SPINAL CORD-ON-A-CHIP: A NOVEL MICROFLUIDIC MODEL TO INVESTIGATE NEUROLOGICAL CELL RESPONSES TO SPINAL IMPLANT WEAR PARTICLES

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INTRODUCTION

Biomaterials such as metals, polymers and ceramics are widely used in spinal implants. However, the interfaces and bearings of certain combinations of materials like metal-on-polymer can generate substantial volumes of wear particles. These particles have the potential to impact the spinal cord negatively, leading to structural damage of spinal cord meninges, inflammation, hypersensitivity, DNA abnormalities, and neurotoxicity [1]. Despite the intense research on orthopaedic implants, the impact of wear particles on neurological cells is unclear, and the possible indirect effects of implant wear are yet to be explored. Current 3D in-vitro models like hydrogel-based cell cultures are inadequate to study the indirect wear particle response and struggle to precisely control the microenvironment and mimic the spinal cord [2].

To address this, we have devised a microfluidic model optimising the analysis of neurological cell responses to wear particles, providing a cost-effective and time-efficient means to conduct relevant experiments in a controlled environment.

METHODS

Design and development: The model was designed in Autodesk Inventor. Microfluidic resin moulds were fabricated using a Digital Light Processing (DLP) 3D printer, followed by casting polydimethylsiloxane (PDMS) chips. The device features two channels for cell culture and a middle channel with micropillars separating the other two channels.

Particle Characterisation & Optimisation: Polyether ether ketone (PEEK) particles were filtered and characterised according to their size using scanning electron microscopy (SEM) imaging. GelMA and collagen were added to the middle channel and tested for leakage between the microfluidic channels, using sterile water and media containing particles and cells.

Experiments on biological response: For the functionality test, rat glioma cells (C6, astrocytes) and PEEK particles (with a dose of 100 μm^3 of particles per cell ranging from 0.1 to. 10 µm in size) were added and cultured in the microfluidic device followed by viability experiments [3].

RESULTS AND DISCUSSION

The micropillars prevented any leakage of cells or particles between the channels and enabled indirect cell connection with collagen in the middle. The PEEK particles used in the experiments had varying shapes, from round and elongated, to varying sizes. Cells were evenly distributed across the channels, and the live/ dead assay for a span of four days revealed live cells dominated. The viability experiments confirmed the compatibility of our device for neurological cell studies.

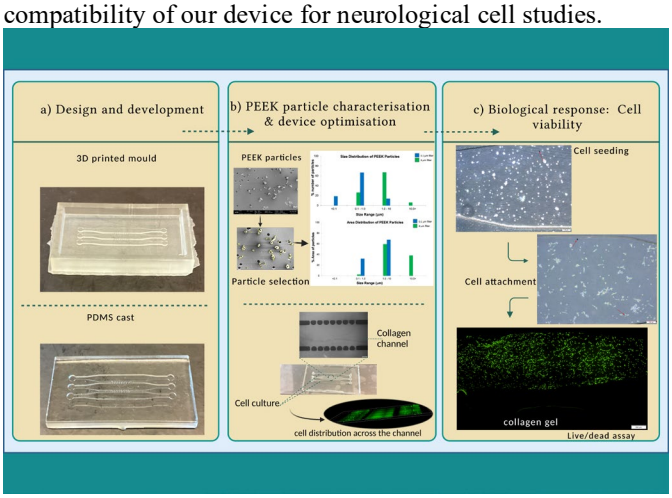

Figure 1: a) Developed 3D printed resin mould (top) and PDMS cast (bottom), b) Size and area distribution of PEEK particles in four ranges (<0.1 um, 0.1–1 µm, 1-10 µm and >10 µm) with 0.1 µm and 8 µm filters; uniform cell distribution across the channels with collagen in the middle, c) Cell channel displaying attached astrocytes; red arrow denotes PEEK particles; Green stained cells represent the live cells (Created with BioRender.com).

CONCLUSIONS

Our microfluidic model facilitates neurological cell analysis to wear particles and provides a platform for indirect cell studies. This model will be an effective tool for researchers in developing longer-lasting implants with enhanced properties and may reduce the likelihood of implant failure.

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