Novel Composite Scaffold for the Engineering of Hollow Organs and Tissues

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Introduction

Several types of biomaterials (artificial and naturally derived) have been used either with or without cells for augmenting hollow organs and tissues, such as the bladder, urethra, ureter, esophagus, intestine, uterus, vagina and blood vessels. However, each type has desirable traits which were exclusive of the other. The ideal biomaterial for these tissues should be elastic, like naturally derived matrices, and porous, like artificial matrices. In this study we designed and fabricated a novel composite scaffold and tested its potential for the engineering of hollow organs in a bladder tissue model.

Materials and Methods

The composite scaffolds were configured to accommodate a large number of cells on one side and were designed to serve as a barrier on the other side. The scaffolds were fabricated by bonding a naturally-derived collagen-based acellular matrix to polyglycolic acid polymers with threaded collagen fiber stitches. The two-layered composite scaffolds were heat reinforced at 200^{o}C for 80 minutes, followed by lyophilization and sterilization.

Canine bladder urothelial and smooth muscle cells were grown, expanded and seeded on the composite scaffolds. The cell-seeded scaffolds were implanted into nude mice for 2 and 4 weeks and in vivo tissue formation was assessed. Biocompatibility, physical and biomechanical characteristics were evaluated. The cell-seeded scaffolds were implanted in the subcutaneous space of athymic mice for up to 4 weeks and analyzed.

Results and Discussion

The composite scaffolds, consisting of a naturally-derived collagen-based acellular matrix and polyglycolic acid polymers, are tightly bonded after fabrication, and maintained their ultrastructural properties (Figure 1). The bladder cells readily attached and proliferated on the composite scaffolds and formed bladder tissue structures in vivo, as confirmed histologically, by immunohistochemistry and Western blots (Figure 2). The scaffolds possessed a similar porosity index as native bladder and were watertight. The biomechanical studies demonstrated that the tissues were readily elastic while maintaining their pre-configured structures.

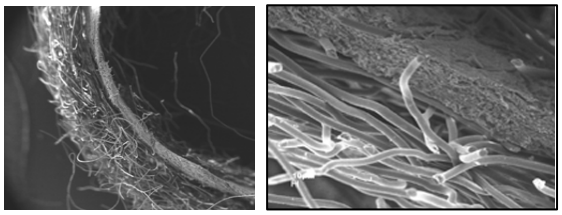

Figure 1. The composite scaffolds, consisting of a naturally-derived collagen-based acellular matrix and polyglycolic acid polymers, are tightly bonded after fabrication, and maintained their ultrastructural properties.

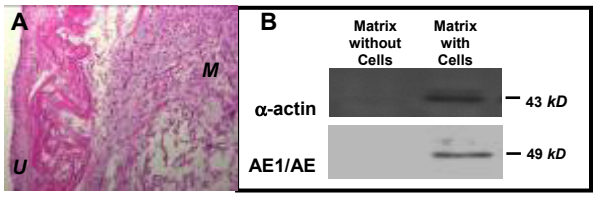

Figure 2. A) Histology of cell seeded composite scaffolds 2 weeks after implantation shows the formation of urothelial (U) and muscle cell (M) layers within the composite scaffolds. B) Western blot analyses using a-actin and pancytokeratins AE1/AE3 antibodies demonstrate the presence of protein expression within the cell seeded matrices.

Conclusions

This study demonstrates that a composite scaffold can be fabricated with two completely different polymer systems for the engineering of hollow organs. These novel scaffolds are biocompatible, possess ideal physical and structural characteristics, and are able to form tissues in vivo. This scaffold system may be useful in the future in patients requiring hollow tissue replacement.

Acknowledgements

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