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Effects of crosslinking agent and biological properties of silk fibroin/gelatin/ chitosan ternary system electrospun nanofiber mats

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Abstract

In this study, electrospinning technique was used for ternary system to fabricate nanofiber mats from silk fibroin (SF):gelatin (G):chitosan (C) with various mass ratios i.e. 10:20:0, 10:20:0.5, 10:20:1, 10:20:1.5, 10:20:2, and 20:10:1. An increase in chitosan content of the mats was found to decrease average fiber diameter and with narrow size distribution. Tensile strength of SF:G:C nanofiber having greater SF content was lower than that of the fiber mat having lower SF content. The obtained fiber mats were then crosslinked by three different crosslinking agents including ethanol, glutaraldehyde and 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide hydrochloride (EDC)/N-hydroxysuccinmide (NHS). The smooth fiber with high porosity of the nanofiber mat was observed after crosslinked using EDC/NHS agent. A less swollen fiber was noticed in the fiber mats having higher SF content. The results from in vitro study revealed the good cell adhesion and proliferation of gingival tissues. Such results indicated the potential use of SF:G:C nanofiber mats as membrane application.

1. Introduction

Guided bone regeneration (GBR) is an important therapy to repair mandible and alveolar bone defects affected by periodontal diseases. In this technique, a barrier membrane is adapted to help prevention of ridge resorption after extraction, augmentation of alveolar ridge defects and improvement of bone healing around dental implants [1]. The barrier membranes are categorized into two types based on their resorbability i.e. non-resorbable and resorbable membranes. Commercial non-resorbable membranes are made from synthetic polymer such as expanded-polytetrafluoroethylene (ePTFE: Gore-Tex®), cellulose acetate (Millipore filter), and polytetrafluoroethylene (PTFE: TefGen-FD®) whereas resorbable membranes are made from either synthetic polymer such as polylactic acid (Guidor®), polylactic/polyglycolic acid (Vocryl®) or natural materials such as collagen (Bio-Gide®, BioMend®) [2].

Materials for membrane fabrications have been extensively developed over the years in clinical field as the utilization of membrane based techniques tends to increase. The materials must stay intact as physical barriers with the ability to take out unwanted cells until regeneration is complete, yet not interfere with the growth of newly formed tissue. Each material has its advantage and disadvantage inherent for the application in which it is insuring success. The biological and physical characteristics of biomaterials used to manufacture membranes can significantly influence barrier function as well as host tissue reaction.

Physical characters of the barrier membrane including pore size, tri-dimensional topography and method of membrane fabrication play an important role in GBR. The pore size of the barrier membrane affects the prevention of excessive fibrous tissue penetration into the bone defect therefore allow neovascularization and bone formation [3]. Pores membrane are necessary for cell migration [4]. It can change the cell occlusion properties and the biological reaction of different cell types to the membrane.

Electrospinning is a novel membrane fabrication method which can produce ultrafine fiber in a level of microns to nanometers and produce the tri- dimensional structure [5]. Silk, gelatin (G), and chitosan (C) are bunch of natural materials in Thailand that can be constructed and utilized in medical treatments due to inexpensive, biocompatible and biodegradable. Moreover, those kinds of materials can be fabricated into membrane by electrospinning technique [6-8].

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