Designing Electrospun Scaffolds with Architectures Suitable for Tendon Repair

Designing Electrospun Scaffolds with Architectures Suitable for Tendon Repair

LA, Bosworth and S, Downes
School of Materials, The University of Manchester, Manchester, UK
Lucy.bosworth@manchester.ac.uk

We propose using electrospinning to create nanofibrous structures, with architectures similar to the tendon tissue ultrastructure, as an innovative tendon repair device.

INTRODUCTION

With a lack of suitable donor tissue available to repair damaged tendons, the use of synthetic, biodegradable scaffolds as a medical device are in demand as a novel intervention.

Using electrospinning we have fabricated several poly(ε -caprolactone) nanofibrous scaffolds with different architectures, in an attempt to replicate the ultrastructure of tendons.

SCAFFOLD FABRICATION & PROPERTIES

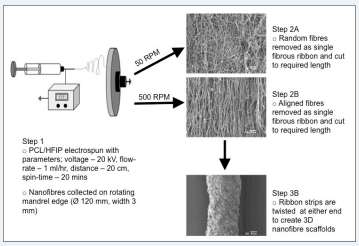

Fig. 1: Methodology for producing electrospun poly(ε-caprolactone) (PCL) fibre scaffolds from a 10 %w/v solution of PCL dissolved in acetone.

Electrospun Scaffold	Young's Modulus (MPa)	Tensile Strength (MPa)
2D Random	1.54 ± 0.26	0.45 ± 0.09
2D Aligned	4.84 ± 0.13*	1.30 ± 0.14*
3D Scaffold	14.11 ± 3.76*§	4.74 ± 1.64*§

Table 1: Tensile properties of scaffolds, strained to failure using Instron 1122, 5 N load cell and 5 mm/min cross-head speed (n=5; *§p<0.05; one-way ANOVA).

IN VITRO CHARACTERISATION

Equine superficial digital flexor tenocytes were seeded (50,000 cm^{-2}) on ethanol sterilised and media-treated scaffolds, and cultured up to 14 days.

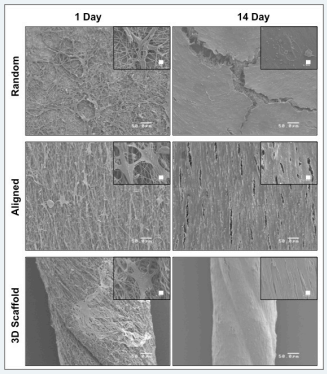

Fig. 2: SEM of fibre scaffolds with seeded tenocytes cultured up to 14 days. Cells appear to be guided by the underlying fibre direction after 24 hrs. By 14 days, cells have proliferated and the entire scaffold surfaces' are covered by orientated cells.

IN VIVO ASSESSMENT

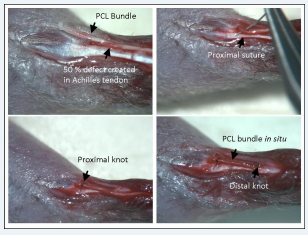

Fig. 3: Surgical procedure for creating a purpose-made defect, and grafting single 3D scaffolds into the Achilles tendon of a mouse.

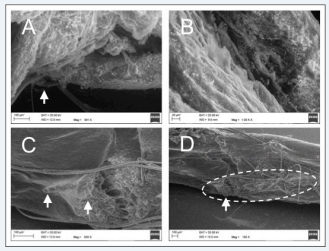

Fig. 4: SEMs of PCL graft immediately after implanting into the Achilles tendon (a,b); and position of graft after 3 weeks (c,d).

Discussion

Using electrospinning it was possible to control the orientation of emitted polymer fibres, and further manipulate those fibres as required. All fibre scaffolds supported the adhesion and proliferation of tenocytes; however, a parallel arrangement of cells could only be achieved using 2D aligned and 3D scaffolds. Tensile properties were greatest for 3D scaffolds - being significantly stronger compared to the 2D fibre scaffolds. 3D scaffolds were implanted into murine Achilles tendons' up to 3 weeks. Upon implantation, the scaffold lay in close proximity to the remaining tendon tissue, and by 3 weeks had been fully integrated with new tissue formation.

3D electrospun scaffolds provide a superior architecture, in terms of tensile strength, guided cell growth and biocompatibility *in vivo*, compared to electrospun 2D fibre networks.