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Textile Reinforcement of Fibrin Based Tissue Engineered Heart Valves

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Introduction

Conventional valve prostheses have several disadvantages such as a life-long anticoagulation therapy, calcification, a limited lifetime and no growing capability. To overcome these disadvantages tissue-engineered heart valves are developed with the aim of creating a living prosthesis capable to remodel self repair and grow. This is extremely important especially for pediatric patients. Despite the high potential and the promising results already shown for tissue engineered heart valves, shortcomings such as low mechanical strength and cell-mediated tissue shrinkage remain to be resolved. To solve the mentioned shortcomings, we propose to combine 3D complex geometries of cell-embedded fibrin scaffolds and textile technology to reproduce the micro-architecture of the natural valve leaflets.

Methods

The developed textile structure is a composite of multifilament and an electro-spun nonwoven carrier. As a first step multifilament fibres were placed on an even surface to mimic the collagen-structure in natural leaflets. Spreading the multifilament into single filaments, the created structure became even closer to nature. The electro-spun nonwoven is directly laid on the pattern and fixes the fibres in the position defined before. To finish the reinforcement tissue-engineered heart valve, the composite was embedded in a fibrin moulding. The valves were produced by polymerizing a fibrinogen solution in TBS (10 mg/ml) with $CaCl_2$, thrombin in a 3D mould.

Results

Textile leaflets composed of an electro-spun nonwoven carrier and load-oriented single fibres were developed and successfully implemented in the moulding process to obtain fibrin-based heart valves. The single fibres were placed according to the stress lines occurring in native leaflets and continued into the wall in correspondence of the commissures.

Conclusion

The results show the potential of fibre reinforcement towards the development of fibrin-based tissue engineered heart valves with improved mechanical properties. Ongoing research focuses on the optimization of the textile reinforcement and the cultivation of the developed scaffolds with embedded cells.