severity can be different. (1) But they first commonly appear as "silky-glazed" dull surfaces where some of the usual characteristics, such as perikymata, have disappeared. (2) In general, the most affected surfaces are the lingual and buccal ones of the maxillary anterior teeth. (2)

In the case of intrinsic erosion, palatal surfaces of those teeth are the first areas being affected as the buccal mucosa and the tongue protect the rest from acid exposure – although when the predicament progresses, these structures are not enough. (1,2) Concave depressions will be seen with a thin and translucent enamel. (3) The perimylolysis lesions are the most characteristic sign of voluntary regurgitation, found on the palatal surfaces of maxillary incisors, being described by the decalcification of the dental structure and smooth lesions with pigmented stains and rounded margins in the teeth [Figure 2]. (1,14)

Figure 2: 28-year-old patient known for vomiting over years presenting severe wear in palatal surface of maxillary anterior teeth (15)

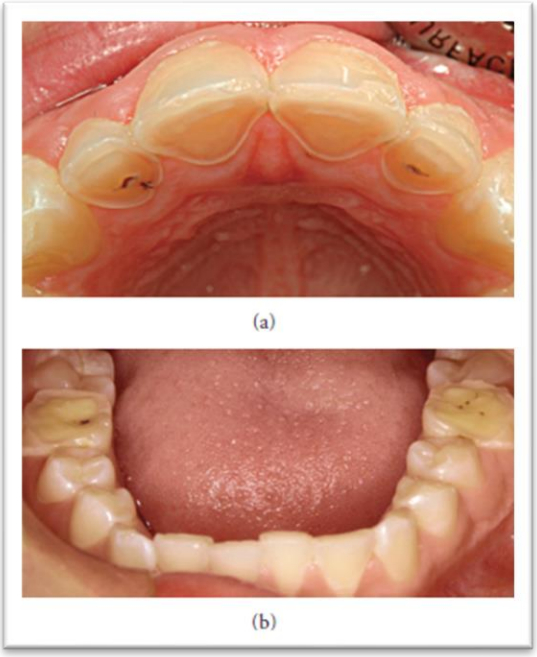

Figure 3: 12-year-old patient with high intake of cola presenting (a) palatal and buccal erosion in maxillary anterior teeth and (b) cupped mandibular molars (16)

But in the case of extrinsic erosion, the characteristic lesions observed are widespread cupped out ones with a pattern specific to the dietary habit of the patient. (2) They will often impact the buccal cervical areas of the maxillary teeth, especially in erosion caused by environmental factors by exposure at work, and the occlusal ones of the mandibular posterior teeth [Figure 3.] (1,4)

In moderate cases affecting only enamel, the appearance is shiny and smooth with loss of some of the anatomical characteristics but in advanced cases, there is a complete destruction of enamel with dentinal exposition. We have the characteristic ring of enamel in those cases, surrounding the gingival third of the teeth. This is thought to be due to the neutralisation of the acid by the gingival crevicular fluid. But the exposure of the dentine makes it more susceptible to acid attacks and the loss of tooth structure in this area is faster.

And the more the lesion advances, the more hollowed or cupped out surfaces are observed. [Figure 4] (1,2)

Figure 4: 28-year-old patient known for having 7 acidic intakes per day and regurgitating presenting occlusal cupped out surfaces on posterior teeth – the composite restoration is above the occlusal level on the 44 (15)

The tooth can appear more translucent than usual due to the loss of enamel or darker because of the exposition of the underlying dentine. Teeth become more fragile and present easier chipping or fracture, especially in the anterior ones. (1)

The staining of the teeth can help determine if the teeth are still exposed to the erosive agent: when the process is still active, there's usually absence of staining while if the dentine is apparent and stained, it means the erosive agent is not acting on the teeth anymore. (1)

3. Abrasion

The clinical manifestation depends on the causative agent which influences the localization and the severity of the wear. (1) But in general, the most affected surfaces are the cervical region of teeth, possibly associated to gingival recessions. (2) Localized lesions are observed when resulting from a bad habit, for example when an object is held between the teeth; in this case, the wear will match the shape of the object [Figure 5]. When the

toothbrushing is done with too much strength, it will present as rounded grooves in the cervical area; it can be localized to the canines and premolars primarily or generalized depending on the toothbrushing technique [Figure 6]. And it seems that right-handed people will have a tendency to form more wear on the left side and same for left-handed people on the right side. (1)

Figure 5: Incisal edge abrasion corresponding to the electric wire the patient has the habit to put between his teeth in his work as an electrician (17)

Figure 6: Unilateral abrasion in the upper left arch, thought to be caused by brushing technique (17)

Abrasive wear usually presents sharp defined margins, which helps differentiate it from the erosive one which displays as broader shallow lesions. (1)

4. Abfraction

The lesions are manifested as wedge-shaped defects at the level of the cementoenamel junction [Figure 7]. (6) They are very similar to the abrasive ones due to toothbrushing, but they are recognizable due to their more angular aspect whereas in abrasion, lesions are more rounded and smoother, usually associated to more or less severe

gingival recession. (3) Gingival recessions can actually also be found in abfraction but are not characteristics of this phenomenon. (3)

Figure 7: Abfraction lesion in patient presenting a multiple aetiology TSL (18)

d. Epidemiology

It has been observed that dental wear has increased in terms of severity and prevalence, in elders, mainly due to the increased life expectancy, but also in younger generations. (2) However, the exact prevalence of TSL is hard to establish because of the multiple various assessment criteria. (3)

1. The situation in children and adolescents

In Europe, an augmenting prevalence of cases in children has been observed in the last decade, in association with the increasing age, particularly in the deciduous dentition. The data are being collected through the Child Dental Health Survey in United Kingdom since 1973 and are repeated every 10 years; the last one was done in 2013 and corroborates the previous results. In 5-year-old patients, 57% of them presented dental wear on lingual surfaces with 4%

affecting the dentine or pulp and 33% of buccal surfaces with 16% affecting the dentine or pulp. In 15 year-old patients, 44% of them presented dental wear on the palatal surfaces of maxillary incisors and 31% of them on occlusal surfaces on the first permanent molars. (1) They generally do not suffer severe attrition but rather erosion. (3)

2. The situation in adults

In the United Kingdom, it's the NHS Information Centre commission that collects data about adults' dental health every decade through surveys. Their most recent statistics are from the 2009 survey. It was observed that since the last survey in 1998, dental wear has increased from 66% to 76%. There was also a rise in the number of teeth affected to dentine, at 77% in the anterior teeth. (1)

It is commonly found in adults where prevalence increases with age, particularly on occlusal and incisal surfaces (6) A systematic review by Van't Spijker has indeed revealed that 3% of 20-year-olds presented severe dental wear versus 17% in 70-year-olds. (1,3) And in 2013, Bartlett et al found that 29% of the European adults between 18-35 years old were affected by TSL. (3)

It has also been suggested that dental wear was more commonly found in males with the theory that they have more tooth retention and more occlusal forces. (1)

But the prevalence studies for adults are actually scarce for it may be difficult to select participants and keep track of them in time. (1)

3. The situation according to types

According to Smith and Knight, attrition was the main pathological cause of dental wear, found in 11% of cases and in two-thirds of the combined aetiologies of TSL. Awake bruxism is very common, with a prevalence of 20% and nocturnal one with a prevalence of 8-10%. (10)

They also observed that in 89% of patients with severe TSL, erosion was aetiologically implicated. (1) In general, a high prevalence of erosion is observed in United Kingdom, in adolescents with a percentage of 53% and in adults with a percentage of 77%. (1)

Erosion has shown a massive rise in industrialized societies, particularly with the ideal body image conveyed by the industry of fashion and social media where slenderness is defended. It has created an obsession around body shape and diet leading to an augmentation of eating disorders as anorexia, exposing the oral environment to the abnormal presence of acids. (2) In this particular case, the male to female ratio is 1:10 but males have been observed to be less inclined to seek medical care therefore are at similar risk of eating disorders. (1)

II. Diagnosis of Dental Wear

a. Patient's Anamnesis

Interrogating patients is unquestionably relevant to the proper diagnosis of dental wear, especially which type they're dealing with. The dentist should be asking about the diet, habits, oral hygiene techniques, anything that could be linked to the aetiology of wear. In patients where erosion factors are suspected, it is recommended keeping a three-day comprehensive diet diary to have a better analysis of the diet. (4)

If the patient comes with a chief complaint, it is important to note it down, as well as any information about all the symptoms they've had. The concerns of the patient should be examined, related to sensitivity, pain, fractured teeth, discoloration… (6)

This phase can actually also help the dentist determine the level of motivation of the patient, if he's willing to change his habits or lifestyle, if he will be able to handle a huge treatment, especially involving appliances. (4)

b. Patient's General Examination

An extraoral examination is necessary to assess the temporomandibular joints and the related muscles, checking the possible presence of clicks or crepitations or if there's a deviation during the opening or closing. (3) Any referred abnormality should be documented. A parotid gland enlargement should also be registered as it is often seen in bulimic patients. (1)

The facial vertical proportions should be evaluated as the presence of a lower facial height could be a sign of severe dental wear. For that purpose, the resting vertical dimension, the occlusal dimension and the freeway space should be measured. The aesthetics can also be assessed through smile by examining the smile line and the lip line. (1)

The intraoral examination includes soft and hard tissue exploration, with an appraisal of the oral hygiene and a periodontal inspection. (1)

c. Indexes: Qualitative Methods

The 2 most famous ones are the Tooth Wear Index (TWI) and the Basic Erosive Wear Examination (BEWE). At this moment, none has been accepted as the universal method of classifying dental wear. Most of them are based on the diagnosis and monitoring of TSL, grading its severity, and often using numbers to do so. But they have limitations as they are focused only on the prevalence of the wear at the moment of the evaluation without having the reference of the natural dentition before the defect occurred and they are often based on a subjective visual estimation. (1,19) They can be used on both teeth or models. (20) However, it appears that the application of these indices solely on casts tends to lead to an underestimation of the actual loss due to wear. (21)

1. Tooth Wear Index (TWI)

The **TWI** is currently the most commonly used. Smith and Knight designed it for research into the aetiology, prevention but also for the management and monitoring of TSL

and epidemiology, being the first index to do so. It evaluates the four surfaces of the tooth, with scores depending on the loss of enamel, dentine, the change of the contour assessed clinically [Table 1]. Its authors also added different pathological levels depending on the patient's age. Nevertheless, it presents limitations regarding the thresholds for pathological wear, making the scoring more difficult. (1) It has also been blamed for its dependence to the very subjective visual assessment of exposed dentine and for the exclusion of restored dentition and etiology. (3)

Table 1: Tooth Wear Index (TWI), according to Smith and Knight (5)

Score	Tooth Surface	Criteria
0	Labial/Oral/Occlusal/Incisal Cervical	Without signs of enamel loss Without signs of crown contours loss
1	Labial/Oral/Occlusal/Incisal Cervical	Loss of enamel surface relief Minimal loss of crown contours
2	Labial/Oral/Occlusal Incisal Cervical	Loss of enamel dentine baring less than 1/3 of surface Loss of enamel with minimal baring of dentine The depth of defect is less than 1mm
3	Labial/Oral/Occlusal Incisal Cervical	Loss of enamel; dentine baring more than 1/3 of surface Significant loss of enamel and dentine The depth of defect is 1-2mm
4	Labial/Oral/Occlusal/Incisal Cervical	Extensive loss of enamel and dentine with baring of dental pulp The depth of defect is more than 2mm; baring of dental pulp

Millward *et al* adapted this index to study erosion by making "mild", "moderate" and "severe" categories for primary and secondary dentine but wear tends to be overestimated. (1)

The latest modification was done by Fares *et al* to reach the **Exact Tooth Wear Index** [Table 2]. They scored enamel and dentine wear separately and their scoring can find its correspondence in the Smith and Knight classification to make comparisons when necessary. (1,22)

These indices are considered easy to understand and are often applied to research. (1)

Table 2: The Exact Tooth Wear Index, according to Fares *et al* (22)

Score	Exact Tooth Wear Index for Enamel
0	No tooth wear: no loss of enamel characteristics or change in contour
1	Loss of enamel affecting less than 10% of the scored surface
2	Enamel loss affecting between 10% and 1/3 of the scored surface
3	Enamel loss affecting at least 1/3 but less than 2/3 of the scored surface
4	Enamel loss affecting 2/3 or more of the scored surface
Score	**Exact Tooth Wear Index for Dentine**
0	No dentinal tooth wear: no loss of dentine
1	Loss of dentine affecting less than 10% of the scored surface
2	Dentine loss affecting between 10% and 1/3 of the scored surface
3	Dentine loss affecting 2/3 or more of the scored surface, no pulpal exposure
4	Exposure of secondary dentine formation or pulpal exposure

2. Basic Erosive Wear Examination (BEWE)

The **BEWE** was designed in 2008 by Bartlett, Ganss and Lussi for both practitioners and researchers and uses the Basic Periodontal Examination. It is based on a partial scoring system that registers the status of the most affected surface of each tooth then the most affected tooth of each sextant. A sum up of the value of each sextant is made and a total value of BEWE is obtained, giving the general status of erosion [Table 3]. (5) It has been considered an acceptable system for scoring erosion with satisfactory inter-examiner reliability for wear in dentine; however, more divergences were found for wear affecting enamel. (1,5) It has also shown to be more efficient than the TWI to detect severe wear but requires an experimented dentist to assess the more moderate cases. (23) It was considered as being the ideal one for a while due to its simplicity and rapidity and has even been approved to be used for other types of wear than erosion. (8)

Table 3: The Basic Erosive Wear Examination (BEWE), according to Bartlett, Ganss and Lussi (5)

Score	Criteria
0	Intact surface
1 – Moderate Erosion	Initial loss of surface enamel layer
2 – Advanced Erosion	Obvious defect of hard dental tissues affecting up to 50% of tooth surface
3 – Serious Erosion	Extensive defect of hard dental tissues affecting more than 50% of tooth surface
Total Value of BEWE	**Erosion status**
Between 3-8	Moderate stage of erosive lesions
Between 9-13	Advanced stage of erosive lesions
≥ 14	Serious stage of erosive lesions

3. Anterior Clinical Erosive classification (ACE)

Vailati and Belser introduced a new classification in 2010 called the **ACE** with the purpose to be easier to apply than the BEWE. (1,3) The classification is made on six classes and five parameters are taken into account for the treatment and prognosis: the preservation of incisal edges, the dentine exposure in the interproximal areas, the length of the remaining clinical crown, the pulp and the presence of enamel on the vestibular area. For each class, a different treatment option is recommended. Similarly to the BEWE, to classify the patient in one of those classes, the most affected tooth will be used as a reference. However, this method also has shown its limitation as it is designed only for anterior maxillary teeth, although the treatment plan usually also includes the posterior teeth rehabilitation. (1)

4. Tooth Wear Evaluation System (TWES)

It is a modular clinical guideline that helps in the qualifying and quantifying diagnosis of dental wear. (3) It was made of ten modules, four for basic diagnostic, three for extended

diagnosis and three for management. (24) Because of its complexity, it has been revised in 2020 and nowadays, it uses a 5-point ordinal scale for occlusal and incisal surfaces and another 5-point ordinal scale for the non-occlusal and non-incisal surfaces for natural dentition [Table 4]; a supplementary 5-point ordinal scale is currently being implemented for restorations but needs testing first. (25)

Table 4: The Tooth Wear Evaluation System (TWES 2.0), according to Wetselaar *et al* (25)

Grade	**Occlusal and Incisal criteria**
0	No (visible) wear
1	Visible wear within the enamel
2	Visible wear with dentin exposure and loss of clinical crown height ≤ 1/3
3	Loss of clinical crown height > 1/3 but < 2/3
4	Loss of clinical crown height ≥ 2/3
Grade	**Non-Occlusal and Non-Incisal criteria**
0	No (visible) wear
1	Wear within the enamel
2	Wear with dentin exposure (<50% of the area)
3	Wear with dentin exposure (≥50% of the area)
4	Wear with dentin exposure (complete tooth loss of enamel or pulp exposure)
Grade	**Classification of the Tooth Wear**
0 – In all sextants and the anterior palatal sextant	No wear
1 – In any sextants and/or the anterior palatal sextant	Mild tooth wear
2 – In any sextant and/ or the anterior palatal sextant	Moderate tooth wear
3 – In any or all sextants	Severe tooth wear
4 – In any or all sextants	Extreme tooth wear

It is based on only two diagnosis modules nowadays, with the Tooth Wear Screening and the Tooth Wear Status. They are performed with a mirror and a form that needs to be filled according to the criteria previously seen for each tooth. The occlusal surfaces are being recorded as well as the palatal for the sextant 2 for the Tooth Wear Screening and all the non-occlusal and non-incisal areas for the Tooth Wear Status and a general classification of the tooth wear can be done [Table 4]. (25) They were designed to be easy and fast to perform.

According to the severity of the wear, other parameters are evaluated, such as the aetiology through clinical signs, the detection of pathological signs and symptoms, a specific oral history questionnaire can be used or a salivary analysis can be performed. (25) This system is the first one that includes that many factors, taking into the account the aetiology and trying to add the restorations wear. Furthermore, it actually gives specific treatment guidelines to each diagnosis.

5. Measuring of Tooth Restorations Wear

There are also classifications exclusively for restorations wear, with the modified United States Public Health Service (USPHS) criteria and the FDI (World Dental Federation) criteria being the most frequently used criteria for evaluating composite restorations among others. (26)

The **modified USPHS criteria** or **Ryge criteria** was initially based on the evaluation of the colour match, the marginal adaptation, the cavo-surface marginal discoloration, caries and the anatomical form and was revised a few years later to be more inclusive of factors such as the occlusion, retention, fracture or post-operative sensitivity. (27) It uses codes Alpha, Bravo, Charlie and Delta for each parameter; to rate the restoration, the worst code among the parameters evaluated is taken. (5,26) However, the criteria were developed when the use of amalgam was prevailing, and the adhesive materials were not as reliable as today. (27)

The **FDI criteria** was then created by Hickel *et al*, analysing functional, aesthetical and biological factors, which are divided in subgroups for a more precise analysis. It works on a five-scale grading and as for the USPHS criteria, the most severe score is recorded. Only a few

parameters should be used during an evaluation to prevent an exhaustive diagnosis. In 2008, it was considered as the Standard Criteria, and ultimately has gone through revision in 2010 after feedback. (27)

In general, the USPHS has been more used than the FDI criteria but is also older; in fact, since 2010, the use FDI criteria as been increasing as it was reported practical, thanks to its variety and freedom of choice regarding the criteria, relevant and standardized. Both of them were more applied to direct restorations but haven't proven their efficiency yet for indirect ones, which would require further studies. (27)

All those indices show their limitations, especially in matter of incapacity to adapt when there are small variations. Most of them don't include in the criteria for classification the patient's perception of the wear, when the symptoms have started, the appearance of sensitivity or if a lowering of the lower facial height has been observed, which should be taken into consideration. And the TWI, compared to its successors, requires more time in the dental office, while being often used. (1)

d. Additional Quantitative Methods

They can be used to overcome the limitations brought by the single use of indexes and include for example profilometry, radiographies or ultrasounds. (28) While they can be helpful, those methods are actually complicated to relate to the clinical situation *in vivo*. (29,30) They are often time-consuming and costly. (28)

1. Optical Coherence Tomography (OCT)

It is a technique that is often used for the passive observation of dental structures which provides a cross-sectional image of internal structures [Figure 8]. (31) Thanks to the distinct scattering properties of enamel and dentin, the emission of light gives data about the thickness of the different tissues, which makes it useful in detection of cracks, dental caries and possible micro-gaps in adhesive restorations as well. (30,31) Kawashi *et al* studied OCT and its accuracy in monitoring dental wear and came to the conclusion that it seemed to be a suitable method for this purpose. Nevertheless, this technique presents drawbacks as the scanning range is limited to a few millimetres, meaning it cannot assess the situation in large lesions. It also has a long processing time, implying there's a bad image quality if it is done hastily. (30) Additional *in vivo* studies would be necessary for more adequate results.

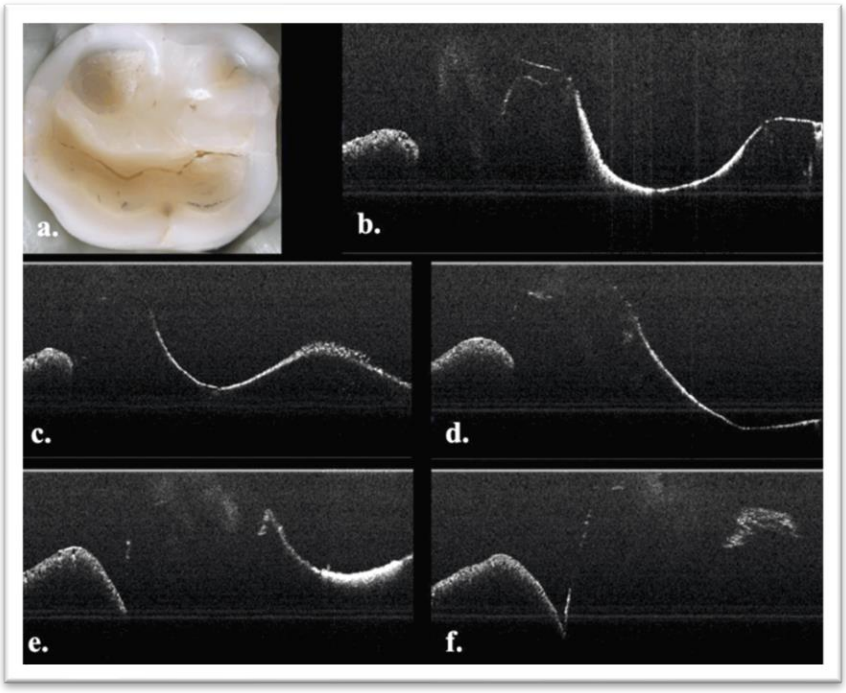

Figure 8: Tooth affected with erosive wear. (b) OCT of occlusal area with demineralized enamel ridge; (c) erosive cavity; (d) strong demineralization of bottom erosive cavity; (e) cavity bottom with amorphous dentin; (f) buccal enamel ridge. (32)

2. Quantitative Light-Induced Fluorescence (QLF)

This technique uses the fluorescence property of dentine when being under ultraviolet excitation: a diminished fluorescence, characterized by darkened areas, suggests a decrease of mineral content in the dental tissues. Therefore, it was first used for the early detection of caries with a non-invasive approach. (28) Kim *et al* used this method to measure dental wear, establishing the possible exposure of dentinal structure in occlusal surfaces. Studies have suggested that the fluorescence increased with the progression of occlusal dental wear; this technique seems then to offer a good method to identify dental wear, even though it needs further research [Figure 9]. (30) Indeed, until now, the studies have been performed in controlled environments with artificially induced wear; it would interesting having clinical results. (28)

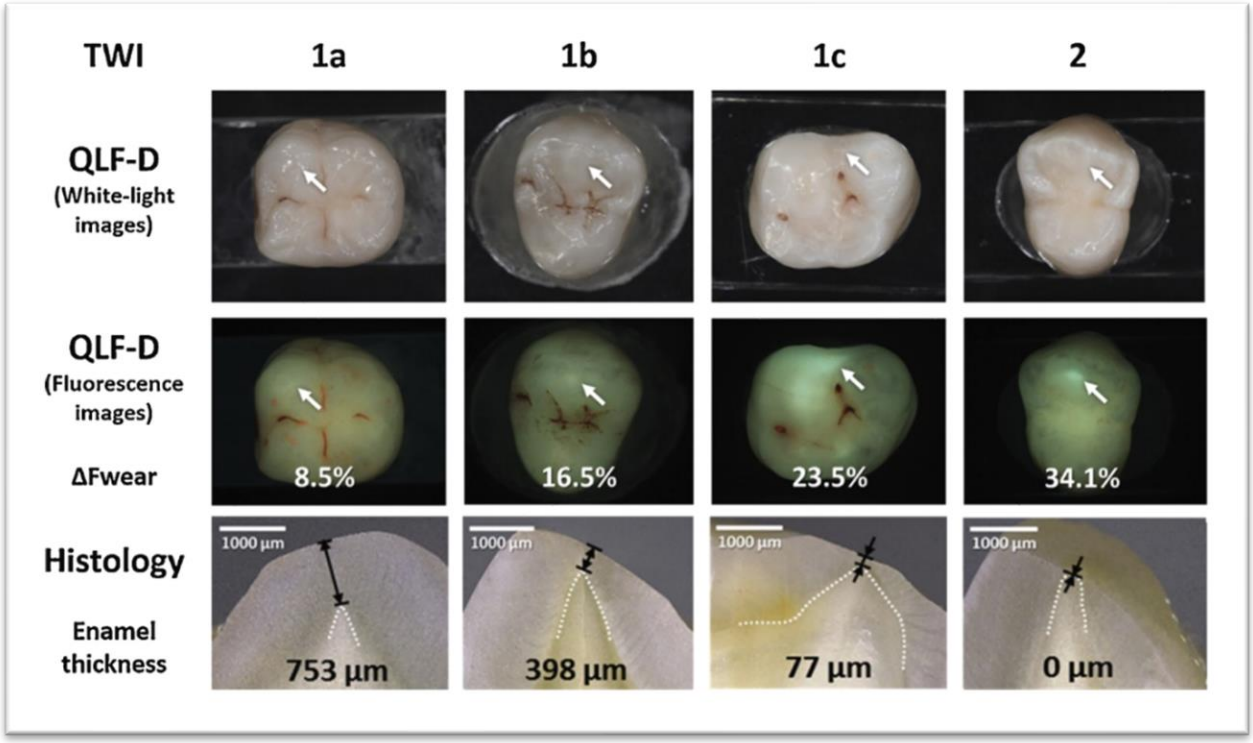

Figure 9: QLF digital (white-light and fluorescence) and stereomicroscope images according to TWI (28)

3. Intra-Oral Scanner (IOS)

This method was designed for the early detection and follow-up of TSL based on both *in vitro* and *in vivo* information, obtaining information from the patient's mouth or from a physical model [Figure 10]. Studies have proven that there was a higher sensitivity detection with the use of a qualitative method – index – on digital three-dimensional models than with conventional clinical assessment, making the diagnosis easier thanks to the possibility of image magnification and assessing the TSL without the inconvenience of soft tissues. (23,29) In a study performed by Tomás et *al*, the detection of dental wear using IOS *in vivo* has shown results corresponding its prevalence in the general population, found as well on palatal surfaces of central incisors, occlusal surfaces of first molars and incisal surfaces of canines; only the amount of affected incisors detected by IOS was lower than the percentage found in the population. (23) Nonetheless, the study was performed on 53 young students, making it necessary to carry out further studies with bigger and more heterogeneous samples in order to get more accurate results. For now, IOS is a solution that seems promising for the daily use in the dental office in the future.

