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Guided bone regeneration in rat mandibular defects using resorbable poly(trimethylene carbonate) barrier membranes

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ABSTRACT

The present study evaluates a new synthetic degradable barrier membrane based on poly(trimethylene carbonate) (PTMC) for use in guided bone regeneration. A collagen membrane and an expanded polytetrafluoroethylene (e-PTFE) membrane served as reference materials. In 192 male Sprague–Dawley rats, a standardized 5.0 mm circular defect was created in the left mandibular angle. New bone formation was demonstrated by post mortem micro-radiography, micro-computed tomography imaging and histological analysis. Four groups (control, PTMC, collagen, e-PTFE) were evaluated at three time intervals (2, 4 and 12 weeks). In the membrane groups the defects were covered; in the control group the defects were left uncovered. Data were analysed using a multiple regression model. In contrast to uncovered mandibular defects, substantial bone healing was observed in defects covered with a barrier membrane. In the latter case, the formation of bone was progressive over 12 weeks. No statistically significant differences between the amount of new bone formed under the PTMC membranes and the amount of bone formed under the collagen and e-PTFE membranes were observed. Therefore, it can be concluded that PTMC membranes are well suited for use in guided bone regeneration.

1. Introduction

Guided bone regeneration (GBR) has proven to be a predictable procedure for alveolar ridge augmentation prior to implant dentistry [1,2]. In guided bone regeneration, a barrier membrane prevents ingrowth of fibroblasts and provides a space for osteogenesis within the underlying blood clot [3]. This blood clot is necessary for new bone formation [4]. The membrane also excludes inhibiting factors and preserves growth factors [5].

This barrier effect can be achieved with various biocompatible materials. Currently, two sorts of barrier membranes are available: non-resorbable and resorbable membranes. Although the non-resorbable membranes have better space-maintaining properties than the resorbable membranes, a main disadvantage is the need for their removal in a second operation. Another disadvantage is the increased risk of infection, which can lead to the necessity of early removal [6,7]. The majority of clinically used resorbable membranes are based on collagen. As the collagen is animal derived, these membranes carry the risk of disease transmission from animal to human [8–10]. Another group of available resorbable barrier membranes are synthetic membranes based on lactide and glycolide polymers. However, due to an extensive foreign body reaction, adverse effects like postoperative swelling have been reported for these materials [11–18]. Furthermore, as it is known that these materials can produce significant amounts of acidic compounds during degradation in the body, and since bone dissolves in acidic environments, it can be expected that these polymers will not be the most suitable membrane materials in guided bone regeneration [12,17,19,20]. The ideal membrane should be clinically manageable and occlusive, and possess space-maintaining properties. Furthermore, it should be prepared from a synthetic biocompatible material, which resorbs in a favourable manner [21].

We have developed a novel, synthetic resorbable membrane based on poly(trimethylene carbonate) (PTMC). Poly(trimethylene carbonate) is an amorphous polymer with a glass transition temperature of ~−15 °C and a relatively low elastic modulus of 5–7 MPa at room temperature. The flexible polymer can be cross-linked into a creep-resistant and form-stable network by gamma irradiation [22]. Most importantly, PTMC is a biocompatible polymer that degrades enzymatically in vivo without the formation of acidic degradation products [23,24] by a surface erosion process.

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