THE INCIDENCE OF PROSTHETIC MATERIALS ON WEAR MECHANISM OF ANTAGONIST DENTITION: A REVIEW

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Abstract

Wear is a process that includes both natural teeth and restoration materials. Wear mechanism remains unclear and conflicting results are still found. It is normally a slow multifactorial process. Various influencing factors have been cited through the literature. This paper presents an overview of the prosthetic materials commonly used and their implication in the wear process of antagonist teeth or prostheses. A search was conducted on PubMed and Elsevier using the following key-words: wear, wear resistance, abrasiveness, prostheses wear, prostheses resistance, restorations wear, prostheses material, abrasion etiology and abrasion physiopathology. Patient and material–related factors were reported. Comparison of the protocols remains difficult due to the differences in the methodology.

Key-words: Restorations – antagonist teeth - abrasiveness.

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L'INCIDENCE DE MATÉRIAUX PROTHÉTIQUES SUR LE MÉCANISME D'USURE DE LA DENTITION ANTAGONISTE: UNE REVUE DE LA LITÉRATURE

Résumé

L'abrasion est un processus qui inclut les dents naturelles ainsi que les restaurations prothétiques. Ce mécanisme n'est pas bien défini et des résultats contradictoires sont encore rapportés. Il s'agit habituellement d'un processus multifactoriel lent. L'influence de divers facteurs a été citée dans la littérature. Une recherche par « PubMed » et « Elsevier » a été réalisée. De nombreux facteurs, reliés au patient ainsi qu'aux matériaux de restaurations, ont été identifiés. Ce papier est une revue de la littérature traitant les différents matériaux de restaurations prothétiques et leur impact sur l'abrasion des dents ou des prothèses antagonistes.

Mots- clés: restaurations – dents antagonistes - abrasion.

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Introduction

The wear process, initially physiological, may in some cases, become pathological. Restorations should counteract abrading forces without being harmful to opposing teeth or prostheses [1, 2].

New materials are proposed to fulfill esthetic requirements. Functional properties have still to be considered. Metal alloys, ceramics, composites and unfilled polymers are some of the restorative materials available on the market. The wear mode may differ in each category. The aims of the present article were to overview the restorative materials currently in use and to focus on some wear related properties.

An electronic search was conducted, during July 2013, on PubMed and Elsevier using the following keywords: wear, wear resistance, abrasiveness, prostheses wear, prostheses resistance, restorations wear, prostheses material, abrasion etiology, and abrasion physiopathology. Peer-reviewed articles were retained. Available full-text articles were read. Related articles were also scrutinized. No hand search was driven.

Current prosthetic restorations

Metal-ceramic prostheses are considered the gold-standard in dentistry based on the long-term documented performance and longevity as well as the reasonable esthetics results [3]. Porcelain can adhere to any clean gas-free metal covered with an adherent layer of oxide [4]. However, the high-gold alloys remain the alloys of choice based on the adequate oxide production that assures a solid metal-porcelain bond [5].

Nowadays, metal-free restorations are more and more requested. They are provided by different techniques, as by split-cast, pressing or milling.

Industrially-produced ceramic blanks can be structurally more reliable than the manually-processed ceramic materials [6]. High strength ceramic crystals dispersed within a glassy matrix can enhance porcelain mechanical properties [5]. Still, crown fracture is the most common complication reported with all-ceramics [7]. However, lithium disilicate glass-ceramic showed high fracture loads [8], whereas aluminous porcelain exhibited poor tensile strength and fracture resistance under shear forces [9]. The In-Ceram system has a flexure strength suitable for most locations [9- 11].

Zirconia restorations were proposed to increase strength and reliability of the metal-free tooth-colored restorations [12]. In most cases, the prosthesis is composed of a zirconia core covered by feldspathic porcelain. Even if zirconia is considered as the most suitable for posterior restorations [13], high incidence veneer chipping is frequently reported [4, 14, 15]. Zirconia ceramic without veneering is proposed when occlusal or palatal space is insufficient [16]. The wear behavior of the zirconia material is to be considered when it is an antagonist to natural teeth or ceramic restorations [17].

Material properties and generated wear

The wear behavior of restorative materials is dictated by different product properties such as type, microstructure, surface toughness and strength [17, 18]. Abrasion is defined as the property of one material to wear away another material by means of frictional contact [19].

In metallo-ceramic crowns, the porcelain that layers the metal framework is usually a feldspathic one. Mechanical degradation, crack growth, low fracture toughness and porosities inclusion are reported to affect its longevity [20]. Aqueous environment reduces its strength by inducing corrosion-fatigue mechanism [21, 22]. In this type of ceramics, the glassy matrix will largely control the mechanical properties instead of the crystalline phase [23].

