Reliable Quantitation with Preclinical Magnetic Particle Imaging

Overcoming challenges with in vivo quantitation

One of the main challenges with preclinical imaging solutions is accurate quantitation. Signal obtained with optical imaging or ultrasound is highly sensitive to tissue attenuation, while in the case of MRI there is a non-linear relationship between signal and proton density due to differing T1 and T2 relaxation effects. Even with PET there can be issues with tissue attenuation.

With Magnetic Particle Imaging, there is a direct linear relationship between the quantity of super-paramagnetic iron oxide and the signal obtained (S_{Fe}). This signal is quantitative regardless of the particle used or the timing of acquisition.[1]

The MOMENTUM™ MPI system from Magnetic Insight accurately detects and quantitates the same amount of iron regardless of dilution or volumetric shape, providing reliable measurements for preclinical applications.

Experimental setup

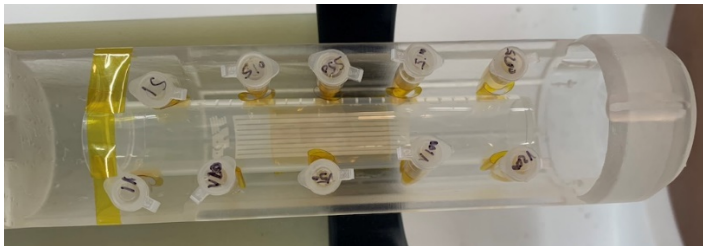

Figure 1 - Sample placement on the imaging bed. Different tracer dilutions in 1-200 uL of Synomag®-D 70 (top row) and VivoTraxTM (bottom row) were used.

In this experiment, 5 samples were prepared with different volumes (1µL to 200µL) (Figure 1). Each sample contained the same total quantity of iron oxide tracer, 1µL of stock Synomag®-D 70 (top row) or VivoTrax™ (bottom row). Using a single projection scan, images show identical intensity between samples of the same tracer (Figure 3). Following a 3D acquisition the changes in shape matches the expected changes in volume (Figure 2). Using an image analysis software on both 2D and 3D images, regions of interest were drawn over each sample and the total signal was quantified from each ROI.

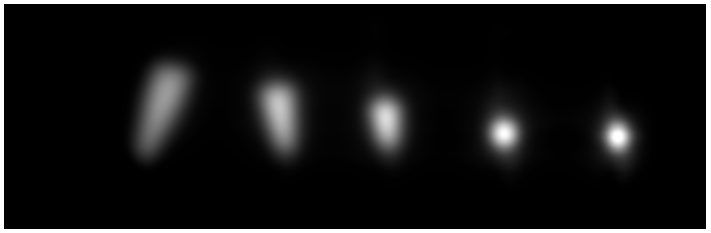

Figure 2 - Slice image of volume acquisition (Synomag®-D) showing the same amount of iron in different dilution volumes. The characteristic shape of Eppendorf's tube is clearly visible.

Results

All ten samples are visible with MPI. The Synomag®-D 70 (top row) is more concentrated (25mg/mL) than Vivotrax™ (5.5mg/mL, bottom row) and therefore gives rise to more signal.

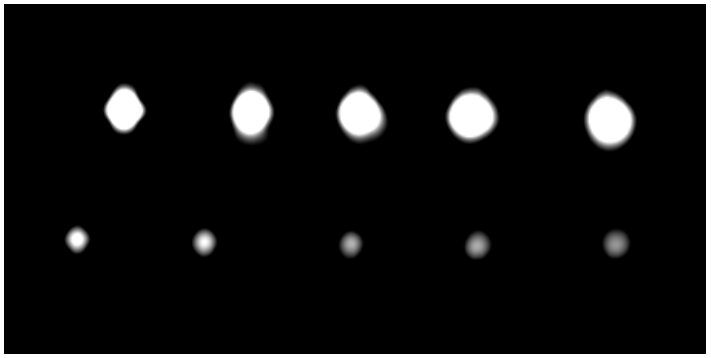

Figure 3 - Projection image of the setup presented in Figure 1. Synomag®-D (top) is 5 times more concentrated than VivoTrax™ (bottom) and shows much higher signal for the same volumes

In projection images, the difference in quantitation between dilutions is less than 4% and 9% when using Synomag®-D 70 and VivoTrax™, respectively. Signal for

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Synomag®-D is also 5 times higher than the signal for VivoTrax™, confirming linearity within the same image.

The differences between dilutions with volumetric quantitation is less than 10% for each particle (data not shown).

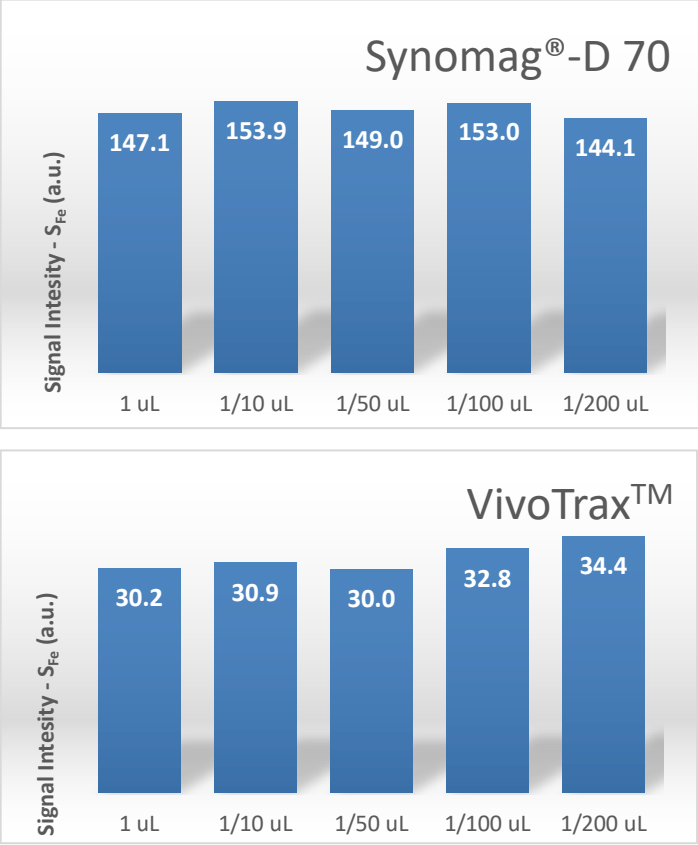

Figure 4 – 2D Signal quantitation for Synomag®-D (top) and VivoTrax™ (bottom)

Conclusions

Accurate quantitation of *in vivo* signal is important for many pre-clinical applications. Here we demonstrate MPI's robust quantitative independence to dilution effects. The total signal is not only similar across dilution for each tracer, but the quantitation holds the same ratio of total iron oxide between tracers. Previous work has also shown the strong signal linearity of this technique over several orders of magnitude regardless of depth[2]. This presents a tremendous advantage for preclinical applications where biodistribution can now be assessed both qualitatively and quantitatively through the direct imaging of nanoparticle tracers.

Acknowledgments

Data was collected on the MOMENTUM™ MPI system at Magnetic Insight. Images were analyzed using 3DSlicer[3] image processing software. MPI particles used are available for purchase at micrmod Partikletechnologie GmbH (Synomag®-D) and Magnetic Insight (VivoTrax™).

References

1. Saritas et al. J Mag Res. 2013; 229: 116-126

2. Goodwill et al. IEEE Trans Med Imaging. 2012 May; 31(5): 1076-1085

3. Fedorov A. et al. Magn Reson Imaging. 2012 Nov;30(9):1323-41

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