Acta Biomaterialia 8 (2012) 2986–2995

Contents lists available at SciVerse ScienceDirect

Acta Biomaterialia

journal homepage: www.elsevier.com/locate/actabiomat

Performance of electrospun poly(ε-caprolactone) fiber meshes used with mineral trioxide aggregates in a pulp capping procedure

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ARTICLE INFO

Article history:
Received 19 January 2012
Received in revised form 27 March 2012
Accepted 19 April 2012
Available online 25 April 2012

Keywords:
Electrospun fiber
Pulp capping
Dentin–pulp complex
Odontoblast
Mineral trioxide aggregate

ABSTRACT

Living dental pulp tissue exposed to the oral environment should be protected with an appropriate pulp capping material to support the dentinogenesis potential of the pulp cells. Mineral trioxide aggregate (MTA) is the material of choice for the treatment of pulp. However, due to cytotoxicity during the initial setting phase of MTA, a new material is required that can act as a barrier to direct contact but facilitate the favorable effect of MTA. This study examined the feasibility of using electrospun poly(ε-caprolactone) fiber (PCL-F) meshes in the MTA-based pulp capping procedures. An experimental pulp capping was performed on the premolars of beagle dogs, and the efficacy of the PCL-F meshes was evaluated after 8 weeks. PCL-F/MTA formed a dentin bridge that was approximately fourfold thicker than that formed by the MTA. Columnar polarized odontoblast-like cells with long processes and tubular dentin-like matrices were observed beneath the dentin bridge in the PCL-F/MTA. The cells were also intensely immunostained for dentin sialoprotein. In cell cultures, PCL-F/MTA reduced cell death to ~8% of that in the MTA group. The proliferation of the cells cultured on PCL-F/MTA was much greater than that of cells cultured on MTA. Furthermore, PCL-F/MTA promoted the differentiation of MDPC23 cells to odontoblast-like cells and biomineralization, as confirmed by the expression of alkaline phosphatase and dentin sialophosphoprotein, and by the deposition of calcium. Based on these histologic findings and the cell responses observed in this study, PCL-F may be used efficiently in the MTA-based dental pulp therapy.

1. Introduction

Dental pulp is the soft connective tissue that occupies the central portion of the tooth. As a vital tissue, it is highly vascularized, innervated, and connected to periodontal tissues. It supports the dentin, responds to various stimuli, and is involved in reparative processes. Living dental pulp tissue that is exposed to the oral environment by caries, trauma, and/or mechanical injury should be protected with an appropriate pulp capping material to sustain its vitality and function. The pulp capping material needs to prevent the noxious stimuli of the oral environment from entering the pulp and must support the dentinogenesis potential of the pulp cells to form a dentin bridge [1,2]. Various materials have been used in pulp capping and pulpotomy procedures. For instance, calcium hydroxide is commonly used in dental clinics. However, due to several disadvantages of calcium hydroxide, including the irritation to the pulp tissue, its poor sealing properties, and the presence of porosity in the dentin barrier that it produces, there have been attempts to develop more effective and reliable pulp capping materials [1–4]. Recently, mineral trioxide aggregate (MTA) has been demonstrated to induce significantly greater dentin bridge formation with less pulp inflammation than does calcium hydroxide [5–7]. Therefore, MTA has become the material of choice for pulpotomies or direct pulp capping procedures. MTA has been shown to up-regulate the levels of the transcription factors and matrix adhesion proteins that regulate the differentiation of stem cells into preodontoblasts and odontoblasts [8–10]. This process contributes to the formation of the dentine bridge. However, the cytotoxicity of MTA during the initial setting phase [8,11–13] requires the use of a new material that can act as a barrier to direct MTA contact but permits the favorable effects of MTA.

Previous studies have shown that a fibrous engineered matrix mimicking the architecture of the natural extracellular matrix

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1742-7061/$ - see front matter
http://dx.doi.org/10.1016/j.actbio.2012.04.032