

Application of Optical Coherence Tomography in Tissue engineering

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INTRODUCTION: Monitoring cell profiles in 3D porous scaffolds presents a major challenge in tissue engineering. The fabrication of 3D thick tissue constructs has been limited by our ability to visualize the complex cellular dynamics and morphological organizational events occurring deep within these constructs by conventional imaging techniques, such as light microscopy. Optical coherence tomography (OCT) has recently emerged as a promising imaging technique, mainly for medical applications. The original development of OCT was for transparent tissues, such as cornea and retinal tissues. Current OCT technology enables non-transparent, soft and hard tissues to be examined. Several features in OCT are unique and highly attractive for tissue engineering. Measurements by OCT can be realized on-line and non-destructive; the resolution is up to the cellular dimension (0.9-10 μm); the penetration depth for a non-transparent object can be up to 2 mm. A number of different forms, but fundamentally identical OCT, have evolved over the past decade that are developed to image/quantify the different parameters of biological tissue, these including microstructures (time-domain OCT), flow (Doppler OCT), birefringence (polarization sensitive OCT), metabolic states (spectroscopic OCT), biomechanical properties etc. OCT operating in a single function or a combined function may tackle different monitoring tasks in tissue engineering. In this paper, we outline how OCT can be applied to monitor the parameters of tissue engineered constructs non-destructively and dynamically.

METHODS: Two types of OCT system were used for this investigation. One was a time-domain Michelson interferometer based and fiber-optic integrated OCT which employed a 1300 nm superluminescent diode with a bandwidth of 52 nm. The light source yielded 14 μm axial resolution in free space, or 10 μm in the tissue. Another system was a whole field optical coherence microscopy (WFOCM) based on a Linnik interferometer. The X \times Y \times Z imaging resolutions for the current system were experimentally determined at 0.9 \times 0.9 \times 0.7 μm when the objective lenses were immersed in water. Porous PLA scaffolds and chitosan scaffolds with

micro-channel were produced in the lab. MG63 bone cells and tenocytes were seeded onto the scaffolds with different seeding density and culture conditions. The blank scaffolds and the cultured constructs were scanned by the OCT systems. The quantitative evaluation of the structure changes in the constructs has been undertaken.

RESULTS: OCT was capable of revealing the microstructure of blank scaffolds and the cultured constructs clearly (Fig 1). Quantitative calculation of the change in the porosity, pore size and microchannel-filling ratio reflected the profiles of cell proliferation and matrix production within the constructs (Fig2).

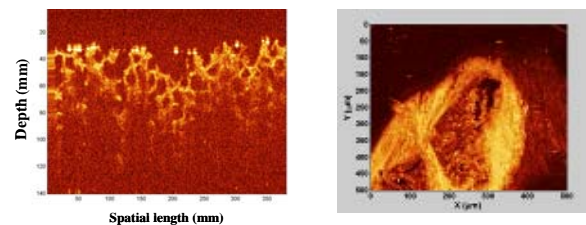


Fig. 1: Time-domain OCT image of a blank PLA scaffold (left), and WFOCM image of a PLA scaffold seeded with 4×10^6 bone cells for 5 weeks (right)

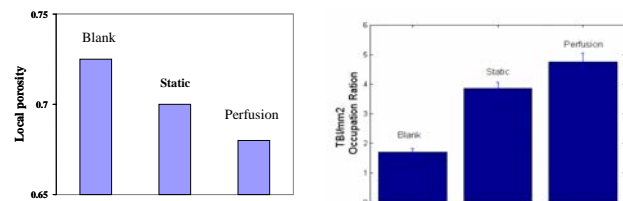


Fig 2: Quantitative evaluation of the changes of the porosity and microchannels in the constructs under different culture conditions

DISCUSSION & CONCLUSIONS: It is confirmed that OCT can monitoring cell growth profile based on its ability to reveal the change of pore architecture in the constructs. The mechanical properties and the components within the constructs can be characterized by OCT well. OCT demonstrate a great potential in tissue engineering. **ACKNOWLEDGEMENTS:** This work was supported by BBSRC (BBS/B/04277, BBS/B/04242) and EPSRC (GR/S11510/01).