Susceptibility Weighted Imaging of Arteries and Veins with Ferumoxytol

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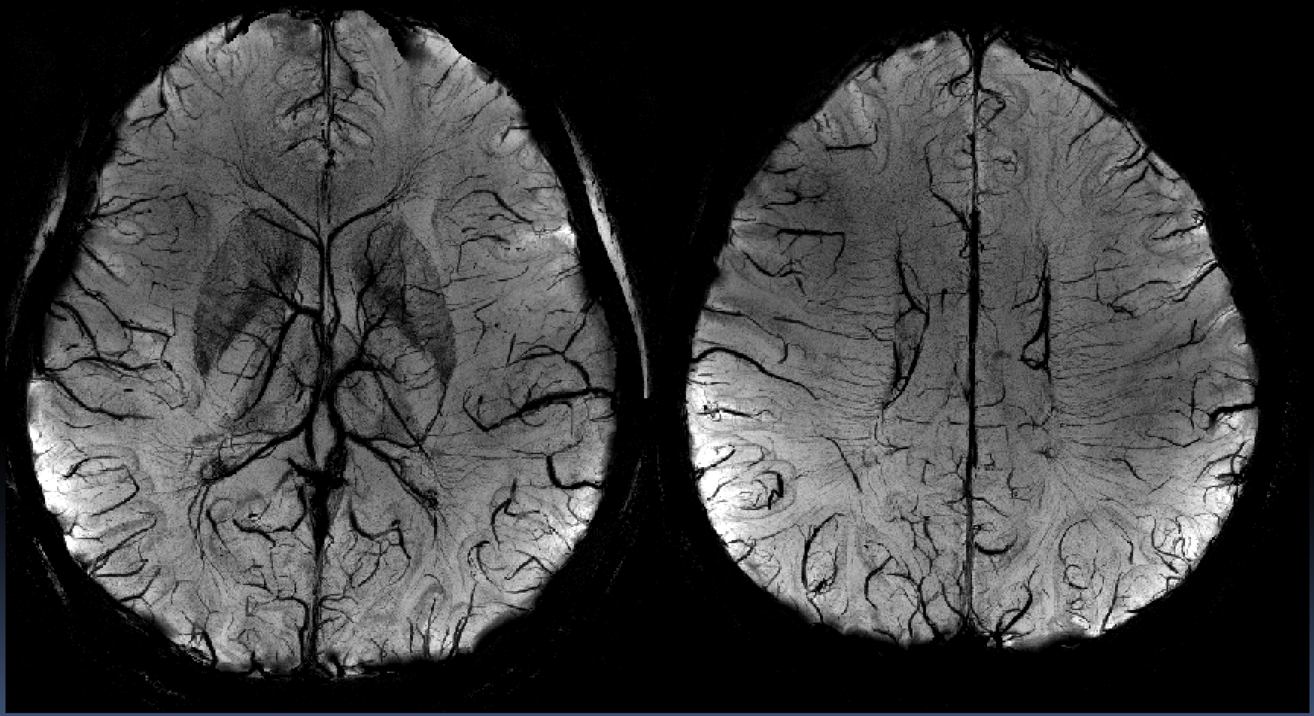
Visualizing Veins using Susceptibility Weighted Imaging (SWI)



Minimum intensity projections of SWI. Effective slice thickness = 16mm.
B_0=7T, TE=16ms, voxel size = 0.22 x 0.22 x 2 mm^3.

