Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 7, Issue, 01, pp.11564-11567, January, 2015

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

NANOSIZE BIPHASIC CALCIUM PHOSPHATE USED FOR TREATMENT OF PERIAPICAL LESIONS

***,[1]Gusiyska, A. and [2]Ilieva, R.**

[1]Department of Conservative Dentistry, Faculty of Dental Medicine, Medical University - Sofia, Bulgaria
[2]Institute of General and Inorganic Chemistry, Bulgarian Academy of Sciences - Sofia, Bulgaria

ARTICLE INFO

Article History:
Received 22nd October, 2014
Received in revised form
19th November, 2014
Accepted 05th December, 2014
Published online 23rd January, 2015

Key words:
Apical periodontal lesions, Bone remodeling, Hydroxyapatite, Injectable calcium phosphate bioceramics, Nanomertical biphase calcium phosphates.

ABSTRACT

Nanotechnology has revolutionized all aspects of health care and is a new paradigm of state-of-the-art patient care beyond traditional, and dentistry is no exception. Nanodental techniques for major tooth repair may evolve through several stages of technological development, first using genetic engineering, tissue engineering and regeneration, and later involving the growth of whole new teeth in-vitro and their installation. Since biomaterials interact with body through their surfaces after implantation, the properties of the outer surface of material are critical features in controlling biological response and also in regenerative medicine. Nanostructured surfaces provided more favorable architecture for normal cell attachment and osteoblast differentiation, proliferation and functional activity.

INTRODUCTION

Science is undergoing yet another change, in helping mankind enter a new era, the era of nanomedicine. "*Nano*" is derived from the Greek word for 'dwarf'. Nanotechnology is the science of manipulating matter measured in the billionths of meters or manometer, roughly the size of 2 or 3 atoms (Kaehler, 1994). All human life will be impacted by advances in tissue nanobioengeneering in the near future. Physicist Richard Feynman in 1960 had the first notion of how nanotechnology could be applied to medicine. In his historic lecture in 1959, he concluded: "this is a development which I think cannot be avoided." (Chandra Mouli *et al.,* 2012) Since biomaterials interact with body through their surfaces after implantation, the properties of the outer surface of material are critical features in controlling biological response (Rodriguez 2008, Weiss 2005). Nanostructured surfaces provided more favorable architecture for normal cell attachment and osteoblast differentiation and functionality. Bioceramic of calcium phosphate is a branch of biomaterials that supplied various kinds of materials to fit the field of dental and orthopedic biomedical application. Recently, nano-hydroxyapatite attracts researchers as it plays a significant role in various biomedical applications, due to its unique fictional properties, high surface area to volume ratio and its ultra fine structure, similar to that of the biological bone apatite (Webster *et al.,* 2000; Elliot, 1994; Mostafa *et al.,* 2009).

Corresponding author: Gusiyska,
Department of Conservative Dentistry, Faculty of Dental Medicine, Medical University - Sofia, Bulgaria.

In these points of view several modifications of biomaterials were investigated to highlight the problems of implant integration by creating osteoconductive surfaces (Silva *et al.,* 2003). Upon implantation, a series of complex events are initiated at the interface between bone/implant materials. A cascade of processes are followed the healing process such as bone like apatites transformation, proteins adsorption mineralized layer formation, recruitment of mesenhymal cells by cytokines, their differentiation into osteoblast responsible for bone matrix. Formation the matrix provides sites for nucleation of calcium phosphate crystals and subsequent crystal growth leading for bone formation.

Having in mind this complex sequence of events it is of clinical interest to motivate the use of the nano-structured material for biotemplating in physiological environment. In this context, we hypothesize that controlled nanoscale architectures of biphase calcium phosphate (BCPs) ceramics will be able to promote osteoblast differentiation, matrix production and stimulated healing processes in tissue repairing of apical periodontal lesions. Nanostructured surfaces are a new direction for development in dental medicine (Dikova and Milkov, 2008). The aim of this study was to synthesize nanosize biphasic calcium phosphate. The received material was used for medical application for treatments of apical periodontal lesions.