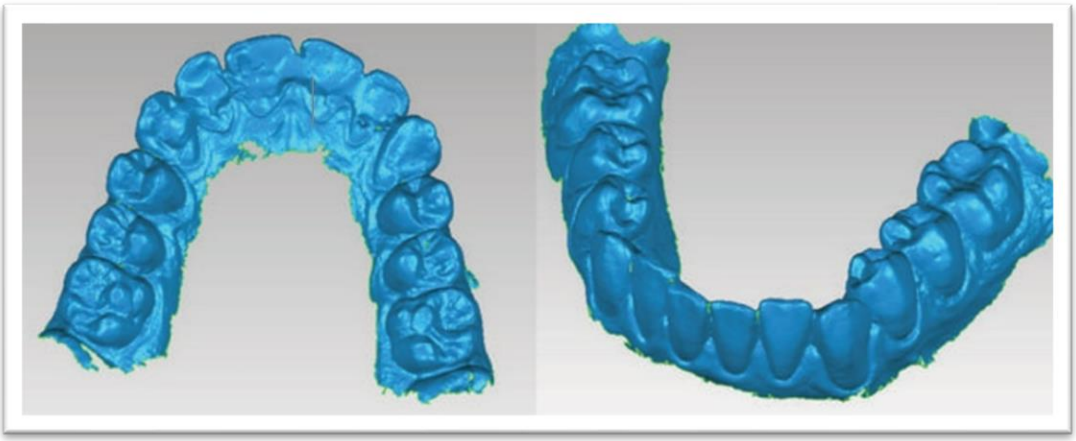

Figure 10: IOS record of maxilla and mandible in a patient with TWI score 1 and 2 (23)

III. Prevention of Dental Wear

The different treatment options should follow a gradual guideline, with the minimally invasive options explored first, then going on with more aggressive ones only when the previous have failed or aren't possible.

This part has its importance nowadays, due to the increased incidence particularly in children, so putting in place the appropriate preventive measures early can avoid any complications in the adulthood. But it is actually hard to identify individuals that will eventually be affected by TSL so establishing primary prevention is challenging. Furthermore, there are few significant evidence regarding the clinical effectiveness of the most preventive and non-invasive measures. (1,2)

a. Monitoring & Dietary advice

Monitoring and counselling are actually the first option when no symptoms, no aesthetic nor functional impairment are being observed. (9)

The monitoring is actually also important after wear treatment has been performed, to prevent further lesions and to assess its efficiency. In this case, it is suggested that high quality photographs are made of the patient to allow comparison and check the evolution, periodic study casts should be done every six to twelve months for the same purpose and make a more thorough evaluation. Sectional silicone indexes can be produced from the first cast to be employed as a reference guide. (6) New technologies have also emerged, reinforcing the interest of patients in their condition: the CAD/CAM (Computer-Aided Design / Computer-

Aided Manufacturing) methodology uses a scanner that records the patient's data. It can be helpful to rapidly get and store his data and also for him to see and have a detailed visualization of his problem, to be more involved in the management of his wear. A one-year follow-up initiated by Ahmed *et al* has proven CAD/CAM monitoring of TSL was feasible and applicable in the dental office [Figure 11]. (33)

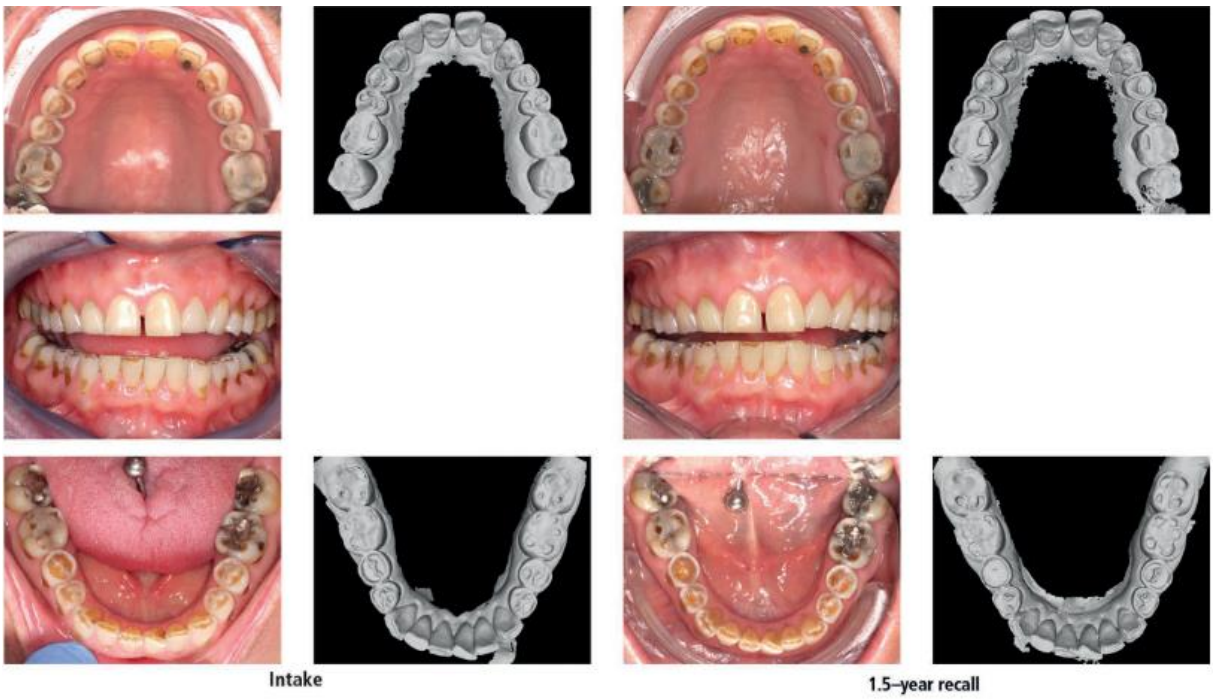

Figure 9: Monitoring of a severe wear in a 50-year-old patient. Pathological wear observed in the 1.5-year-follow-up, related to erosion, without identification of the exact aetiological factor (34)

As for the recommendations, they should be made according to the type of wear as they are indeed very different in nature and aetiologies. Nevertheless, most preventive measures researches have aimed at limiting the erosive wear. (1)

It has been noted that early diagnoses of dental wear when enamel was still present have led to its slower rate of progression when the appropriate preventive advice had been given. But

it did not prevent the occurrence of severe wear when facing a change of situation, lifestyle, especially in moments of stress. (1)

In the case of erosion, the main objective is to reduce the exposition of the dentition to acid content. That would mean decrease the amount and frequency of consumption of the acidic foods and beverages. If taken, those foods should be limited to mealtimes and fruit juice intake should be restricted to once a day. (1,3,4) For drinks, it should be recommended to patients to use wide bore straws to avoid tooth contact and to avoid keeping the beverages in the mouth. (1,3) Neutral drinks should be preferred, such as water and milk. (3) It has been shown that the consumption of dairy products, including hard cheese, or chewing-gums following acidic intakes helps the stimulation of the salivary flow, the increase of its pH, favouring the re-thickening of enamel and reducing the erosive effects of the causative agent. (1,6)

b. Medical Referral

The preventive actions can also include a therapy in association with a psychologist and/or a psychiatrist for the behavioural and psychological management of eating disorders or a gastroenterologist for a medical management of the gastric reflux. (2) Patients in this case could benefit from the use of antacids, omeprazole and ranitidine to reduce the acid production and reflux. (1) If a medication causes xerostomia as side-effect, the medical practitioner should find an alternative or prescribe salivary stimulants. (4) It was shown that with an adequate management of gastro-oesophageal reflux, enamel erosion was reduced in the six weeks of treatment. (2)

Regarding attrition caused by SSRIs, it could be interesting suggesting a change in the drug for the management of depression and anxiety to the medical practitioner in order to reduce the associated side-effects. (10)

c. Oral Hygiene Education and Suppression of Bad Habits

Giving advice about toothbrushing is of high relevance, explaining the damage of a too fiery toothbrushing technique and the need to avoid highly abrasive toothpastes. It should be mentioned to be especially careful with the ones that supposedly favour tooth whitening. Remineralizing toothpastes have proven to be more efficient than conventional fluoridated toothpastes as they increase the hardness of the teeth surface. The timing of toothbrushing is also relevant as it should not be performed right after acid exposure, through vomiting or acidic food or drink intakes. (1,3)

Neutral sodium fluoride mouthrinses or gels could be added as a recommendation as studies have demonstrated the use of topical fluoride could help in wear caused by acids. The daily use of a 0.05% sodium fluoride mouthwash could be recommended. It also helps in the prevention of symptoms such as sensitivity. The use of toothpastes containing potassium and tooth mousse has its advantage against dentine sensitivities as well. (1,3,6)

It is also important to encourage the suppression of bad habits, giving patients concrete examples such as pen-biting, nail-biting, holding or opening objects with teeth to avoid damaging both sane and already worn teeth. (1) It should also be reminded to the patient that he should reduce stress as much as he can, especially if he has parafunctional

disorders, in order to preserve the remaining dental structure; if he had a stressful routine, he should consider a change of lifestyle. (3)

d. Preventive treatments in the dental office

To help protect dental structure, the application of fissure sealants and dentine bonding agents could be beneficial, also to lower dentinal sensitivity. They appear to be efficient for a period of nine months post-application but do not last in teeth already suffering severe wear. (4)

Glass ionomer cements are used for the same purpose, being efficient especially on exposed dentinal areas. (1,6) The latter can even be used on posterior teeth in the pre-treatment phase of a restoration, in order to keep the occlusal space. (2) Fluoride varnishes or 0.7% fluoride solutions might be applied as well in the dental office for dentinal hypersensitivity, then should be followed by a 0.4% stannous fluoride application at home by the patient. (4,6)

e. Occlusal Splints

The use of splints is advisable in the case of ongoing tooth wear to prevent further tooth surface loss due to attrition. They help distributing the forces across the masticatory system and reduce the frequency of the heavy occlusal loads, but they do not limit their intensity. They should cover the whole arch and the occlusal areas of all teeth – otherwise overeruption of the uncovered teeth may occur –, have flat even contacts and allow disocclusion. (9)

They can be either hard or soft. The hard ones are made of polymethylmethacrylate (PMMA), heat-polymerized ones being better in the long-term due to their superior strength and lower toxicity. They help giving a provisional ideal occlusion. The soft ones are made of ethylene-vinyl acetate (EVA) and are used only as a short-term solution because of their lack of stability; the 4mm thickness is the most commonly used and the 2-3mm one is the one suitable for children. (9)

It is advised to give them a hard consistency as they last longer in time than the soft ones. The bilaminar ones which are hybrids are considered as being the most cost-effective. But in case of more severe bruxism, full coverage hard acrylic occlusal splints are more adapted, with a Michigan splint or Tanner appliance. They are more expensive but have more effectiveness in the management of severe dysfunctions and can also establish mandible repositioning with a reproducible retruded contact position before engaging into restorative treatments. (1,6,9)

A particular attention should be given to patients requiring splints due to erosive wear, notably in night reflux cases, where more counselling should be performed, as without care, the acidic agents could accumulate in the splint and worsen the prognosis of the dentition. Bulimic patients are recommended to wear their splint when vomiting then take it out and clean it. Soft vacuum-formed appliances modified to include reservoirs also have their benefit when filled with desensitizing agents, topical neutral fluoride gels or acid neutralizers like sodium bicarbonate for night-time remineralization; they can be made with the application of a die spacer on the treated teeth in the model before the thermoforming. (1,4,9)

V. Treatment of Dental Wear

a. Decision to treat

After thorough indexing, the decision on how to manage the patient's wear should be taken. The classification and severity of the TSL will help take the decision but some criteria can also be taken into account. Following the TWES, for grade 0 or 1, only a preventive approach is needed and for grade 2 involving non-occlusal or non-incisal surfaces, grade 3 and 4, a restorative approach is preferred. (25)

It was shown that facing a patient who is asymptomatic, with no active wear or who does not seem implicated in dealing with his condition, taking only preventive measures was more effective. (3) On the other hand, restorative treatments have proven valuable when the patient presented symptoms as sensitivity, pain or when rehabilitation of mastication, phonation and restoration of aesthetics were needed. (3,13)

The choice of materials for patients suffering dental wear is essential so the remaining dental structure can last in time and be protected from any damaging factors, but unfortunately most studies were made in laboratory trials so their use in real life might give different results. This is why it is for now recommended to delay the invasive treatments as long as possible preferring a conservative approach at first. (3,13)

b. Planning

Once the wear diagnosis has been established, an assessment of the patient's situation is necessary. Preliminary investigations are first made through clinical and radiological exploration. (13) The information obtained during the extraoral and intraoral examination for the diagnosis will also be used in the treatment planning.

It is crucial to evaluate the OVD in this type of patient, which can be done through assessment of phonetics, with the help of the interocclusal distance or evaluation of soft tissues; the most frequently used in literature involves the freeway space evaluation, the Resting Vertical Dimension (RVD) and the employment of callipers. (3) The choice of treatment will indeed depend on parameters like the OVD, as well as the aetiology and pattern of wear, the teeth affected, the remaining tooth structure, the space requirements of the material chosen and the patient's expectations. (3,13) The endodontic need should also be evaluated with sensitivity tests through ethyl chloride or warmed gutta-percha that have proven useful. (3)

Some patients will require an interim hard heated-cured full coverage splint to diminish signs and symptoms of potential temporo-mandibular disorders before engaging into restorative treatments. It can also help them test their tolerance to the new programmed change in OVD. (3,13)

Before starting any treatment, impressions should be made, from which result casts that are mounted in the articulator with occlusal records. A diagnostic wax-up can also be realized so the patient can assess the aesthetics and the functional restoration planned. (3,13)

c. Fixed Treatments

The choice will be made between metal restorations, porcelain-fused-to-metal (PFM) restorations, all-ceramic restorations, indirect ceramic veneer, indirect resin restorations, direct resin restorations and combinations. (13)

1. Indications and Contraindications

This option is recommended in patients affected by localized or generalized tooth wear who complain of pain or discomfort, have aesthetic concerns, compromised structural integrity of their teeth, functional disturbances or alveolar compensation with insufficient occlusal space for restorations. (13)

However, it should not be performed in periodontal patients, when there are extensive caries, teeth that are not restorable – meaning with vertical root, horizontal or oblique fractures, failed root canals –, soft tissue defects, extensive edentulous spaces or insufficient posterior support. (13)

2. Materials

It is important to assess the aetiology of the tooth wear to find out if after the treatment the restorative materials will be submitted to those same factors, especially in bruxist patients. Most times, the failure is primarily biological, then can be secondary to a mechanical failure. (13) In the case of augmentation of OVD, the material chosen should be even more resistant to wear. (12)

In the recent approaches, the survival of the remaining tooth structure is of upmost importance compared to the survival of the restorative material. So nowadays, the use of direct composite resin is increasing due to its less invasive technique. (13)

a. Composite Resin Restorations

Composite resin is a material often chosen for its good aesthetics. It is interesting in the treatment of wear as it is minimally abrasive to antagonist structures and can be easily adjustable. (3) It can even serve as a temporary solution, to prevent further damage to worn teeth until the definitive restorations are placed. (35) However, it also suffers wear more easily than other materials, making its use unrecommendable in the posterior areas, especially in cases of full-mouth rehabilitation. (13) An *in vitro* study performed by Xavier *et al* showed that composite suffered a decrease in surface microhardness when exposed repeatedly to acid drinks, with phosphoric acid being the most aggressive agent: thus, it does not have high resistance facing erosive agents. (36)

It can be used as direct or indirect restorations.

The direct technique has a very conservative approach, is well tolerated by pulpal tissues, is minimally abrasive to antagonist structures, has a good quality/cost ratio and can be done in a single appointment. (3) However, it requires good quantity and quality of enamel for adequate adhesiveness, needs excellent moisture control, may suffer bulk fracture and polymerization shrinkage which can lead to marginal micro-leakage as well as staining, offers limited control over occlusal and interproximal contours and demands satisfactory dental skills. (3,35)

The indirect resin restorations allow a better control of occlusal contour – especially in the case of multiple restorations –, they suffer less polymerization shrinkage than in direct techniques and have more abrasion resistance and hardness. (3) But they have the disadvantages to possibly present undercuts and can be oversized resulting in possible wear. At least two appointments are required, but on the other hand, chairside time is decreased. (3,37) The adhesion to dental tissues is acceptable but is lesser than ceramics. (38) It used to have a worse marginal fit compared to other materials used in indirect restorations but nowadays, new technologies as CAD/CAM techniques or even modern handmade have improved this feature. (3,39) The CAD/CAM resin composites have also upgraded the wear characteristics: Lawson *et al* reported that they caused less wear than infiltrated ceramic and glass ceramic and suffered less wear than enamel. (40) There are much less studies regarding the indirect techniques used in restorations so statements about the outcome and the survival cannot be given with certainty. (37)

b. Ceramic restorations

In general, ceramic restorations have a good resistance to wear, high marginal fit and aesthetics. But they can also be hard to reline and correct. (37) Also, because of brittleness, they can suffer fracture and chipping, notably in thin areas, but nowadays, this feature specifically applies to layered aesthetic restorations as monolithic ceramics have overcome this issue. (41) Daibs *et al* suggested ceramics were the best option for patients exposed to erosive factors, especially in eating disorders with recurrent episodes. (42)

There are several choices for ceramic restorations.

Lithium Disilicate (LDS) gives excellent aesthetic given by its translucency and high flexural strength. Thanks to its good mechanical properties, it is often the material indicated in fixed partial dentures extending to three elements. (41) It can be pressed or milled, layered with feldspathic porcelain or monolithic and be used in crowns, inlays, onlays as well as in veneers which seem to give good outcomes. (43) It has a bit more strength than enamel but indeed, it seems to offer a good option when used as palatal veneers in anterior teeth affected by wear. (12) Etman obtained results suggesting IPS e.max Press crowns – so LDS – had the best behaviour in a follow-up of three years in a study of materials used in wear management. (44) Thanks to its good strength of adhesion to substrate, it usually is the first choice in partial coverage restorations. (45)

Zirconia is a very good material to choose for occlusal surface restoration even if its toughness is high and the **high-strength zirconia ceramic** has been introduced in dentistry lately, possessing high dimensional stability and binding strength which made its use more frequent. Compared to the felspathic porcelain, it has more frictional resistance. Due to its high surface hardness, it was expected to cause excessive dental wear, however, it was less abrasive than feldspathic porcelain: Rosentritt *et al* haven't even found wear over enamel structure in their *in vitro* study. (6) As systematic review conducted by Guo *et al* has even revealed that well-polished monolithic zirconia was less abrasive to natural dentition than PFM restorations *in vivo*. (46) Nonetheless, it should not be used as monolithic crowns in the anterior sector because its aesthetics is not considered enough in this area, nor in palatal surfaces of anterior teeth because of its poor adhesive properties. (12) Because of that, its use is generally oriented to full coverage crowns and not to partial restorations. It still is considered as giving

good aesthetic, especially compared to PFM restorations, for less removal of healthy structure. (47)

c. Metal restorations

Etman studied materials for wear treatment and declared metal crowns were the ones causing the least TSL compared to feldspathic porcelain, PFM and glass-ceramic. (44) But they are not often chosen, especially in aesthetic areas, because of their colour. They tend to be used on palatal surfaces of anterior teeth in wear management. (47)

d. PFM restorations

They have good strength and acceptable aesthetic. (47) PFM restorations in the anterior were considered, adding metal in palatal surfaces to allow a lesser reduction of healthy dental structure during the preparation and have a material that is resistant and not causing wear in occlusion. However, in those areas, their aesthetic is considered too low. (12) Moreover, the porcelain material used is often feldspathic which is highly abrasive for the antagonist dentition and the preparation for the whole structure is very invasive, especially compared to the new all-ceramic restorations introduced in the market.

Gold and ceramic have shown similar resistance in laboratory trials, being three to four times less susceptible to wear than composite resin. From there, the usual choice for high load conditions is metal or metal-ceramic restorations but if the case is extreme, it seems there is no material capable of withstanding such forces in the long-term. (13)

Hamburger *et al* affirmed after having studied multiple ceramics, direct and indirect composite resins in severe wear that the choice of materials and techniques – direct or indirect – might be have to be based on the brands themselves because of the differences of manufacturing. (48) It should be kept in mind when it comes to the election of the appropriate material facing wear as a supplementary criteria.

