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Guided bone regeneration in the treatment of segmental diaphyseal defects: A comparison between resorbable and non-resorbable membranes

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Summary This study compares non-absorbable, ethyl cellulose (EC) membranes and absorbable, chitosan (CH) membranes in a rabbit model. Bone regeneration, evaluated by radiological and pathological parameters, was seen in both groups. In the EC group the process was faster but was followed by a sharp decrease, whereas in the CH group it was slower and continuous.

Introduction

Only a few studies have been published on the use of polymer membranes in the treatment of large defects in weight bearing bones.[12,16,20,21,23,29] The application of guided bone regeneration in large, vertical osseous defects in weight bearing bones is especially valuable in our efforts to provide a proper surgical solution for this complex problem.

We recently designed a scoring system for quantitative measurement of new bone regeneration in a large bone defect.[21] This scoring system is based on histological analysis, and was developed in order to attain accurate marking of new bone formation during the treatment. It provides more quantitative information on gradual bone formation in the different sites inside and around the bone gap in a rabbit radial critical size bone defect. At the same time, a radiographic quantitative evaluation was made possible by means of a computerised system. The computerised digitising radiological analysis added more quantitative data related to the new bone volume and bone density. Using both evalua-

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tion methods together enabled a comparison between different types of membranes in the treatment of critical size defects in long weight bearing bones.[21]

In this study, we investigated the difference between non-absorbable ethyl cellulose membranes and absorbable chitosan membranes.[6,15]

Materials and methods

Membranes

Two types of membranes were used: a non-resorbable membrane made of ethyl cellulose (EC, N-type, Hercules Inc., Delaware) and a resorbable membrane made of low molecular weight chitosan (CH, poly(D-glucosamine), Aldrich).

Films of 100 ± 5 μm in thickness were prepared by casting polymer solution into Teflon moulds (round plates, inner diameter 9.6 cm), and subsequent evaporation of the solvent.

To make the EC membranes, 740 mg EC and 11 mg diethyl phthalate (as plasticiser, Aldrich) per mould were dissolved in 15 ml dichloromethane (5% w/v solids), as described by Friedman et al.[6] The solvent was added to the pre-weighed diethyl phthalate. EC was then added under vigorous stirring and was stirred continually until the EC dissolved completely. The solution was poured into the moulds and the solvent evaporated overnight in a hood at room temperature. The films were kept in airtight containers until surgery.

CH membranes were made of 750 mg chitosan for each mould, dissolved in 75 ml 0.1N acetic acid by stirring for 24—48 h. After casting, the solvent evaporated at 37 °C. Subsequently, the acetic acid was neutralised in 1% (w/v) NaOH for 30 min. The membranes were then washed thoroughly with water and kept immersed in water in a sealed container until used.

Animals

We used16 mature New Zealand rabbits, weighing 2.8—4.2 kg, with complete closure of the epiphysis proved by radiological films. In both forelimbs of each rabbit a segmental radial bone defect was created and covered by a membrane; absorbable membrane was inserted in one forelimb, and the non-absorbable membrane in the contra-lateral limb.

Surgical procedure

The rabbits were sedated using intramuscularly Ketamine (30 mg/kg), ksylosin (3 mg/kg), and Atropine (1 mg/kg). The forelimbs were shaved and sterilised. Intravenous Pentothal 30 mg/kg was provided for anaesthesia. An anterior approach was used in order to expose the middle third of the radius. Proximal and distal osteotomies were performed and a 1 cm (2.5 times the radial bone diameter) segmental radial defect was created, including complete removal of the periosteal membrane. A cylinder of the synthetic membrane was inserted in the osteotomy gap, covering both edges of the resected radius.

Figure 1 Computerised radiography evaluation. Measurements of density and area of new bone formation were taken. Data calibration was accomplished using the diameter and density of the olecranon process as a standard reference. All measurements are in millimeters on a film with a factor of 1.86.