

BONE MIMETIC FOR CONFECTION OF BIO INSPIRED CERAMIC MATERIALS: LITERATURE REVIEW

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ABSTRACT

The loss of bone mass is a very common condition that is affecting people of various ages and causing a decline in quality of life of these people. Currently there is the possibility of using bone grafts to replace this bone loss, which can be autogenously, halogen or heterogeneous, with autogenously those get better results, but with disadvantage of providing two surgical sites in patients. In this sense, and also for other reasons related to properties of materials, authors are seeking to mimic natural bone for the production of ceramic biocompatible materials that can retain the structure and properties of natural bone tissue. Such material should present structure dense/porous structure similar to the cortical and cancellous bone. With this, these materials can have good future applications, including the replacement of lost bone tissue, and then becoming one more option to improve the quality of life of these patients. Thus, the objective of this study was a literature review of the ceramics that mimic the bone tissue, which are then considered bio inspired materials.

KEYWORDS: bio inspired materials, bio ceramic, bone tissue R Periodontia 2015; 25: 28-31.

INTRODUCTION

Among the various diseases that affect the bone structure, the loss of bone mass has been studied due to reduced quality of life. Mainly occurs in patients with advanced age, but also reaches young, mainly due to some kind of accident. Authors have reported that the magnitude of these health problems among the population has led researchers looking for materials that can replace appropriately these damaged bones (Kawachi *et al.*, 2000).

The materials used to replace bone fall into a class called biomaterials and must show biological and physical properties compatible with tissues of the host, to stimulate an appropriate response (Kawachi *et al.*, 2000).

The usual bone grafts goal is to provide enough bone to allow the insertion of endosseous implants in compromised maxillary or remedy the and aesthetic and / or prosthetic patient's needs (Misch, 2000). The even better method to

achieve these grafts derived from autogenously bone grafts, which are made by removing a bone grafting and put in the local region that is missing from the same host bone, an example is the removal of bone from the chin area and grafting this bone in maxilla. The main disadvantage of this procedure is to perform two surgical sites in patient. There is the possibility of performing heterogeneous bone grafts (bone bank) and the use of allograft bone (lyophilized bovine bone), but the both do not have the same quality as autogenously bone grafts have (Lee, 2006; Thorwarth *et al.*, 2005). Thus, it is still a challenge for clinicians which kind of bone grafts should be used in terms to be more suitable and less damaging to the patient.

Various systems and materials used can be considered inspired materials by the observation of natural systems. A great selection for survival and adaptation that some living organisms have shown great potential to be used as inspiration for making new materials, which have been called

bio inspired materials (Trask, Willians, Bond, 2007; Ortiz, Boyce, 2008; Zhou, 2000; Sanchez, Arribart, Guille, 2005). Concern to implant dentistry, which is a specialty of dentistry that has been growing in recent years, bio inspired materials also can be very helpful especially those related to bio ceramic materials that can mimic bone properties (Zhang *et al.*, 2007), and assist surgical procedures for placement with bone implants.

In this sense, due to bio inspired materials in bone tissue may have excellent applications in the near future, it is timely to review the literature related to these materials, relating their characteristics, properties and possible applications, thus seeking a greater understanding of this very promising biomaterial.

REVIEW OF LITERATURE

Recently a study on the adhesiveness found in the gecko's legs was published; this adhesiveness feature can be mimicked by making bio inspired materials which can be used for many applications (Lee, Lee, Messersmith, 2007). Biomimetic and/or bio inspiration for use in materials is considered one of the most promising scientific and technological challenges of the coming years, authors looking to gain the understanding of the structure of materials, phase separation, containment, possibilities for relations with external stimuli and use for making genetics proteins (Sanchez, Arribart, Guille, 2005). Due to biological systems and biological half-systems the development of fully synthetic or artificial materials capable of mimicking the movement performed by direct biological systems has been now studied (Kelly, 2003; Collin *et al.*, 2001; Pease *et al.*, 2001; Balzani *et al.*, 2000).

The bio ceramic beta-tricalcium phosphate (β -TCP) are being extensively explored for use as bone graft, being seen as a bio inspired material due to its biocompatibility and biodegradability. The bio ceramic porous structure which mimic the morphology of the medullary bone being used due to greater osteoconductive and porous structure that is capable for promoting adhesion, proliferation, and differentiation, thus establishing ways for bio fluids transport and allowing tissue growth (Zhang *et al.*, 2007).

The natural bone has been used as a source of inspiration for new biomaterials due to its structural feature and excellent biomechanical properties. Bone tissue is considered a complex system with a hierarchical biomineralized microstructure formed by a deposition of mineral hydroxyapatite in a collagen matrix. Macroscopically, the bone is divided into medullary bone (internal structure) and cortical bone (external structure) these structures keep excellent biomechanical characteristics (Zhang *et al.*, 2007; Bretcanu *et al.*, 2004).