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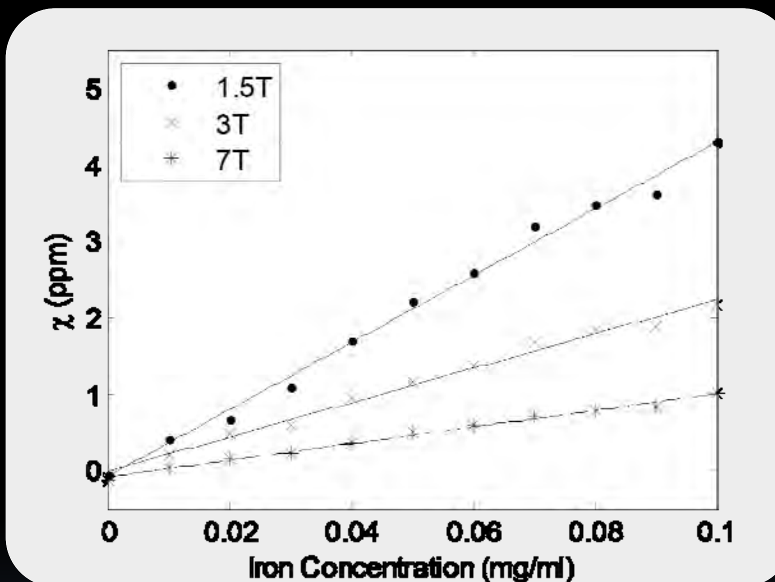
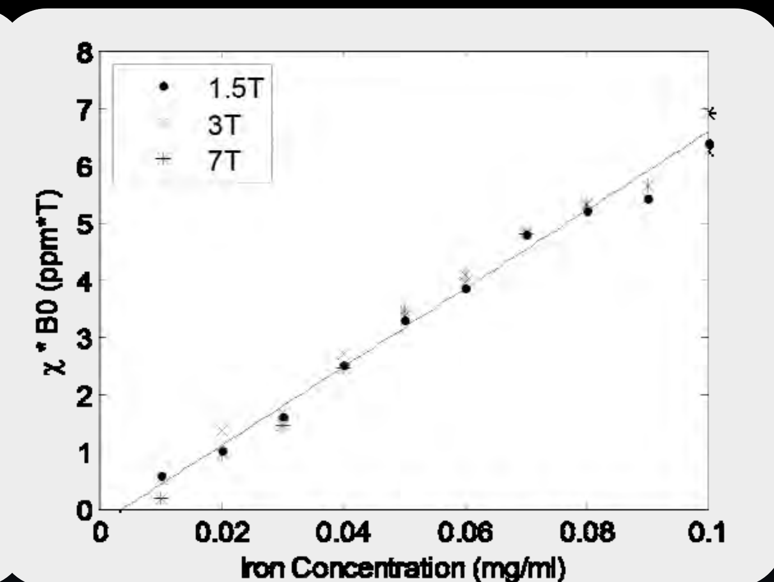
Phantom Studies





- $\chi_{1.5T} = 43.75 Iron - 0.09$ [1]
- $\chi_{3T} = 22.47 Iron - 0.02$ [2]
- $\chi_{7T} = 10.87 Iron - 0.09$ [3]

- $\chi B_0 = 68.45 Iron - 0.27$ [4]

Assuming blood volume 4700ml and weight 60kg, with 4mg/Kg Ferumoxytol at 7T (1.0mg/Kg, at 1.5T; 1.6mg/Kg, at 3T), the expected susceptibility of the arteries is ~450ppb.

