Magnetic Particle Imaging (MPI) A Breakthrough Approach for Stem Cell Tracking

Introduction to MPI

MPI is a new breakthrough cell tracking approach offering solutions for cell therapy, immune oncology, tumorigenesis and many other related research areas. While substantial gains have been made in each of these areas effective cell tracking approaches currently limit progress. The ideal imaging modality should have excellent spatial resolution, sensitivity and should be able to guide the delivery of cells and longitudinally monitor stem cell fate. However, until recently all existing imaging approaches fell short of achieving this benchmark. This has all changed with the release of the Momentum™ (Magnetic Insight, Inc.) preclinical MPI system. This system is safe (no radiation exposure), non-invasive and linearly quantitative (Figure 1c) [1].

MPI uses superparamagnetic iron oxide (SPIO) tracers, similar to currently FDA approved contrast agents commonly used for clinical MRI (magnetic resonance imaging) scans [2]. However, MPI is not MRI and acquires images through a different mechanism [3]. Notably, MPI can detect the tracer anywhere in the body and independent of penetration depth (Figure 1b) or image artifacts, which are commonly seen in other modalities [1]. Additionally, tissue is invisible to MPI and only the tracer signal is detected, meaning there is essentially no background [4]. However, anatomical reference points can be included in the acquired images through co-registration with either CT (computed tomography) or MRI.

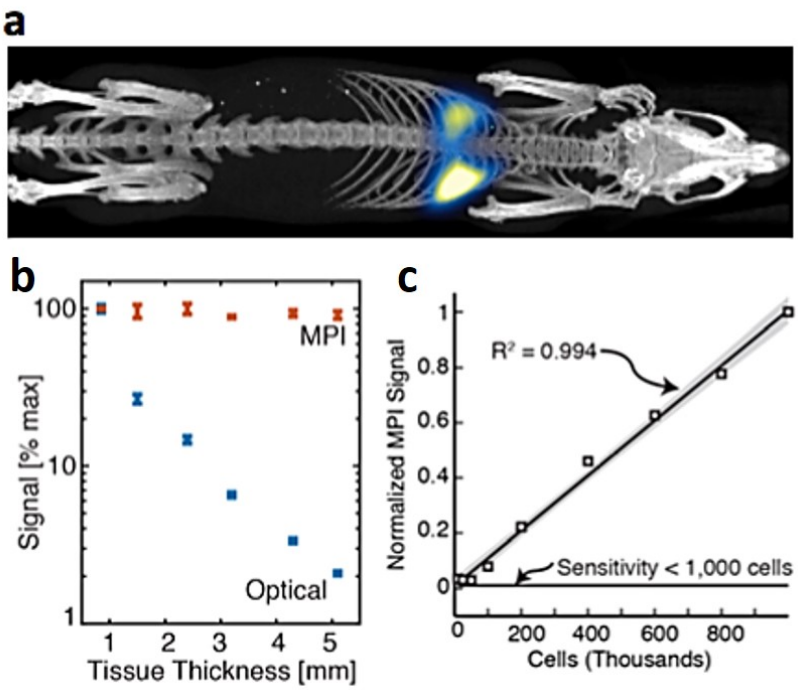

Figure 1: ((a) SPIO-labeled hMSCs localize to the lungs 5 min after tail vein injection. FOV 6 cm x 4 cm x 4 cm, scan time 15 min. (b) No signal attenuation occurs in MPI regardless of depth of the SPIO in tissue, however significant attenuation is observed in optical imaging. (c) MPI signal resulting from SPIO-labeled hMSCs is linearly quantitative and cell numbers can easily be determined anywhere in the body [1].

Cell Labeling

Cells must first be labeled with SPIOs prior to cell tracking experiments. A wide array of cell types including stem cells can be loaded with SPIOs using a simple standard cell-labeling protocol. Cell are seeded and grown to confluence followed by labeling with SPIOs such as Ferucarbotran (VivoTrax™, Magnetic Insight, Inc.), a known gold standard tracking agent used for MPI. SPIOs are added directly to the culture media and incubated overnight to allow the SPIOs to be taken up by the cells. Following incubation, cells are ready to be harvested prior to in vivo administration.

Applications

Once cells have been labeled they can be administering either as a bolus to investigate local effects or systemically for more global monitoring. As an example, shown in Figure 1, hMSCs (human mesenchymal stem cells) were labeled and injected intravenously into a rat. Animals were then scanned up to a period of 12 days. Cells become localized in the rat lungs as seen in Figure 1a producing a high resolution image, which was co-registered to CT [1]. However, many other applications are possible such as multi-color MPI, which has the capability to track multiple cell types simultaneously using SPIOs of different sizes and having different magnetic properties.

Cell Labeling

MPI is easy to use having a similar workflow as optical imaging and is able to scan an entire animal in the order of seconds for a projection image or within minutes for 3D images enabling cellular detection at sub-millimeter resolutions.

Conclusion

MPI offers new imaging capabilities allowing for more effective cell monitoring. This technique offers high sensitivity to track small numbers of cells, high resolution to spatially determine cell location, a linearly quantitative signal and positive contrast with straight-forward analysis. This system is high-throughput, easy to operate and is translatable to the clinic.

References

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