3. Restorative materials requirements

The restorations' outcome rests on the physical properties of the chosen material and its location. Composite, acrylic and type III gold have the advantage of not causing wear to the antagonist teeth in opposition to the other materials: so in case of restorations on both opposing teeth, analogue materials should be used. (13) Ideally, to reduce as much as possible the abrasive properties of the different materials, it would be necessary to adequately polish the restoration, especially in areas that have been adjusted. (12)

The conventional metal-ceramic restorations require the biggest space, with up to 2mm in the occlusal surface. (13) The all-ceramic ones need less reduction, with the same amount for full-contour zirconia crowns and full metal crowns. (13) The adhesive metal onlays necessitate at least 1mm of occlusal diminution and adhesive metal palatal veneers require less, as they need a minimum of 0,7mm reduction according to the manufacturer and the implicated load. (13) As for direct resin composite, Poyser *et al* mentioned that a minimum thickness of 1.5-2mm placed in functional loading surfaces increased the restoration survival. (3)

The space can be acquired through different techniques among others:

- **Occlusal reduction of the treated teeth:** it should be done with care, especially in few remaining dental structures.
- **Reduction of opposing teeth:** done in the case those teeth are sound and the treated teeth shouldn't be reduced more.
- **Orthodontics**: appliances might be necessary when tooth and little axial movements are needed to offer localized prosthetic space. It is a controlled and predictable technique.
- **Crown lengthening surgery**: it helps increasing retention and resistance of the treated tooth, even if it does not technically create space.
- **Increasing the OVD:** it requires an adaptation of the occlusal scheme with reconstruction of one or both dental arches. It is very complex, time-taking and not the preferred option. (13)

4. According to wear Extension and Severity

a. Localized Tooth Wear

The studies for tooth wear management are mainly revolving around the localized form with big discrepancies when comparing the outcomes and the survivals of the restorations. (13)

The usual approach is oriented towards ceramic restorations which have shown good results in worn dentition, but nowadays the adhesive techniques with composite resin restorations

are starting to emerge, thanks to the advances regarding the physical properties of resin. It is reported that the annual failure of direct composite resin restorations goes from 0.7 to 26.3%. (13)

Studies were made to compare different options to deal with localized tooth wear. Gulamali *et al* came to the conclusion that composite resin restorations were a good option for the management of dental wear in the medium-term as they were the least destructive option for the remaining dental tissue and when failure is observed, the restorations could be repeated. (13) Gow and Hemmings compared direct and indirect composite resin restorations in predominantly erosive tooth wear patients and concluded indirect restorations did not present advantages over direct composite. (13) In 2020, a systematic review realized by Vajani *et al* revealed that direct hybrid composite resin could be considered as an applicable solution for worn teeth in the short to medium-term. (49) Mehta and Banerji have found evidence backing its use as medium-term solution for anterior aesthetic region. (37) Yanishen *et al* studied the wear of different materials and added that leucite was also a good option for the anterior region, providing good wear resistance. (50) So it seems that with the studies made on the different options, composite resins seem to offer acceptable results in localized wear, whether it is under direct or indirect form.

b. Generalized Tooth Wear

The old approach implied full mouth rehabilitation with cast indirect restorations with no proof of its efficiency and it could only be done when having fulfilled additional postgraduate training. Nowadays, direct composite resins seem to offer good clinical results,

when also being a less invasive option. The direct hybrid ones have shown acceptable results in posterior restorations too. (13)

In general, studies have been scarce about how to deal with the generalized form of wear, especially when comparing direct and indirect restorations.

Hamburger *et al* have studied direct composite resin as an option for severe dental wear due to erosion, bruxism or a combination of both and have concluded the direct hybrid composites were a good option for cases of severe tooth wear. (13) Roque *et al* have however performed a study about the exposure of composite resin to erosive agents such as hydrochloric acid, which has revealed that the surface roughness was affected when being repeatedly exposed. So they recommended that in patients with GERD among others, the composite restorations should be made of the smallest particles – nanohybrid ones – as they were the most resistant to those erosive factors. (51) Composite resins are the second option after ceramics for Daibs *et al* when facing acid exposure but there should always be previous measures taken to remove the erosive factors for any chosen materials for optimal results and durability of the restoration. (42) Milosevic and Burnside advanced that direct hybrid composite resin restorations were a predictable option in the management of generalized dental wear with low failure rates. (13) Vailati studied indirect palatal composite restorations and labial porcelain veneers in severely eroded teeth but only made conclusions upon observations on anterior teeth without taking into account the restored posterior ones; she found good clinical results for ceramic in erosive wear but due to the non-easy repair of the material in case of failure, especially in case of parafunction, it should be used with care. (13) One study focused on the comparison of composite resin, metal-ceramic and gold restorations in severe

generalized wear and showed 74.5% of cumulative survival estimates for indirect restorations versus 62% for direct restorations but there is not enough statistical significance; there were less failures for full gold crowns compared to the metal-ceramic ones, mostly due to biological complications. More fractures were observed in composite restorations. (13)

Indirect restorations, especially in ceramic, seem to offer a more stable occlusion in extended wear, notably when there's a change of OVD involved. Edelhoff *et al* performed an 11-year prospective clinical study that revealed that monolithic LDS occlusal onlays could be considered as a decent treatment option in severe generalized wear but there are not enough data to validate their long-term efficacy and survival. (52)

The data obtained on the generalized dental wear are very limited, especially due to the fact that parafunctional disorders were not taken into account in most of the studies whereas they highly influence the prognosis of the restoration. They mainly were carried out on short periods of time and there were divergences in the findings. So the good results found on composite resins are to be considered carefully and more clinical researches should be performed to have clearer results.

c. <u>Severely worn teeth</u>

They could be restored with conventional and adhesive techniques after having realized the proper restorability assessment, but some parameters should be evaluated more carefully in these cases:

- **Remaining enamel & dentine**: when presence of enamel, especially in the erosive pattern with the enamel ring, the tendency will be the use of adhesive techniques, even though the techniques of dentine adhesion are improving. (13)
- **Remaining clinical crown height:** conventional restorations will need sufficient dental structure for resistance and retention, depending on the amount of coronal dentine. This parameter is less imperative in the case of adhesive restorations. They generally need 50% of the initial tooth structure otherwise the success might be compromised. (13)
- **Pulp state:** the more a tooth loses structure, the more the exposition of dentinal tubules, increasing the susceptibility to be affected by bacteria. And the preparation required for conventional restorations can create physical and thermal stimuli possibly initiating pulp pathologies. (13)

Researches have shown there were no statistically significant difference regarding the survivals of composite resin when placed directly and indirectly in old patients with advanced dental wear, with a lower durability for the direct ones. Composite resin could be a good alternative as in case of failure, the repair is not as critical as it is for crowns, often involving endodontic treatments or extractions. (53) Hamburger *et al* said it offered the best performance to restore severely worn teeth in the direct technique. (48)

But for now, crowns are still the most common treatment option for severely worn teeth and give adequate results. Studies about indirect ceramic and composite restorations are still not being conclusive enough about their efficiency in severe wear and need further research. (3)

If the outcome of the treatment relies on the choice of the proper restoration and material, it also depends on the identification of the patient's worries regarding his/her teeth, whether they are sensitivity or aesthetic concerns. It needs to be discussed so the patient understands the importance of being treated, it helps getting him/her more involved so that the treatment and the new measures adopted are followed. (2)

Most patients have a preference for more conservative options involving resin composite restorations against the ones in porcelain, considered as a more destructive option. They see resin composite as being conservative, predictable and aesthetic enough. (2)

CONCLUSIONS

1. Dental Wear is characterized by a loss of tooth surface non associated to caries, with a pattern specific to each type – attrition, erosion, abrasion -, associated to dentine hypersensitivity, impaired function and change of OVD in the most severe cases.
2. Each type of wear has its own aetiologies: attrition is primarily due to parafunctions as bruxism, erosion comes from acid exposure – intrinsically or extrinsically –, abrasion from the use of abrasive toothpastes and bad habits involving holding objects between teeth, all of this influenced by modifying factors.
3. To diagnose wear, patient's anamnesis and exploration are needed, combined to qualitative methods involving indexes, the BEWE being the easiest to use and the TWES being very promising for the future, and additional quantitative methods where the IOS seems to offer good results for daily application in the dental office. To this day, no measure technique has been elected as gold standard.
4. The minimally invasive methods should be used for the management of wear, as prevention through monitoring and advice, followed by restorative treatments when symptoms have appeared and at the patient's will. Composite resin and ceramic restorations offer good results according to the severity, location and etiology of the wear, the first one beginning to be used more thanks to the advances in its manufacturing and adhesion techniques. However, further studies are needed to assess the efficacy of each management option as none has been universally accepted as the ideal solution.

This work has a purpose that is in line with economic sustainability with its will to make dental professionals more informed about a problem that is very common in the dental office and often ends up being treated when too advanced. All the different measurement methods reviewed and ways to diagnose dental wear early participate in a precocious management of the condition, allowing not only to save dental structures and avoid further damage but also to be cost-effective, with much simpler and cheaper measures than if identified too late.

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GLOSSARY

ACE: Anterior Clinical Erosive Classification

BEWE: Basic Erosive Wear Examination

CAD/CAM: Computer-Aided Design / Computer-Aided Manufacturing

EVA: Ethylene-Vinyl Acetate

GORD: Gastro-Oesophageal Reflux Disorder

IOS: Intraoral Scanner

LDS: Lithium Disilicate

OCT: Optical Coherence Tomography

OVD: Occlusal Vertical Dimension

PFM: Porcelain-Fused-to-Metal

PPMA: Polymethylmethacrylate

QLF: Quantitative Light-Induced Fluorescence

RVD: Resting Vertical Dimension

SSRIs: Selective 5-hydroxytryptamine Reuptake Inhibitors

TSL: Tooth Surface Loss

TWES: Tooth Wear Evaluation System

TWI: Tooth Wear Index

USPHS: United States Public Health Service

ANNEXES

Ken Hemmings

Angharad Truman, Sachin Shah and Ravi Chauhan

Tooth Wear Guidelines for the BSRD Part 1: Aetiology, Diagnosis and Prevention

Dent Update 2018; 45: 3–10

Tooth wear (TW) is a common condition affecting patients who often require advice and treatment from dentists. Physiological TW is normal and accepted by most patients. Pathological TW, by virtue of symptoms or rapid wear, will prompt the need for dental care. It can range from mild sensitivity from an abrasion lesion to gross destruction of the dentition. Similarly, treatment can range from simple operative care to full mouth reconstruction with crowns or complex dentures. Too little or too much treatment can lead to tooth loss and patient complaints.

These guidelines are designed to help dentists manage tooth wear. A selected literature review covers three sections:

1. Aetiology, diagnosis and prevention of tooth wear;
2. Fixed management of tooth wear;
3. Removable management of tooth wear.

Each section is concluded with a summary of key points which can act as a quick reference checklist for the busy practitioner. It is hoped that effective treatment or advice given at the right time can reduce the amount of long-term maintenance care required in the future. However, it is acknowledged that some severe bruxist patients will always require regular repairs or replacement restorations.

Guidelines become out of date immediately they are published. The society will review and update these guidelines on a 3-yearly basis. The work that the authors have put in to draft these guidelines is gratefully received. The British Society of Restorative Dentistry (BSRD) Council and members of the society are also thanked for their comments in improving the document. Effective treatment does exist and it is most gratifying to make a dramatic difference to patients with tooth wear when guidance is provided.

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Definition

Tooth wear, or as it is also often referred to as non-carious tooth surface loss (TSL), can be described simply as 'the pathological non-carious loss of tooth tissue'.[1]

The distinction between pathological and physiological TW can be difficult to determine. Wearing of the teeth is a normal physiological process. The estimated normal vertical loss of enamel from physiological wear is thought to be approximately 20–38 µm per annum.[2] It is important to remember that just because a tooth has some element of wear this does not always necessitate treatment. Tooth wear may be regarded as pathological if the rate of wear is greater than that expected for the patient's age, the patient has concerns over the wear or the prognosis of the tooth is compromised due to the wear.

Tooth wear is often multifactorial in nature and can be difficult to distinguish between, but it is often subdivided into:

- Attrition;
- Erosion;
- Abrasion; and
- Abfraction (abfraction is often described but, as yet, is not universally accepted as a true form of tooth wear).

Attrition

'The loss of tooth substance or a restoration as a result of mastication or contact between occluding surfaces of approximal surfaces'.[1]

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Review Article

Biologically Based Restorative Management of Tooth Wear

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The prevalence and severity of tooth wear is increasing in industrialised nations. Yet, there is no high-level evidence to support or refute any therapeutic intervention. In the absence of such evidence, many currently prevailing management strategies for tooth wear may be failing in their duty of care to first and foremost improve the oral health of patients with this disease. This paper promotes biologically sound approaches to the management of tooth wear on the basis of current best evidence of the aetiology and clinical features of this disease. The relative risks and benefits of the varying approaches to managing tooth wear are discussed with reference to long-term follow-up studies. Using reference to ethical standards such as "The Daughter Test", this paper presents case reports of patients with moderate-to-severe levels of tooth wear managed in line with these biologically sound principles.

1. Introduction

Tooth wear (TW), also known as tooth surface loss (TSL), is an insidious and cumulative multifactorial process involving destruction of enamel and dentine which can threaten tooth survival and the oral health related quality of life of affected individuals [1, 2]. Despite the overall trends towards improved oral health and reduced dental caries incidence over the last decades, epidemiological evidence supports the contention that TW is increasing in severity and prevalence, not only amongst older people who are living longer and retaining more teeth, but also amongst those in the early decades of their adult life [3, 4].

Greater understanding of the pathophysiology of TW has driven advances in dental materials and techniques for the benefit of affected patients. These advances have led to biologically based prosthodontic strategies that challenge many traditional or currently prevailing concepts of TW management. This is especially the case when one considers the ethical health care maxim: "Firstly, do no harm" (Primum est non nocere). Adopting biologically sensible TW management strategies will ensure that as much good as possible is achieved for the patient (beneficence) whilst avoiding harm (nonmaleficience) and upholding the patients' rights to have the reasonable treatment undertaken that most closely matches their wishes and expectations (autonomy). Traditional concepts must now be reassessed in order to achieve a radical paradigm shift in the philosophies behind TW management.

This paper will therefore, review the fundamental principles that should be considered when deciding how to manage patients with TW. The current state of knowledge of the aetiology and differential diagnoses of TW will be discussed, followed by an analysis of patient wishes and expectations when seeking sensible solutions for their TW problems. The relative risks and benefits of the possible management options will then be weighed up with reference to current available evidence. Possible solutions which aim to put patients' long-term interests first will be outlined with reference to ethically sound healthcare principles and using some case examples.

2. Aetiology and Differential Diagnoses of Tooth Wear (TW)

There are three main, or widely recognized, aetiologies of TW, namely, erosion, attrition, and abrasion [5]. There is a fourth aetiological factor which has been recognized by some

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Principles and guidelines for managing tooth wear: a review

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Abstract

Non-Carious Tooth Surface Loss (NCTSL) is considered as a current issue of concern. It's management is challenging. Through this paper, the focus will be put on the different forms, locations and causes. Emphasis is placed on the importance of a thorough examination and indexing to assess the severity of tooth wear.

A systematic and integrated approach leads to favorable and predictable prognosis. We aim to provide clear recommendations on the best treatment strategy and simplified guidelines to succeed tooth wear management? considering the patient's expectations, the esthetic demand as well as the risk profile.

The patient should be fully informed. Restoration of severe tooth wear should ideally be delayed as long as possible.

The different treatment modalities will be discussed according to the localization and the severity of tooth wear.

The conservative, minimally invasive restoration, should first be considered.

Introduction

Non-Carious Tooth Surface Loss (NCTSL) also termed Tooth Wear (TW) is a current issue of concern to dental practitioners regarding the diagnosis, identification of the etiological factors, prevention, and execution of an adequate treatment [1,2].

It is a physiological process that occurs as part of the aging process [1,3], causing an enamel loss of between 28-30 µm per annum as proved by Van't Spijker et al., in 2009 [4].

Whereas, in 2013, Bartlett et al confirmed that practitioners are often faced with patients suffering from Tooth Substance Loss (TSL). When it compromises tooth survival or when it is disproportionate to the presenting age, it is therefore, referred as to being pathological [5].

Indeed, various forms of TW that commonly occur are linked to: diet, bruxism, parafunctional activity and so on. This leads to the loss of hard tissues [6,7] because of the combination of mechanical and chemical processes.

TSL forms do not include trauma, or bacteria [2] or developmental disorders [8]; they are currently considered challenging when it comes to their management. (Figure 1)

Tooth Wear prevalence

The precise prevalence of TSL is hard to establish due to differences in assessment criteria complicated by coexisting factors [7].

As expected, all studies showed an increase in prevalence that goes with age [9,6].

Van't Spijker et al. 2009 showed an increase in the prevalence of severe tooth wear in the adult population from 3% (at 20 years of age) to 17% (at 70 years of age [4].

In 2013, Bartlett et al. proved that 29% of the European adults aged 18–35 years old presented NCTSL [5].

As for the children and adolescents, authors have also noticed that they do not exhibit severe attrition [sh1], but there are indications of wear, mainly because of dental erosion [10,11].

Classification

According to Grippo classification established in 1991, four types of surface loss have been identified and distinguished by the different causes [12].

1) Attrition

Attrition is defined as the wearing away of tooth substance (or restoration) due to tooth to tooth contact [9]

It can be mostly remarkable in patients with a vegetarian diet. It is generally associated with parafunctional activity. [3].

The wear from attrition may be localized on the occlusal surfaces of posterior teeth, the palatal surfaces of maxillary anterior teeth, the

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Key words: *Abrasion, Attrition, Abfraction erosion, Tooth wear, Prevention, Restorative treatment*

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Tooth wear: causes, diagnosis and prevention

A combination of patients keeping their teeth longer due to more preventative approaches and advances in materials and techniques has led to an increase in incidence of tooth wear. This article describes the incidence, causal agents, lifestyle factors and how tooth wear can be identified and prevented

Tooth wear is a general term that describes the loss of hard tissues from the surface of teeth caused by factors other than dental caries, trauma or developmental disorders (Mehta et al, 2012). It is a normal physiological process that is incremental with age and is macroscopically irreversible. Normal vertical loss of enamel from physiological wear is approximately 0.02–0.04 mm a year (Lambrechts et al, 1989).

Tooth wear is considered excessive when it causes functional or aesthetic concerns to the patient, is disproportionate for their age or causes symptoms of discomfort. If the degree of tooth wear is so severe that it causes recurrent symptoms or presents a considerable restorative challenge then it is deemed 'pathological' tooth surface loss.

Incidence

The percentage of adults presenting with severe tooth wear generally increases from approximately 3% in young people in their early 20s, to 17% in those over the age of 70 (Van't Spijker et al, 2009). However, of particular concern is the alarming rate of tooth wear that is now been seen in children and young adults. This problem was first noted in the Children's Dental Health survey of 1993, when children under the age of 5, especially those consuming carbonated drinks, showed signs of abnormal erosion. It also reported that almost half of the 5- and 6-year-olds demonstrated signs of erosion affecting the primary dentition, with almost 25% showing signs of dentinal or pulpal tissue involvement, while 25% of 11-year-olds and 32% of 14-year displayed signs of erosion affecting the palatal surfaces of their maxillary incisor teeth (O'Brien, 1994).

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Figure 1. Carbonated soft drinks are a major factor in tooth wear in children and young adults

Causal agents

Erosive tooth wear is caused by acidic substances from either the stomach or from an external (usually dietary) source. The increasing consumption of soft drinks in the UK is believed to be a significant factor in the rising levels of child and adolescent tooth wear (Mehta et al, 2012) (see *Figure 1*). Sales of these beverages multiplied seven fold between the 1950s and 1990s (Shaw and Smith, 1994), with adolescents and children accounting for 65% of all purchases, with a reported per capita intake of 15 litres per person (see *Table 1*).

The ingredients of these drinks responsible for erosive activity are acids, such as citric, malic and phosphoric acids. However, the damaging nature of these drinks is not wholly down to the pH, the buffering capacity (resistance to pH change) of the substance extends its erosive qualities, while the calcium chelating or binding capacity prevents the neutralisation of the acidic substance by saliva (Zero and Lussi, 2005).

Another factor which may be responsible for some of the increased rates of erosive tooth wear is voluntary regurgitation, which is frequently seen among patients with eating disorders such as bulimia nervosa.

Clinical history

The initial management of any case of tooth wear (*Figure 2*) is based on deriving an accurate diagnosis, the identification of possible causative factors, the prevention of further damage and monitoring change throughout the

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Methods of Wear Measuring in Dentistry

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Abstract: *Wear in dentistry affects both the natural tooth structure as well as reconstructive materials that replace them. For perfect understanding of the properties and the correct indication of dental materials it is necessary to understand their wear mechanism. Wear of hard dental tissues and dental reconstructions can be measured in vivo or in vitro. In developing of new materials their investigation using different devices is especially important. It's the first system to distinguish inappropriate material that could in extreme cases threaten the patients. It is also an orientation aid for the dentist with respect to be able to compare materials without distorting by the patient individuality. In doing so, it should be kept in mind that it is impossible strictly use only laboratory or clinical tests, but it is always necessary to combine them. In the paper the authors descript the measuring methods of hard dental tissues and dental reconstructions wear.*

Keywords: *filling materials wear, nanoindentation, scratch test, microscopy, wear indices*

I. Introduction

One of the physiological properties of hard dental tissues is their natural wear throughout the life. Besides physiological wear, there is also aware a pathological wear that also affects the surface of filling materials substituting the enamel and dentin. The mechanism of tooth wear lies in the interplay of various factors such as the mechanical load due to compression, flexion and tension, friction and chemical influences. Rarely these factors operate separately, so the term multifactorial nature of hard dental tissues wear is mostly used. A similar effect these factors have on restorative materials. For the correct choice of dental restorative material it is important to understand perfectly their chemical and mechanical properties, as well as take into account their wear during exposure to the effects described above. For example, an incorrect choice of too hard materials can result in wear of antagonists due to attrition. The use as a substitution for hard dental tissue of the material that is not quite resistant against the acidic environment of the oral cavity, occurring in patients with frequent vomiting, reflux, or after consumption of large amount of acidic foodstuffs and drinks, could eventually lead to the failure of reconstructive therapy and the need for making of new restorations. Wear of the tooth surface and reconstructive materials can be measured in in vivo and in vitro conditions.

II. Measuring in Vivo

2.1. Measuring of Tooth Wear- Wear Indices

For the determination of hard dental tissues wear degree different indices are used. The most commonly used index is a tooth wear one according to Smith and Knight (1) (Table 1) distinguishing the wear of incision edge, occlusal surfaces as well as the cervical area of the teeth.

Table 1 Tooth Wear Index (TWI) according to Smith and Knight (1)

Score	Tooth surface	Criteria
0	Labial/oral/occlusal/incisal Cervical	Without signs of enamel loss Without signs of crown contours loss
1	Labial/oral/occlusal/incisal Cervical	Loss of enamel surface relief Minimal loss of crown contours
2	Labial/oral/occlusal Incisal Cervical	Loss of enamel; dentin baring less than 1/3 of surface Loss of enamel with minimal baring of dentin The depth of defect is less than 1 mm
3	Labial/oral/occlusal Incisal Cervical	Loss of enamel; dentin baring more than 1/3 of surface Significant loss of enamel and dentin The depth of defect is 1–2 mm
4	Labial/oral/occlusal/incisal Cervical	Extensive loss of enamel and dentin with baring of dental pulp The depth of defect is more than 2 mm; baring of dental pulp

Review Article

Tooth surface loss revisited: Classification, etiology, and management

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ABSTRACT

Tooth wear is a general term describing the loss of dental hard tissues from the surfaces of the teeth. As the lifespan of individuals increase and the teeth are increasingly retained for life the incidence of non-carious tooth surface loss has also shown a rise. Little is understood about the aetiology and management of these lesions and there are several occasions where the condition is often neglected. The prevalence of tooth surface loss is difficult to establish and the reported clinical and epidemiological data are difficult to compare, due to differences in terminologies and many indices involved. The purpose of current review is to focus on the classification, aetiology and management of common non-carious conditions causing tooth surface loss.

Keywords: Tooth surface loss, tooth wear, parafunction

INTRODUCTION

Tooth wear is a general term describing the loss of dental hard tissues from the surfaces of the teeth caused by factors other than dental caries, trauma, and developmental disorders.[1,2] Attrition, erosion, and abrasion usually cause alterations of the tooth surface and manifest as tooth wear. These processes act by distinct progressions and exhibit unique clinical characteristics [Figure 1].

Prevalence of tooth surface loss is increasing and younger patients are said to be at higher risks. The particular concern is the alarming rate of tooth wear that is now been seen in children and young adults. This was first noted in the Dental Health Survey of children in 1993, when children under the age of 5, especially those consuming carbonated drinks, showed signs of abnormal erosion.[3] The problem is likely to continue as patients' demands and expectations rise and healthy natural teeth are retained during the old age. For many years, erosion was a condition which invited little interest in clinical dentistry, community health services, and in dental research.[4]

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Physiological wear causing vertical loss of enamel in a normal individual is approximately 0.02–0.04 mm a year[5] and wear is considered excessive when it causes esthetic concerns to the patient and causes symptoms of discomfort. Once the amount of tooth wear becomes so severe that recurrent symptoms are caused, then it is deemed 'pathological' tooth surface loss and becomes a challenge for a restorative dentist. The challenges faced during the clinical management of patients with tooth wear has raised considerable professional interest as its impact could be severe and may also affect an individual's quality of life.

