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Review

Human tooth wear in the past and the present: Tribological mechanisms, scoring systems, dental and skeletal compensations

Emmanuel d'Incau [a,b,*], *Christine Couture* [b], *Bruno Maureille* [b]

[a] *Université Bordeaux Segalen, Faculté d'Odontologie, 16-20 cours de la Marne, 33082 Bordeaux Cedex, France*
[b] *Université Bordeaux, UMR 5199 PACEA, "Anthropologie des Populations Passées et Présentes", Université Bordeaux 1, Avenue des Facultés, 33405 Talence Cedex, France*

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ABSTRACT

This review of human tooth wear describes the fundamental mechanisms underlying this process. Using the tribological approach they can be systematised and this in turn aids our understanding of them. In past populations wear was ubiquitous, intense, abrasive and physiological as it was related to their food and their technologies. In these populations, it affected the proximal surfaces, and the occlusal surfaces which modified the occlusal plane profoundly. To categorise this wear many different classification systems are used, from which we can determine diet, cultural changes and the age at death of individuals. They also illustrate the evolution of certain functional dental and skeletal compensations in the masticatory apparatus such as continuous dental eruption, mesial drift of the arches and incisor lingual tipping which can then be monitored. These physiological adaptations related mainly to function and ontogenesis can also be found in present-day populations where wear is moderate, although they are much less obtrusive. Apart from certain pathological cases associated with a specific parafunction, iatrogenic tooth brushing or an eating disorder and encouraged by an acid environment, they are the result of a physiological process that should not be halted. To ensure this, it is essential to prevent lesions related to tooth wear, to detect them early and establish a reliable diagnosis. Types of tooth wear that had remained unchanged since the origin of humanity have undergone profound changes in a very short space of time. Today's tribochemical pathological model has replaced the abrasive physiological model of the past.

Contents

* *Corresponding author at*: Université Bordeaux Segalen, Faculté d'Odontologie, 16-20 cours de la Marne, 33082 Bordeaux Cedex, France. Tel.: +33 557 107 957.
E-mail address: e.dincau@pacea.u-bordeaux1.fr (E. d'Incau).
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1. Introduction

Wear is deterioration as a result of use. Tooth wear has existed since the beginning of humanity and in all civilisations. It occurred systematically and intensively in past populations, but is considered a physiological process. However, this notion is often unclear as nowadays, although the process is less well developed, it is sometimes pathological in nature. In addition, it depends on many complex mechanisms, synchronous or sequential, synergetic or additive which can also often mask its true origin. With the aim of improving the diagnosis of tooth wear and for a better understanding of its various manifestations, in this review we first present the fundamental mechanisms of wear and their consequences, both in past populations and in contemporary industrialised populations. The second part looks at the categorisation of wear and choosing the most appropriate of the scoring systems used in odontology and dental anthropology according to origin, location and the populations studied. The last part covers dental and skeletal compensation mechanisms and explains how the masticatory apparatus adapts as wear progresses in order to maintain a functional occlusion throughout our lifetime.

2. Fundamental wear mechanisms

In dentistry, wear is a generic term commonly used to describe phenomena of attrition (proximal and occlusal inter-dental friction), abrasion (friction with the intervention of particles) and erosion (chemical dissolution). Although this longstanding terminology introduced by Hunter[1] is the one that is normally used, it does not entirely take into account the reality and variety of the physical and chemical mechanisms involved. In addition, it suggests that these three phenomena act independently, whereas in fact it is more often the case that they interact together, which makes diagnosis all the more difficult.[2] Another approach is to use terminology borrowed from the science and technology of tribology (from the Greek *tribein*, meaning to rub) which covers the study of friction, wear and lubrication.[3–5] To facilitate diagnosis of the different forms of wear of dental tissues and restorative materials, the oral cavity can be likened to a tribological system made up of four elements[6]:

- a solid body represented by a tooth, which may or may not be restored,
- a counter body usually represented by a solid (opposing tooth, tongue, soft tissue, object, etc.) less frequently by a liquid, a gas or a combination of these different elements,
- there may be an interfacial element represented by a solid (particles in the food bolus, in toothpaste, etc.), a liquid which lubricates to varying degrees (saliva), less frequently a gas or a combination of these different elements,
- an environment, usually represented by air.

Within this tribological system, four basic wear mechanisms can be described.[6] Their occurrence depends on many different parameters and enables us to qualify the behaviour of the dental tissue and the restorative materials. These may be (1) flexible or rigid depending on their capacity to deform reversibly, (2) hard or soft depending on their capacity for irreversible plastic deformation, (3) brittle or ductile depending on their capacity to resist crack propagation, and act as a shock-or energy-absorber.

2.1. *Abrasive wear*

Abrasive wear is the most common type of wear.[6] At the microscopic scale, no surface is entirely smooth. When there is contact between different materials it is through asperities which act as abrasive particles. Depending on the microroughness of these materials a number of microcontacts are made and define the real surface area, which is in fact much smaller than the maximal theoretical surface area. In addition, even though the overall pressure exerted between different materials may be low, the pressure developed locally at each microcontact is sometimes so great during displacement that it may lead to deformation or to rupture. Depending on the number of materials in contact, tribology distinguishes two types of abrasive wear: two-body abrasion and three-body abrasion.[3–6]

2.1.1. *Two-body abrasion*

This type of abrasion (from the Latin verb *abradere*, to abrade) is the friction between two solid bodies in movement where the surfaces are in direct contact. Tribology distinguishes four models of two-body abrasion, determined according to the angle of attack and the geometry of the asperities, the friction coefficient, the speed of the displacement, the pressure, the