Biomedicine & Pharmacotherapy 105 (2018) 553–557

Contents lists available at ScienceDirect

Biomedicine & Pharmacotherapy

journal homepage: www.elsevier.com/locate/biopha

Review

A short view on nanohydroxyapatite as coating of dental implants

Javad Yazdani[a], Elham Ahmadian[b], Simin Sharifi[b], Shahriar Shahi[b,c,*], Solmaz Maleki Dizaj[b,d,**]

[a] Faculty of Dentistry, Tabriz University of Medical Sciences, Tabriz, Iran
[b] Dental and Periodontal Research Center, Tabriz University of Medical Sciences, Tabriz, Iran
[c] Faculty of Dentistry, Department of Endodontics, Tabriz University of Medical Sciences, Tabriz, Iran
[d] Student Research Committee, Tabriz University of Medical Sciences, Tabriz, Iran

ARTICLE INFO

Keywords:
Titanium implants
Nanotechnology
Nanohydroxyapatite
Osseointegration
Cell attachment

ABSTRACT

Introduction: Titanium based (Ti-based) materials have been used as dental implants due to their high biocompatibility, good mechanical strength and ideal osseointegration properties. Osseointegration of an implant is dependent on surface characteristics such as surface chemistry and topography. Nanotechnology has presented new and interesting applications in dentistry in recent years. The presence of nanoparticles on the implant surface can affect both the topography and surface chemistry, leading to different and outstanding specifications for implant.

Method: A literature review was performed in electronic databases by means of MeSH keywords to collect relevant published literature in English about the effect of nanohydroxyapatite on osseointegration of titanium implants. No limitations on publication date were imposed. Data regarding titanium implants; nanotechnology; nanohydroxyapatite; osseointegration and cell attachment were collected and reviewed.

Results and conclusion: According to reviewed literature, nanohydroxyapatites have a nanostructured surface with higher surface area and then higher reactivity, letting them to bind to bone creating a biomimetic coating on implants. However, more studies are needed on the cell–substrate interface to develop an effective implant due to the interaction of the cells and the biomaterial surface after the implantation.

1. Introduction

Dental implants have been effectively applied for the replacement of dental elements in the treatment of total or partial edentulism. Titanium dental implants have shown good abilities owing to their high biocompatibility, good mechanical strength and great corrosion resistance as well as osseointegration properties. Generally, surface modification of Ti-based implant is performed to avoid implant failures [1–4]. The surface morphology of implants also impacts bone metabolism. It has been reported that rougher surfaces stimulate differentiation, growth and attachment of bone cells, and enhance mineralization. The chief approaches for producing implant roughness include acid etching, plasma spraying, sandblasting as well as hydroxyapatite (HA) coating [5].

Osseointegration can be defined as the formation of a direct interface between an implant and bone, without interrupting the soft tissue. Then, an osseointegrated implant is an implant comprising pores for migration of osteoblasts and supporting connective tissue [6]. Thus, according to oral implantology, it can be considered as bone grown right up to the implant surface without interrupted soft tissue. It has been shown that coating of bioinert materials with ability to induce osseointegration on the Ti implant surfaces may improve the physical properties and lead to a stable implant with high fixation and low failure [7,8].

Nanoparticles are ultrafine particles that can be prepared from basically any type of biocompatible materials [9]. It has been reported that they can advantageously improve properties of the materials compared to their similar bulk ones [2,3,10–13]. Literature search has shown that nanoparticles can be applied as particle coatings to the dental implant surface to progress soft tissue integration and therefore enhance dental implants success [3]. Osteoconductive nanoparticles are able to induce a chemical bond with bone to gain an ideal biological fixation when are used as coating of dental implants. Furthermore, bone generation and regenerative properties of these materials may provide a proper situation for new bone formation [3,10,14]. According to reports, some nanoparticles have shown ability to increase the density of osteoblast cells on the implant which can lead to more stable implant [15].

Abbreviations: HA, Hydroxyapatite; CHN, Conventional hydroxyapatite nanocrystal

* Corresponding author at: Dental and Periodontal Research Center, Tabriz University of Medical Sciences, Tabriz, Iran.
** Corresponding author at: Dental and Periodontal Research Center, Tabriz University of Medical Sciences, Tabriz, Iran.
E-mail addresses: shahis@tbzmed.ac.ir (S. Shahi), Maleki.s@tbzmed.ac.ir (S. Maleki Dizaj).

https://doi.org/10.1016/j.biopha.2018.06.013
Received 21 April 2018; Received in revised form 1 June 2018; Accepted 2 June 2018
0753-3322/

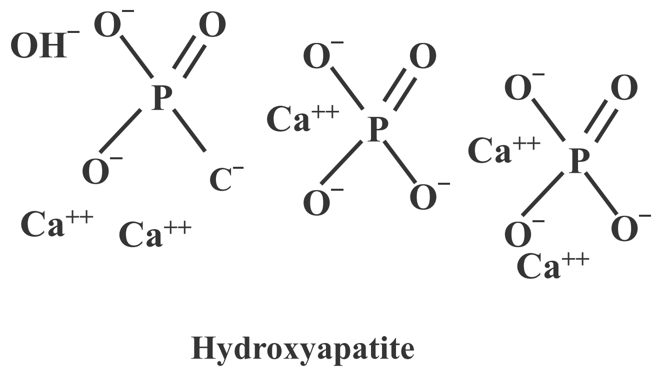

Fig. 1. Hydroxyapatite structure.