EPIDEMIOLOGY

The proportion of adults with severe tooth wear generally rises from approximately 3% in young people in their early 20s and to 17% in those over the age

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REVIEW

The evolution of tooth wear indices

Penny Fleur Bardsley

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Abstract Tooth wear—attrition, erosion and abrasion—is perceived internationally as an ever-increasing problem. Clinical and epidemiological studies, however, are difficult to interpret and compare due to differences in terminology and the large number of indices that have been developed for diagnosing, grading and monitoring dental hard tissue loss. These indices have been designed to identify increasing severity and are usually numerical. Some record lesions on an aetiological basis (e.g. erosion indices), others record lesions irrespective of aetiology (tooth wear indices); none have universal acceptance, complicating the evaluation of the true increase in prevalence reported. This article considers the ideal requirements for an erosion index. It reviews the literature to consider how current indices have evolved and discusses if these indices meet the clinical and research needs of the dental profession.

Keywords Tooth wear · Tooth wear indices

Introduction

There is both a clinical and a scientific need to be able to measure tooth wear, and the literature abounds with many methods which can be broadly divided into quantitative and qualitative in nature. Quantitative methods tend to rely on objective physical measurements, such as depth of groove, area of facet or height of crown. Qualitative methods, which rely on clinical descriptions, can be more subjective if appropriate training and calibration are not carried out but which, with correct safeguards, can be valuable epidemiological tools. In a clinical intra-oral examination, there will be an inclination towards descriptive assessment measures, such as mild, moderate or severe, rather than quantitative measurement, which is easier to perform reliably on a model or in the laboratory. Such methods tend to be more sensitive but do not lend themselves readily to clinical use—especially in epidemiology, where fieldwork data collection is often carried out in an environment lacking sophisticated equipment.

Quantitative and qualitative methods typically utilise grading or scoring systems designed to identify increasing severity or progression of a condition; these are described as indices and are usually numerical. An ideal index should be simple to understand and use, clear in its scoring criteria and be demonstrably reproducible. Its application should be useful for research into the aetiology, prevention and monitoring of a condition, essentially being an epidemiological and clinical tool.

Review of the literature reveals the fact that many different tooth wear indices have been developed for clinical and laboratory use all over the world. Unfortunately, the production of so many indices does not allow for ready comparison of results between different working groups, and this is especially important in epidemiology when trying to define the prevalence of a condition. Confusion is further generated in the literature as the majority of researchers, in their attempts to quantify the amount of tooth tissue loss due to tooth wear, have historically concentrated on one aetiology only, and these indices tend to be surface limited. Often, the wear patterns described do not appear to reflect the aetiology suggested, and this relates to lack of uniformity with tooth wear terminology and translation errors. Many diagnostic indices do not properly reflect the morphological

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Victor Ka Cheong Yim

Tooth Wear: Screening, Diagnosis and Management in General Dental Practice

Abstract: : Recent epidemiological data shows that the prevalence of tooth wear (TW) is increasing. Current available assessment tools are either too complicated to carry out on every patient or inadequate in identifying the nature of the condition. Moreover, early onset or localized lesions may be overlooked. This article describes a screening tool which may overcome these problems. This tool involves using the existing Basic Erosive Wear Examination scoring system and a proposed age-related grid. This will lead to an associated pathway, which indicates the recommended level of further investigations and management.

CPD/Clinical Relevance: Early identification and prevention of pathological tooth wear in the primary care setting is the key to slowing down the disease progression.

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Tooth wear (TW) or Tooth Surface Loss (TSL) is used to describe the progressive loss of dental hard tissue by chemical and mechanical actions other than those caused by caries or trauma. It is a multifactorial process comprised of erosion, attrition, abrasion and abfraction.[1]

In England, Wales and Northern Ireland, improved dental health awareness and dental services in the last 30 years have reduced edentulous adults from 28% in 1978 to 6% in 2009. Compared with 30 years ago, the percentage of adults aged 45–50 who have over 20 natural teeth increased nearly two-fold (Figure 1).[2] Because natural teeth now survive for longer, the impact of TW is critical to the ageing population. The overall prevalence of tooth wear has increased since 1998.[3] The increase of anterior TW in the younger group, aged 16 to 24, was significantly higher than the older groups.[3] Fortunately, the prevalence of TW-related dentine and pulp exposure for children aged 12 to 15 remains at a low level.[4] This supports the fact that TW is not aggressive, but rather a slow process. Therefore it requires long-term preventive and monitoring strategies. The earlier the disease or potential risk is identified, the more likely a well-designed management regimen would be successful.

The aim of this article is therefore to describe a screening tool, which involves using the current Basic Erosive Wear Examination (BEWE)[5,6] and a proposed age-related Red-Amber-Green (RAG) grid. This tool aims at effectively identifying the pathological or physiological nature of TW. According to the nature, one of the three management pathways can then be followed. The recommended additional investigations would inform a sound individualized dynamic diagnosis. A fit for purpose preventive, monitoring and restorative plan can then be formulated.

Victor Ka Cheong Yim, BDS(HK), MFGDP(UK), FRACDS(Aus), DPDS(Brist), MFDSRCPSG, MSc(Restorative Aesthetic Dentistry)(UManc), Associate Dentist at Park Lane Dental Clinic, Hong Kong (during preparation of this article).

Initial assessment – screening

During routine dental examinations, patient's complaints (Table 1) and histories (Figure 2) may already highlight the condition of TW.

Indices have been used in the past to assess the severity of tooth wear. Table 2[5-9] summarizes the four most popular ones used in previous research.[10] Clinically, it is impractical for busy general dental practitioners (GDPs) to carry out full TW charting for every patient as a part of their examination. Therefore, the simple and quick BEWE (Table 3) is ideal for screening purposes. In addition, the associated management guideline (Table 4) also provides clear guidance according to different cumulative scores.[5,6] Although the BEWE was originally developed to examine and record the severity of erosive wearing lesions, it was validated to assess all types of TW.[11] Nonetheless, the BEWE management

PREVENTION AND MANAGEMENT OF TOOTH WEAR: THE ROLE OF DENTAL TECHNOLOGY

JAMES IJ GREEN

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Figure 1: Attrition caused by bruxism

ABSTRACT

Tooth wear is a multifactorial condition and the term is used to describe all types of non-carious tooth substance loss: abrasion (produced by interaction between the teeth and other substances), attrition (produced during tooth-to-tooth contact), erosion (produced by a chemical process) and abfraction (produced through abnormal occlusal loading that predisposes tooth substance to mechanical and chemical wear). Dental technology has an important role in preventing, managing and monitoring tooth wear in a variety of ways. Hard poly(methyl methacrylate) or soft ethylene-vinyl acetate splints can be prescribed to alleviate bruxism, the most common cause of attrition. Thermoformed appliances can be used for the application of products that reduce dental erosion such as fluoride gel. Patients with significant tooth surface loss may require laboratory-made restorations, as well as removable appliances with bite planes that generate inter-occlusal space to facilitate restorations, or surgical templates to provide guidance in preparing restorations for those requiring surgical crown lengthening. Dental study models and digitised models can also prove valuable in terms of monitoring the condition. This paper presents a review of the role that dental technology plays in tooth wear prevention, management and monitoring.

Introduction

The term 'tooth wear' describes all types of non-carious tooth substance loss.[1] This has been seen in archaeological artefacts, predating the appearance of caries, and can also be more difficult to prevent.[2] There are four types of tooth wear and these describe specific aetiological factors:

- Abrasion is tooth substance loss through abnormal mechanical processes that involve foreign objects or substances repeatedly introduced in the mouth and contacting the teeth. This is most commonly attributed to tooth-brushing.
- Attrition is tooth substance loss resulting from tooth-to-tooth contact with no foreign substance intervening.
- Erosion is tooth substance loss by a chemical process that does not involve bacteria and is not directly associated with caries or mechanical or traumatic factors.
- Abfraction is a term proposed to describe tooth substance loss by flexure and failure of tooth substance from occlusal loading at a location away from the loading, most typically the cervical enamel.[3]

Dental technology has a role in terms of preventing and reducing tooth wear, providing restorations for those with a significant loss of tooth structure as well as removable appliances to assist with this restorative work. Dental study models can also be used for long-term monitoring of the condition.

KEY WORDS

Bruxism, Occlusal Splints, Orthodontic Appliances, Preventive Dentistry, Tooth Abrasion, Tooth Attrition, Tooth Erosion, Tooth Movement, Tooth Intrusion, Tooth Wear

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Preventing and reducing attrition and bruxism

Attrition is most commonly caused by bruxism (see Figure 1). While there is no widely accepted definition,[4] bruxism has been defined as "the grinding or clenching of teeth at other times than for the mastication of food."[5]

Forces generated during a bruxism episode can be six times greater than during normal mastication.[6] Dental appliances can prevent this[7] by distributing the force across the masticatory system and reducing the frequency, but not the intensity, of bruxism.[8] Muscle activity is likely to return to its previous level once the appliance is removed[9] so should be worn continuously.[10] Because of this, appliances should cover the occlusal surfaces of all teeth in the arch, as partial coverage can lead to overeruption of any exposed teeth. These appliances have many other applications and are commonly prescribed for the management of temporomandibular disorders.[11] They can be can be worn on the maxillary or mandibular arch and fabricated in hard or soft materials.

Hard splints

Hard acrylic splints are made from poly(methyl methacrylate) (PMMA; see Figure 2). Heat-polymerised acrylic should be used rather than the auto-polymerised (cold cure) variety due to higher strength and lower cytotoxicity,[12] especially if the appliance is intended

A guide to the clinical management of attrition

J. S. Rees*[1] and S. Somi[2]

Key points

- Discusses aetiology of attrition.
- Discusses signs and symptoms of attrition.
- Discusses clinical management of attrition including adhesive and conventional techniques.

Attrition is an enigmatic condition often found in older individuals and often as a result of bruxism which can take place as a result of either day bruxism, night bruxism or both. Various studies and systemic reviews clearly shown that tooth wear is an age-related phenomena and the last Adult Dental Health Survey showed that 15% of participants showed moderate wear and 3% severe wear with 80% of patients over 50 years of age showing signs of wear. This review examines current theories around the aetiological factors contributing to attrition together with the clinical management of attrition focusing on minimal intervention where possible.

Introduction

Attrition is formally defined as the loss of tooth substance caused by tooth-to-tooth contact so although it is predominantly seen occlusally, attrition can also occur interproximally as lateral movement of the teeth produces broader interproximal contacts over time[1](Fig. 1).

Typically, this type of wear is seen as marked wear facets with complimentary wear facets being seen in the upper and lower jaws. In very general terms, patients often tend to brux in an anterior/posterior direction or in a lateral direction. If they tend to brux anterior/posteriorly marked matching wear facets are often seen on the anterior teeth and if they brux laterally marked matching wear facets are seen affecting the upper and lower canines (if the patient has a canine guided occlusion), and wear facets may be seen on the premolars and molars if the patient has a group function occlusion. With more advanced wear a patient may 'convert' themselves from a canine guided occlusion to a group function type occlusion, once wear of the canines allows contact of the posterior teeth in lateral excursion.

It is also important to realise that erosion may be superimposed or coexist with attrition/abrasion and this is often seen with patients who consume significant numbers of oranges for example. The citric acid within the oranges[2] can cause erosion while the fibrous structure of the fruit can cause abrasion and this is often seen on lower molars. In this scenario, once the occlusal dentine is exposed then the tooth wear may accelerate as dentine tends to be lost two to five times faster than enamel.[3]

Fig. 1 Examples of attrition

Diagnosis

The signs and symptoms typically found in a patient presenting with attrition are outlined below.[4]

Symptoms

- Tooth grinding at night
- Jaw pain, fatigue and limited opening on waking
- Teeth feel loose (localised or generalised)
- Sore teeth or sore gums
- Headaches in the temporal region
- Grinding or clenching of the teeth while awake.

Clinical signs

- Tooth wear and marked wear facets, particularly in protrusion or lateral excursion
- Tooth fractures – natural teeth or restorations
- Tooth mobility
- Pulp necrosis – as loads cause limitation of blood supply
- Traumatic ulcers
- Linear alba.

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The Role of Oral Hygiene: Does Toothbrushing Harm?

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Abstract

Although toothbrushing is considered a prerequisite for maintaining good oral health, it also has the potential to have an impact on tooth wear, particularly with regard to dental erosion. Experimental studies have demonstrated that tooth abrasion can be influenced by a number of factors, including not only the physical properties of the toothpaste and toothbrush used but also patient-related factors such as toothbrushing frequency and force of brushing. While abrasion resulting from routine oral hygiene can be considered as physiological wear over time, intensive brushing might further harm eroded surfaces by removing the demineralised enamel surface layer. The effects of brushing on eroded dentine are not fully elucidated, particular under in vivo conditions. However, there are indications that brushing after an acid impact causes less additional hard tissue loss in dentine than in enamel. Toothbrushing frequency and force as well as toothbrush hardness were shown to act as co-factors in the multifactorial aetiology of non-cervical carious lesions. In vitro studies showed that toothbrushing abrasion is primarily related to the abrasivity of the toothpaste, while the toothbrush acts as a carrier, only modifying the effects of the toothpaste. The benefits of normal oral hygiene procedure exceed possible side effects by far, but excessive toothbrushing – especially of eroded teeth – might cause some harmful effects.

Toothbrushing is generally considered to be a safe and effective means for maintaining oral health [1]. In situ studies have reported clinically irrelevant levels of enamel loss (0–0.5 µm enamel loss after 28 days [2] and 0.5–0.7 µm after 6 months of simulated normal hygiene [3]). In contrast, dentine is less resistant to abrasion and 35–45 µm of dentine loss after 6 months of normal oral hygiene were reported [3]. Extrapolation to 10 years of normal toothbrushing reveals enamel and dentine losses of around 20 µm and 1 mm, respectively.

Although anecdotal reports about the severe misuse of oral hygiene products are rare [4, 5], clinical studies have shown some correlation between toothbrushing frequency [5, 6], brushing force or toothbrush bristle hardness [7] and the development of non-carious cervical defects. Only very few clinical or in vivo studies on the effect of combined chemo-mechanical impacts on dental hard tissue exist. However, a number of in vitro and in situ studies have shown that toothbrushing might further harm the surface of eroded enamel and dentine. In vitro, short-term erosive challenges (1–3 min) leave a partially demineralised and softened enamel surface layer of up to several hundred nanometres behind, which is

La importancia de los materiales en el mantenimiento de la oclusión (Dr.Ernest Mallat)

Dr. Ernest Mallat Articulos científicos, Carillas palatinas, Cerámica, Dimensión vertical, Disilicato de litio, Materiales dentales, Oclusión, Prótesis fija, Prótesis parcial removible, Prótesis sobre implantes, Sobredentaduras sobre implantes Nov, 25, 2018 No Comments

En este post describo la importancia de seleccionar adecuadamente los materiales restauradores. , siempre teniendo en cuenta el antagonista con el que ocluirán, con el fin de conseguir que la oclusión se mantenga en el tiempo y no se vea alterada ya sea por la excesiva dureza del material restaurador ya sea por su baja resistencia al desgaste.

Antes de iniciar una rehabilitación y decidir el material restaurador es conveniente conocer la dureza del propio material restaurador. La importancia de este aspecto en el futuro de nuestro tratamiento se muestra en estas dos imágenes. Se trata de una paciente, misionera, tratada con una rehabilitación completa de oro-resina 42 años antes de estas imágenes (el tratamiento fue realizado por el Dr.Ernest Mallat Desplats). Durante estos 42 años ha vivido en África y no se le pudo realizar ningún seguimiento. Pasado este tiempo, acude a la consulta y se puede observar que la arcada antagonista presenta un desgaste que podría ser considerado absolutamente natural en una persona cercana a los 70 años (similar al que presentaría si la arcada superior hubieran sido dientes naturales). El éxito en este tratamiento se debe, además de al trabajo del odontólogo y del técnico de laboratorio, a la buena elección del material restaurador.

Ken Hemmings

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Tooth Wear Guidelines for the BSRD Part 2: Fixed Management of Tooth Wear

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The management of tooth wear (TW) may often present a dilemma to the clinician. The clinical decision-making process between monitoring and active management can be difficult. Thorough history-taking and clinical assessment are essential parts of gathering sufficient information to allow the clinician and the patient to make these treatment decisions.

Uncontrolled tooth wear can lead to poor aesthetics, dentine hypersensitivity and functional problems, ultimately resulting in a reduced quality of life. Significant tooth structure loss can also lead to difficulties with any potential rehabilitation.[1] Patients often only become aware of their TW when the appearance of their teeth begins to deteriorate or they become symptomatic. Enamel may appear thin or discoloured, begin to fracture and the teeth may appear shorter.[2] Exposure of dentine can lead to transient pain in response to chemical, thermal, tactile or osmotic stimuli. This is commonly known as dentine hypersensitivity and may occur following loss of enamel with dentinal exposure secondary to tooth wear.[3] This pain can often be unsettling for the patient and may lead to limitation of the types of food or beverage ingested.

Loss of tooth structure can have many restorative implications. The need to conserve tooth structure, in particular enamel, remains vital to the predictability of adhesive restorations which are indicated, where possible, to avoid removal of more tooth structure, as is required with conventional crown and bridge work.[4] Further restorative difficulties can be encountered as TW causes loss of interocclusal space, thereby leaving limited space for the restorative material.

Uncontrolled tooth wear may ultimately result in decreased quality of life, affecting patients' satisfaction with their dentition, in particular; aesthetics, oral comfort and/or mastication.[5] Correct diagnosis is therefore critical for successful management of TW. The predominant aetiology should be determined and the patient concerns identified.[6] Although the rehabilitation of worn teeth is common clinical practice, there appears to be a stark absence of documented outcomes. It has been identified in numerous reviews that there is no strong published evidence on management strategies.[6,7] To date, most recommendations are based on published, evidence-based, expert opinion or observational studies, with a lack of high quality research supporting individual restorative measures for the replacement of tooth tissue.[7]

The decision to treat arises when the patient's needs, severity of the wear and potential for progression are of concern. There is a lack of evidence to suggest that the presence of TW will predictably lead to severe wear.[6] In the absence of aesthetic or functional issues, monitoring of the TW and preventive advice, including diet counselling, may be preferable.[8,9]

The preservation of tooth

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Perimolysis: case report

Perimólise: relato de caso clínico

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ABSTRACT

Perimolysis is a form of dental erosion, characterized by dental tissue demineralization without bacterial involvement. It can be of intrinsic or extrinsic origin. Extrinsic origin is considered when it is caused by excessive consumption of acid drinks and foods such as soft drinks, alcoholic beverages, acid fruit and prescription drugs for daily use. When caused by gastrointestinal disorders, such as those resulting from bulimia, anorexia nervosa and gastroesophageal reflux, it is considered of intrinsic origin. The acid action can cause erosion on palatal/lingual incisor surfaces, and occlusal and palatal/lingual posterior tooth surfaces causing pain (dental hyperesthesia). Treatment is often multidisciplinary, and the causes should be identified, eliminated or controlled. In dentistry, the approach must include preventive measures to reduce future risks, and restorative intervention using materials such as glass ionomer cement, resin composite, or endodontic and prosthetic rehabilitation in more complex cases. The aim of this study was to describe the restorative treatment in the case of a patient with this condition.

Indexing terms: *Acidity. Dental enamel. Esthetics. Tooth erosion.*

RESUMO

Perimólise é uma forma de erosão dentária, caracterizada pela desmineralização do tecido dental sem envolvimento bacteriano, de origem intrínseca ou extrínseca. É considerada de origem extrínseca quando causada pelo consumo excessivo de bebidas, alimentos e substâncias ácidas, como refrigerantes, bebidas alcoólicas, frutas ácidas e medicamentos de uso contínuo. Denomina-se intrínseca quando causada por distúrbios gastrintestinais como os que ocorrem como conseqüência da bulimia, da anorexia nervosa e do refluxo gastresofágico. A ação ácida pode causar erosão nas faces palatina/lingual dos incisivos e palatina/lingual e oclusal dos dentes posteriores levando a dor, ou seja, hiperestesia dental. O tratamento geralmente é multidisciplinar, devendo identificar e eliminar ou controlar as causas. A abordagem odontológica deve associar medidas preventivas para diminuir riscos futuros e intervenção restauradora utilizando materiais como cimento ionômero de vidro, resina composta ou até mesmo endodontia e reabilitação protética para casos mais complexos. Este trabalho teve como objetivo descrever o tratamento restaurador de um caso clínico de paciente com esta patologia.

Termos de indexação: Acidez. Esmalte dentário. Estética. Erosão dentária.

INTRODUCTION

Perimolysis is a form of tooth erosion, characterized by dental tissue demineralization without bacterial involvement; that is, wear or mineral loss from the tooth surface caused by chemical agents[1-2].

Mineral loss (erosion) from the tooth surface may lead to painful conditions (dentin/tooth hyperesthesia), with esthetic and functional compromise, factors that lead to the patient going to the dentist[1-4].

Areas of wear may be promoted by acid substances frequently coming into contact with the teeth. These substances may be of intrinsic or extrinsic origin [1,2,4]. Wear arising from extrinsic substances are very common nowadays, because of changes in the dietary habits of human beings, who now consume more products of industrial origin. In the majority of cases, these contain acid substances as preservatives that contribute to the appearance of perimolysis[5-6].

Among the main factors related to the type of diet involved in the high rates of tooth erosion are the consumption of citrus fruits, habit to suck acid or sour candies, in addition to the ingestion and continuous use of some medications, such as Vitamin C and acid mouth washes[7].

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Erosive tooth wear: Diagnosis, risk factors and prevention

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ABSTRACT: ***Purpose:*** To provide an overview on diagnosis, risk factors and prevention of erosive tooth wear, which is becoming an increasingly important factor when considering the long term health of the dentition. ***Results:*** Awareness of dental erosion by the public is still not widespread due to the cryptic nature of this slowly progressing condition. Smooth silky-glazed appearance with the absence of perikymata and intact enamel along the gingival margin, with cupping and grooving on occlusal surfaces are some typical signs of enamel erosion. In later stages, it is sometimes difficult to distinguish between the influences of erosion, attrition or abrasion during a clinical examination. Biological, behavioral and chemical factors all come into play, which over time, may either wear away the tooth surface, or potentially protect it. In order to assess the risk factors, patient should record their dietary intake for a distinct period of time. Based on these analyses, an individually tailored preventive program may be suggested to patients. It may comprise dietary advice, optimization of fluoride regimes, stimulation of salivary flow rate, use of buffering medicaments and particular motivation for non-destructive tooth brushing habits. The frequent use of fluoride gel and fluoride mouthrinse in addition to fluoride toothpaste offers the opportunity to minimize abrasion of tooth substance. (*Am J Dent* 2006;19:319-325).

CLINICAL SIGNIFICANCE: Since erosion, attrition and abrasion often occur simultaneously, all causative components must be taken into consideration when planning preventive strategies.

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Introduction

There is some evidence that the presence of dental erosion is growing steadily. Hence, erosive tooth wear is becoming increasingly significant in the management of the long-term health of the dentition. As lifestyles have changed through the decades, the total amount and frequency of consumption of acidic foods and drinks have also changed. Soft drink consumption in the USA increased by 300% in 20 years,[1] and serving sizes increased from 185 g (6.6 oz) in the 1950s to 340 g (12 oz) in the 1960s and 570 to g (20 oz) in the late 1990s. Between 56% and 85% of children at school in the USA (circa 1995), consumed at least one soft drink daily, with the highest amounts ingested by adolescent males. Of this group, 20% consumed four or more servings daily.[2] Particularly, studies in children and adults have shown that patients with more than four dietary acid intakes per day is associated with the presence and the progression of erosion when other risk factors (such as holding the drink in the mouth) are present.[3,4]

National dental surveys are not routinely undertaken and when conducted have seldom included measures of tooth wear, specifically erosion. Erosion was first included in the U.K. childrens' dental health survey in 1993 and is repeated periodically. The prevalence of erosion was shown to have increased from the time of the children's dental health survey in 1993 to the study of 4 to 18 year-olds in 1996/1997.[5] There was a trend towards a higher prevalence of erosion in children aged between 3.5 and 4.5 years; and in those who consumed carbonated drinks on most days, compared with toddlers consuming these drinks less often. In another U.K. study, 1308 children were examined at the age of 12 years and 2 years later. In ths study, 4.9% of the subjects at baseline and 13.1% 2 years later had deep enamel or dentin lesions. Twelve percent of erosion–free children at 12 years developed the condition over the subsequent 2 years. New or more advanced lesions were seen in 27% of the children over the study period.[6]

Awareness of dental erosion by the public is still not widespread, and the diagnosis of erosion by dentists and the differentiation from abrasion, attrition and abfraction may be difficult. In a survey in England, 34% of children surveyed were aware of tooth erosion but only 8% could recall their dentist mentioning the condition.[7] What is considered an acceptable amount of wear is dependent on the anticipated lifespan of the teeth, which is different for primary teeth compared to permanent teeth. However, erosive damage to the permanent teeth occurring in childhood may compromise the growing child's dentition for their entire lifetime and may require repeated and increasingly expensive restorations.[8]

Therefore, it is important that diagnosis of the tooth wear process in children and adults is made early and adequate preventive measures are undertaken. Early intervention can only be initiated when the risk factors as well as the biological and behavioral modifying factors are taken into account.

