Scientific Paper:

Biotechnology and Bioengineering (2016)

Oxygen Mapping: Probing a Novel Seeding Strategy for Bone Tissue Engineering

Ines Westphal[1,2], Claudia Jedelhauser[1], Gregor Liebsch[3], Arnd Wilhelmi[4], Attila Aszodi[1], Matthias Schieker [1,2]

[1]Experimental Surgery and Regenerative Medicine, Department of General, Trauma and Reconstructive Surgery, University Hospital, Ludwig-Maximilians University of Munich, Germany
[2]LivImplant GmbH, Starnberg, Germany
[3]PreSens Precision Sensing GmbH, Regensburg, Germany
[4]Tutogen Medical GmbH, Neunkirchen am Brand, Germany

Abstract:

Bone tissue engineering (BTE) utilizing biomaterial scaffolds and human mesenchymal stem cells (hMSCs) is a promising approach for the treatment of bone defects. The quality of engineered tissue is crucially affected by numerous parameters including cell density and oxygen supply. In this study, a novel oxygen-imaging sensor was introduced to monitor the oxygen distribution in three dimensional (3D) scaffolds in order to analyse a new cell-seeding strategy. Immortalized hMSCs, pre-cultured in a monolayer for 30 – 40 % or 70 – 80 % confluence, were used to seed demineralized bone matrix (DBM) scaffolds. Real-time measurements of oxygen consumption in vitro were simultaneously performed by the novel planar sensor and a conventional needle-type sensor over 24 h. Recorded oxygen maps of the novel planar sensor revealed that scaffolds, seeded with hMSCs harvested at lower densities (30 – 40 % confluence), exhibited rapid exponential oxygen consumption profile. In contrast, harvesting cells at higher densities (70 – 80 % confluence) resulted in a very slow, almost linear, oxygen decrease due to gradual achieving the stationary growth phase. In conclusion, it could be shown that not only the seeding density on a scaffold, but also the cell density at the time point of harvest is of major importance for BTE. The new cell seeding strategy of harvested MSCs at low density during its log phase could be a useful strategy for an early in vivo implantation of cell-seeded scaffolds after a shorter in vitro culture period. Furthermore, the novel oxygen imaging sensor enables a continuous, two-dimensional, quick and convenient to handle oxygen mapping for the development and optimization of tissue engineered scaffolds.

Keywords: bone tissue engineering, mesenchymal stem cells, 3D scaffolds, oxygen measurement, time point of harvest, cell density