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Performance analysis of bone scaffolds with carbon nanotubes, barium titanate particles, hydroxyapatite and polycaprolactone

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Abstract. This paper presents a novel structural composition for artificial bone scaffolds with an appropriate biocompatibility and biodegradability capability. To achieve this aim, carbon nanotubes, due to their prominent mechanical properties, high biocompatibility with the body and its structural similarities with the natural bone structure are selected in component of the artificial bone structure. Also, according to the piezoelectric properties of natural bone tissue, the barium titanate, which is one of the biocompatible material with body and has piezoelectric property, is used to create self-healing ability. Furthermore, due to the fact that, most of the bone tissue is consists of hydroxyapatite, this material is also added to the artificial bone structure. Finally, polycaprolactone is used in synthetic bone composition as a proper substrate for bone growth and repair. To demonstrate, performance of the presented composition, the mechanical behaviour of the bone scaffold is simulated using ANSYS Workbench software and three dimensional finite element modelling. The obtained results are compared with mechanical behaviour of the natural bone and the previous bone scaffold compositions. The results indicated that, the modulus of elasticity, strength and toughness of the proposed composition of bone scaffold is very close to the natural bone behaviour with respect to the previous bone scaffold compositions and this composition can be employed as an appropriate replacement for bone implants.

Keywords: artificial bone scaffold; carbon nanotube; hydroxyapatite; polycaprolactone; barium titanate; finite element analysis

1. Introduction

Bone is an extraordinary bio composite that, in addition of having low inertia to minimize the amount of energy needed to move the body, it must also have enough strength to withstand the body weight and the common forces involved in daily activities. Bones are continually restoring tissue, and are usually self-repaired and welded by itself due to non-acute fractures or damages. Therefore, bone is one of the tissue with the self-healing ability. But after 25 years, the amount of bone resorption is slightly increased, which leads to a gradual decrease in bone density.

In severe injuries that result in large amounts of bone loss or localized infection, the bone will no longer be able to fully restored, and the defects will remain intact. Also due to diseases such as osteoporosis, the bone regeneration cycle is slowed down and its density decreases significantly. It

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