This review provides an overview for the clinical management of erosive tooth wear which includes the early diagnosis and monitoring, identification of risk factors and strategies for its prevention.

Diagnosis

Diagnosis in the early forms of erosive tooth wear may be easily overlooked, as it is accompanied by few signs and fewer if any symptoms. There is no device available in routine dental practice for the specific detection of dental erosion. Therefore, clinical appearance is the most important feature for dental professionals to diagnose dental erosion. This is of particular importance in the early stage of erosive tooth wear. The appearance of smooth silky-glazed appearance with the absence of perikymata and intact enamel along the gingival

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Review Article

Dental Erosion and Its Growing Importance in Clinical Practice: From Past to Present

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Since the mid-1990s, the focus of studies on tooth wear has steadily shifted from the general condition towards the more specific area of dental erosion; equally, a shift has occurred from studies in adults to those in children and adolescents. During this time, understanding of the condition has increased greatly. This paper attempts to provide a critical overview of the development of this body of knowledge, from earlier perceptions to the present. It is accepted that dental erosion has a multifactorial background, in which individual and lifestyle factors have great significance. Notwithstanding methodological differences across studies, data from many countries confirm that dental erosion is common in children and young people, and that, when present, it progresses rapidly. That the condition, and its ramifications, warrants serious consideration in clinical dentistry, is clear. It is important for the oral healthcare team to be able to recognize its early signs and symptoms and to understand its pathogenesis. Preventive strategies are essential ingredients in the management of patients with dental erosion. When necessary, treatment aimed at correcting or improving its effects might best be of a minimally invasive nature. Still, there remains a need for further research to forge better understanding of the subject.

1. Introduction

Interest in dental erosion and its role in tooth wear increased considerably since the mid-1990s. Early studies on tooth wear in humans were, in the main, based on teeth from archeologically obtained skulls. In later studies, contemporary adult populations were examined, but in neither the early nor the later periods of study, erosion was rarely, if ever, mentioned as a possible etiological factor [1] (Figure 1). The definition and diagnosis of dental erosion have not been agreed upon among researchers and clinicians, which can explain some of the confusion and perhaps the earlier lack of interest in the subject [2]. The diet of our ancestors was often tough and contained coarse particles, which required heavy chewing. The resulting wear facets were further influenced by the abrasive components of the food. Modern diets would appear to lack such abrasives but can contain acids, which can demineralize enamel and potentiate attrition and abrasion. Nevertheless, there are findings supporting the existence of dental erosion even in medieval populations [3, 4].

Although the terms attrition, erosion, and abrasion are the commonly accepted nomenclature used in dentistry to characterize tooth wear, the terms do not explain the wear process. Neither do they imply causation, instead describing clinical outcomes of a number of underlying events. In this regard, the science of tribology may more accurately characterize the process of tooth wear. There are several tribological mechanisms, although the mechanisms that apply in tooth wear may be explained in terms of two-body abrasion (typically attrition) or three-body abrasion interacting with an acidic or abrasive fluid/slurry (typically erosion and abrasion) [5].

The earliest form of tooth wear was found mainly on occlusal, incisal and proximal surfaces, whereas modern erosive tooth wear has additional characteristics that include

ABRASION: A COMMON DENTAL PROBLEM REVISITED

ALEX MILOSEVIC

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ABSTRACT

Dental abrasion is most commonly seen at the cervical necks of teeth, but can occur in any area, even inter-dentally from vigorous and incorrect use of dental floss. Acid erosion has been implicated in the initiation and progress of the cervical lesion, while tooth-brush abrasion has long been held as the prime cause of cervical abrasion. Identification of the risk factors is clearly important in order to modify any habits and provide appropriate advice.

KEY WORDS
Toothwear, Tooth Surface Loss, Dental Abrasion, Non-carious Cervical Lesions

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Dental abrasion is defined as the wear of teeth by any substance other than tooth substance. The cervical is the most commonly abraded site and the term non-carious cervical lesions (NCCLs) is the appropriate term to describe the lesions formed. Abrasion can, however, occur on any area, even inter-dentally from vigorous and incorrect use of dental floss.[1] Abrasion alone can be difficult to distinguish from combined erosion and abrasion.

NCCLs can have two quite distinct clinical presentations:

- Flat, shallow, dish-shaped lesions.
- Deep, wedge-shaped lesions.

Both types of lesion may share common aetiological factors. Acid erosion has been implicated in the initiation and progress of the cervical lesion, while tooth-brush abrasion has long been held as the prime cause of cervical abrasion. Should acid erosion be suspected, then questioning the patient regarding risk factors (see paper on erosion, also in this issue) is appropriate.

Non-carious cervical lesions (NCCLs)

Figures 1 and 2 illustrate the presentation of NCCLs. In Figure 1, the unilateral distribution in the upper left quadrant may indicate an association with horizontal tooth brushing or "scrub technique" in a right handed individual. The gingivae are likely to be inflammation free and possibly hyperkeratinised from toothbrush trauma. The defects are well delineated and deep with pulpal exposure.

Various factors have been postulated for toothbrush abrasion including using a hard brush, too much pressure, high frequency of brushing and an inappropriate technique. The abrasivity of the toothpaste has also been associated with cervical abrasion, although most commercially available toothpastes meet stringent low abrasion

Figure 1: Unilateral abrasion in the maxillary left quadrant, possibly caused by a scrub technique

Figure 2: Cervical defects with wear labially in an older female. The presence of gingivitis precludes tooth brush abrasion as an aetiology. There is incisal edge wear also. The aetiological factors could not be identified

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REVIEW

Abfraction lesions: etiology, diagnosis, and treatment options

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Abstract: Abfraction is a type of noncarious cervical lesion (NCCL) characterized by loss of tooth tissues with different clinical appearances. Evidence supports that abfraction lesions, as any NCCLs, have a multifactorial etiology. Particularly, the cervical wear of abfraction can occur as a result of normal and abnormal tooth function and may also be accompanied by pathological wear, such as abrasion and erosion. The interaction between chemical, biological, and behavioral factors is critical and helps to explain why some individuals exhibit more than one type of cervical wear mechanism than others. In an era of personalized dentistry, patient risk factors for NCCLs must be identified and addressed before any treatment is performed. Marked variations exist in dental practice concerning the diagnosis and management of these lesions. The lack of understanding about the prognosis of these lesions with or without intervention may be a major contributor to variations in dentists' management decisions. This review focuses on the current knowledge and available treatment strategies for abfraction lesions. By recognizing that progressive changes in the cervical area of the tooth are part of a physiologically dynamic process that occurs with aging, premature and unnecessary intervention can be avoided. In cases of asymptomatic teeth, where tooth vitality and function are not compromised, abfraction lesions should be monitored for at least 6 months before any invasive procedure is planned. In cases of abfraction associated with gingival recession, a combined restorative-surgical approach may be performed. Restorative intervention and occlusal adjustment are not indicated as treatment options to prevent further tooth loss or progression of abfraction. The clinical decision to restore abfraction lesions may be based on the need to replace form and function or to relieve hypersensitivity of severely compromised teeth or for esthetic reasons.

Keywords: abfraction, tooth wear, noncarious cervical lesions, tooth restoration

Introduction

Noncarious cervical lesions (NCCLs) develop as a result of normal and abnormal or pathological wear and cause abfraction, abrasion, and erosion or chemical degradation of dental tissues.[1] Clinical appearance of NCCLs can vary depending on the type and severity of the etiological factors involved.[2] Of all possible etiological factors for NCCLs, occlusal stress forces have received maximum attention over the years. Tensile stress from malocclusion and masticatory forces was initially proposed as the primary factor in NCCLs;[3] shortly thereafter, these lesions were termed as abfraction lesions.[4] Despite many efforts to demonstrate that occlusal forces are the main cause of abfraction, its etiology remains poorly understood and controversial.[5] Nowadays, it is generally incorrect to designate only one mechanism to be the cause of any type of NCCLs.[6] Instead, current evidence supports a multifactorial etiology for all NCCLs

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An accurate and efficient method for occlusal tooth wear assessment using 3D digital dental models

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Tooth or material wear in a dentition is a common finding that requires timely diagnosis for management and prevention of further loss or associated esthetic or functional impairment. Various qualitative and quantitative methods have been suggested to measure tooth or material wear, but they present with limitations, such as imprecision, subjectivity, or high complexity. Here we developed and assessed an efficient 3D superimposition method to accurately measure occlusal tooth wear on 3D digital dental models. For this purpose, teeth on plaster casts were manually grinded on their occlusal surfaces to simulate various degrees of tooth wear. The casts were scanned using a surface scanner. Grinded tooth crowns (T1) were segmented and compared to the original crowns (T0) using five 3D surface superimposition techniques and a gold standard technique (GS). GS measurements were obtained by using intact adjacent structures as superimposition references. The technique of choice (complete crown with 30% estimated overlap of meshes) showed the best reproducibility (maximum difference $< 0.050\ mm^3$) and excellent agreement with the GS technique (median difference: $0.032\ mm^3$). The suggested 3D superimposition method offers a highly efficient and accurate tool for tooth wear assessment, which could be applicable to clinical conditions.

Tooth wear in a dentition can be a result of attrition, erosion or abrasion and is expressed as loss of dental matter, especially of enamel. Timely diagnosis is necessary to manage this condition and avoid further tooth loss or other associated esthetic or functional impairment in the future[1,2]. Wear of dental materials is also critical since restorations have to be resistant to structural and form changes, without causing damage to the opposing teeth[3,4].

Over the past few years, various qualitative and quantitative methods have been suggested to measure tooth wear. Conventional approaches, such as those of Eccles[5], Smith and Knight[6], the New Tooth Wear Index (NTWI)[7], or the Basic Erosive Wear Examination (BEWE)[8] assess dental material loss qualitatively through the use of indices. The main shortcoming of such indices is that they are subjective and their sensitivity is unsatisfactory, especially when tooth wear is assessed in relatively short time-spans[9].

For this reason, quantitative methods on 3-dimensional (3D) dental models have been developed[10]. These are considered advantageous, since they are more objective and they provide more accurate estimation of the outcome, usually as tooth height or volume loss[11]. However, the utilization of such methods *in vivo* or *ex vivo* is usually rather complicated and time-consuming[12], and thus not feasible in a regular clinical basis or even for research purposes, if the required expertise and special equipment are not available. To our knowledge, when considering these specialized techniques, there is only one study that used a validated technique to measure the 3D occlusal enamel wear in a clinical setting[11,13].

The steadily increasing usage of intraoral scanners in contemporary clinical dentistry[14] could provide the required surface models for quantitative 3D wear assessment and the available software in the market could facilitate the *ex vivo* implementation of the relevant techniques on a regular clinical setting. Previous *ex vivo* wear assessment methods relied mostly on superimposition of tooth areas that were not considered to be affected by tooth wear between two or more time points[11,15–17]. However, the selection of such areas and the validation of these methods compared to a gold standard measurement, which would provide the true value, has not been adequately investigated[11]. Numerous factors can influence wear assessment through these techniques, such as movement of teeth between two time points, the accuracy of the obtained 3D surface model, especially in areas

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11 Emerging techniques for the analysis of tooth wear

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Abstract

Changing patterns of tooth wear have been used extensively to obtain information about the lifestyle and culture of pre-historic and modern humans. The assessment of tooth wear in previous anthropological studies has been largely based on quantitative analysis of wear indices and qualitative analysis of micrographs. Wear indices are simple to use and can be sensitive tools, but there is a lack of international standardization in their use. Micrographic assessment of pits and scratch marks on the worn surfaces of teeth can assist in dietary reconstruction of humans, but this approach has low reliability and high observer error. This review will provide an update on a new wear index and novel nano-techniques that hold promise for improving the analysis of tooth wear. Recently, a new wear index, termed the Basic Erosive Wear Examination index, has been proposed as a standardized universal tool for diagnosing erosive tooth wear. However, its value seems to be limited when assessing the dentitions of populations, in whom tooth wear occurs predominantly by attrition and abrasion. Optical techniques involving scanning confocal microscopy combined with fractal analysis can provide an objective assessment of the worn surface. Other nanotechnology-based methods, such as nanohardness measurements, nano-computed tomography and mass spectrometry, can be also useful in physical and chemical characterization of both sound and worn teeth, but these techniques are limited to use in vitro. A combined assessment of the worn dentition using all of these techniques promises to provide the best holistic approach to analyse tooth wear.

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Wear measurement of dental tissues and materials in clinical studies: A systematic review

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ABSTRACT

Objectives. This study aims to systematically review the different methods used for wear measurement of dental tissues and materials in clinical studies, their relevance and reliability in terms of accuracy and precision, and the performance of the different steps of the workflow taken independently.

Methods. An exhaustive search of clinical studies related to wear of dental tissues and materials reporting a quantitative measurement method was conducted. MedLine, Embase, Scopus, Cochrane Library and Web of Science databases were used. Prospective studies, pilot studies and case series (>10 patients), as long as they contained a description of wear measurement methodology. Only studies published after 1995 were considered.

Results. After duplicates' removal, 495 studies were identified, and 41 remained for quantitative analysis. Thirty-four described wear-measurement protocols, using digital profilometry and superimposition, whereas 7 used alternative protocols. A specific form was designed to analyze the risk of bias. The methods were described in terms of material analyzed; study design; device used for surface acquisition; matching software details and settings; type of analysis (vertical height-loss measurement vs volume loss measurement); type of area investigated (entire occlusal area or selective areas); and results.

Sinificance. There is a need of standardization of clinical wear measurement. Current methods exhibit accuracy, which is not sufficient to monitor wear of restorative materials and tooth tissues. Their performance could be improved, notably limiting the use of replicas, using standardized calibration procedures and positive controls, optimizing the settings of scanners and matching softwares, and taking into account unusable data.

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A New Index of Tooth Wear

Reproducibility and Application to a Sample of 18- to 30-Year-Old University Students

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Key Words
Dentine · Enamel · Tooth wear index · Tooth wear, prevalence

Abstract
A modified wear index, in which the wear of enamel and dentine are recorded separately, is described. The index was applied to estimating the prevalence and extent of tooth wear in a single convenience sample of 18- to 30-year-old students attending a university in London. The subjects were examined under good lighting in a dental chair away from a dental school. A total of 707 females and 303 males were recruited with a mean age of 21.9 years (standard deviation = 0.1, range = 18–30) and examined by 3 trained and calibrated examiners. Intra-examiner intra-class correlation coefficients showed a range of 0.44–0.88. The unweighted κ scores were above 0.88 for enamel and dentine. The presence of enamel wear was common to all subjects, but 6.1% of the participants had more than one third of the tooth surface affected. Dentine was exposed on 5.3% of all surfaces, with the largest proportion accounting for less than 10% of the tooth surface (grade 1). The proportion of subjects with at least 1 surface with dentine exposed was 76.9% of the total population. The males had significantly more wear in dentine than the females ($p = 0.001$). The inter-examiner intra-class correlation coefficients for enamel and dentine were 0.87 and 0.92, respectively. The reproducibility of the index was comparable to other analyses and provides an opportunity to assess the prevalence of enamel wear in large population-based studies.

The most common method to record changes on teeth resulting from wear has been the use of indices. The most frequently reported index is the Smith and Knight Tooth Wear Index [1984a], which classifies tooth wear on a 5-point scale at 4 sites per tooth. The index records wear or depth changes into dentine with 3 grades, whereas changes to enamel, which can be equally widespread, are notified as a single grade. The reason for this is that most of the early indices were aimed at assessing the need for operative intervention and are therefore more repeatable at the severe levels of dentine involvement. The difficulty with most indices is that wear on enamel is normally given a single score, which under-represents the damage to enamel particularly if the surface lesion is widespread. The relative inaccuracy of the current indices at the enamel level also restricts their use for interventional studies on prevention as the most likely short-term change resulting from wear is on enamel. The only other method to accurately measure tooth wear is using profilometry, but this would be inappropriate for assessing the prevalence on large sample populations as the time needed for scanning would be impractically long.

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ARTÍCULO ORIGINAL

APLICACIÓN DE NUEVAS TECNOLOGÍAS EN EL USO DEL ÍNDICE SMITH Y KNIGHT PARA EL DESGASTE DENTAL

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RESUMEN

El propósito de este trabajo es aplicar la tecnología actual usando los escáneres intraorales para posibilitar un diagnóstico más objetivo del desgaste dental. Se realizó un estudio de evaluación de desgaste sobre 53 alumnos de Odontología, utilizando como medio de registro de ambas arcadas el escáner intraoral True Definition 3M® (ESPE, Seefeld, Germany). Para evaluar el desgaste se utilizó el índice Smith & Knignt aplicándolo a las superficies vestibular, palatina/lingual y oclusal/incisal desde el primer incisivo incisivo a primer molar en ambas arcadas. Los resultados mostraron una mayor superficie de desgaste en el grupo ántero-incisal (superior) por palatino, caninos por incisal, primeros premolares superiores e inferiores por oclusal. Las localizaciones de las superficies de desgaste encontradas en este estudio concuerdan con los datos hallados en la literatura científica. El escáner intraoral se muestra, en las condiciones de este estudio, como una herramienta eficaz en la detección del desgaste dental.

PALABRAS CLAVE

Desgaste; Escáner intraoral; Índice Smith & Knignt.

NEW TECHNOLOGIES USE IN THE APPLICATION OF THE SMITH & KNIGHT INDEX FOR DENTAL WEAR

ABSTRACT

The purpose of this paper is to apply current technology using intraoral scanners to enable a more objective diagnosis of dental wear. An evaluation study on 53 Denstritry students using as a recording medium of both arches intraoral scanner True Definition 3M was performed. To assess the Smith & Knignt wear index was used by applying to, palatal / lingual and occlusal / incisal from the incisor to first molar buccal surfaces. The results showed increased wear surface in the anterior-incisal group (superior) palatal, incisal canines, occlusal upper first premolars and first molars occlusal. The locations of the wear surfaces found in this study are consistent with data found in the scientific literature. The intraoral scanner is shown under the conditions of this study, as an effective tool in the detection of dental wear.

KEY WORDS

Tooth wear; Intraoral scanner; Smith & Knight index.

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Review

The tooth wear evaluation system: a modular clinical guideline for the diagnosis and management planning of worn dentitions

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SUMMARY **Tooth wear is a multifactorial condition, leading to the loss of dental hard tissues, viz. enamel and dentine. Tooth wear can be divided into the subtypes mechanical wear (attrition and abrasion) and chemical wear (erosion). Because of its multifactorial aetiology, tooth wear can manifest itself in many different representations, and therefore, it can be difficult to diagnose and manage the condition. A systematic approach is a *sine qua non*. In the below-described tooth wear evaluation system (TWES), all necessary tools for a clinical guideline are present in different modules. This allows the dental clinician, in a general practitioner setting as well as in a referral practice setting, to perform a state-of-the-art diagnostic process. To avoid the risk of a too cumbersome usage, the dental clinician can select only those modules that are appropriate for a given setting. The modules match with each other, which is indispensable and essential when different modules of the TWES are compared. With the TWES, it is possible to recognise the problem (qualifying), to grade its severity (quantifying), to diagnose the likely causes and to monitor (the progress of) the condition. In addition, a proposal for the classification of tooth wear is made. Further, it is possible to determine when to start a treatment, to make the decision which kind of treatment to apply and to estimate the level of difficulty of a restorative treatment.**

KEYWORDS: **clinical guideline, diagnosis, qualifying, quantifying, management planning, tooth wear**

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Introduction

Tooth wear is a multifactorial condition, leading to the loss of dental hard tissues, viz. enamel and dentine (1). Tooth wear can be divided into the subtypes mechanical wear (attrition and abrasion) and chemical wear (erosion). Attrition is intrinsic mechanical wear as a result of function and/or parafunction (e.g. bruxism), due to tooth-to-tooth contact. Abrasion is extrinsic mechanical wear as a result of other factors than function and/or parafunction, viz. oral hygiene procedures and habits such as nail-biting and pen-biting. Erosion is chemical wear, not caused by caries, as a result of intrinsic or extrinsic acids (2–4). Individual wear mechanisms rarely act alone, but interact with each other (1, 5). As all individuals chew and therefore have attrition, and in modern society, most individuals have an erosive diet and therefore have erosion, it is virtually impossible to separate these phenomena. Recently, it was stated that the role of erosion in the multifactorial tooth wear process is increasing (6). This can be explained by the growing consumption of acidic drinks and food (4). While for many years, tooth wear was a condition of little interest in daily clinical practice, nowadays this is changed. Tooth wear is becoming increasingly significant in maintaining the long-term health of the dentition (4). This becomes especially

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Diagnosing tooth wear, a new taxonomy based on the revised version of the Tooth Wear Evaluation System (TWES 2.0)

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Abstract

Background: Tooth wear is a multifactorial condition, leading to the loss of dental hard tissues. Physiological tooth wear is a slow process that normally does not lead to any subjective symptoms. When the condition progresses, it can become pathological, and several signs and symptoms may occur. The Tooth Wear Evaluation System (TWES) was described to implement a systematic diagnostic and management approach. Recently, management guidelines were presented in a European Consensus Statement (ECS) as well.

Objectives: To evaluate the TWES in practice and to integrate the principles described in the ECS in order to compose a renewed TWES 2.0 and a new taxonomy.

Methods: The TWES and the recommendations of the ECS were used by dental clinicians, in order to test its applicability in practice.

Results: Agreement was reached that the TWES 2.0 will use a stepwise approach, with a straightforward Tooth Wear *Screening* part and a more detailed Tooth Wear *Status* part. Also, the assessment of pathology from the ECS is incorporated in the TWES 2.0 (both classification and taxonomy).

Conclusions: In the TWES 2.0 is described that tooth wear is pathological if moderate/severe/extreme tooth wear is present, in combination with one or several described signs and symptoms. Aetiology can be assessed by findings that indicate a chemical and/or a mechanical cause. The taxonomy may help to identify situations in which preventive (restorative) interventions in early stages of tooth wear can be indicated. The reliability and validity of the adapted parts must be proven.

KEYWORDS

classification, diagnosis, European Consensus Statement (ECS), management, pathological, physiological, taxonomy, tooth wear, Tooth Wear Evaluation System (TWES)

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ORIGINAL ARTICLE

Choosing the Criteria for Clinical Evaluation of Composite Restorations: An Analysis of Impact on Reliabilty and Treatment Decision

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Abstract

Objective: To assess the reproducibility of two clinical criteria for the evaluation of restorations in primary teeth and the impact on treatment decision. **Material and Methods:** A cross-sectional study was performed selecting 71 resin-based composite restorations placed in primary molars of children who had sought dental treatment at a dental school. Two trained examiners evaluated independently the restorations using modified FDI and USPHS criteria. All restorations were assessed separately with each system in random order to avoid memory bias. Kappa statistics were used to determine inter-examiner reliability considering each parameter of both criteria and score final about treatment decision. McNemar test was used to compare the treatment decision with two criteria. The significance level was set at 5%. **Results:** Kappa values ranged from 0.28 to 0.93 with USPHS and 0.28 to 0.88 with FDI, considering each parameter separately. Inter-examiner agreement for treatment decision was excellent for both criteria (Kappa: 0.85-0.90). For clinical decision-making, no difference between criteria was found, irrespective of examiner. **Conclusion:** Low inter-examiner agreement for evaluation of each parameter of USPHS and FDI criteria does not reflect on reproducibility for treatment decision. Both criteria may be suitable for evaluation of composite restorations in primary teeth.