Air bubbles can also be entrapped within the mass by mixing powder and liquid, during porcelain preparation. This may increase the stress in the porous area [23]. Particles size, viscosity of the matrix and firing temperature are also contributing factors in fracture incidence [24]. More porosity is exhibited within low-fusing ceramics [24, 25].

Crystals in a glass matrix form a non-homogenous material. So, wear will act by fracture rather than by plastic deformation as with metals. Poor relationship exits between ceramic hardness and enamel wear due to porcelain composition [23].

Fracture toughness is influenced by crystal size, aspect ratio, orientation and distribution of the glass phase, added to the porosities entrapped [17, 26].

The dominant fracture mode reported was radial cracking beneath the contact area. Debonding near the shoulder of the crown was also induced by off-axis-loading [27].

Clinicians should also be aware of the wear effect of dental restorations on the opposing teeth or restorations. Ceramic, particularly when unpolished, can destroy enamel [28]. A metal occlusal surface, especially a high noble one, is recommended to limit wear of antagonist teeth [29]. Gold (types III and IV) wears approximately at the same rate as enamel [30-32]. Chrome-Cobalt is also less abrasive than ceramics {Kim M-J, 2012 #69;Graf A, 2002 #73} [32].

Greater abrasion of dental enamel induced by ceramic substrates has been reported, compared to that generated by dental alloys [12, 33, 34].

Wear mechanism remains unclear and conflicting results are reported [35]. Cast and pressed ceramics are reported to be less abrasive than layered one [36], with the pressed ceramic being the least enamel abrasive and the most wear resistant [37]. Oral environment as well as ceramic microstructure and surface roughness are cited as influencing factors [23].

Layered feldspathic ceramic on zirconia cores exhibited high chipping complication rates. The CAD/CAM veneers proposed to replace the layered porcelain presented less fracture

[6]. The zirconia, when placed without a veneering ceramic, showed significantly less vertical and volumetric loss [17]. No material wear has been detected [35, 38]. Still, its incidence on the antagonist is to be clarified [38]. Kim et al. reported that zirconia ceramics caused less wear on the opposing enamel than feldspathic porcelain [33].

Ceramic against ceramic are reported to produce severe attrition under high occlusal forces [39]; the porcelain wear mechanism is clearly classified as a fatigue type. A microfilled resin, proposed as shock absorber, showed three to four times wear rates higher than porcelain [31].

Staining materials are routinely used. They are essentially metal oxides particles which are abrasive to enamel. Glassy phase, being less wear-resistant, wears preferentially. Porosities incorporated during their application can also increase enamel abrasion [23, 40].

Porcelain surface has to remain smoothly glazed or highly polished to be less harmful on antagonist dentition [23, 37, 40]. Results from studies that compare polishing smoothness to glaze surface are conflicting [41, 42]. Polishing techniques to create surfaces as smooth as glaze couldn't be identified [42, 43]. However, this glaze layer is lost after a short period in function or by occlusal adjustments at chairside [17, 35].

During porcelain processing, the added flaws will reduce ceramic strength and augment enamel wear [25]. Elmaria reported more enamel wear when opposed to IPS-Empress, compared to when opposed to condensable All-ceram [44]. CAD/CAM restorations are also polished to eliminate surface defects caused by machining [38]. Intra-oral polishing may be needed after post-cementing occlusal adjustments [45] Intra-oral zirconia polishing to prevent excessive wear of the opposite dentition, remains difficult to obtain [38].

Patient related factors

Tooth enamel, as well as ceramics, may be affected by environmental interactions. Heavy biting forces and parafunctional habits, incorrect toothbrushing /dentifrices, abrasive and acidic diets, regurgitation, reduced salivary flow and altered saliva composition, defective tooth structure and reduced posterior tooth support are some of the cited patient related factors reported to increase tooth and restoration wear [46].

Declared bruxers presented 60% rate of major porcelain fractures among patients who showed the common clinically observable occlusal wear patterns [47].

The microstructural components of the ceramic will surely dictate its behavior [23]. In wet environment, the sodium ions loss to the aqueous milieu will reduce the ceramic surface hardness. At the microscopic level, the softened glass surface will stick easily to sharp asperities [48]. Also, the presence of aqueous media will increase the coefficient of friction [49].

In the oral environment, the softened glass surface can be abraded by microscopic sharp asperities [48]. On the other hand, in case of regurgitation, pH levels are very low. Studies showed that the glassy matrix can be dissolved in the presence of extreme pH [50, 51]. Chemical deterioration is further related to glass ceramic composition and crystal incorporation [52].

Fluoride applications will also chemically attack a glassy matrix to form water-soluble fluorosilicate [53].

