Polyetheretherketone Multifilament and Monofilament Woven Tissue Engineering Scaffolds

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Introduction: Polyetheretherketone (PEEK) is a semi-crystalline thermoplastic polymer. It combines good strength and stiffness with excellent thermal stability and good chemical resistance. Studies have found good biocompatibility with fibroblasts and osteoblasts *in vitro* [1, 2], with no cytotoxic effects *in vivo* [3]. Given these properties, PEEK has been used in a number of biomedical applications, including spinal disc fusion, bone trauma repair, and craniomaxillofacial repair [4].

PEEK medical devices are typically produced by manufacturing methods like injection moulding [5], laser sintering [6], and machining. To meet the demands of more flexible implant devices, other methods of manufacture are required. The aim of this work was to fabricate flexible woven PEEK scaffolds. These scaffolds were biologically assessed with L929 mouse fibroblast cells, for up to 16 days *in vitro* culture, and results compared to those obtained for fabricated polyethylene terephthalate (PET) woven scaffolds.

Methods: Implantable grade PEEK Optima (Invibio Ltd.; UK) monofilament (10.2 tex) and multifilament (7.5 tex/15 filaments) yarns, and PET multifilament yarn (8.3 tex/36 filaments), were woven into plain weave scaffolds. Following standard methods fabrics were assessed for their physical and tensile properties.

All scaffolds were washed and sterilised (autoclaved) prior to cell seeding. Mouse L929 fibroblast cells (passage 13) were suspended in supplemented Dulbecco's modified Eagle's medium at a concentration of 6.5 x 10^4 cells/mL. Cell suspension (1.37 mL) was statically seeded onto scaffolds; secured using polymer ring holders. Samples were incubated for up to 16 days *in vitro*, changing the medium three times per week. Prior to conducting the assays scaffolds were rinsed in phosphate buffered saline to remove non-adherent cells. At regular intervals an MTS assay (Promega CellTiter 96®) was performed to give an indication of cell attachment and proliferation. Cell viability was assessed using fluorescent microscopy to visualise live calcein AM stained (green) cells and dead, ethidium homodimer-1 stained (red) cells. Scanning electron microscopy (SEM) was used to observe cell morphology, using standard sample preparation procedures.

Results: PEEK scaffolds of mass per unit area and thickness, ranging 55 to 75 g/m^2 and 180 to 690 µm, respectively, were fabricated using multifilament and monofilament yarns, respectively. A tensile load at break of 657 N was determined for the PEEK multifilament scaffold, with a strain at break of 18%.

Both the PEEK and PET scaffolds were found to support cell attachment and growth. The MTS assay determined the PET scaffold to sustain slightly higher cell numbers than the PEEK scaffolds in the early stages of culture. This may have been due to the smaller inter-yarn pores resulting in a higher cell seeding efficiency. With increased incubation time similar cell numbers were found an all scaffolds, with slightly lower numbers on the PEEK monofilament scaffold by day 10 of culture.

Fluorescent microscopy revealed few dead cells on the scaffolds throughout the culture period. Little infiltration into the large pores (average pore size of 307 µm) of the monofilament PEEK scaffold was observed by day 10. Conversely, the smaller pores (average pore size of 95 µm) of the multifilament PEEK scaffold were partially filled (Figure 1). Cells were found to be aligned with the filament direction (Figure 2 left) by day 6 of culture, with extracellular matrix (ECM) deposition by day 10.

SEM micrographs revealed cells to be flattened with processes extending onto the PEEK filaments. See Figure 2 right.

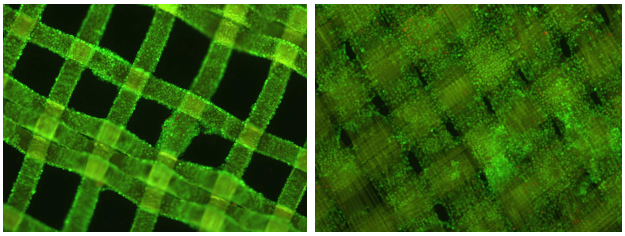

Figure 1. Fluorescent micrographs of fibroblasts attached to PEEK monofilament (left) and multifilament (right) scaffolds on day 10 of culture.

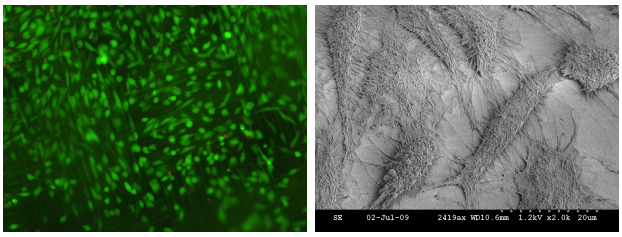

Figure 2. Fluorescent micrograph of fibroblasts oriented on multifilament weave (left) and SEM micrograph of flattened fibroblasts on PEEK filament on day 8 (right).

Conclusions: Multifilament PEEK woven scaffolds were lighter and thinner than monofilament PEEK scaffolds, with higher strength and lower extensibility. Woven PEEK scaffolds were found to support fibroblast cell attachment and proliferation, and ECM production. Cells were found to orientate with the filament direction, and, in places, span pores of the multifilament scaffold. The results of this study indicate that fibrous PEEK structures have potential as scaffolds for tissue engineering.

References:

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