MATERIALS AND METHODS

For the purpose of this study were synthesized and characterized BCPs sintered samples (Ilieva *et al.,* 2011).

Subsequently they were treated with high energy dry milling process for different time to receive nanosize biphase calcium phosphate ceramic with average particle sizes about – 50-100 nm. The result materials was evaluate for phase transformations, particle size, crystal size, chemical structural phase composition, X-ray diffraction crystallinity, IR spectroscopy and micro-scale morphologies by SEM. For medical application we used this material for remodeling in chronic apical lesions. This is a pilot study in one of the conflicting challenges zone of endodontic treatments of critical size apical defects with mark damage of apex.

The subjects of this study were eleven clinical cases with radiographical evidence of periapical lesions. The diagnoses and outcome were determinate using periapical index (PAI) with score 3, 4 and 5 by Ørstavik (Ørstavik *et al.,* 1986).

RESULTS AND DISCUSSION

The challenges in engineering bone scaffolds reflect the complexity of bone as an organ. The organic-inorganic hybrid system design aims to provide signals within a conductive apatite layer to promote cell adhesion, proliferation and ultimately differentiation into bone tissue. Dual functioning peptides designed to specifically adhere to the apatite layer, while promoting cell adhesion via cell recognition sequences, may increase cell adhesion, leading to increased osteogenesis (Segvich *et al.,* 2009). Changing of crystal size as a function of milling time for both of phases (HA and β-TCP) were presented on Fig. 1. It is seen that after 20h milling the crystal sizes are about 30 nm for both phases. Ultrastructural micro morphological characteristics of mechanochemical treated biphase calcium phosphate sintered at 1100^{o} C, dry milling for 20 hours are illustrated in Fig.2a,b. More details for the physico-chemical characteristics of the received material will be find in another our work (Ilieva *et al.,* 2011). Prerequisite for these clinical studies are a lot of data in the literature about the successful used of BCPs ceramics as bone implant materials, as well as theirs antimicrobial properties (Opalchenova *et al.,* 1996).

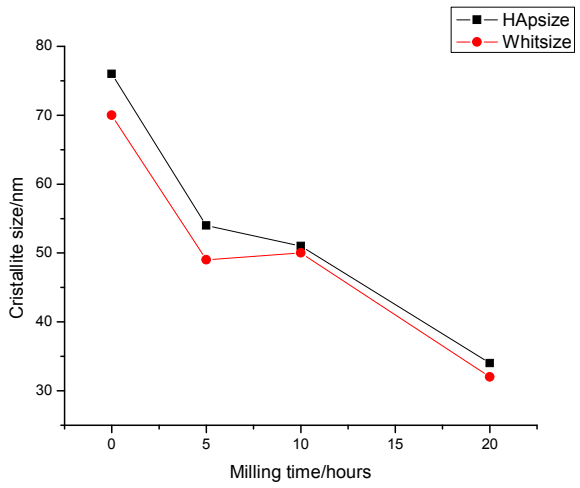

Figure 1. The crystal size decreases considerably from 70 nm (TCP) and 77nm (HAP) to about 30 nm after 20h milling. The cell parameters of both phases decreased with milling time, more pronounced for β-TCP

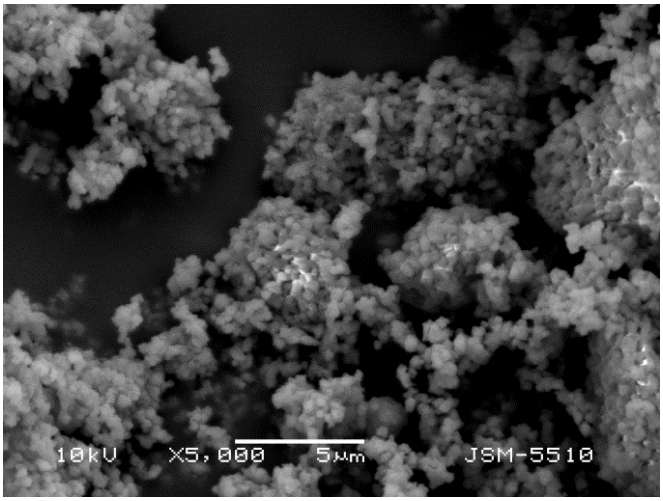

Figure 2a. Morphological characteristics of mechanochemical treated biphasic calcium phosphate (SEM, x 5 000)