Hydroxylapatite (Fig. 1), also named as hydroxyapatite (HA), is a naturally occurring mineral form of calcium apatite with the formula $Ca_5\ (PO_4)_3\ (OH)$. It is usually written $Ca_{10}\ (PO_4)_6\ (OH)_2$ to show that the crystal unit cell includes two entities. It has been applied as coating material on the Ti implants for years and has gained promising outcomes [16].

HA is recognized as an osteoconductive material with accelerated bone healing ability and close adaptation of bony tissue [17,18]. *In vivo* studies have revealed faster bony healing around implants that are coated with HA. According to some reports, there is a direct bonding of HA to bone defined as biointegration. The exact mechanism of this phenomenon is still unclear and needs more biological and clinical investigations [5,19–21].

In recent years, the growth in nanotechnology has opened novel prospects to prepare low-priced hydroxyapatite in micro and nano forms by different methods especially *via* “bottom up” procedures. The surface of these HAs is in nanostructured form and shows higher surface area and then higher reactivity. HA in nano-form can present outstanding properties in different medicinal fields, especially in dental implantology. HA nano-coated dental implants have been reported to show good futures as implant coating materials. They can induce a chemical bond with bone and result in enhanced osseointegration and biological fixation [22,23].

A literature review was performed in electronic databases by means of MeSH keywords to collect relevant published literature in English about the effect of nanohydroxyapatite on titanium implants. No limitations on publication date were imposed. Data regarding titanium implants; nanotechnology; nanohydroxyapatite; osseointegration and cell attachment were collected and reviewed.

1.1. Ti- based implants and osseointegration

Ti-based dental implants have shown good abilities owing to their high biocompatibility, good mechanical strength and great corrosion resistance as well as osseointegration properties. For these implants, the interface between the implant and bone must be closely direct with no involving fibrous tissue. In implantology science, this special interfacial state is known as osseointegration [24]. This condition occurs once the bone grows to within 100 angstroms of the Ti surface with no sign of collagen or fibrous tissue existence. Just a few materials like pure titanium, some titanium alloys, tantalum, and several ceramic materials (like zirconia) have permitted as implant materials so far. The sign for an osseointegrated implant is not a virtually detectable mobility of the implant in the bone. Furthermore, for effectiveness of an implant, osseointegration must be preserved during the lifetime of the implant [25].

1.2. Osseointegration versus biointegration

As mentioned before, osseointegration is the existence of extremely close proximity between a titanium implant and its supporting bone with no involving fibrous tissue or collagen [26]. But, biointegration is defined as the incidence of continuity of ceramic implant to bone without intervening space. The main possession in both phenomena is the vitality of the supporting bone.

Indeed, the biointegration process need a chemical degradation of the ceramic implant to improve bone formation and integrate the ceramic implant with the surrounding bone that itself possess a significant ceramic component. The mechanism or nature of both processes are not completely known. Besides, the advantages of them over each other are not well recognized. However, it is reported that both interfaces are similar to the clinical ankylosis of natural teeth. It has been shown that metallic implants coated with a ceramic firstly encourage a biointegrated interface, but in long time, the stability of the interface is less strong due to its degrade with time [27]. Fig. 2 shows these two processes clearly.

1.3. Conventional HA nanocrystals and synthetic HA nanocrystals

Calcium carbonate and calcium phosphate are the most important

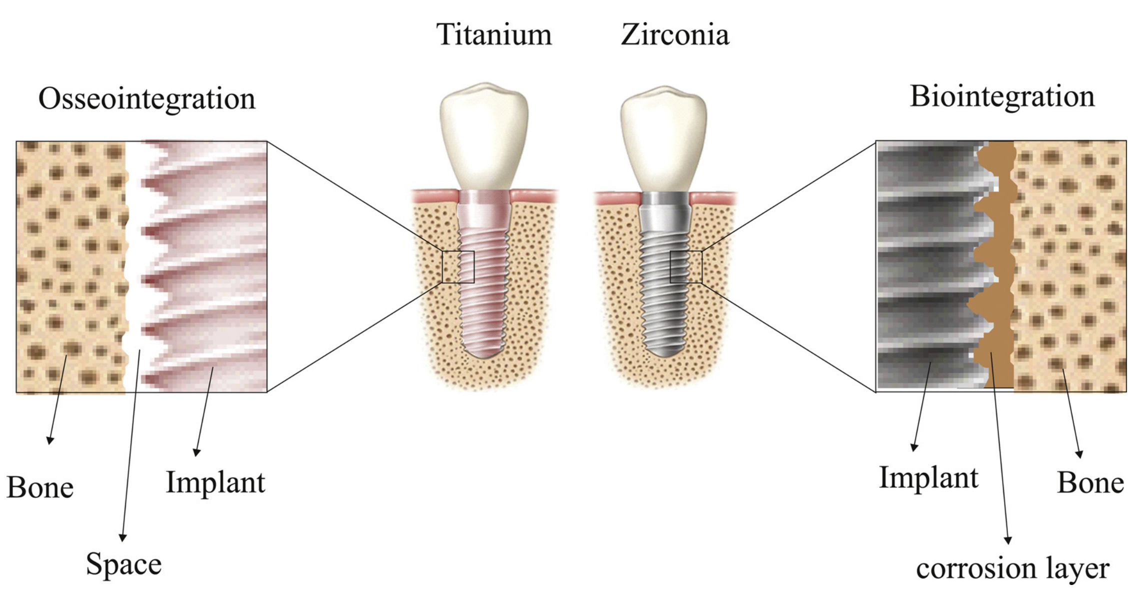

Fig. 2. Osseointegration versus biointegration.