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A Multi-Functional Single Stem Cell-Based Microrobot for Treating Neurological Diseases

K. Chan
Faculty of Dentistry, University of Hong Kong, Hong Kong, China

Objectives Stem cell-based therapy has already been used for treating neurological diseases. However, researchers are still facing challenges of how to deliver stem cells to the target area and differentiate them into the correct type of cells. This research aims to explore a magnetically actuated single stem-based microrobot called “SCAPBOT” to deliver the stem cells from apical papillae (SCAPs) to bypass the blood brain barrier for the treatment of neurological diseases.
Methods The magnetic iron oxide nanoparticles (MIONs) were synthesized and then characterized TEM and SEM. After the fabrication of magnetic, oxygen generating and BDNF loaded GelMA hydrogel, the SCAPBOT was manufactured by using droplet microfluidic platform. The SCAPBOT's level of oxygen was measured by oxygen sensor meter. SCAPs were assessed for whether it has been differentiated into neural lineage by BDNF through immunostaining with antibodies to the specific neuronal marker. For investigating *in vitro* magnetic actuation, the SCAPBOT were observed with time-lapse imaging within a microfluidic channel under an external magnetic field. One image per well will be taken, with a total of 8 technical repeats per biological repeat. Data were analyzed using ImageJ with images from 3 biological repeats.
Results The microstructure of SCAPBOT was observed to confirm that it had a suitable shape and size. The capacity of oxygen release indicated that the CaO_2 was distributed among the GelMA hydrogel. Moreover, the biocompatibility of the MIONs, SCAPs viability, and cytotoxicity of microrobot showed that the SCAPBOT had a high level of viability and proliferation. Furthermore, the results of immunocytochemistry revealed that the SCAPs had expressed neurogenic biomarkers and differentiated into the neuronal lineage. The SCAPBOT could also achieve safe, effective, and controllable locomotion when it was actuated within a microfluidic channel under an external magnetic field.
Conclusions This research has developed a novel multi-functional SCAPBOT that can transport therapeutic stem cells such as SCAPs to a precise location, direct stem cells toward a pre-destined cell lineage, and support its survivability, proliferation, and differentiation for the treatment of neurological disorder.