Hybrid nanofibers designed to deliver oxygen favorable for cell survival and osteogenesis

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Statement of Purpose: Low oxygen (O_2) level results in death of living cells or tissues like bone.[1] Much effort has thus been exerted to overcome this, and ultimately to apply for tissue engineering.[2] For instance, calcium peroxide (CaO_2) was introduced within scaffolds to generate oxygen.[3] Here, we designed oxygen-generating core-shell nanofiber scaffolds which were composed of calcium peroxide (CaO_2) / polycaprolactone (PCL) as a core part and mesoporous silica / bovine liver catalase as a shell component.

Methods: To fabricate core–shell nanofibers, a mixture of PCL/CaO_2 as a core segment and sol-gel processed silica /catalase as a shell segment was electrospun via a coaxial-nozzle. The nanofibers were characterized by transmission electron microscopy (TEM), scanning electron microscopy (SEM), X-ray diffraction (XRD) spectrometry, and Fourier transform infrared (FT-IR) spectrometry. The calcium ions released from the core part of the nanofibers was measured. Cell viability on the nanofibers was performed by CCK-8 assay. Alkaline phosphatase (ALP) activity was determined and the expression of osteogenic genes was measured by real time reverse transcriptase polymer chain reaction (RT-PCR).

Results: From TEM images, the core-shell structure of the nanofibers was confirmed. The shell thickness was measured to be around 55 nm. The FT-IR spectra of the hybrid core-shell nanofiber showed characteristic peaks of siloxane (Si-O-Si) and silanol (Si-OH) groups due to sol-gel processed silica xerogel. The XRD patterns showed silica amorphous phase, implying the coverage of silica over the nanofiber scaffolds. The hybrid nanofibers also showed excellent apatite forming ability in SBF. The hybrid nanofibers with the core-shell structure released calcium ions and H_2O_2 from the core part in aqueous media continuously up to 3 weeks. The cell viability on the designed core-shell nanofiber was significantly higher than the conventional CaO_2-containing nanofiber, implying the effective role of bovine liver catalase present in the silica shell phase. As a result, the cells were smoothly differentiated into an osteogenic lineage, expressing substantial levels of osteogenic genes and representing high ALP activity.

Conclusions: This study showed a novel design of oxygen releasing nanofiber scaffold through the core-shell structure and the use of bovine liver catalase. The enhanced cell viability and proper osteogenic differentiation suggest the potential use of the scaffolds for tissue engineering.

References:

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