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EDITORIAL

Developing of Load-bearing Bones Replacement Based on Cerium Compounds/Nano-hydroxyapatite Composites

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ABSTRACT

The importance of implantable biomaterials is growing up in recent days for modern medicine, especially fixation, replacement, and regeneration of load-bearing bones. Through the past several years, metals, ceramics, polymers, and their composites, have been used for the reconstruction of hard tissues. Special standards such as adequate mechanical and biocompatible properties are required to avoid rejection reactions of the tissues. Recently, a number of novel advanced biomaterials are developed as promising candidates. Amongst those, cerium-based biomaterials acquired attention as a substitution material for hard tissues reconstruction because of cerium antioxidative properties, which enabled it to be used to decrease mediators of inflammation. In addition, the eminent mechanical properties, as well as the perfect chemical and biological compatibilities, make cerium-based biomaterials attractive for biomedical application.

In view of the significance and the influence of load-bearing bones on human health, scaffolds proper for load-bearing applications are essential. It is well known that bones have the ability to deteriorate and rebuilt. Bones are composed of cortical (almost 80% of the total skeleton) and cancellous (about 20%) bones. Osteoporosis is the most bone damage' disease. The majority sites that suffer from osteoporosis are around the hips, spine, knee and wrist. Because these bones carry out almost the whole-body weight, they are known as load-bearing bones. Besides osteoporosis, the load- bearing bones are deteriorated from injuries and failure caused by continuous fatigue [1]. For the production of successful bone-bearing scaffolds, it is important to compromise between the bone's strength and the elasticity. It is also essential to take into consideration the degradation as well as the stabilization rates of the implanted scaffolds during the whole recovery period [2].

Among many load- bearing composites, researchers designed ceramic/ metal ones. Such composites mostly were unsuccessful in fulfilling the needed requirements due to the weak linkage between the metal and the

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ceramic [3]. In addition, ceramic /metal composites possess a limited life extension of 10-12 years, which means that it needs to be replaced after such period. On the other hand, ceramic/ bioactive materials composites are promising substitution for ceramic/metal composites. Alumina and zirconia are among the widely employed materials due to their favorable properties in comparison to metals [4]. Zirconia toughened alumina (ZTA) and Al_2O_3/ZrO_2 composites (AZC) were proposed to face the drawbacks that present from the usage of monolithic ceramics [5-7]. The main idea of proposing such composites is to avert the crack propagation caused by zirconia by the presence of alumina as isolation particles. It will grant that the designed composites will have the reasonable toughness of Al_2O_3 together with the ageing impact of ZrO_2. It was shown that modifying the surface of Alumina-zirconia composites by phosphoric acid to encourage the formation of HA layer after immersion in SBF improve the bioactivity of the composites without affecting their mechanical or ageing properties [8]. In a study carried out by Singh and Reddy [9], they showed that introducing HA, MgF_2 and CaF_2 in different ratios to ZTA composites improved the sinterability and bioactivity of the composites. They claimed that the optimum HA addition is 30%. Higher and lower addition negatively affected bioactivity. Ponnilavan et al [10] inserted Ca^{2+} and PO_4^{3-} through in-situ reaction to AZC to enhance the bioactivity of the system. They reported that the mechanical and in vitro bioactivity tests accomplish the suitability of the studied composites for the bone substitution.

Recently new materials and composites are suggested as substitutes for the preparation of load-bearing bone. A new composite of silicon-carbon fibre/HA bio-ceramics was prepared by pressureless and hot-press sintering for the application in the load-bearing bone sites. It was found such composites exhibited the best mechanical properties. According to the research results, the Si coating, the domination of the alignment of fibres and hot-press sintering enhanced the mechanical properties of resulting composites. It was stated that the proposed composites are quite satisfying the demands of load-bearing bones [11]. Bioglass containing cerium was also recommended for the preparation of the load-bearing applications. The in vitro study for the bioglass containing up to 5 mole % ceria proved the biocompatibility and non-cytotoxic activity of ceria [12].

3D printing technique was used for the preparation of complicated bone shapes. Lee et.al. used an alumina nano-scale granulated powder for a special 3D printing method called 'solvent jetting on granulated feedstock containing binder' to achieve an interconnected macropore structure with high strength. Their method resulted in the preparation of scaffolds having controllable porosity, high strut density, wide neck formation, small grain size and consequently, high mechanical strength [13].

Cerium was considered one of the interesting elements used for curative because of its advantageous biological behavior. It is used as antibacterial [14], antioxidant [15], besides its positive effect on primary osteoblasts [16]. It is to be mentioned that the in vitro study for the bioglass containing up to 5 mole% ceria proved the biocompatibility and non-cytotoxic activity of ceria [12]. Accordingly, the use of ceria compounds/nano-hydroxyapatite composites to replace load-bearing bones will be an interesting subject for research.

The abovementioned review pointed to the necessity for research needed for applying tissue engineering for the production of functional substitutes to restore, and maintain the functionality in load-bearing bones. Fabrication of clinical used load-bearing bone substitute has become one of the most needed topics in the biomaterials and clinical field.

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