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Structural characterization of 3D-reconstructed artificial blood vessels

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Introduction

Creating a small-diameter blood vessel substitute is one of the goals of tissue engineering. These substitutes could be used for coronary artery bypass graft surgery.
The cell-seeded polymer scaffold approach offers the ability to form tissue substitutes in vitro relatively rapidly with the properties and shape representative of native tissue.
The challenge in this research area is to find the best combination of scaffold material, cells and seeding- and culture procedures. The properties of the tissue-engineered blood vessel can be influenced by mechanical and biochemical conditioning during culture.

Objective

Finding the ideal combination of shear and stretch protocols (i.e. mechanical conditioning) to influence the development of the blood vessel constructs.

Scaffolds

Different scaffold materials are used for tissue engineering applications. The desired characteristics of the scaffold material are:

- highly porous interconnected pore network
- biocompatible and bioresorbable
- suitable surface chemistry for cell attachment, proliferation and differentiation
- mechanical properties to match those of the tissues at the site of implantation
- be reproducible processed into variety of shapes and sizes

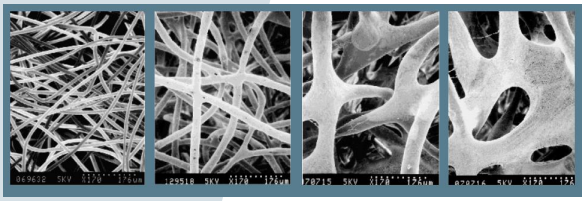

Figure 1: PGA matrices sprayed with a solution containing 5 % (w/v), final mass of PLLA bonded to PGA was 0, 69, 265 and 395% of the initial PGA mass [1]

One of the most used material is non-woven Poly(glycolic acid) (PGA), which has a fiber-like structure. Because PGA is stiff and brittle and degrades in a few weeks, it is often coated. An example of such a coating is Poly(L-lactide) PLLA which increases strength and degradation time. A picture of PLLA coated PGA is shown in figure 1. Besides spraying the coating on the PGA, the scaffold can also be dipped into the coating. SEM images of PLLA-dipped PGA scaffolds are shown in figure 2.

Another, new, scaffold material is that of Radi Medical Systems (Sweden).

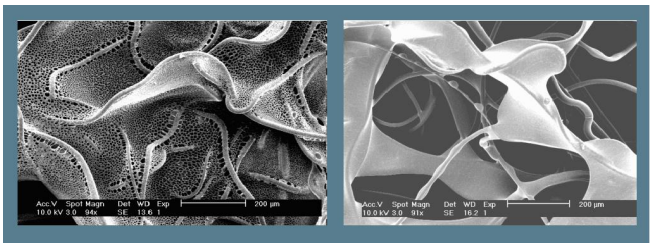

Figure 2: PLLA coated PGA, dipped (left) versus annealed(right)

SEM images (figure 3) show structures containing macro- and micropores.

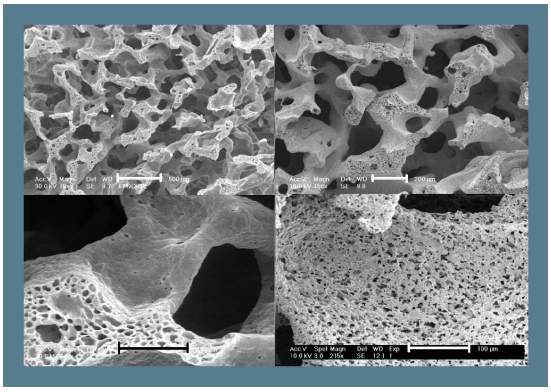

Figure 3: Radi scaffold material at different magnifications

Cells

The scaffold material will be seeded with human cells, i.e., human coronary artery smooth muscle cells (HCASMC) and endothelial cells (HCAEC)(Clonetics). The first step is to investigate whether the cells attach and grow on the material. Figure 4 shows SEM images of HCASMCs attaching to the Radi material.

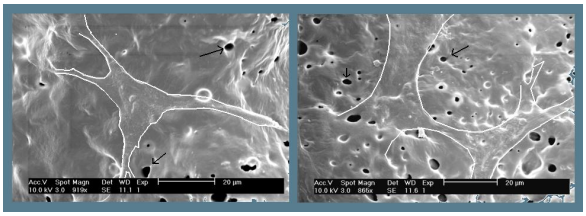

Figure 4: HCASMC on Radi scaffold, arrows indicate pores

Conclusions

The Radi material seems to be an appropriate scaffold material with a highly porous structure. HCASMC grow on this new material.

Future

Seeding HCASMC on tubular constructs made of Radi material and of PGA/PLLA and trying to influence the structure of the bloodvessel by mechanical conditioning (shear, stretch).

References

[1] Kim and Mooney, J Biomed Mater Res. 1998 41(2)