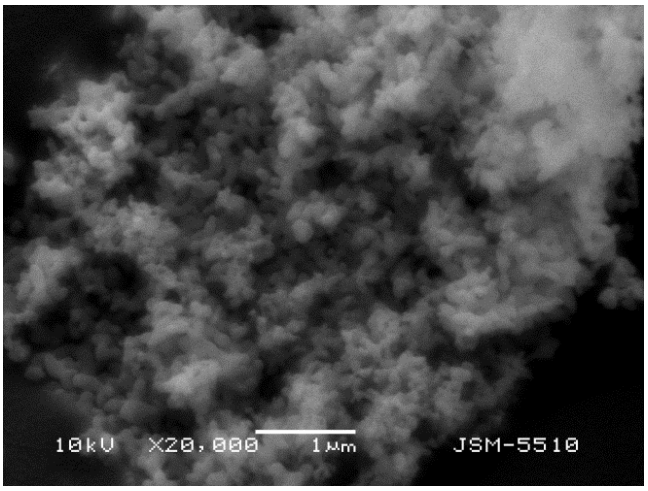

Figure 2b. Morphological characteristics of mechanochemical treated biphasic calcium phosphate (SEM, x 20 000)

Following the practice of the injectable implant material (Daculsi, 2006) in this study milled material was used as a scaffold, mixed with saline solution. The received Besides the nano size, the similarity between the structures of the material with that of the teeth also increases the biocompatibility between the material and the teeth, thereby increasing its adhesive strength. The adhesive strength is crucial in ensuring the success of the root canal treatment. For purpose of this study the received material was mixed with saline solution 149, 5 mM and used for filling of critical sized apical defects trough the tooth canal for stimulated healing processes and remodeling of apical lesion areas. Critical sized apical defects of 5-10 mm were subject of study for two years. The results show healing processes and remodeling in the zone of implant materials in apical lesion defects. On the other side well compacted and tightly adapted ceramic to the tooth apex, realized biomimetic obturation of the destructed apical foramen. The used operative technique was follow by successful root canal filling, with lateral condensation as it is seen in presented cases. The results obtained demonstrate that the received nano-sized BCP ceramic is a promising material for clinical endodontic application (Fig.3).