Keywords: Clinical Decision-Making; Dental Restoration Failure; Tooth; Deciduous.

The use of FDI criteria in clinical trials on direct dental restorations: A scoping review

Thomas Marquillier, Sophie Doméjean, Justine Le Clerc, Florence Chemla, Kerstin Gritsch, Jean-Christophe Maurin, Pierre Millet, Matthieu Perard, Brigitte Grosgogeat, Elisabeth Dursun

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Evaluation of tooth wear by estimating enamel thickness with quantitative light-induced fluorescence technology

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ABSTRACT

Background: Various techniques have been suggested to quantitatively assess tooth wear; most have limited clinical application. The first aim of this *in vitro* study was to estimate the residual enamel thickness of teeth with various degrees of occlusal wear using quantitative light-induced fluorescence (QLF). The second aim was to identify relationships between the fluorescence parameters of QLF and the conventional tooth wear index (TWI) system.

Methods: Sixty-nine extracted permanent premolars and molars with initial stages of tooth wear (TWI score 1a-2: enamel wear to dentin exposure) were used. Two blinded and trained examiners participated in evaluation procedures. Occlusal QLF-digital (QLF-D) images were acquired for selecting area of interest (AOI) and calculating fluorescence for occlusal tooth wear (ΔF_{wear}) of the AOI by the first examiner. Each specimen was cross-sectioned in the buccal-lingual direction. Enamel thickness from images obtained by stereomicroscopy and TWI of each sample was determined by the second examiner. Spearman correlation was used to determine the relationship of ΔF_{wear} with enamel thickness and TWI. ΔF_{wear} values were compared between histological scores with the Mann-Whitney *U* test.

Results: Seventy-six AOIs were analyzed. As enamel thickness decreased, ΔF_{wear} values significantly increased and strongly correlated with enamel thickness (Spearman rho = -0.825, $P < 0.001$). There were significant differences in ΔF_{wear} values among TWI scores ($P < 0.001$); ΔF_{wear} strongly correlated with TWI (Spearman rho = 0.753, $P < 0.001$).

Conclusions: ΔF_{wear} values, which denote fluorescence difference by using QLF, showed a strong correlation with residual enamel thickness and tooth wear severity.

1. Introduction

Tooth wear is the irreversible loss of dental hard tissue by physical and chemical factors [1,2]. The main cause of tooth wear is aging, during which the effects of occlusion and mastication processes accumulate. However, abnormal tooth wear due to excessive physical and chemical stimulation is known as pathological tooth wear. Particularly, dentin has a lower hardness than enamel, such that when the dentin is exposed by tooth wear, the subsequent speed of the tooth wear rapidly increases [2–4].

As life span lengthens, the importance of long-term maintenance of healthy teeth increases. Therefore, problems of pathological tooth wear are increasingly recognized [5,6]. Previous research has shown that tooth wear affects oral health-related quality of life, as well as psychological characteristics [7,8]. Although it is possible to restore lost dental hard tissue with prosthodontic treatment, restored teeth require continuous monitoring and retreatment. Therefore, prosthodontic treatment is not a treatment option to completely replace natural teeth in terms of time and cost [9,10]. Therefore, to ensure long-term preservation of natural teeth, it is essential to detect early stages of pathological wear and provide preventive interventions to inhibit or postpone its progress, primarily by continually monitoring and

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Detecting early erosive tooth wear using an intraoral scanner system

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ABSTRACT

Objectives: To assess the feasibility of detecting and monitoring early erosive tooth wear using a 3D intraoral scanner (IOS) aided by specific software.

Methods: Extracted sound permanent teeth were assembled in two shortened artificial dental arches and scanned at different intervals with an IOS (3Shape TRIOS® 3) before and after an erosion/abrasion protocol (*i.e.* 1 h up to 24 h immersion in citric acid solution and subsequent brushing). The 3D models obtained at consecutive time points were superimposed with the baseline model using dedicated software (3Shape TRIOS® Patient Monitoring, version 2.1.1.0) and reference surface alignment. Surface profile differences between the baseline 3D model and the respective models from different time points were expressed as tooth substance loss.

Non-parametric tests were used to assess the significance of tooth substance loss at different time points. Spearman's correlation was applied between the tooth substance loss at the end of each erosion/abrasion cycle and the immersion time in acid.

Results: Significant tooth substance loss (0.08 mm, IQR = 0.05) was detected by the software after 3 h of erosive-abrasive challenge ($p = 0.045$). The overall median loss increased gradually from baseline to 24 h showing a strong correlation with the immersion time in acid ($r_s = 0.971$, $p < 0.01$).

Conclusions: The use of an IOS aided by specific software showed good performance for early detection and monitoring of tooth wear *in vitro* and has promising potential for *in vivo* application.

Clinical significance: Detection and monitoring of early erosive tooth wear can be reliably aided by intraoral scanning supported by specific software. The measurement error and uncertainty involved in this method should be taken into consideration when interpreting the tooth substance loss measurements. Furthermore, presuming the difficulty in defining reference surfaces *in vivo*, clinical validation is needed to determine the system's *in vivo* performance.

1. Introduction

Tooth wear is a multifactorial condition with increasing incidence globally, particularly in Western societies [1]. Early detection and monitoring of tooth wear remains extremely challenging using traditional clinical examination methods [2,3].

Clinical detection and diagnosis of tooth wear is usually based on visual examination of lesion characteristics, sometimes also supported by the acquisition of clinical photographs and study models [3–5]. However, visual examination is subjective even when specific criteria such as the Basic Erosive Wear Examination (BEWE) [6] are adopted, as these have previously shown only moderate reproducibility when employed by general practitioners [7]. Furthermore, visual assessment shows low sensitivity; tooth mineral loss is usually only visually perceptible when a significant amount of hard dental tissue is already lost. Another disadvantage of the visual examination is inability to quantify tooth substance loss over time, a significant limitation when the activity and progression rate of the disease needs to be defined in order to decide the patient's treatment plan [3].

A number of methods other than visual examination have been assessed to aid detection and/or quantification of tooth substance loss [2,5]. Numerous *in vitro* studies have employed techniques including quantitative light-induced fluorescence (QLF) [8–10], profilometry [11–15], and optical coherence tomography (OCT) [8,16]. Applying these methods *in vivo* is difficult; for example, the use of profilometry is time-consuming as it requires obtaining physical models of the dentition. QLF and OCT, although they can potentially be applied directly in the mouth [17], show suboptimal reproducibility in longitudinal studies involving patients [2,3,5,18,19].

The use of IOS has been recently suggested for early detection,

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Quantitative light-induced fluorescence technology for quantitative evaluation of tooth wear

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Abstract. Various technologies used to objectively determine enamel thickness or dentin exposure have been suggested. However, most methods have clinical limitations. This study was conducted to confirm the potential of quantitative light-induced fluorescence (QLF) using autofluorescence intensity of occlusal surfaces of worn teeth according to enamel grinding depth *in vitro*. Sixteen permanent premolars were used. Each tooth was gradationally ground down at the occlusal surface in the apical direction. QLF-digital and swept-source optical coherence tomography images were acquired at each grinding depth (in steps of 100 μm). All QLF images were converted to 8-bit grayscale images to calculate the fluorescence intensity. The maximum brightness (MB) values of the same sound regions in grayscale images before ($MB_{baseline}$) and phased values after (MB_{worn}) the grinding process were calculated. Finally, 13 samples were evaluated. MB_{worn} increased over the grinding depth range with a strong correlation ($r = 0.994$, $P < 0.001$). In conclusion, the fluorescence intensity of the teeth and grinding depth was strongly correlated in the QLF images. Therefore, QLF technology may be a useful noninvasive tool used to monitor the progression of tooth wear and to conveniently estimate enamel thickness.
 [DOI: 10.1117/1.JBO.22.12.121701]

Keywords: tooth wear; occlusal wear; autofluorescence; quantitative light-induced fluorescence.

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1 Introduction

Pathological tooth wear occurs progressively through the enamel and dentin layers by the interaction of mechanical and chemical factors.[1–3] Tooth wear is an irreversible loss consisting of damage to the dental hard tissue. It can therefore affect the lifespan of the entire dentition.[4] The progression of tooth wear to the stage of dentin exposure without preventive management or treatment requires restorative treatment. This is because the ensuing esthetic defect due to the loss of structural integrity or discoloration increases dentin hypersensitivity and the risk of pulpal exposure. Once the restorative treatment commences, it involves a prolonged and continuous course. In addition, the cost for the re-restoration and subsequent monitoring of the restored damage and natural teeth is considerable.[5,6]

Improvements in dietary or parafunctional habits and other etiological factors by continuous counseling and education for those at risk of developing pathological tooth wear or those who already have progressive teeth wearing are necessary to avoid or postpone the need for restorative treatment. Therefore, early diagnosis of tooth wear and monitoring of the process are crucial strategies. Finally, the goal of preventive interventions is to limit the loss of dental hard tissue to the enamel layer as much as possible.[4,6–8]

Indices based on subjective criteria using the naked eye and measurements of the decrease in length of the incisor clinical crown have been conventionally used to evaluate the severity of tooth wear. However, these subjective criteria are not particularly accurate or consistent because determining the presence of dentin exposure or the remaining enamel depends on highly subjective human decisions.[9,10] Furthermore, although the latter strategy uses a relatively simple method to evaluate tooth wear, it also has limitations in its reflection of the wear of the palatal and posterior regions.[7,11]

Various technologies for the observation of tooth structure and the determination of decreased enamel thickness or wear-induced exposure of dentin have been suggested. These include profilometry, microradiography, scanning electron microscopy, and computer-aided design-computer-aided manufacturing laser scanning.[8,12–14] However, most devices have clinical limitations. These limitations include difficulty of use in the oral cavity, considerable time requirements, and low resolution of images.[7,13,15] Optical coherence tomography (OCT) is actively used in dentistry for the noninvasive observation of tooth structures.[16] Because enamel and dentin have different scattering properties, OCT images can represent light-scattering intensity from different layers of dental hard tissue and provide information regarding enamel thickness.[13] However, as the scanning range of OCT is only a few millimeters, it is not sufficient to screen large or multiple lesions in the dentition. In addition, image quality may be degraded due to insufficient processing time when rapid image acquisition is required.[16]

A previous study showed that teeth emit different fluorescence depending on the type and condition of the hard tissues, and particularly that of dentin, which emits a much more

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Diagnosis of Occlusal Tooth Wear Using 3D Imaging of Optical Coherence Tomography Ex Vivo

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Abstract: The aim of this study was to assess the utility of 3D imaging of optical coherence tomography (OCT) for the diagnosis of occlusal tooth wear ex vivo. Sixty-three extracted human molars with or without visible tooth wear were collected to take digital intraoral radiography and 3D OCT images. The degree of tooth wear was evaluated by 12 examiners and scored using 4-rank scale: 1—slight enamel wear; 2—distinct enamel wear; 3—tooth wear with slight dentin exposure; 4—tooth wear with distinct involvement of dentin. The degree of tooth wear was validated by the histological view of confocal laser scanning microscopy (CLSM). The sensitivity, specificity, and area under the curve (AUC) of receiver operating characteristic analysis were calculated. Diagnostic accuracy was compared with the agreement with CLSM observation using weighted kappa. The results were statistically analyzed at a significance level of $\alpha = 0.05$. Three-dimensional OCT showed significantly higher sensitivity ($p < 0.05$) for all the diagnostic thresholds of enamel wear and dentin exposure than digital radiography (0.82, 0.85, and 0.79 vs. 0.56, 0.52, and 0.57, respectively). Three-dimensional OCT showed higher AUC and kappa coefficients than digital radiography ($p < 0.05$), where mean AUC and Kappa values were 0.95 and 0.76 for OCT and 0.92 and 0.47 for radiography, respectively. No significant difference of specificity was observed ($p > 0.05$). Three-dimensional OCT could visualize and estimate the degree of tooth wear and detect the dentin exposure at the tooth wear surface accurately and reproducibly. Consequently, a new guideline for tooth wear assessment can be proposed using OCT.

Keywords: occlusal tooth wear; erosive tooth wear; SS-OCT; 3D imaging; enamel thickness; dentin exposure; demineralization

1. Introduction

Tooth wear is defined as the loss of dental hard tissue by physical or chemical factors that occur throughout life [1]. The progression of tooth wear is irreversible and its prevalence increases with age [2,3]. The literature considers tooth wear resulting from a multifactorial etiology with interactions of physical and chemical agents. Although the changes resulting from physiological tooth wear are usually subtle and asymptomatic, excessive physical or chemical stimulation can lead

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Optical coherence tomography applications in tooth wear diagnosis

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Abstract

Dental wear represents an irreversible loss of dental hard tissue under the action of physical, chemical and mechanical factors, excluding dental caries and acute trauma. Four clinical forms of dental wear are described: erosion, attrition, abfraction, and abrasion. Most experts agree that in each clinical form multiple etiological factors are involved, one being predominant. Optical coherence tomography (OCT) is a non-invasive optical method characterized by a micronic resolution. The applications of this type of investigation are multiple in the medical field in recent years, and OCT is gaining a growing importance in dentistry. The study pointed out through OCT imaging for the erosive tooth wear lesion the existence of chemical aggression, with strong demineralization of enamel and dentin. For attrition lesion, OCT images showed the contribution of excessive force and friction movements specific to bruxism. In abfraction, OCT image revealed the importance of the mechanic factor in producing this form of tooth wear and abrasion damage studied may be considered physiological, according to patient age. OCT examination may reveal existing lesions in hard dental tissues for each clinical form and could bring evidence on the mechanisms involved.

Keywords: tooth wear, erosion, attrition, abfraction, abrasion, optical coherence tomography.

Introduction

Tooth wear is a term referring to different processes, which, either individually or in association, lead to the irreversible loss of hard dental tissue [1]. Currently, the tooth wear is considered as the result of three processes: erosion (dissolution of hard tissue by acidic substances), attrition (wear through tooth–tooth contact), and abrasion (wear produced by interaction between teeth and other materials) [2]. In addition, some authors appreciate that a further process (abfraction) might potentiate wear by abrasion and/or erosion [1–3]. However, clinically it is difficult (if not impossible) to isolate a single etiological factor when a patient presents with tooth wear.

Tooth wear is an important dental lesion since it has a high prevalence, it involves also decidual and permanent teeth, sometimes in childhood, producing consequences that affect the individual for the rest of his life, and forcing the clinician to perform difficult and costly treatments [4–6]. Therapeutically difficulties are drifting from difficult identification of the clinical subform of tooth wear and from the burden of the restoration of the hard tissue loss, with a high rate of failure [7, 8].

In order to specify the etiological factors and subforms of tooth wear, different techniques are developed to analyze dental wear *in vitro*: microhardness, surface profilometry, surface roughness, microradiography, atomic force microscopy (AFM), AFM nanoindentation, scanning electron microscopy (SEM), white light interferometry (WLI), confocal laser scanning microscopy (CLSM) [9–11]. Optical coherence tomography (OCT) is a new high-resolution optical technique that permits minimally invasive imaging of near-surface abnormalities in complex tissues, provides real-time structural imaging, and is based on low coherence interferometry using broadband light. Application of OCT in dentistry was used for hard tissue but also for soft tissue, oral mucosa and periodontal tissue. Today, OCT could be used to detect qualitative and quantitative morphological changes of oral tissues *in vivo*, and to diagnose incipient tooth lesions as caries and tooth wear, progression of periodontal disease and tooth wear, and detecting oral cancer [12].

The aim of the study was to highlight the morphological changes in tooth wear and microstructural tooth changes of the wear surfaces by OCT.

Materials and Methods

Tooth samples

One hundred and forty-seven teeth were extracted from 98 patients in Prosthetic Clinic of the Faculty of Dental Medicine, according to complex treatment plan for which informed consent was recorded. The study was approved by the Ethical Committee of the University of Medicine and Pharmacy of Craiova, Romania. Twenty-five teeth were selected from the extracted teeth. Selected teeth were divided in five groups, four groups, one group

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Clinical Monitoring of Tooth Wear Progression in Patients over a Period of One Year Using CAD/CAM

Khaled E. Ahmed, BDS, MSc, PhD[1]/John Whitters, BSc, PhD[2]/Xiangyang Ju, BEng, MEng, PhD[3]/S. Gareth Pierce, BSc, PhD[4]/Charles N. MacLeod, MEng, PhD[5]/Colin A. Murray, PhD, BDS[6]

Purpose: The aim of this study was to clinically monitor the progression of tooth wear over a period of 1 year in a cohort of referred tooth wear patients through the use of a computer-aided design/computer-assisted manufacture (CAD/CAM) scanner and a standardized scanning/assessment methodology. ***Materials and Methods:*** Polyether impressions were made of 11 participants (130 teeth) at baseline and at 1 year. Impressions were poured in type IV dental stone and the anterior teeth were 3D scanned. A surface-matching software was used to compare 1-year and baseline scans and identify any dimensional differences. ***Results:*** Parafunctional habits were reported by all patients. All participants exhibited tooth wear ≥ 140 µm in depth and extending to ≥ 280 µm in at least one tooth. Maxillary central incisors were the most commonly and severely affected teeth. ***Conclusion:*** The ability of the developed CAD/CAM scanning methodology in clinical monitoring of tooth wear was demonstrated. Further research is needed to assess its practicality in large-scale epidemiologic tooth wear studies. *Int J Prosthodont 2017;30:153–155. doi: 10.11607/ijp.4990*

Given the subjective nature of currently available tooth wear indices[1] and the limited evidence supporting various tooth wear management approaches and their long-term outcomes,[2,3] development of a method for objectively quantifying tooth wear in vivo is pertinent. Computer-aided design/computer-assisted manufacture (CAD/CAM) scanning can offer a more accurate and reliable alternative for monitoring tooth wear progression in patients.

The aim of this study was to clinically monitor the progression of tooth wear over a period of 1 year in a cohort of patients using a standardized three-dimensional (3D) scanning and assessment methodology.

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Materials and Methods

Ethical approval was obtained from the West of Scotland Research and Ethics Committee (REC: 10/S0709/59, R&D Ref: GN10DN412). Participants were recruited between March 2011 and April 2012 through three restorative dentistry consultants' clinics at Glasgow Dental Hospital and School. Participants completed a questionnaire addressing their medical and dental history, lifestyle factors, habits, and diet.

Study inclusion criteria were as follows:

- Consenting adults aged older than 16 years
- Patients referred solely for management of tooth wear
- Patients requiring management that only involved monitoring of tooth wear, dietary advice, oral hygiene instructions, and/or referral to hypnotherapy

The accuracy of the scanning system (3D scanner and dental stone casts) was previously assessed using a custom-made stainless steel model resembling the dimensions of the dental arch.[4]

Initial and 1-year recall visits involved making polyether impressions (Impregum Penta Soft, 3M ESPE) of participants' dentition. Retrieved impressions were visually inspected, and if deemed satisfactory, disinfected for 10 minutes (Perform-ID 3%, Schülke & Mayr). After 24 hours, impressions were poured in ISO type 4 die stone (Suprastone, Kerr) mixed according to the manufacturer's recommendations.

At 1 month postpouring, all anterior teeth were contact scanned on the cast replicas using a CAD/

A guide to managing tooth wear: the Radboud philosophy

B. Loomans*[1] and N. Opdam[1]

Key points

- Provides an overview of the philosophy and the management of the Radboud Tooth Wear Project from monitoring and counselling to a full rehabilitation.
- Emphasises the need of counselling and monitoring to objectively evaluate the progression of tooth wear over time and determine the patients' commitment for a possible restorative rehabilitation.
- Illustrates several minimally invasive and adhesive restorative strategies for the treatment of severe tooth wear patients.

This paper explains a conservative, pragmatic and minimally invasive intervention concept for the treatment of severe tooth wear patients based on the Radboud Tooth Wear Project in the Netherlands. Guidelines and flowcharts for management of severe tooth wear patients and rehabilitation in increased vertical dimension of occlusion are presented. We concluded that: (a) Restorative treatment is not always indicated, even for patients with severe tooth wear. (b) If the patient has no complaints, counselling and monitoring is probably the best option. (c) Minimally invasive and adhesive restorative strategies are preferred when severe tooth wear patients are to be treated in increased vertical dimension, especially when young patients are involved. (d) Clinical evidence for a suitable restorative treatment protocol is limited to five-year follow up for direct composites. This material seems to be suitable for rehabilitation in increased vertical dimension on the middle long term. Clinical results for indirect techniques are not available yet. (e) Restorations, including those that are considered 'definitive' may prove to have a limited lifetime in patients with severe tooth wear due to bruxism and erosion. Explanation of the possible treatment options and expected complications should be included in the informed consent.

Introduction

Especially among younger generations, more people are tending to keep their teeth for life, resulting in teeth having to function for 80 years and more. As a result, tooth wear may pose new challenges to the dental profession[1] as it seems to become more and more common and is considered increasingly as a concern in oral health, especially among younger people.[2–4] However, while prevalence of erosive tooth wear of permanent teeth in children and adolescents is reported to be 30%[5,6] the consequences, and especially severe wear, for maintaining a dentition during lifetime is not yet clear. Therefore, in 2012 the 'Radboud Tooth Wear Project' was started at the dental school of the Radboud University Medical Center in Nijmegen, the Netherlands, aiming to answer several questions:

- Is tooth wear a continuous or episodic process?
- Is the stage of wear a predictor for future wear and related to quality of oral health problems?
- Which aetiological factors are responsible for those cases of tooth wear that are threading for a lifelong maintenance of quality of oral health?
- If tooth wear needs restorative intervention, which restorative strategies are optimal for these patients.

In this paper we will address these questions and explain the Radboud philosophy on the management of severe tooth wear from monitoring and counselling to a full rehabilitation based on principles of 'conservative, pragmatic and minimally invasive interventions'.

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Guideline for the management of severe tooth wear

To help the general practitioner in the decision-making process on the management of severe wear cases, a decision flow chart was developed in a recent European Consensus Meeting (Fig. 1).[7] The aim of this flowchart might help the clinician to make the appropriate decision and give treatment advice, from counselling and monitoring towards restorative treatment.

Diagnosis of severe tooth wear

Tooth wear is often mentioned as 'erosion', indicating that it is the main responsible factor. A more suitable term would be 'erosive tooth wear' or just 'tooth wear', meaning that also mechanical factors like attrition and abrasion are important aetiological factors contributing to tooth wear. Especially in cases of severe and pathological wear the aetiology will be multifactorial in most cases.[8] For diagnosis, one has to realise that tooth wear is a physiological process, while caries is a pathological process in itself. As a result, a diversity of tooth wear stages may be observed in patients that can be considered as expressions of physiological wear. In individual cases, also among younger patients, tooth wear may become severe or pathological. 'Severe tooth wear' is defined as 'tooth wear with substantial loss of tooth structure, with dentin exposure and significant loss (≥1/3) of the clinical crown'.[7] However, this

Virat Kumar Hansrani

Abdullah Barazanchi, Dominic Laverty and Paul Brunton

The Use of Direct Resin Composite Restorations in the Management of Localized Anterior Tooth Wear: a Clinical Update Part 1

Abstract: The aim of this article is to provide the reader with the necessary information to manage localized anterior tooth wear cases successfully using minimally invasive and conservative methods in a general dental practice setting. This article will focus on the use of direct resin composite restorations. It will provide an update on the different techniques available to restore anterior tooth wear using direct resin composite and its method of application.

CPD/Clinical Relevance: Numerous epidemiological studies have reported tooth wear to be increasing in incidence amongst the general population. This article aims to describe a methodical conservative approach for the management of worn teeth.

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Tooth wear is loss of hard dental tissue, from causes other than bacterial involvement such as caries, trauma or developmental disorders.[1,2] Continuing pathological tooth wear poses a risk to both the remaining tooth structure and pulpal health.

The definitions and causes of tooth wear are briefly summarized in Table 1. Patients tend to present with evidence of multiple tooth wear types due to the multifactorial aetiological nature of tooth wear.[3,4] Erosion is regarded as the most significant cause.[5,6] These causes present with a specific clinical presentation (Table 2). An example of multifactorial tooth wear is seen in Figure 1 a–c.