The vast majority of previous studies of the bones as bio inspired materials, devoted mainly to obtain microstructural information and tissue components such as hydroxyapatite and collagen matrix, however the study of biomimetic bone macrostructure, as the relationship between cortical/cancellous bone, has received little attention. Thus, the authors have aimed in their studies mimic the structure of natural bone to troubleshoot application of porous bio ceramic β -TCP as in places that must withstand loads and / or be subjected to some kind of force, and thus improve mechanical properties of these materials.

After confection of bio ceramic material, it is important to note that the internal or pore structure mimics the bone marrow and external structure or dense capsule resembles cortical bone tissue (Zhang *et al.*, 2007).

The interface between the porous and dense parts of the bio ceramic material is compact and sturdy, which is very important to determine the dense/porous properties of bio inspired components. Comparing this characteristic to natural bone it is also seen that the interface between cortical/cancellous bone presents itself firmly.

Importantly the porous structure of bio inspired ceramics is different from the "pores" observed in normal bone tissue, but the size, interconnectivity and pore diameter of these materials can be planned and modulated (Zhang *et al.*, 2007).

An ideal structure for bone engineering must meet a number of criteria: 1 biocompatibility to allow adhesion, cell differentiation and proliferation, 2 osteoconductive capacity of bone neoformation, 3 biodegradability in the average adequacy rate of tissue formation, 4 mechanical competence; structural strength must be sufficient to provide mechanical stability at the loads site before regeneration of new tissue, 5 porous structure with a porosity > 90% and pore size of between 300 and 500 microns for tissue cell penetrating, bone growth and vascularization (Bretcanu *et al.*, 2004; Agrawal, Ray, 2001; Yang *et al.*, 2001).

DISCUSSION

Biomaterials constantly derive inspiration from materials scientists and engineers. Most biological materials are made from proteins or protein assembly with inorganic minerals. Researches on nanomaterials in the current stage of bio inspired materials include mimic some biological biomaterials for making new aspects, emphasizing the structural complexity that has a biological material, for example we can cite DNA. Even with the difficulties to mimic and develop methods for producing these new "bionanomaterials", the

authors conclude that biology will always be the greatest source of inspiration for researchers of advanced materials (Lu, Liu, 2007).

These materials are sophisticated and require a long period of study and observation, yet they are characterized by their complexity of confection, mainly due to the difficulty in mimicking their micromechanics, and micro/nanostructure related to a particular organ system.

The materials found in nature combine several inspirational properties such as sophistication, miniaturization, hierarchical organizations, hybridization, resistance and adaptive properties. Bio inspired materials reproduce principles and structures found in animals or plants, which can actually offer clinical applications and interactions with cellular matrix (Sanchez, Arribart, Guille, 2005).

Thus, Zhang *et al.*, 2007 set out to evaluate porous materials for normal bone tissue could have a satisfactory growth. In fact, these materials should be dense/porous to reduce the brittleness of the material and increase biomechanical properties, by this reason the researchers seek inspiration in natural bone which has the cortical (dense) and cancellous (porous) regions.

An important field of tissue engineering involves the use of engineering materials with high porosity, scaffold materials, which should act as temporary templates for adhesion, proliferation and cell migration, thus resulting in a tissue formation (Bretcanu *et al.*, 2004).

The materials that more closely resemble the tissue that will be replaced will have priority in choosing. This is particularly found in bone tissue engineering, in which the structural architecture, competence and ability to sustain mechanical loads are essentials (Zhang *et al.*, 2007; Bretcanu *et al.*, 2004).

It is noteworthy that a low porosity and a decrease in pore size can increased the mechanical properties of material, but this feature may decrease the capacity for growth inherent in the bone (Zhang *et al.*, 2007). Porous structures with regular shapes pores show a higher mechanical strength compared to the structures which present irregulars pores (Wang *et al.*, 2006; Bose *et al.*, 2003).

The findings of the study by Zhang *et al.* 2007 also relate microstructural manipulation of bio inspired materials; it was observed that the mechanism of the increase in mechanical properties is mainly due to the incorporation of a dense outer layer with the porous center.

In general, porous materials have not very good mechanical properties. Applications of porous calcium phosphate have limited use due to low resistance. Numerous techniques have been evaluated as bio activation properties in order to obtain better mechanical properties to these

materials, but these techniques are restricted to the use of porous calcium phosphate in loaded areas (Zhang *et al.*, 2007; Prashant *et al.*, 2005; Ramay, Zhang, 2004; Zhang, Zhang, 2002).

Thus, the bio ceramic model was fully inspired in macro structural components of natural bone; this bio inspired macrostructure is considered simple, however an effective way to improve the mechanical properties of porous materials, and in this way to solve the problem of brittleness inherent to porous materials.

FINAL REMARKS

The use of bio ceramic materials to replace the “damaged” bone tissue which has been missed for various reasons such as age or trauma, will show an improvement in the field of oral surgery regarding to bone grafting procedures, materials engineering and bio inspired materials. This can be seen due to such bio inspired ceramics materials have the potential to mimic the natural bone tissue, which retain characteristics and mechanical properties, and can then be used as option for bone regeneration.

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