As for the glassy matrix, researchers raised some concerns regarding zirconium dioxide structural stability when exposed to the oral environment [38, 54].

To reduce the risk of chipping, gold-acrylic fixed partial dentures have been proposed for heavy bruxers. However, resin-based materials wear rate exhibited three to four times more than gold or ceramics wear rate [55].

Crown material has a great influence on the maximum principal stress in the crown. Material thickness, cement modulus, load position, and supporting tooth core are also contributing factors [56].

Zirconia core material shows a strength comparable to conventional metal frameworks. Still, framework fractures are reported to be related to occlusal trauma [57 -59].

The concentration of heavy stresses in the connector area increases the risk of catastrophic fracture. Cantilevered all-ceramic fixed partial dentures remains questionable [2]. In case of confirmed bruxism, splinting must be avoided [29].

Discussion

This paper tried to overview the prosthetic materials commonly used and their implication in the wear process of antagonist teeth or prostheses. Studies were not scrutinized on the basis of evidence-based dentistry. A limitation of this literature review is that it included studies with non-declared sample size, or measurement methods. Other studies were *in vitro* experiments, whereas, non-randomized controlled studies were lacking. Well-structured clinical prospective studies remain essential in addition to well-designed *in vitro* studies. Comparison of the protocols remains difficult due to the differences in the methodology. Studies investigated frictional wear, that is, masticatory attrition, as well as abrasion by tooth brushing.

Methodically, attrition is defined as the physiological wearing away of the tooth structure as a result of tooth-to-tooth contact, as in mastication, without (two-body wear) or with abrasive substance (three-body wear) intervention [60, 61].

Wear is normally a slow process [62]. Attrition clinically manifests as a flat circumscribed facet on enamel and/or on restorative material. As the lesion progresses, there is a tendency towards the reduction of the cusp height and flattening of the occlusal inclined planes. That may lead to loss of vertical dimension [61].

How well this phenomenon can be imitated experimentally, with the help of artificial masticators to assess the adequacy of restorative materials still remains a matter of discussion [38, 63].

Reproducing intra-oral conditions, during the *in vitro* studies, is quite difficult. An effort was made to create artificial oral environments by applying cyclic forces in artificial saliva, under fluctuating temperature [64]. Results were then extrapolated to intraoral conditions. Long-term clinical studies are still needed to demonstrate the true outcomes [29, 65] and make conclusions [66]. Many restorations may continue to provide satisfactory service, despite minor chipping [46].

Some dogma has blamed hardness for the accelerated loss of material. Strong correlation between ceramic hardness and enamel wear rates has not been confirmed by scientific studies. Ceramic microstructure, roughness of contacting surfaces, and environmental influences are directly involved [23]. Internal porosities and surface defects increase wear by acting as stress concentrators. Glazing is quickly lost under function. Underlying polished surface is mandatory. Internal characterization of ceramics is preferred to avoid abrasive metal oxide present in shading materials [23].

Dysfunctional occlusion or parafunctional habits such as clenching and bruxism can be triggered by a degraded ceramic surface. This may accelerate the wear process. In case of extreme bruxism, excessive occlusal parafunctional forces may lead to posterior core fail [9].

There is no evidence that prosthetic therapy, or any other available treatment, can eliminate bruxism. Equally, there is no evidence that bruxism can be caused by prosthetic therapy. The need for research in this area remains clearly great [67]. Splinting has to be avoided in case of confirmed bruxism [29]. Physiological tooth mobility will be preserved. Cementation and crown failure can be detected and more easily corrected [55].

Heavy biting forces necessitate the placement of metal or metal-ceramic restorations [46]. A well distributed occlusion has an important effect on the wear process [23]. Multiple contact areas (rather than a single point of contact) can lower the stress concentrations. Therefore minimizing sliding contacts in centric and eccentric movements is essential when placing new ceramic restorations [23].

Conclusion

Wear mechanism remains unclear and conflicting results are still reported. Materials as well as patients related factors have been implemented. Despite the limitations of the present paper, several issues were raised.

Patient selection and controlling wear factors may reduce complications rate. Adapted tooth preparation, adequate ceramic support and proper occlusal equilibration may increase prosthetic treatment longevity.

Ceramic materials, as well as metal alloys are very wear-resistant. However, ceramic materials can be harmful to the opposing enamel. Fracture toughness, internal porosities and surface defects are cited as major material factors in the wear process.

Machined ceramics have been reported to be less abrasive than layered ones.

Although scarce, research showed low enamel wear when opposed to full zirconia.

In case of heavy bruxers, metal or metal-ceramic restorations seem to be the safest choice in cases of high load conditions. Splinting must be avoided.

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