Epidemiological studies in developed nations assessing the extent and severity of tooth wear have shown it to be a common condition which is increasing in both extent and severity,[7] and is increasingly presenting in younger patients.[8,9] With the population retaining teeth for a longer period, significant numbers of patients are presenting to general dental practitioners and specialists requesting treatment.[10]

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Management of tooth wear

A thorough history and examination, including appropriate investigations, should be carried out before considering treatment. Emphasis should be on identifying the aetiological factors involved in the tooth wear and controlling or minimizing their effect on the patient's dentition. This is an acceptable treatment plan in patients presenting with minor tooth wear which has not yet resulted in clinical symptoms, aesthetic or functional problems. Where tooth wear has resulted in clinical signs and symptoms related to function and/or aesthetics, active restorative intervention may become

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Repeated exposure of acidic beverages on esthetic restorative materials: An *in-vitro* surface microhardness study

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Abstract

Background: A manifold increase in the consumption of aerated beverages has witnessed a twin increase in tooth wear and raised demand for esthetic restorative materials. This study aimed to evaluate the surface microhardness changes of esthetic restorative materials following treatment with aerated beverages in an in-vitro situation.

Materials and Methods: The initial surface microhardness of the restorative materials GC Fuji II LC, GC Fuji IX, Nano Glass ionomer, Resin and Nano composite was recorded. These materials were studied under 3 groups that included those exposed to the acidic beverages daily, weekly once in a month and those that had no exposures at all. The final surface microhardness of the materials was recorded following experimentation and was subjected to statistical comparisons.

Results: The restorative materials were compared for their surface microhardness changes following respective treatments using the T-test and One-way ANOVA analysis. Inter-comparisons between the groups showed statistical significance ($p<.05$), when treated with both the beverages. The five restorative materials revealed surface microhardness loss; the maximum reduction noticed with the Nano glass ionomer cement tested ($p<.0005$).

Conclusions: The surface microhardness of restorative materials markedly reduced upon repeated exposures with acidic beverages; the product with phosphoric acid producing the maximum surface microhardness loss.

Key words: *Restorative materials, acidic beverages, surface microhardness, resin composites, glass ionomers.*

Introduction

Excessive consumption of acidic food and beverages, or unusual eating and drinking habits such as sipping an acidic drink over a long period of time have proven to increase the acid challenge to teeth (1). However, the extent of impact of acidic interactions in the oral environment is not yet conclusively established.

Esthetic restorative materials are marketed in various types with different physical characteristics and colors. However, under acidic conditions, all dental restorative materials have shown degradation over time (2). Deterioration at low pH, low resistance to wear and high technique sensitivity are few reported drawbacks of glass ionomer cements. Studies on organic acids of plaque

The restorative management of tooth wear involving the aesthetic zone

S. B. Mehta*[1,2] and S. Banerji[3,4]

Key points

- Outlines the protocol for carrying out a systematic assessment of the aesthetic zone for a patient with toothwear.
- Describes the clinical techniques for helping to establish a predictable aesthetic- functional outcome when attempting to restore worn down teeth in the aesthetic zone.
- Overviews the data for the success and survival of restorations/restorative materials used to manage tooth wear affecting the aesthetic zone.

The aim of this article is to describe a systematic approach that facilitates the establishment of a clear and appropriate diagnosis when a dentate patient presents with tooth wear involving their aesthetic zone. It will also detail the protocols that are required to allow for the development of an acceptable aesthetic prescription within the limits of the functional constraints presented by the patient (where active restorative intervention may be indicated), as well as to communicate the manner by which this information can be transferred to ultimately enable the successful and predictable rehabilitation of the affected areas. An overview will also be provided of the tooth-coloured dental materials and restorative techniques that have been commonly applied to deliver the predictable and effective dental care of worn teeth in the aesthetic zone.

Introduction

The term aesthetic zone (also known as the smile zone) is frequently applied in the dental literature, and is used to refer to all of the hard and soft tissues that are visible when the patient makes a broad smile.[1] Among more severe cases of tooth wear, the effects of the aetiological processes leading to the irreversible loss of the dental hard tissues can have a dramatic effect upon the patient's aesthetic zone, as shown in Figure 1.

Given the increasing prevalence of tooth wear, with the UK Adult Dental Health Survey of 2009 reporting 77% of the 6,469 participants examined showing signs of tooth wear at their anterior teeth (compared with 66% in 1989),[2] it is likely that dental practitioners will be seeing a steady increase in patients presenting with tooth wear, with specific concerns relating the effects of tooth wear on their oro-facial appearance. This aspect was emphasised as part a study by Wazani *et al.*[3] involving the retrospective evaluation of the clinical records of approximately 300 patients referred to a UK-based University Dental Hospital for the condition of tooth wear. Aesthetic concerns were reported to be the most prevalent cause for the presenting complaint (59%), followed by sensitivity (40%), functional problems (17%) and pain (14%). Similar outcomes in relation to impact of alterations in dental appearance were reported by Al-Omiri *et al.*,[4] with aesthetic concerns being the most likely presenting complaint for patients suffering from the effects of tooth wear.

Fig. 1 An example of a patient with severe tooth wear. This patient unsurprisingly, presented complaining with concerns primarily relating to their aesthetic appearance

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Cementation of ceramics and indirect composite resin to enamel and dentin using different resin-based cements – Shear bond strength

Cimentação de cerâmica e resina composta indireta ao esmalte à dentina usando diferentes cimentos resinosos - resistência ao cisalhamento

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Abstract

Objective: To evaluate the shear bond strength of three different resin cements: self-etching (P), etch-and-rinse (R) and self-adhesive (U), to enamel and dentin using two types of restorative materials. Methods: One hundred twenty bovine incisors had the buccal surface ground to obtain a flat and smooth surface of approximately 25 mm². Half of the specimens had the enamel exposed (E), and the other half had the dentin exposed (D). An adhesive tape with a 3 mm-diameter orifice delimited the bonding area. Sixty 3 x 3 mm lithium disilicate glass-ceramic cylinders (C) and 60 indirect composite resin cylinders (R) were cemented to enamel or dentin using three types of resin cements, resulting in 12 experimental groups represented by symbols allusive to treatment protocols: PEC; PER; PDC; PDR; REC; RER; RDC; RDR; UEC; UER; UDC; and UDR. Shear bond strength test was performed with a crosshead speed of 0.5 mm/min. The data were subjected to ANOVA and Tukey's test with a significance level of 5%. Results (MPa ± DP): the highest mean value obtained, REC group (17.46 ± 3.29), differed significantly from others, except for the PEC group (14.60 ± 5.88). Among the groups with lower mean values, there was a predominance of those where the indirect resin was used regardless the substrate and type of resin cement, and the UDR group (1.03 ± 1.03) was statistically different from the others. Conclusion: In this study, all three experimental variables tested influenced the shear bond strength of tooth-cement-restoration interfaces.

Keywords: Dental cements. Ceramics. Composite resins. Shear strength. Dental materials.

Introduction

Dental esthetics has been given great emphasis in modern restorative dentistry. Dental materials are given much credibility when they show both functional and esthetic results, which in turn improve the quality of the treatment and patients' general oral health[1].

Adhesive materials have dramatically transformed dentistry, not only in terms of conservation of tooth structure due to less invasive procedures, but also for allowing bonding between indirect restorations and the tooth[2,3].

When the dimensions of the prepared cavity exceed the safe parameters for direct restorations, the use of indirect ones is a viable alternative, which will also help to strengthen the remaining tooth structure due to bonding mechanisms[4]. Amongst such restorative materials are dental ceramics and indirect composite resins.

Indirect composites can offer good posterior esthetics in case of large restorations[5]. In addition, they show lower polymerization shrinkage and other improved characteristics when compared to direct composites. Laboratory phases and higher costs are some of the disadvantages associated to indirect composites[1,5].

Dental ceramics show various desirable characteristics, such as biocompatibility, high compres-

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Marginal fit of indirect composite inlays using a new system for manual fabrication

ABSTRACT

Aim *This in vitro study compares a new system for manual chair side fabrication of indirect composite restorations, which uses silicone models after alginate impressions, to CAD/CAM-technology and laboratory manual production techniques.*

Methods and study design *Each 10 composite inlays were fabricated using different types of production techniques: CAD/CAM-technology (A), the new inlay system (B), plaster model after alginate impression (C) or silicone impression (D). The inlays were adapted into a metal tooth and silicone replicas of the cement gaps were made and measured. Statistical analysis was performed using ANOVA and Tukey's test.*

Results and Statistics *In group A the biggest marginal gaps (174.9 µm ± 106.2 µm) were found. In group B the gaps were significantly smaller (119.5 µm ± 90.6 µm) than in group A (p=0.035). Between groups C (64.6 µm ± 68.0 µm) and D (58.2 µm ± 61.7 µm) no significant differences could be found (p=0.998), but the gaps were significantly smaller compared with group B,*

Conclusion *Chairside manufacturing of composite inlays resulted in better marginal precision than CAD/CAM technology. In comparison to build restorations in a laboratory, the new system is a timesaving and inexpensive alternative. Nevertheless, production of indirect composite restorations in the dental laboratory showed the highest precision.*

Keywords *CAD/CAM technology; Composite inlays; Indirect composite restorations; Marginal fit.*

Introduction

The concept of minimally invasive therapy has become an important strategy in modern dentistry [Tassery et al., 2013; Walsh and Brostek, 2013]. Composite is an established material to fill small cavities. When children or disabled patients are treated, the treatment often has to be performed within a short time. The application of direct composite restorations can be very difficult in these situations. The main problem is to maintain a sufficiently dry field during the complete application time of the composite. Perugia et al. [2013] conclude that the method of immediate dentin sealing is sufficient for adhesive luting of indirect composite restorations. They found good hybrid layer with good adhesion properties after immediate application of dental adhesives before taking impressions. Furthermore polymerisation shrinkage of direct restorations is a persistent problem [Mantri and Mantri, 2013; Garcia et al., 2014; Bortololllo et al., 2013]. These problems might be reduced by the use of indirect fabrication of restorations. This procedure has been discussed in literature since the 1980s [Robinson et al., 1987; Cassin and Pearson, 1992; Plasmans et al., 1992; Cetin et al., 2013]. In 1992 Plasmans et al. [1992] studied the fabrication time which was needed to build indirect composite restorations using the ICS system. The overall mean time was 120 min. Mendonca et al., [2010] also evaluated the clinical success of direct and indirect composite restorations. After one year both types of restorations showed excellent clinical performance. In 2013, Cetin et al. evaluated the clinical success of direct and indirect composite restorations in posterior teeth after 5 years using the USPHS criteria and found no significant differences between both groups.

Because of the development and improvement of materials characteristics of modern composite-materials, indirect composite restorations attract interest again, especially in the field of paediatric dentistry as the working time in the patient's mouth can be reduced [Perugia et al., 2013; Koyuturk et al., 2013]. Moreover, in addition to a high survival rate, Koyuturk et al.[2013] found no significant differences in the survival rates between direct and indirect composite restorations, but direct restorations showed significantly higher values for marginal inaccuracy after six month. For the fabrication of indirect restorations, such as crowns, bridges or inlays, impressions are usually taken with silicone to obtain plaster models of the clinical situation. However, the high accuracy of silicon impressions needs sufficient patient's compliance. If children or special need patients are treated, this compliance might be reduced. An insufficiently dry field or movements of the patient during the setting time of the silicone can significantly diminish the quality of the impression. This problem can be overcome by using alginate as impression material. Guiraldo et al., [2012] found clinically acceptable detail reproduction and dimension accuracy on plaster-models

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Wear, strength, modulus and hardness of CAD/CAM restorative materials

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ABSTRACT

Objective. To measure the mechanical properties of several CAD/CAM materials, including lithium disilicate (e.max CAD), lithium silicate/zirconia (Celtra Duo), 3 resin composites (Cerasmart, Lava Ultimate, Paradigm MZ100), and a polymer infiltrated ceramic (Enamic).

Methods. CAD/CAM blocks were sectioned into 2.5 mm × 2.5 mm × 16 mm bars for flexural strength and elastic modulus testing and 4 mm thick blocks for hardness and wear testing. E.max CAD and half the Celtra Duo specimens were treated in a furnace. Flexural strength specimens (n = 10) were tested in a three-point bending fixture. Vickers microhardness (n = 2, 5 readings per specimen) was measured with a 1 kg load and 15 s dwell time. The CAD/CAM materials as well as labial surfaces of human incisors were mounted in the UAB wear device. Cusps of human premolars were mounted as antagonists. Specimens were tested for 400,000 cycles at 20 N force, 2 mm sliding distance, 1 Hz frequency, 24 °C, and 33% glycerin lubrication. Volumetric wear and opposing enamel wear were measured with non-contact profilometry. Data were analyzed with 1-way ANOVA and Tukey post-hoc analysis (alpha = 0.05). Specimens were observed with SEM.

Results. Properties were different for each material ($p < 0.01$). E.max CAD and Celtra Duo were generally stronger, stiffer, and harder than the other materials. E.max CAD, Celtra Duo, Enamic, and enamel demonstrated signs of abrasive wear, whereas Cerasmart, Lava Ultimate, Paradigm MZ100 demonstrated signs of fatigue.

Significance. Resin composite and resin infiltrated ceramic materials have demonstrated adequate wear resistance for load bearing restorations, however, they will require at least similar material thickness as lithium disilicate restorations due to their strength.

1. Introduction

A recent study reported that lithium disilicate was chosen as the material of choice for 20% of surveyed dentists for posterior crowns and 55% of dentists for anterior crowns [1]. When used with in-office CAD/CAM systems, lithium disilicate materials, such as e.max CAD (Ivoclar Vivadent, Schaan, Lichtenstein), are provided to the dentist in a softened state to expedite milling. After milling, this material is crystallized in a furnace to improve its mechanical properties. In order to save the clinician time, new CAD/CAM restorative materials have been introduced which do not require heat treatment to achieve acceptable strength.

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Critical Review
Dental Materials/Dentistry

Dental ceramics: a review of new materials and processing methods

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Abstract: The evolution of computerized systems for the production of dental restorations associated to the development of novel microstructures for ceramic materials has caused an important change in the clinical workflow for dentists and technicians, as well as in the treatment options offered to patients. New microstructures have also been developed by the industry in order to offer ceramic and composite materials with optimized properties, *i.e.*, good mechanical properties, appropriate wear behavior and acceptable aesthetic characteristics. The objective of this literature review is to discuss the main advantages and disadvantages of the new ceramic systems and processing methods. The manuscript is divided in five parts: I) monolithic zirconia restorations; II) multilayered dental prostheses; III) new glass-ceramics; IV) polymer infiltrated ceramics; and V) novel processing technologies. Dental ceramics and processing technologies have evolved significantly in the past ten years, with most of the evolution being related to new microstructures and CAD-CAM methods. In addition, a trend towards the use of monolithic restorations has changed the way clinicians produce all-ceramic dental prostheses, since the more aesthetic multilayered restorations unfortunately are more prone to chipping or delamination. Composite materials processed via CAD-CAM have become an interesting option, as they have intermediate properties between ceramics and polymers and are more easily milled and polished.

Keywords: Ceramics; Dental Materials; Dental Porcelain; Computer-Aided Design; Composite Resins.

Introduction

The evolution of computerized systems for the production of dental restorations associated to the development of novel microstructures for ceramic materials has caused an important change in the clinical workflow for dentists and technicians, as well as in the treatment options offered to patients. One of the most important changes in this scenario was the introduction of monolithic restorations produced from high-strength ceramics, like zirconia. This concept *per se* is not new, since ceramic materials have been used for a relatively long time for the production of monolithic restorations, but it was only when zirconia started to be used to produce full-contour crowns that dentists and technicians became more confident to indicate a ceramic material for crowns and bridges in the posterior region.

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Microstructural analysis of restorative materials submitted to acid exposure

Análise microestrutural de materiais restauradores submetidos à exposição ácida

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ABSTRACT

The study aimed to evaluate, through surface roughness and microhardness tests, the amount of damage caused by hydrochloric acid to restorative materials. Five different materials were used: direct composite resin (Z 350), indirect composite resin (Resilab Master), conventional glass-ionomer cement (GIC) (Vidrion R), resin modified GIC (Vitremer) and ceramic (Empress II). Twenty one specimens of each material were constructed and had their initial roughness and microhardness evaluated. Sixteen specimens of each material were immersed in a gastric fluid without enzymes simulating acid episodes. Other 5 specimens of each material were immersed in artificial saliva (control groups). After 7 days of immersion, the specimens had their surfaces evaluated again. Then, after another 21 days of immersion the specimens were submitted to a third mensuration. One specimen at each stage of the research was subjected to analysis in scanning electronic microscopy. The samples demonstrated changes in roughness and microhardness after the immersion of the restorative materials in the acid solution. The roughness results showed that for both glass ionomer cements, there was a significant difference between the first and last reading, with an increase in their roughness. In ceramic and direct resin materials, no significant difference among the periods was observed. Concerning to microhardness, the behavior of the materials showed a tendency towards decreasing hardness. The results showed the degradation of the restorative materials when exposed to acid episodes.

KEYWORDS

Restorative materials; acid erosion; roughness; microhardness.

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EC DENTAL SCIENCE
Case Report

Conservative Approach for Treating Erosive Tooth Wear Patient : A Clinical Report

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Abstract

Diagnosis and Treatment planning for erosive tooth wear patient are not an easy task. The first step of treatment for this type of cases should be started with knowing the cause and try to treat it. However, treating this type of cases ranging from a simple direct restoration to a full mouth rehabilitation. With advancement of technology and material we are able nowadays to provide our patients with a conservative type of treatment which work as well as other type of treatment like what we did in this case. In this case report we will discuss a conservative approach for treating a patient who is diagnosed with erosive tooth wear.

Keywords: *Conservative Approach; Erosive Tooth Wear; Erosion; emax; Bonding*

Introduction

The progressive loss of dental hard tissues from causes other than dental caries, trauma or as a result of developmental disorders is known as Tooth wear [1]. There are many causes for tooth wear ranging from attrition (tooth loss due to tooth-to-tooth contact), abrasion (tooth loss due to mechanical tooth contact with other materials), Ablation (tooth loss due to hyperactivity of soft tissue), erosion (tooth loss due to chemical action) or it can be multifactorial [2-4]. Tooth wear can be regarded as pathological if the teeth become so worn that they do not function effectively. 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 [1]. Proper management of erosive tooth wear patient is difficult and complex. The first step in the management of this type of cases is to determine the etiology in order to get the most predictable outcome. Detailed dental and medical histories with meticulous clinical examination are crucial to identifying the causes of dental erosion [5-7]. It is commonly assumed that extensive occlusal wear results in decreased occlusal vertical dimension. But there is no definitive evidence to support this concept. Therefore, it is critical to verify loss of occlusal vertical dimension (OVD). Turner [8] have been classified the patient with excessive tooth wear into 3 categories:

I. Excessive wear with loss of OVD.
II. Excessive wear without loss of OVD but with space available
III. Excessive wear without loss of OVD but with limited space

So, careful evaluation of etiology, history, and factors relative to OVD are essential to appropriate treatment planning. Nowadays, advancements of technology in dentistry have made possible the forming of dental restorations with high-performance materials that could not be easily shaped with conventional methods. Many of these materials can be adhesively bonded to the tooth allowing for less invasive

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REVIEW

Tooth wear against ceramic crowns in posterior region: a systematic literature review

Rim Hmaidouch and Paul Weigl

The objective of this systematic review was to assess tooth wear against ceramic crowns in posterior region *in vitro* and *in vivo*. An electronic PubMed search was conducted to identify studies on tooth wear against ceramic crowns in posterior region. The selected studies were analyzed in regard to type of crowns, natural antagonist, measuring protocol and outcome. From a yield of 1 000 titles, 43 articles were selected for full-text analysis; finally, no *in vitro* and only five *in vivo* studies met the inclusion criteria. As there is heterogeneity in design, used measuring method, ceramics and analysis-form, a meta-analysis was not possible. Results of these studies are very controversial which makes a scientifically valid comparison impossible. This review indicated that some all-ceramic crowns are as wear friendly as metal-ceramic crowns. Up to now, it has been impossible to associate tooth wear with any specific causal agent. The role of ceramic surface treatment that might be responsible for the changing in rate of tooth wear seems undetermined as yet through clinical trials. The literature reveals that studies on this topic are subject to a substantial amount of bias. Therefore, additional clinical studies, properly designed to diminish bias, are warranted.
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Keywords: all-ceramic; crowns; tooth wear

INTRODUCTION

Wear of tooth structure is a natural unavoidable process which occurs when tooth and tooth, or tooth and restoration are in contact and slide against each other. However, this natural process may be accelerated by the introduction of restorations whose properties of wear differ from those of the tooth structure that they slide against. It has been shown that enamel may be subject to accelerated wear when opposed by ceramic.[1] Therefore and despite the truth that a constant wear of the entire dentition is possible independent of dental restorations,[2] it is desirable that wear behavior of restorative materials is similar to natural enamel, because excessive wear could lead to clinical problems such as damage of teeth occluding surfaces, loss of vertical dimension of occlusion, poor masticatory function associated with temporomandibular joint remodeling, dentine hypersinsivity or death of the tooth and at least may lead to esthetic impairment.[3–5]

In the oral cavity, many factors contribute to the wear of enamel and dentin, such as the nature of the occlusal contacts with antagonist teeth (attrition), chewing of food items, tooth brushing with toothpaste, inhalation of dust (abrasion), acidic attack due to the consumption of certain fruits and beverages, inhalation of industrial acids or vomiting and regurgitation of gastric juice as in the case of bulimia and anorexia nervosa (corrosion).[6]

In order to observe and assess wear, it is necessary to understand tooth wear mechanisms and how it can be measured and evaluated, both clinically and in the laboratory. The terms abrasion, attrition and even corrosion were often used to identify the same thing which is the tooth wear caused mostly by alimentation and utilities use. Contrary, nowadays there is an agreement that the terms, abrasion, attrition and corrosion describe different mechanisms.

Attrition: tooth-to-tooth contact causes this form of wear, this occurs without the presence of food or foreign substances during deglutition and clenching; it is typically characterized by the facets on a tooth and the opposing tooth. It becomes more serious during bruxism.[7]

Abrasion: is the wear caused by friction between a tooth and an exogenous agent. The 'masticatory abrasion', usually occurs by friction from the food and abrasion, which is a result of bad oral habits such as nail biting or hard objects such as pens, pencils or pipes, opening hair pins with teeth. Occupational abrasion may occur among hairdressers because of opening hair pins with their teeth, tailors through cutting thread with their teeth, shoemakers who hold nails between their teeth and musicians who play wind instruments.

Tooth-cleaning, habits such as extreme tooth brushing, improper use of dental floss and toothpicks are the most common cause of abrasion. Even normal tooth-cleaning practices produce some abrasion of dentine over a lifetime. In Western populations, the major abrasive agent is toothpaste, which affects dentine much more than enamel.[8] Tooth brushing without paste has no effect on enamel and clinically negligible effects on dentine.[9]

Corrosion: Is the loss of tooth surfaces caused by chemical dissolution without the involvement of plaque. Depending on the source of the acids causing the dissolution, there are two types of corrosion,

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RESEARCH ARTICLE Open Access

Current status on lithium disilicate and zirconia: a narrative review

Fernando Zarone, Maria Irene Di Mauro*, Pietro Ausiello, Gennaro Ruggiero and Roberto Sorrentino

Abstract

Background: The introduction of the new generation of particle-filled and high strength ceramics, hybrid composites and technopolymers in the last decade has offered an extensive palette of dental materials broadening the clinical indications in fixed prosthodontics, in the light of minimally invasive dentistry dictates. Moreover, last years have seen a dramatic increase in the patients' demand for non-metallic materials, sometimes induced by metal-phobia or alleged allergies. Therefore, the attention of scientific research has been progressively focusing on such materials, particularly on lithium disilicate and zirconia, in order to shed light on properties, indications and limitations of the new protagonists of the prosthetic scene.

Methods: This article is aimed at providing a narrative review regarding the state-of-the-art in the field of these popular ceramic materials, as to their physical-chemical, mechanical and optical properties, as well as to the proper dental applications, by means of scientific literature analysis and with reference to the authors' clinical experience.

Results: A huge amount of data, sometimes conflicting, is available today. Both in vitro and in vivo studies pointed out the outstanding peculiarities of lithium disilicate and zirconia: unparalleled optical and esthetic properties, together with high biocompatibility, high mechanical resistance, reduced thickness and favorable wear behavior have been increasingly orientating the clinicians' choice toward such ceramics.

