

Specialty area: *Molecular & Cellular Imaging: From Bench to the Bed*
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Highlights

- What are the challenges in molecular & cellular MRI and how to address them?
- Unambiguous detection & quantification of target structures via MRI
- Magnetic Particle Imaging: The new MRI for molecular & cellular imaging?

Title: Technical Challenges to Detection

Molecular & Cellular Imaging (MCI) is “the in-vivo characterization and measurement of biological processes at the cellular and molecular level” and aims to image molecular abnormalities associated with diseases and to monitor cell assemblies such as macrophages or stem cells. However, so far, since MRI compared to other imaging techniques is traditionally a low sensitivity modality (orders of magnitude less sensitive than other techniques, such as PET, SPECT or optical fluorescence microscopy), MCI via MRI faces major technical/methodological challenges:

- (1) How to address the chief limiting factor “sensitivity”
- (2) How to unambiguously detect target structures and facilitate their robust quantification
- (3) How to make pre and post contrast images obsolete

In this context, it is important to remember, that MRI contrast agents (such as e.g. coated superparamagnetic iron oxide nanoparticles or paramagnetic agents) are not detected directly, but indirectly, since they only influence the MR signal. This makes a one-to-one identification of labeled structures in many cases difficult, if not impossible. Therefore, new approaches, which allow for a “background-free” identification, imaging and quantification of the labeled structures, are required.

In this teaching session methodological innovations in combination with their contrast agents counterparts are introduced. These approaches enhance the ability to distinguish the molecular/cellular target signal from any background magnetic resonance signal, which greatly facilitates a “Hot-Spot” interpretation of the images in a way similar to PET or SPECT. For the different techniques, selected examples will be reported, with no intention to be exhaustive, but with the aim to cover in more detail the fundamental challenges and their potential solutions using techniques such as 1) MRI-Offresonance Detection, 2) Delta Relaxation Enhanced Magnetic Resonance, and (3) Magnetic Particle Imaging.

The **target audience** envisioned are newcomers and application-oriented researchers in the field, which need both the basics and a broader survey of the unresolved issues of molecular and cellular MRI. Introduction into the topics and more detailed information can also be found in the following references:

- 1) Terreno E, Castelli DD, Viale A, Aime S. Challenges for Molecular Magnetic Resonance Imaging. *Chem. Rev.* 2010; 110: 3019–3042
- 2) Jakob PM & Haddad D. Positive-Contrast Visualization of Iron-Oxide-Labeled Cells. In: Bydder GM, Fullerton GD, Young IR, eds. *MRI of Tissues with Short T2s or T2*s*. John Wiley & Sons; 2012: 273-286
- 3) Gleich B, Weizenecker J. Tomographic imaging using the nonlinear response of magnetic particles. *Nature* 2005; 435, 1214-1217