Development of fibroblast culture in activated carbon fiber and poly(γ-glutamic acid)/gelatin as a scaffold for wound healing study

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Introduction

The fibroblasts contributed to restoring some of the function in the proliferative phase by increasing the number of fibroblasts in the extra cellular matrix, then increasing collagen secretion and protein concentration to help normalize wound healing [1]. In an attempt to overcome these problems, we aimed to generate a new cell scaffold material that was not only biocompatible, but also bioactive, to promote different cell growth interactions depending on the implant application. It has been reported that activated carbon fiber has high adsorption and catalysis capacity and these properties are of interest in several areas, including medical applications, and water and air treatment for the removal of organic and inorganic pollutants [2,3]. Our objectives were to fabricate a multifunctional bi–layer wound dressing composed of activated carbon fiber and gentamicin incorporated in a poly(γ-glutamic acid) (γ-PGA)/gelatin membrane. I*n vivo* experiment was performed to compare wound healing area after treatment with fibroblast cells-containing bi–layer wound dressing, wound dressing alone, tape strip (Nexcare, 3M).

Materials & Methods

A multifunctional bi–layer wound dressing was composed of a layer of activated carbon fiber and a second layer of gentamicin incorporated into a γ-PGA/gelatin membrane. First, activated carbon fiber was produced from the raw oxidized polyacrylonitrile fiber cloths. The precursor of oxidized polyacrylonitrile fiber was treated with phosphoric acid and then co-activated using steam at a flow rate of 0.2 mL/min at high temperature for 10 min. Second, gentamicin was incorporated into a genipin–crosslinked γ-PGA/gelatin membrane. This γ-PGA solution (5 mL) was added to an aqueous gelatin solution (20.0% by w/v, 5 mL), then the antibiotic gentamicin was added as a solution in PBS (1% by w/v, 0.5 mL) with 10 mL of the aqueous γ-PGA/gelatin solution at 37°C with mixing. After 12 hr, our prepared activated carbon fiber was combined with the genipin–crosslinked gentamicin incorporated γ-PGA/gelatin membrane and dried in an oven at 37˚C. After drying, the fabricated dressing membranes were used for healing studies.

Results & Discussion

Clear differences in wound closure were observed between the different wound dressing at 2, 4, 8 and 12 days (Fig 1). Wound closure was improved when rat skin fibroblasts (RSF)-containing wound dressing (activated carbon fiber combined with gentamicin incorporated–γ-PGA/gelatin membrane) was used in comparison with the bi-layer wound dressing alone, tape strip (Nexcare, 3M) or gauze. The reduction in wound defect area was calculated by measuring wound area at different times. As shown in Fig 1, it was found that the wound closure efficiency of the RSF-containing bi–layer wound dressing was better than the other test dressing after different time intervals. This difference was most obvious at 8 and 12 days, with wounds treated with the prepared RSF-containing bi–layer wound dressing showing 88.68 ± 5.18% and 97.79 ± 2.74% closure, compared to 73.19 ± 6.03% and 86.43 ± 5.17% for Nexcare, 3M, and 60.52 ± 4.58% and 71.37 ± 3.55% for gauze in the control group. And, Fig 2 shows florescence images of DilC18(5)–RSF cell migration to the healing wound tissue and the control. As shown, wound tissue treated with the DilC18(5)–RSF containing bi–layer wound dressing exhibited clear fluorescence at both the surrounding edges and the middle of wound site (white arrows). RSFs can migrate from composite wound dressing into damaged tissue, aiding skin regeneration.

Conclusion

The develop bi–layer dressing composed of activated carbon fiber and gentamicin incorporated in a γ-PGA/gelatin membrane, for use as a multifunctional wound dressing. *In vivo* study showed that the fibroblast cells migrated to healing wound site, indicating accelerate wound closure.

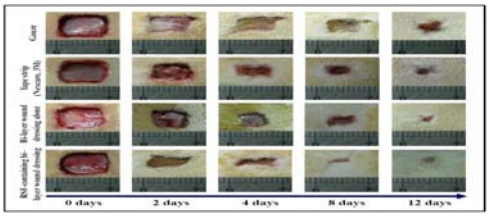

Fig 1 Wound closure rate of SD rat with different wound treatments.

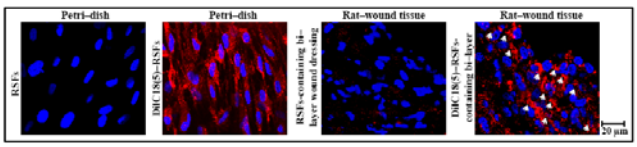

Fig 2 Fluorescent RSF cells migrate to healing wound tissue for 4 days.

References

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