Biomedical applications of magnetic nanoparticles : from cell imaging to tissue engineering

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Abstract

Recent advances in cell therapy and tissue engineering opened new windows for regenerative medicine, but still necessitate innovative techniques to create and image functional tissues. One promising approach is to associate magnetic nanoparticles with cells in order to supply them with sufficient magnetization to be detectable by MRI [1] or manipulated by magnetic forces [2], while maintaining cell viability and functionalities. A few years ago, we proposed the use of anionic iron oxide nanoparticles as efficient agents for cell internalisation without impacting cell functions [1]. Recently we examined the influence of the amount of internalized iron and the state of nanoparticle aggregation on the capacity for mesenchymal stem cell differentiation and MRI single cell tracking [3]. We then demonstrated that high resolution Magnetic Resonance Imaging (MRI) allowed combining cellular-scale resolution with the ability to detect two cell types simultaneously at any tissue depth [4]. In parallel, we adressed the challenge to create a functional tissue from stem cells in vitro. The aim was to confine stem cells in three dimensions at the millimetric scale by using home-designed miniaturized magnetic devices, in order to create cellular patterns for cartilage tissue engineering [5]. The labeling of endothelial precursors provided as well new possibilities to create potential vessel substitutes [6]. Taken togeter, these results have fundamental implications for the use of magnetic nanoparticles for cell therapy, from MRI imaging studies of stem cell fate to tissue engineering.

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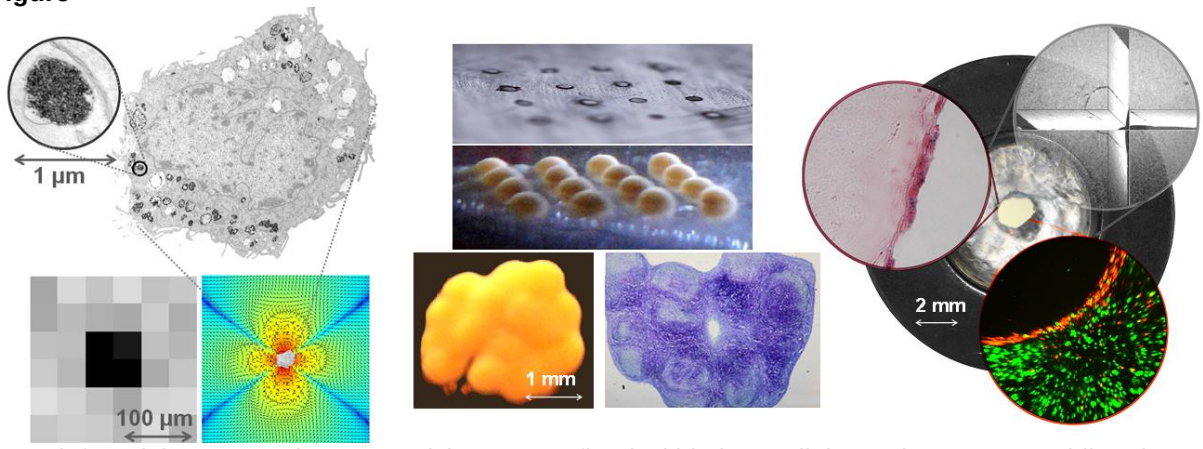
Figure



From left to right : Magnetic nanoparticles are confined within intracellular endosomes, providing the cell with enough magnetization to be detected individually on high resolution MRI scans - Magnetically driven fusion of stem cell aggregates assembled by micromagnets results in the formation of a continuous tissue layer containing abundant cartilage matrix - A technological approach combining a tubular scaffold and magnetic endothelial cells allows creating a pluricellular and organized vascular graft, with in depth MRI detection of individual cellular components.