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Chitosan/bioactive glass nanoparticle composite membranes for periodontal regeneration

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ABSTRACT

Barrier membranes are used in periodontal applications with the aim of supporting periodontal regeneration by physically blocking migration of epithelial cells. The present work proposes a combination of chitosan (CHT) with bioactive glass nanoparticles (BG-NPs) in order to produce a novel guided tissue and bone regeneration membrane, fabricated by solvent casting. The CHT/BG-NP nanocomposite membranes are characterized in terms of water uptake, in mechanical tests, under simulated physiological conditions and in in vitro bioactivity tests. The addition of BG-NPs to CHT membranes decreased the mechanical potential of these membranes, but on the other hand the bioactivity improved. The membranes containing the BG-NPs induced the precipitation of bone-like apatite in simulated body fluid (SBF). Biological tests were carried out using human periodontal ligament cells and human bone marrow stromal cells. CHT/BG-NP composite membranes promoted cell metabolic activity and mineralization. The results indicate that the CHT/BG-NP composite membrane could potentially be used as a temporary guided tissue regeneration membrane in periodontal regeneration, with the possibility to induce bone regeneration.

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1. Introduction

Periodontitis is an inflammatory disease of the periodontal tissues, caused by microorganisms and calculus accumulation on the bacterial biofilm, leading to degradation of the connective tissues and alveolar bone and subsequent formation of soft tissue pockets around the root surface [1]. Regeneration of the periodontal region is challenged by complex inflammatory processes and events related to healing, resulting in unsatisfactory results in clinical cases using the currently available therapies. Ideal strategies should be able to regenerate all damaged structures including the cementum, periodontal ligament and alveolar bone. The number of cells occupying the treated area upon surgery as well as the size of the defect determine the type of connection formed between the cementum and bone. Epithelial cells are the first cells to migrate to the site of injury becoming a problem as they prevent bone formation. The guided tissue regeneration (GTR) technique uses a membrane, which acts as a barrier to prevent epithelial cells and gingival tissue reaching the area of injured tissue [2]. This procedure favors the regeneration of lost and damaged tissue, as it promotes cell repopulation of the periodontal ligament and adjacent alveolar bone, allowing the necessary time for osteoblast proliferation and bone regeneration [3,4]. Cells derived from adult human bone marrow stromal cells (hBMSC) are capable of contributing to the formation of new bone completely surrounding the tooth, which has to be able to anchor itself to the jaw through its roots and periodontal ligament [5]. The continuing process of periodontal tissue repair is followed by the formation of granulation tissue as a source of future periodontal connective tissue cells, such as osteoblasts, periodontal ligament fibroblasts and cementoblasts [5]. Thus human periodontal ligament cells (hPDL) and hBMSCs are ideal cell sources to be used in biological tests to evaluate the performance of GTR membranes.

When selecting an ideal biomaterial for GTR membranes the following requirements must be considered: wound stabilization, space creation and maintenance, protection of the underlying blood clot, and the ability to exclude unwanted tissues or cells (connective tissue and gingival epithelium). Collagen has been

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