Bioceramics Development and Applications

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Bioceramic Applications: The Case of Dentistry and Orthopedics

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Introduction

The use of ceramic materials in the field of biomaterials is rapidly expanding. Biomaterials are a preferred market for ceramics due to their chemical inertia and high hardness, compared to traditional metals. (Inlays, onlays, crowns, bridges, periodontal rings, brackets, implants, etc.). The main applications are orthopedic surgery (artificial joints, bioactive layers for better osseointegration) Seals for pacemakers, defibrillators, neurological stimulators, cochlear implants, etc.). In several cases, ceramic materials replace metallic alloys whose use induce, if poorly controlled, serious environmental problems (Cobalt /Chrome alloy, amalgam lead/Mercury/tin for the dental care, etc.). The metals making up these alloys lead to very serious environmental stresses due to their high toxicity [1-5].

Two main families of ceramic materials are used and developed in the field of biomaterials:

- Inert bioceramics for orthopedic applications.
- Bioceramics for use in dental prostheses.

Inert bioceramics for orthopedic applications

These are essentially alumina and zirconia ceramics, which must have characteristics in accordance with the relevant ISO and ASTM standards [6-12]. These ceramics are used mainly for the production of artificial joints (heads of hip prostheses for example) in combination with an antagonist (cotyle) piece made of polyethylene, or face another ceramic. The advantage of ceramic materials in this field lies in their better resistance to abrasion and corrosion than metals. These properties lead to a better friction behavior of the ceramic /polyethylene and ceramic/ceramic pairs compared to the metal and polyethylene couple, resulting in a longer life of the joint prostheses and greater safety for the patients. This better longevity of joint prostheses with ceramic insert induces reductions in health expenditure because a number of surgical revision procedures are thus avoided. Today, the use of articular prostheses with ceramic insert concerns 99% of the field of hip prostheses.

Use of bioceramics in dental prostheses

Although used since the early 1960s in the field of dental prostheses, ceramics did not really develop until the late 1970s. They are now a class of materials essential in the dental field because of their excellent quality aesthetics associated with perfect chemical inertia [3].

Patients are now guided by a double quest, that of an ever-growing aesthetic and that of a desire to use materials that are totally biocompatible and sustainable over time. As a consequence, a fundamental movement in the patients' habits as well as in the prosthetic treatments the dental technicians and realized by the prosthetists bring the manufacturers of materials ceramics for dental purposes to regularly develop new products able to replace the metals in the mouth [13-16].

Three major families of materials appeared: Glasses; Glass ceramics; Zirconia, aluminas and their derivatives.

Given the growing problems related to the use of metals in the mouth (bimetallism, corrosion Metallic, allergy, etc.), an increase in research in the field of ceramic materials in order to completely replace the metal in the mouth is likely to improve significantly.

Public health

A significant increase in research in this field of activity should contribute to a significant change in the lifetime of the materials used this in parallel with a decrease of the pathologies linked to the rejection of certain types of materials. This would result in an increase in the life span of the prostheses thus limiting the overall cost of the health policy.

The main areas for improvement

Total substitution of the ceramic in the crowns and bridges (replacement of the so-called "ceramic-metal" technique by the technique called "all ceramics").

Advantages

1. Removal of allergies to metal. Removal of metal corrosion problems. Removal of bimetallism problems due to the use of several metals for crowns. Increased aesthetics by disappearance of the gray color of the metal.

2. To develop the bonding works of ceramic inlays and on lays intended to replace mercury/silver type amalgams.

3. Eliminate environmental problems related to the recycling or use of mercury/silver amalgam.

4. To increase the quality of the prosthetic treatment using materials closer to the chemical constitution of dentin and natural enamel.

5. Studies on the aging of ceramic materials in the mouth.

6. Better knowledge of structural changes in different interfaces between materials in order to move from what is today the empiricism related to the decline in use to a better match between the choice of ceramic material and the prosthetic treatment aimed at.

7. Limitation of abrasion of antagonistic teeth.

8. All the ceramic materials used today have hardness superior to natural teeth, generating in the medium term an antagonistic teeth wear. The development of less hard materials with less abrasive properties would reduce the wear of natural teeth. Create a set of homogeneous materials between the dental implant, the dental crown as well as all the parts today made of metal that can be replaced by a

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ceramic material (tenon, supra-structure of implant, etc.).

Conclusion

It seems important to note that while each of the players in the dental and/or orthopedic sector today seems to agree that ceramics will play an increasing part in the field of prosthesis materials, an important part is still used today of metals due to the unavailability of simple shaping methods allowing the use of high-performance ceramic materials. The development of materials and processes would increase the durability of prosthetic while limiting the problem of rejection or aging related to the materials currently used. This significant change would generate substantial public health savings and would lead to the development of knowledge that is likely to be applied in many other areas of activity.

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