Mechanical and Biological Evaluation of Small Diameter Blood Vessels with Weft-Knitted and Electrospun Bilayer Structure

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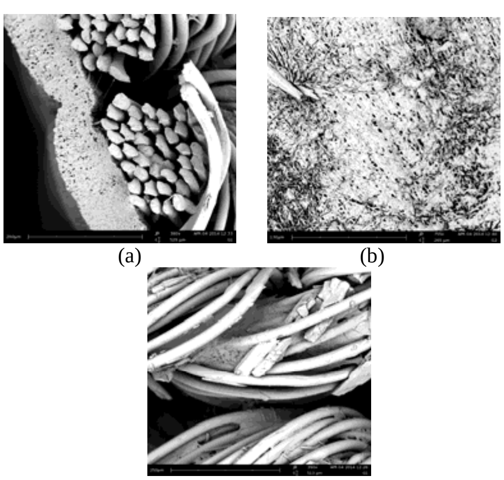
Statement of Purpose: Coronary arterial diseases (CAD) are dominant cardio-vascular diseases accounting for the significant mortality rate worldwide. Autologous vessels are currently the gold standard materials for by-pass surgery, such as the saphenous vein or the internal mammary artery [1]. However, they may not always be available due to aging, previous harvesting or the pre-existing arterial disease. Synthetic commercial ePTFE and polyester (PET) are not suitable for small diameter vascular grafts (<6 mm), mainly due to poor circumferential compliance and rapid thrombus formation. In order to reduce thrombogenicity and improve cell proliferation, the objective of this study was to develop a bilayer graft made of biodegradable and biocompatible polymers to mimic the multilayer structure of native arteries that can also provide the required mechanical properties [2,3].

Methods: Two 170 denier biodegradable polylactic acid (PLA) multifilament yarns were directly fabricated into five weft knitted tubes and then polylactide-co-caprolactone (PLCL) copolymer was electrospun onto three of the PLA tubes. An inversion procedure was applied on one of the three bilayer grafts to turn the electrospun layer inside and then the bilayer graft was impregnated with 0.5 wt% collagen/elastin (1:1 ratio) followed by crosslinking with genipin to ensure the stability of collagen/elastin impregnation. Both the mechanical and biological performance of the five prototype scaffolds was investigated, including circumferential tensile strength, suture retention, bursting strength, compliance, thrombogenicity and endothelial cell biocompatibility via an MTT assay and immunofluorescence.



(a) (b) (c)

Figure 1 SEM images of knitted(ouside) / electrospun(inside)/ impregnated bilayer graft, cross-sectional view (a), inner electrospun layer (b) and outer weft-knitted layer (c).

Results: One of the important mechanical test results, circumferential compliance, is shown in Figure 2. No significant differences were observed amongst the five grafts, namely: 1) the knitted(outside)/electrospun(inside)/ impregnated graft, 2) the knitted(inside)/ electrospun (outside)/ impregnated graft, 3) the knitted/impregnated graft, 4) the knitted(inside)/electrospun(outside)/non-impregnated graft and 5) the simply knitted graft. On the other hand, the knitted(inside)/electrospun(outside) /impregnated graft showed significantly reduced compliance compared to the electrospun inside graft.

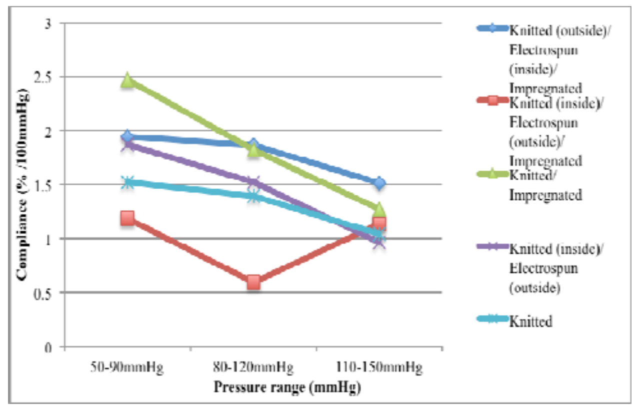


Figure 2. Circumferential compliance of the five prototypes of small diameter vascular grafts.

Conclusions: From these observed results one can conclude that the electrospun inside graft has superior compliance compared to the electrospun outside graft. Other conclusions drawn from the other mechanical tests indicate that electrospinning or/and impregnation improves the bursting strength, suture retention and circumferential tensile strength of the reinforced bilayer graft scaffolds. In addition, the raveling issue of weft-knitted structures was significantly improved by either applying an electrospun layer or by impregnation. For the biological performance of the grafts, the collagen and elastin impregnation reduced the level of thrombogenicity compared with the non-impregnated structures. The electrospun inside graft contributed to a more uniform distribution of endothelial cell proliferation on the inner luminal surface and promoted the migration of the endothelial cells as a confluent monolayer.

References:

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