Fabrication and Mechanical Evaluation of Bicomponent PET/Silk Small Diameter Arterial Prostheses

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Statement of Purpose: Synthetic small diameter artificial blood vessels were needed because of the high morbidity of coronary and cerebrovascular arterial diseases. When fabricating a small diameter arterial prosthesis, both biocompatibility requirements and certain mechanical properties such as compliance and bursting strength must be met. In addition, water permeability is also important as it indicates whether the prosthesis needs to be preclotted or not at implantation. Polyester has excellent mechanical properties, while silk has good biocompatibility[1]. So weaving an arterial prosthesis from a combination of polyester and silk yarns we can take advantage of the superior mechanical strength of polyester as well as the preferred biocompatibility of silk.

Methods: Medical grade PET multifilament yarn (Suzhou Suture Needle Company, China) was chosen as the weft yarn while braided silk (Soho International Silk Co. Ltd., China) were selected for the warp. Using the weaving parameters shown in Table 1 we fabricated three small diameter arterial prostheses on a special narrow shuttle loom[2]. After fabrication, the samples were degummed to remove serecin gum from the silk yarns using 0.05 wt.% sodium carbonate solution in a 96 ℃ water bath for 90 minutes.

Table 1. Weaving parameters of the prototype prostheses

Sample No.	Warp×Weft	NYC (/10cm)	Basic Structure	RWL (mm)
1	204DSilk×100D/36fPET	500×300	1/1 Plain	5.1
2	204DSilk×100D/36f PET	500×400	2/2 Twill	5.1
3	204DSilk×100D/36f PET	500×400	1/3 Twill	5.1

NYC: Nominal yarn counts (Warp×Weft); RWL: Reed width in loom; D: denier, mass in grams of 9,000 m of yarn, f, number of filaments.

After degumming, the following measurements were made on the prototype structures: thickness, woven yarn count, relaxed inner diameter, probe bursting strength, radial compliance and water permeability using ISO 7198 method[3].

Table 2. Dimensions and water permeability of the samples after degumming

Sample No.	YC (/10cm)	Thickness (mm)	RID (mm)	WP
1	440×329	0.275±0.003	3.94	26±9
2	460×420	0.270±0.002	3.65	110±13
3	469×395	0.260±0.001	3.67	109±14

YC: Yarn count(Warp×Weft); RID: Relaxed inner diameter; WP: Water permeability(ml/min•cm^2)

Results: From Table 2 we can see that the inner diameters of the samples were all under 4mm and the thickness results were less than 0.275mm. The water permeability values were between 26 and 110, which lie below 300 ml/min•cm^2, indicating that the arterial prostheses can be implanted without preclotting. The plain weave sample had the lowest water permeability which may be because of its plain weave structure.

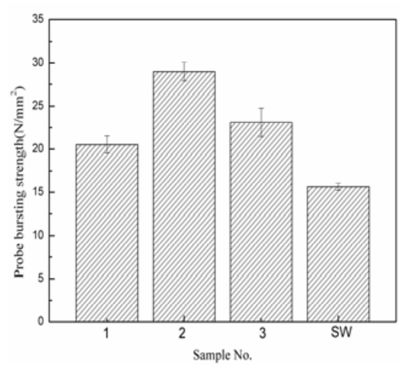

Figure 1. Probe bursting strength

The bursting strength measurements included an ePTFE Goretex Standard Wall (SW) control prosthesis[4]. Figure 1 shows that the probe bursting strength of all the woven samples exceeded that of the ePTFE commercial control, confirming that the woven samples had superior mechanical properties. Among the three woven samples, the sample 2 with the 2/2 twill had the highest probe bursting strength while there was no significant difference between Samples 1 and 3.

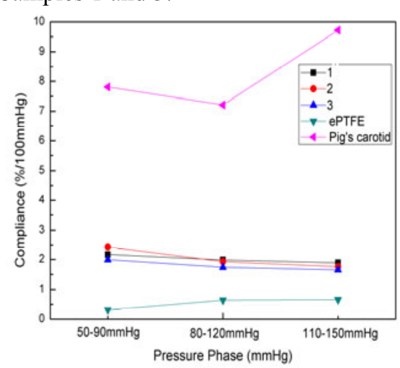

Figure 2. Radial compliance

From Figure 2 we can see that the compliance of the woven samples lies between that of the ePTFE prosthesis and that of the pig's carotid artery [5]. This shows that the woven prostheses have superior compliance compared to ePTFE control. Figure 2 also demonstrates that all three woven samples had a higher compliance values in the 50-90 mmHg pressure range, compared to that in the 110-150mmHg range.

Conclusions: Bicomponent PET/silk arterial prostheses have been woven with a diameter under 4mm with excellent mechanical properties and can be implanted without preclotting. Continuing research is studying these prostheses using in vitro and in vivo methods.

References:

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