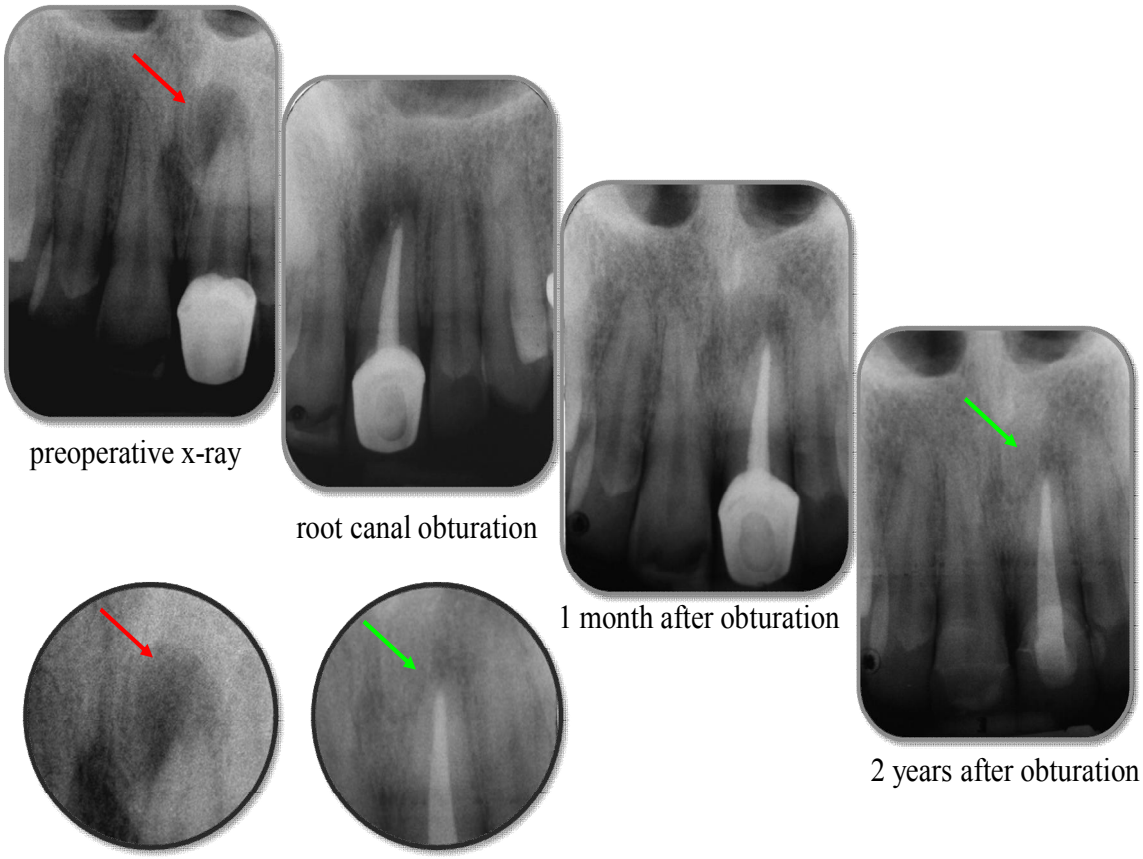

Figure 3. Clinical case – orthograde endodontic treatment on tooth 21

Paste was placed into the defect, using plugger for accurate fit the lesion of the apical foramen – 2mm over to determinate working length.

It was found in general that the repair rate of the defects mainly depends on the wound size, the characteristics and degree of the apical destructions. For clinical point it is important to stress that:

1. The outcome of healing was assessed by X-ray examination and assess with scoring system of periapical index by Ørstavik – from initial PAI 5 to PAI 3 or 2.
2. All of the cases in this study at two year evaluation, demonstrate a good clinical and radiographically healing process to group I of Rud's criteria (Rud *et al.,* 1972).
3. The use of nano biphasic calcium phosphate as apical filling material in chronical apical lesions as an attempt to improve a regenerative healing process and to create conditions for exact canal obturation.

The mechanisms of healing processes caused by calcium orthophosphates usually depending on a complex of physiochemical processes on and in the implant material and from series sequences of biological processes in local biological environment, but the relative significance of these mechanisms is not yet clearly understood.

Conclusion

Nano technological advances should be viewed in the context of other expected developments relevant to oral health in the coming decades. Biological approaches such as tissue and genetic engineering will yield new diagnostic and therapeutic approaches much sooner than nanotechnology. At the same time continual refinement of traditional methods, developments of advanced restorative materials and new medications and pharmacological approaches will continue to improve dental care. Trends in oral health and disease also may change the focus on specific diagnosis and treatment modalities. Deeper understanding of the causes and pathogenesis of other disease processes should make prevention a viable approach. The role of the dentist will continue to evolve along the lines of currently visible trends. The best technical abilities, professional judgment and strong interpersonal skills are the hallmark of the contemporary dentist (Chandra Mouli *et al.,* 2012). The use dry mechanochemical method was useful for preparation of nanosize biphasic calcium phosphate. It was demonstrated that biphasic calcium phosphate material is a good prospects to be used as a repair implant material in critical size defects of chronic apical periodontitis.

