MRI Cell Tracking using Magnetic Nanoparticles

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The clinical use of novel experimental cell therapies calls for suitable methods that can monitor the cellular biodistribution non-invasively following administration. Among the different clinically used imaging techniques, magnetic resonance (MR) imaging has superior spatial resolution with excellent soft tissue contrast. In order for exogenous therapeutic cells to be detected, they need to have a different contrast from endogenous cells. The most sensitive MR label to date are the superparamagnetic iron oxide nanoparticles or SPIOs. SPIOs are clinically approved and create strong local magnetic field disturbances that spoil the MR signal leading to hypo- or hyperintense contrast.

After approximately a decade of animal studies using MRI cell tracking these nanoprobes entered the clinic for cell tracking in 2004. The first phase I trial demonstrated the feasibility and safety of MRI (dendritic) cell tracking in cancer patients. A surprising finding, only observable by MRI, was that misinjection of cells occurred in half the patients. While the injection procedure was performed under ultrasound guidance, neither radionuclide or US imaging was able to reveal the failure of targeted cell delivery. Therefore, MR-guided targeted cell delivery may have significant advantages for clinical implementation of novel treatment paradigms using cellular therapeutics. If the administration is done in real-time under MR guidance, then verification of accurate cell delivery in, adjacent, or remote from the target site is mandatory. As of the end of 2010, 6 clinical trials using SPIO-based cell tracking have now been published, and some of these will be highlighted.