A Resorbable, Reconstituted Type I Collagen Membrane for Guided Tissue Regeneration and Soft-Tissue Augmentation

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Introduction

There are several requirements that a resorbable membrane should meet in order for it to be useful for guided tissue regeneration (GTR) and soft tissue augmentation applications. The membrane should be resorbable, have sufficient mechanical strength to permit suturing of the membrane to the host, be permeable to nutrients and be biocompatible. The particular medical application will define the specifications of each requirement. We present here a new resorbable, reconstituted type I collagen membrane for use in GTR or as a patch for soft tissue augmentation. The results of a comparison between this membrane and a collagen membrane currently marketed for GTR applications are also discussed.

Methods

Collagen Membrane: Two types of collagen membrane were fabricated from purified type I collagen fibers. The collagen fibers were dispersed in an acid solution (pH 2.5), homogenized, filtered, reconstituted, freeze dried, crosslinked, and sterilized by γ-irradiation.

Characterization:

Suture pull-out strength: A size 3-0 silk suture was passed through the membrane, 1.5 cm x 2.0 cm, at about 3 mm from the edge and a loop was tied. The membrane was hydrated in 0.01 M phosphate buffer, pH 7.0, for 10 minutes. The loop was attached to a force gauge (Chatillon, Greensboro, NC) and the sample was secured onto a clamping fixture. The sample was pulled at a rate of 1 inch per minute until the suture was pulled out. The force was recorded.

Permeability: The permeability of the membrane was determined by inserting a sample, 2.0 cm x 2.0 cm, into a specially designed chamber, which is separated into two isolated compartments. On one side of the chamber, a fixed volume of phosphate buffered saline (PBS) containing 50 μg of carbonic anhydrase (CA) (MW 29,000) per ml was added. The opposite side was filled with the same volume of PBS only. The chamber containing the membrane was allowed to equilibrate for 24 hours and the CA assay was conducted on the side initially without CA by the Coomassie plus assay. (1)

In Vivo Resorption Studies: A total of 11 rats were used. Each rat received a lcm^2 membrane implanted subcutaneously. Animals were sacrificed at 4, 8, 12, and 24 weeks after implantation. The explants were evaluated histologically for collagen membrane remaining, tissue reaction and new collagen deposition using standard histologic techniques.

Biocompatibility: Biocompatibility testing was conducted on the collagen membrane in accordance with FDA guidelines.

Results

Table 1 summarizes the characterization studies on the two types of collagen membranes, A and B compared to the commercial product Biomend®. The average suture pull-out strength was 350 g and 290 g, respectively for A and B. This strength is significantly higher than for Biomend®. The total resorption time was obtained through extrapolation via curve fit of the experimental data. The resorption times for the membranes were 27 and 18 weeks respectively for A and B. Both membranes A and B were significantly more stable *in vivo* than Biomend®. Both membranes A and B were permeable to CA, which has a size similar to the Biomend® pore structure, and biocompatible.

Discussion

The use of a membrane for GTR in oral surgery often requires the membrane to be permeable for nutrients but not cells so that the membrane can serve as a cell barrier to guide the specific tissue regeneration. Both membranes A and B and Biomend® can serve that function. Very often, the membrane is required to be stabilized with sutures. In this regard, membranes A and B offer advantages over Biomend® in that they have a ' higher suture pull-out strength. In addition, the *in vivo*, stability of membranes A and B are significantly longer than the Biomend®. Although the significance of this' difference is not known, it would be logical to expect that a *longer in vivo* stability may provide an additional margin of efficacy in using the membrane as a cell barrier. The characteristics of membranes A and B also offer potential applications as soft tissue augmentation devices such as patch material for hernia and heart surgeries.

Table 1. Characterization of Collagen Membranes

Test	Membrane A	Membrane B	Biomend®
Suture pull-out strength (g)	350 ± 80	290 ± 70	74 ± 10*
Pore structure	Permable to CA	Permable to CA	0.004 μm*
In vivo resorption (weeks)	27	18	4-8*

* Reported from 510K (K924408)

1. Bradford, M.M. Anal. Biochem. 72:248, 1976.