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Research paper

Optimum gradient material for a functionally graded dental implant using metaheuristic algorithms

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ABSTRACT

Despite dental implantation being a great success, one of the key issues facing it is a mismatch of mechanical properties between engineered and native biomaterials, which makes osseointegration and bone remodeling problematical. Functionally graded material (FGM) has been proposed as a potential upgrade to some conventional implant materials such as titanium for selection in prosthetic dentistry. The idea of an FGM dental implant is that the property would vary in a certain pattern to match the biomechanical characteristics required at different regions in the hosting bone. However, matching the properties does not necessarily guarantee the best osseointegration and bone remodeling. Little existing research has been reported on developing an optimal design of an FGM dental implant for promoting long-term success. Based upon remodeling results, metaheuristic algorithms such as the genetic algorithms (GAs) and simulated annealing (SA) have been adopted to develop a multi-objective optimal design for FGM implantation design. The results are compared with those in literature.

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1. Introduction

Biomaterials should simultaneously satisfy many requirements and possess properties such as non-toxicity, corrosion resistance, thermal conductivity, strength, fatigue durability, biocompatibility, and sometimes esthetics. A single composition with a uniform structure may not satisfy all such requirements. Natural biomaterials often possess the structure of functionally graded materials (FGMs) which enables them to satisfy these requirements. FGMs provide the structure with which synthetic biomaterials should essentially be formed. The size of biomaterial components is relatively small. In the case of dental applications, the components are generally smaller than 20 mm. This substantially reduces the difficulty of fabricating such materials due to a mismatch in thermal

expansion which causes micro crack formation during the cooling cycle. Biomaterials are essential for life and health in certain cases. They have a generally high added value for their size. Thus, biomaterials form one of the most important areas for the application of FGMs. It is an area for which FGMs, at the present time, are sufficiently developed for practical use. A dental implant is used for restoring the function of chewing and biting, and therefore eating, which is the most fundamental activity of human beings required for living. We are living in an era of longer life expectancy, and thus dental care is becoming especially important for better quality of life in old age. Implants may be classified into “implants”, such as artificial bone for medical use, and “dental implants”, such as artificial teeth for dental use. The specified properties are slightly different depending on their intended use. The

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