Acknowledgements

This work is financially supported by the Bulgarian Ministry of Education, Youth and Science Under Projects CVP-09-0003 and DTK 02-70/2009.

REFERENCES

Chandra Mouli *et al.* 2012. Nanotechnology in Dentistry - A Review. *Int. J. Biol. Med. Res.,* 3(2): 1550-1553.

Daculsi, G. 2006. Biphasic calcium phosphate granules concept for injectable and mouldable bone substitute. *Advances in Science and Technology,* 49: 9-13.

Dikova Ts., Milkov M., Nanomaterials in Dental Medicine, Proceedings of the 10th Workshops "Nanoscience & Nanotechnology", Nov. 27-28, 2008, Sofia, edited by E. Balabanova and I. Dragieva, 2009, *BAS-NCCNT*, p.203-209;

Elliot, JC. 1994. Structure and chemistry of the apatites and other calcium orthophosphates, The Netherlands: Elsevier.

Ilieva R., E. Dyulgerova, O. Petrov, R. Aleksandrova, R. Titorenkova, 2013. Effect of high-energy milling on biphase calcium phosphate. *Advance of Applied Ceramics,* 12 (4): 219- 226.

Ilieva R., E. Dyulgerova, R. Aleksandrova, R. Titorenkova, O. Petrov. 2011. Nanometric bi-phase calcium phosphate and vitality of cell test. *Nanoscience and Nanotechnology,* 11: 199-202.

Kaehler T, Nanotechnology: Basic Concepts and Definitions. *Clinical Chemistry* 1994; 9: 1797-1799.

Mostafa A.A., H. Oudadesse, M.B. Mohamed, E.S. Foad, Y. Le Gal, G. Gathelineau, 2009. *Chemical Engineering Journal*, 153: 187-192.

Opalchenova G., E. Dyulgerova, O. Petrov, 1996. Effect of calcium phosphate ceramics on gram-negative bacteria resistant to antibiotics. *J. Biomed. Mater. Res.,* 3: 473-479.

Opalchenova G., E. Dyulgerova, O. Petrov, 1996. A study of influence of biphase calcium phosphate ceramics on bacterial strains. In vivo approach. *J. Biomed. Mater. Res.,* 2: 219-226.

Ørstavik, D., K. Kerekes, HM. Eriksen, 1986. The periapical index: a scoring system for radiographic assessment of apical periodontitis. *Endod Dent Traumatol,* 2: 20–34.

Rodriguez C, Jean A, Daculci. Five Years Clinical Follow up Bone Regeneration with CaP Bioceramics. Key Engineering Materials 2008; 361-363:1339-1342.

Rud, J., JO. Andreasen, JE. Jensen, 1972. Radiographic criteria for the assessment of healing after endodontic surgery. *International Journal of Oral Surgery,* 4: 195–214.

Segvich S, Biswas S, Becker U, Kohn DH. 2009. Identification of peptides with targeted adhesion to bone-like mineral via phage display and computational modeling. *Cells Tissues Organs.,* 189(1-4): 245-51.

Shellart W.C., Oesterle L.J. 1999. Uprighting molars without extrusion. *JADA*, 130: 381-5.

Silva, C.C., G. Pinheiro, M.A.R. Miranda, J.C. Goes, A.S.B. Sombra, 2003. *Solid State Sci.,* 5: 553- 558.

Webster, T.J., R. W. Seigel, R. Bizios, 2000. Enhanced functions of osteoblasts on nanophase ceramics. *Biomaterials*, 21: 1803-1810.

Weiss, P., Clergeau, L.P., Enckel, B., Amouriq, Y., Giumelli, B., Jean, A., Daculsi, G. 2005. A New Injectable Bone Substitute Concept (MBCP Gel ™): First Clinical Results in Human Maxillo-Facial Surgery. *Key Engineering Materials,* 284-286:1053-1056.

****