Conclusions: The noticeable properties and versatility make lithium disilicate and zirconia materials of choice for modern prosthetic dentistry, requiring high esthetic and mechanical performances combined with a minimal invasive approach, so that the utilization of such metal-free ceramics has become more and more widespread over time.

Keywords: Lithium disilicate, Zirconia, ZLS, Ceramic, Minimally invasive, E.max, MDP, Aging, Translucent cubic zirconia

Background

At "The Digital Dentistry Society II Consensus Conference on Digital Technologies – Marrakech 2018" the main topics of digital interest were thoroughly discussed, in order to draw clinical recommendations based on scientific evidence and, when missing, on the clinical experience shared by the scientific community. The present narrative review is focused on the technical and clinical profile of the two most popular metal-free materials, lithium disilicate and zirconia, in order to briefly shed light on their different indications, advantages and shortcomings.

Methods

An extensive research has been carried out in the literature available on the subject, worldwide, limiting itself exclusively to articles in english, available on the main search engines (Pubmed, Embase, Scopus) and published in the most important indexed journals of the Materials and Dental sector, with and without impact factor. The results highlighted in this narrative review were extrapolated from this literature search, with reference to the authors' clinical experience.

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THE JOURNAL OF PROSTHETIC DENTISTRY

SYSTEMATIC REVIEW

Antagonist enamel wear of tooth-supported monolithic zirconia posterior crowns in vivo: A systematic review

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ABSTRACT

Statement of problem. An assessment of the evidence for the antagonist enamel wear of tooth-supported monolithic zirconia posterior crowns is lacking.

Purpose. The purpose of this systematic review was to identify and summarize clinical studies related to the antagonist enamel wear of tooth-supported monolithic zirconia posterior crowns.

Material and methods. PubMed, Embase, and Cochrane library searches were performed and complemented by manual searches from database inception to December 25, 2017, for title and abstract analysis.

Results. Initially, 198 articles were obtained through database searches. Twenty-one articles were selected for full-text analysis, and 5 studies met the inclusion criteria. Because of the heterogeneity in design, surface treatment, measurement methods, and wear parameters, a meta-analysis was not possible. The selected studies were analyzed regarding the antagonist natural enamel wear of zirconia, measurement methods, and surface treatment. The results of the antagonist enamel wear varied widely, which made comparing them scientifically with absolute values difficult.

Conclusions. This review indicated that the antagonist enamel wear of zirconia was similar to or more than that of natural teeth but less than that of metal-ceramics. Additional properly designed, longer follow-up clinical trials with larger sample sizes are needed to evaluate the antagonist enamel wear of monolithic zirconia crowns in vivo. (J Prosthet Dent 2018;■:■-■)

Ceramic restorations have become increasingly popular because they are metal free and have excellent esthetics and biocompatibility.[1] However, veneered ceramic restorations have a high incidence of chipping and delamination, which are the main causes of failure.[2] The reasons for chipping and delamination include the mismatch of thermal coefficients between the zirconia framework and veneer and the fast cooling rate.[3] Although the incidence of chipping can be decreased by reducing the cooling rate of porcelain,[4] translucent monolithic zirconia restorations without any veneering have become more popular. However, monolithic zirconia restorations have high strength and hardness. Therefore, the abrasion between the zirconia and the opposing natural tooth caused by high hardness and surface roughness is a concern.[5-10]

Dental wear involves different factors and can lead to loss of occlusion height, poor esthetics, increased tooth sensitivity, reduced masticatory function, and temporomandibular joint dysfunction (TMD).[6,11,12] The mechanism of wear involves 3 processes: erosive wear is caused by dissolution of hard tissue by acidic substances; abrasive wear is the interaction of 3 materials including teeth and another material, such as food; and attrition is caused by tooth-to-tooth contact (2-material wear). The 3 processes rarely act alone but combine to contribute to tooth wear.[13,14]

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The management of tooth wear with crowns and indirect restorations

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Key points

- The rationale for using crowns when composites continually fail.
- Indications and management for crown lengthening of worn teeth.
- Material options for definitive crowns in the treatment of tooth wear.

This manuscript summarises the reasons behind choosing indirect restorations in the treatment of tooth wear. The purpose of this article is to discuss the use of crowns as a restorative treatment option for tooth wear. There are also challenges with the use of composites as they can repeatedly fail and in these situations the indications for crowns for treatment of tooth wear is worthy of consideration. This article is part of a themed issue discussing the management of tooth wear.

Introduction

Tooth wear is a multifactorial disease, and the risk factors, prevention and management with composite resins have been discussed in previous papers.[1–3] The purpose of this article is to discuss the use of crowns as a restorative treatment option for tooth wear. There are also challenges with the use of composites as they can repeatedly fail and in these situations the indications for crowns[4] for treatment of tooth wear is worthy of consideration.

The major indicators for operative intervention are aesthetics and protection from future wear. It is unlikely that providing direct or indirect restorations will prevent sensitivity unless preventative measures such as desensitising agents are utilised. A recent European consensus meeting discussed the management of severe tooth wear.[4] The consensus report suggested that restorative care should be delayed as long as possible and that if indicated minimal intervention should be the first port of call. The consensus report has also recognised that management decisions are multi-factorial and depend on the severity of disease as well as the wishes of the patient. It is the wishes of the patient in conjunction with previously failed composites that can lead onto treatment with crowns (Fig. 1).

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Composites vs crowns

The use of full coverage crowns could be considered a controversial intervention as it involves preparation of tooth structure for teeth that have already lost volume due to wear. Direct composite build ups have advantages as they do not require preparation, can be easily adjusted and are considered by some to be reversible. A recent systematic review[5] reported the results of studies utilising composite for the treatment of wear. This review mainly concentrated on direct composites, indirect composites and porcelain veneers, and reported that neither material performed better than another. This review did not include studies of full coverage crowns. Another study by Milosevic[6] showed favourable long term results with direct composites in tooth wear treatment but were all placed by a single operator. However, extensive direct composite restorations are time consuming and can be difficult to achieve ideal aesthetic results and need maintenance. Bartlett and Varma[7] in 2017 reported that composites used in the treatment of tooth wear require continuing repair and constant review, increasing the long-term costs. The restorative challenge is, what to do if composites continually fail, if the tooth wear is too extensive for composites or if patients ask for crowns.

Crowns on the other hand are destructive and can lead to further complications such as loss of vitality. In young patients, the long-term maintenance of restorative treatment must be considered. Walton *et al.*[8] among others[9] suggested that crowns could last up to 15 years, however, this and most other studies tend to be based on single tooth crowns that are not prescribed for patients with extensive tooth wear. There has been a report comparing crowns and composites in toothwear cases[10] showing better survival estimates for anterior crowns; but the patient numbers were low. The European consensus report[5] noted that patient's wishes are a factor in decision making. Therefore, the operative treatment of tooth wear must include consideration for crowns.

Planning crowns for patients with tooth wear

Stabilisation of active disease is a key starting point and a detailed diet history is often used to ascertain potential causes. If there is suspicion of gastro-oesophageal reflux then this should be managed with the appropriate medical colleague. A periodontal assessment should confirm excellent oral hygiene which is necessary for maintenance of multiple crowns particularly if crown lengthening will be required.

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Indirect restorations for severe tooth wear: Fracture risk and layer thickness

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ABSTRACT

Objectives: This in vitro study investigated static failure risk related to restoration layer thickness for different indirect materials and compare them to direct composites.

Methods: Two ceramics (IPS e-max CAD, EmpressCAD (Ivoclar Vivadent)), two indirect composites (Estenia (Kuraray), Sinfony (3M)) and two direct composites (Clearfil AP-X (Kuraray), Tetric EvoCeram (Ivoclar Vivadent)) were chosen. Of each material, 25 discs varying in thickness (0.5–3.0 mm) were prepared and cemented to bovine dentine. For measuring compressive strength, samples were placed in a universal testing device. Each sample was uniaxially loaded until failure occurred. For each material a regression model based on the Weibull distribution was used to estimate the relation between restoration layer thickness and failure. Using these models, the chance of failure, standard error and 95% confidence interval for that chance is estimated. Groups of materials were compared as well.

Results: Except for Tetric Evoceram, all materials show a significant positive association between layer-thickness and compressive strength, with an increased strength of increased thickness. ProCAD performed significantly worse than all other materials, especially when compared to the other ceramic material (IPS e-max CAD) ($p = 0.001$).

Conclusion: For most tested materials, a thicker layer offers more strength, however, this property seems to be material/brand specific.

Clinical relevance: As direct composites showed the best results within the limitations of this in vitro study, dentists should consider these materials as a good choice for restoring severe tooth wear, and may offer superior performance compared to indirect composites and ceramics. For some brands of materials thicker layers result in a stronger restoration.

1. Introduction

Severe tooth wear is mainly caused by erosion, bruxism or a combination of these factors[1] and results often in loss of vertical dimension. In order to gain sufficient space for restoring worn down teeth, an increase of this occlusal vertical dimension is often required. It is still unclear which materials are the best for treating this specific patient group. Recent literature shows that fracture of restorations is the

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REVIEW

Direct Composite Resin for the Management of Tooth Wear: A Systematic Review

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Background: This study systematically reviewed survival of direct composite to restore worn teeth.

Materials and Methods: A comprehensive electronic search of databases sourced from Medline-PubMed, Embase, Cochrane Central, Scopus, Google scholar was performed on literature published between January 1990 and December 2018. Grey literature was also reviewed. Data extraction included sample size, number of composite restorations, operators, composite type, mean or total follow-up time and success rate expressed as either percent of successful restorations or median survival time (MST). Methodological quality was rated using the Joanna Briggs Institute appraisal checklist for case series. Studies on children, non-carious cervical lesions, cast and all-ceramic restorations, case reports and case series with <5 participants were excluded.

Results: A total of 1563 studies were identified and 1472 were screened. Sixty-two full-text papers were assessed for eligibility which resulted in 10 studies that met inclusion criteria. These were mainly case series and assessed 3844 direct composite restorations placed in 373 patients mostly in hospital settings. Survival ranged from 50% to 99.3%. Methodological quality improved from the earlier studies and was rated low to moderate in 7 studies and good in 3. The funnel plot showed a low risk of publication bias but there was considerable heterogeneity (I^2=97.7%). There was a non-significant weak negative association between age and survival (Spearman's rho=−0.12).

Conclusion: Qualitative evaluation of the studies proved difficult because of the nature of case series but reporting improved in the later studies. Despite the generally short duration of studies, small sample sizes in terms of patient numbers and composite restorations, the survival rates of direct hybrid composite resin in the short to medium term are acceptable and support their application for the restoration of worn teeth.

Keywords: systematic review, direct composite, tooth wear

Introduction

The survival of direct composite resin for the restoration of the worn dentition has been described in several studies. There was a lack of evidence, however, on what is the best way to restore the worn dentition, which was the title of a dental evidence-based topic (DEBT) published in 2011.[1] The main advantage of direct composite over conventional approaches for restoration of the worn dentition is that it embraces an additive, minimally invasive approach advocated by the European consensus statement.[2]

Three systematic reviews, published in 2014 and two in 2016, assessed the rehabilitation of worn teeth.[3–5] None were able to produce a meta-analysis and the

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ORIGINAL ARTICLE

WEAR RESISTANCE OF DENTAL MATERIALS WHICH ARE USED FOR ANTERIOR TEETH RESTORATIONS

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ABSTRACT

The aim of this study was to compare the wear resistance of such restorative materials as composite resin, feldspathic ceramic, leucite glass ceramic with intact enamel and to draw an analogy with some similar researches.

Materials and methods: In this research 20 extracted human teeth (maxillary incisors) without fillings and carious cavities were used as samples. All samples were disinfected and stored in saline in order to prevent dehydration. Teeth roots were cut off for the measure of fixation on an organic glass plate using chemically polymerizable resin. If necessary, the teeth were also cut on their lateral sides in order to give them equal size. The samples were placed in a frame-holder, located on the lever of the machine MI-2, which determines abrasion resistance under slipping.

Results: The research has revealed that the average wear resistance of natural teeth was 122,67±4.9 J/mm^3 (Tab 1). The archived result overcomes dental composite resin twice more (62.8±1.21 J/mm^3), feldspathic ceramic 6.5 times more (16.32±1.2 J/mm^3) and leucite ceramic over the half (73.79±3.12 J/mm^3)

Conclusion: Thus, according to this performed research and the analysis of the relative literature sources it can be stated that dental composite resin and leucite ceramics may be proposed as the materials of choice for anterior restoration of teeth. They have shown the good wear resistance and tolerance to antagonizing natural teeth.

KEY WORDS: leucite, composite resin, dental porcelain

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INTRODUCTION

The principle of biomimetics in dentistry is associated with balanced luminosity, translucency, opacity, wear resistance of artificial restorations of teeth being maximally similar to natural dentin and enamel. Restorative material which are used for anterior restorations nowadays should resemble hard tissues of teeth both from mechanical and aesthetic point of view. The ability of restored anterior teeth to stay as worn as natural tooth enamel and not to abrade excessively antagonist teeth often predefines the quality of aesthetic rehabilitation and the quality of life of patient after treatment [1,2] Lambrechts et al. reported that the wear of enamel opposing enamel is approximately 20 to 40 μm per year [3].

Wear of teeth is a physiological process which depends on such factors as mastication habits, food consistency, neuromuscular parameters of masticatory apparatus and material`s abrasive properties of opposing teeth [4].

If the abrasive properties of restorative material differ from natural tissues the wear process may become accelerated comparing to the natural dentition [5].

Nowadays one of the challenging issues for practitioners dealing with anterior restoration is the choice of proper restorative material. The task of the dentist is not only to restore or improve aesthetics but to regain the function and to improve the quality of patients` life on a maximal term. From the list of available restorative materials several types should be underlined. Those are light-curing composite resin, feldspathic ceramic and leucite reinforced glass ceramic [6,7].

Feldspathic ceramic has been in use in dentistry for more then a century. It proved to be a very natural-looking material for tooth restoration with good mechanical properties [8], however rather abrasive to antagonists especially if unpolished [9].

All-ceramics is the restorative material which have been in dental practice for the recent twenty years. While being in practice all-ceramics have proved to be aesthetic, durable, chemical inert, bio-compatible, resistant to fractures and wear [10]. However, despite trying to solve the problem with excessive wear of enamel, all-ceramics haven`t solved this problem completely [9,11,12].

According to some researchers enamel wear pattern depends on the microstructure of opposing material and different oral cavity factors [13]. However, correlation between clinical and laboratory data has revealed to be a challenging task [14].

Some investigations about wear resistance of dental ceramics when opposing intact enamel reported that dental porcelain has been described to be wear resistant against opposing restorative materials and enamel [15,16]. Preis et al. has found that porcelain has comparable or reduced wear

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Surface Roughness of Composite Resins Subjected to Hydrochloric Acid

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The purpose of this study was to determine the influence of hydrochloric acid on surface roughness of composite resins subjected to brushing. Sixty samples measuring 2 mm thick x 6 mm diameter were prepared and used as experimental units. The study presented a 3x2 factorial design, in which the factors were composite resin (n=20), at 3 levels: microhybrid composite (Z100), nanofilled composite (Filtek™ Supreme), nanohybrid composite (Ice), and acid challenge (n=10) at 2 levels: absence and presence. Acid challenge was performed by immersion of specimens in hydrochloric acid (pH 1.2) for 1 min, 4 times per day for 7 days. The specimens not subjected to acid challenge were stored in 15 mL of artificial saliva at 37 °C. Afterwards, all specimens were submitted to abrasive challenge by a brushing cycle performed with a 200 g weight at a speed of 356 rpm, totaling 17.8 cycles. Surface roughness measurements (Ra) were performed and analyzed by ANOVA and Tukey test ($p \leq 0.05$). Surface roughness values were higher in the presence (1.07±0.24) as compared with the absence of hydrochloric acid (0.72±0.04). Surface roughness values were higher for microhybrid (1.01±0.27) compared with nanofilled (0.68 ±0.09) and nanohybrid (0.48±0.15) composites when the specimens were not subjects to acid challenge. In the presence of hydrochloric acid, microhybrid (1.26±0.28) and nanofilled (1.18±0,30) composites presents higher surface roughness values compared with nanohybrid (0.77±0.15). The hydrochloric acid affected the surface roughness of composite resin subjected to brushing.

Key Words: dental materials, composite resins, hydrochloric acid.

Introduction

Dental erosion is one of the main factors for tooth wear (1) that occurs without bacterial involvement by chemical dissolution of the dental structure (1-3) by acids (1). These acids are derived from the dietary and endogenous factors, such as eating disorders and gastroesophageal reflux (1,4).

The hydrochloric acid released by gastroesophageal reflux may be responsible for a severe tooth wear, when it remains in contact with the oral cavity for a long time (5). If tooth structure loss reaches a high severity, functional and esthetic rehabilitation of the teeth becomes indispensable (1). The choice of an adequate restorative material plays an extremely relevant role in the durability of the restoration.

Composite resin provides excellent properties for restoration, including wear resistance (6). However, dental erosion can damage the physical and mechanical properties of the composite (3), leading to organic matrix degradation and exposure of the inorganic filaments (7). These changes lead to increase of surface softening and roughness, which are responsible for the decrease in restoration durability (8).

Likewise, the resin matrix may be eroded by tooth brushing, leading to irregularities on the material's surface (9). The abrasion resulting from brushing acts synergistically with the erosion phenomenon, leading to product degradation over the course of time (3).

Recently, a composite resin containing nanofillers, which has better mechanical properties than those of microhybrid resin, was introduced on the market. The insertion of a large quantity of small, homogeneously distributed fillers provides the organic matrix greater protection against wear, thereby enhancing the material resistance to degradation (10).

It is essential to choose material suitable for restoring the teeth of patients with gastroesophageal reflux in order to ensure longevity of the procedure, because contact with hydrochloric acid may be cause for superficial alteration in composite resin. This may especially occur simultaneously with brushing. Thus, the aim of this study was to evaluate the effect of hydrochloric acid on the surface roughness of composite resins submitted to brushing. The tested null hypotheses were: 1) hydrochloric acid does not affect the surface roughness of composite resins submitted to brushing; 2) The composition of material has no influence on the wear resistance of composite resin.

Material and Methods

Experimental Design

The experimental design was factorial, with the evaluated factors composite resin at three levels: microhybrid composite (Z100), nanofilled composite

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Clinical performance of occlusal onlays made of lithium disilicate ceramic in patients with severe tooth wear up to 11 years

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ABSTRACT

Objectives. Evaluation of survival and complication rate of monolithic occlusal onlays made of lithium disilicate ceramic used in patients with severe tooth wear up to 11 years of clinical service.

Methods. In a prospective non-randomized clinical study 7 patients (4 male, 3 female; median age: 44.3 ± 6.56 years old) were restored full mouth with a total of 103 adhesively bonded occlusal onlays made of lithium disilicate ceramic (IPS e.max Press, Ivoclar Vivadent, Schaan, Liechtenstein). All restorations were examined during annual recall visits using periodontal parameters according to the modified United States Public Health Service (USPHS) criteria: (a) marginal discoloration, (b) secondary caries, (c) marginal integrity, (d) surface texture, (e) restoration fracture, and (f) occlusal wear, rating with Alpha, Bravo and Charlie over an observation period up to 11 years (68–139 months; median: 94.9 ± 26.1 months). Data was statistically analyzed using the Kaplan–Meier estimation.

Results. Monolithic lithium disilicate occlusal onlays presented a 100% survival rate. Four restorations within one patient (3.9%) presented marginal discoloration, one after 60 and three after 108 months (all rated Bravo). One restoration (1%) showed a marginal crack formation (technical complication) after 120 months, rated Bravo. No biological complication, debonding or secondary caries could be found and tested periodontal parameters showed excellent results.

Significance. Based on the analyzed data up to 11 years, monolithic occlusal onlays made of lithium disilicate ceramic can be considered as a reliable treatment option for full-mouth rehabilitations in patients with severe tooth wear.

1. Introduction

Continuing socioeconomic changes, advances in dental healthcare, and increased awareness of oral hygiene support patients in keeping their natural teeth for longer. According to the Fifth German Oral Health Study, extraction rates due to carious or periodontal lesions have decreased significantly in the last few decades [1]. The number of remaining teeth at an advanced age has increased significantly: younger seniors aged 65–74 years old had on average at least five more of their own teeth in 2014 than in 1997 [1]. Beyond this background, there is a clear trend moving from traditional removable prostheses towards fixed restorations [1,2].

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Long-term Survival of Direct and Indirect Restorations Placed for the Treatment of Advanced Tooth Wear

Roger J. Smales* and Thomas L. Berekally†

Abstract - *Advanced tooth wear was restored with direct resin-based composites (RBCs) in 17 patients, and with indirect ceramo-metal crowns (CMCs) and full gold crowns in 8 other patients. The mean patient age was 64.9 (8.6 SD) years, with each patient having a mean of 13.8 (5.4) restorations. In this retrospective case series study, the mean restoration age was 5.0 (3.0) years for the direct and 5.9 (2.6) years for the indirect restorations. Over 10 years, cumulative survival estimates were 62.0% for direct and 74.5% for indirect restorations (P=0.23). Survival estimates were 58.9% for anterior RBCs and 70.3% for anterior CMCs (P=0.06). RBCs usually failed from fractures, and CMCs from complete losses. RBC failures were usually replaced or repaired, while CMC failures often required root canal therapies or extractions. The findings from this relatively small study require confirmation by large long-term controlled clinical trials.*

KEY WORDS: Tooth wear, Resin composite, Crowns

INTRODUCTION

Tooth wear or tooth surface loss is observed increasingly in both younger and older persons in modern societies[1,2]. Although the aetiology is often multifactorial, acid erosion (corrosion) is a principal cause in younger persons and also is observed frequently in older persons[3,4]. Advanced tooth wear with large areas of exposed dentine is a restorative problem for older patients who want to retain their remaining teeth. Traditional restorative treatments for these patients usually involve costly laboratory-fabricated multiple crowns and fixed prostheses as a 'full-mouth reconstruction'.

However, the concept of the 'shortened dental arch'[5,6], the often localized sites of tooth wear, the ability of non-occluding permanent teeth to continue to erupt[7-9] (following an increase in occlusal vertical dimension), and the continued improvements in resin-based composites (RBCs) and adhesives have resulted in more conservative restorative treatment approaches. The potential advantages of using direct tooth-coloured restorative materials include the preservation of sound tooth substance, less overall clinical time and costs, an acceptable appearance and high patient acceptance[8-11].

Reports on the use of direct placement RBCs for the treatment of tooth wear have been largely confined to the treatment of localized anterior tooth wear[9,12-15]. The few clinical studies that have been published on the results of using RBCs to treat localized anterior tooth wear, have reported encouraging results over periods of up to approximately 5 years[9,14]. There have been very few reports on the treatment of localized posterior tooth wear and generalized tooth wear with RBCs[10,11], and the authors were unable to locate any English language publications of controlled clinical trials. The authors were also unable to locate any studies which compared the long-term clinical behaviour of RBCs with that of conventional indirect single crowns used to treat advanced tooth wear in older persons.

The objective of the present retrospective case series study was to investigate the long-term survivals of single direct and indirect restorations placed in two separate groups of older patients for the restoration of advanced tooth wear. The null hypothesis proposed is that there are no significant long-term restoration survival differences between the two groups of patients.

MATERIALS AND METHODS

In 2004, an independent reviewer (RJS) examined the dental records of patients who had been treated for advanced tooth wear (as shown by large areas of exposed dentine) by two prosthodontists at the Adelaide Dental Hospital, Adelaide, South Australia. Records were found for 17 patients where only direct restorations were placed following a treatment policy change, and for 8 patients (controls) where only indirect restorations were placed as was the previous practice. The direct placement restorative materials were fine-particle hybrid RBCs. The indirect placement restorative materials were low-gold content casting alloys and sintered porcelains. The University of Adelaide Committee on the Ethics of Human Experimentation approved the study.

Data collected from the dental records included: ages of patients and restorations; principal reasons for seeking dental treatment and the probable aetiology of the tooth wear; numbers of opposing tooth contacts and restored tooth types, restoration classes, removable partial dentures made; restoration failures and subsequent treatments. Restorations were deemed to have failed when either the restorations or the restored teeth required further operative treatments.

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