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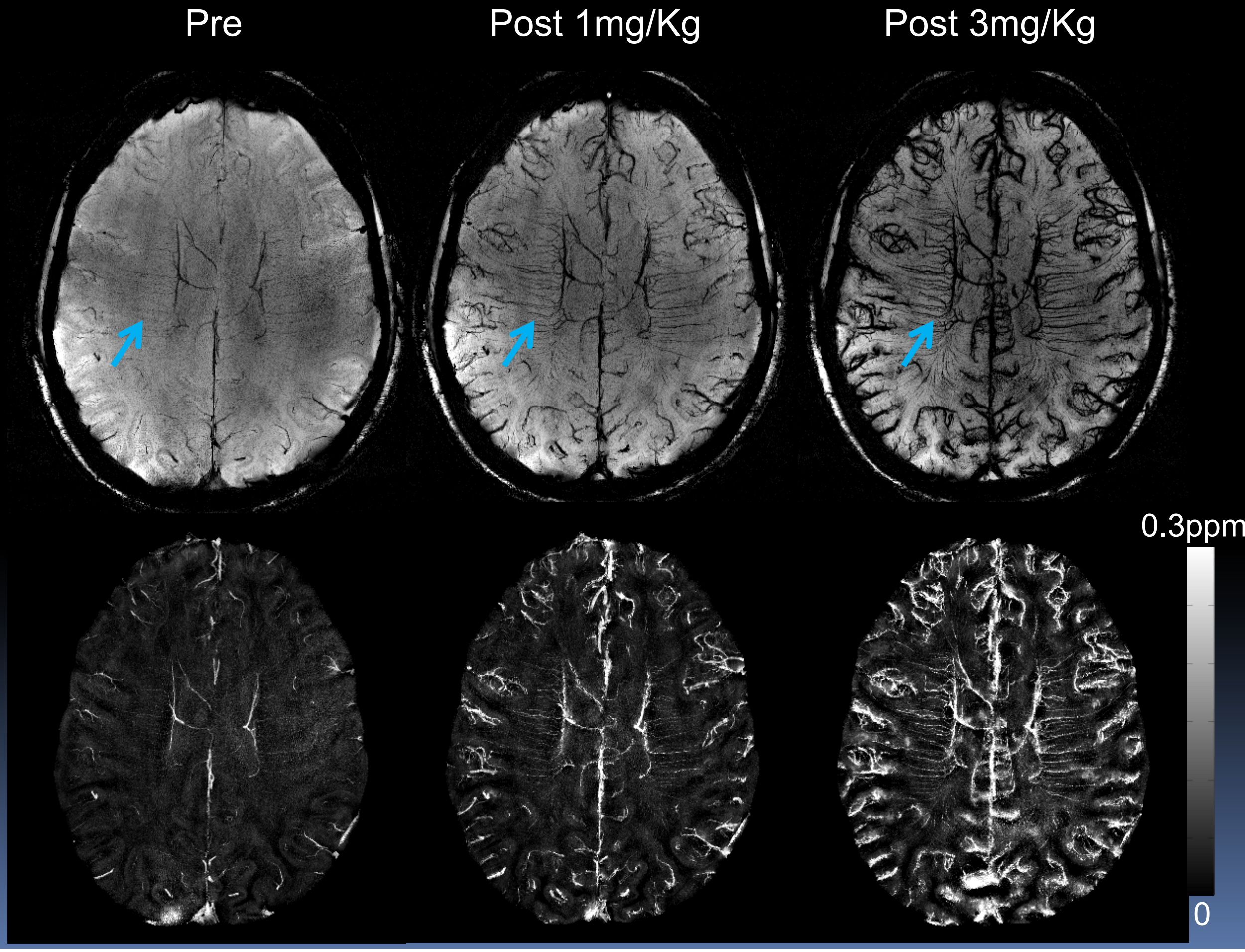
In vivo Data Acquisition and Processing

- Pre- and post- Ferumoxytol (1mg/Kg, 2mg/Kg, 3mg/Kg, 4mg/Kg) data were collected on 3 healthy volunteers at 7T, using a high resolution asymmetric gradient echo sequence. The highest in-plane resolution was 110um.
- Phase images were reconstructed with Echo Center Correction[1], and were unwrapped using Laplacian unwrapping[2].
- For generating SWI, 64x64 homodyne high-pass filter was used to remove the artifacts in phase images[3].
- Susceptibility maps were generated using iterative SWIM algorithm[4]. The background field was removed using SHARP[5].

1. Liu, S. et al. 2016, NMR Biomed. doi: 10.1002/nbm.3552. 2. Haacke et al. 2015, MRI 33:1–25
3. Haacke et al. 2004, MRM 52:612–618. 4. Tang et al. 2013, MRM, 69: 1396–1407
5. Schweser et al. 2011, NeuroImage 54:2789–2807

In vivo Data Results



mIP of SWI, Effective
Slice Thickness = 6.4mm

B_0=7T, TE=10ms, TR=24ms,
FA=10^o, BW/px = 244 Hz/px,
Voxel size = 0.13x0.13x0.8mm^3

MIP of QSM, Effective
Slice Thickness = 6.4mm

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Differentiate Arteries from Veins

- Strategies to differentiate arteries from veins in the post-contrast data:
  - Pre-contrast magnitude => arteries
  - Pre-contrast SWI and QSM => veins
  - Susceptibility difference between arteries and veins in the post-contrast QSM
  - Connectivity between the pixels

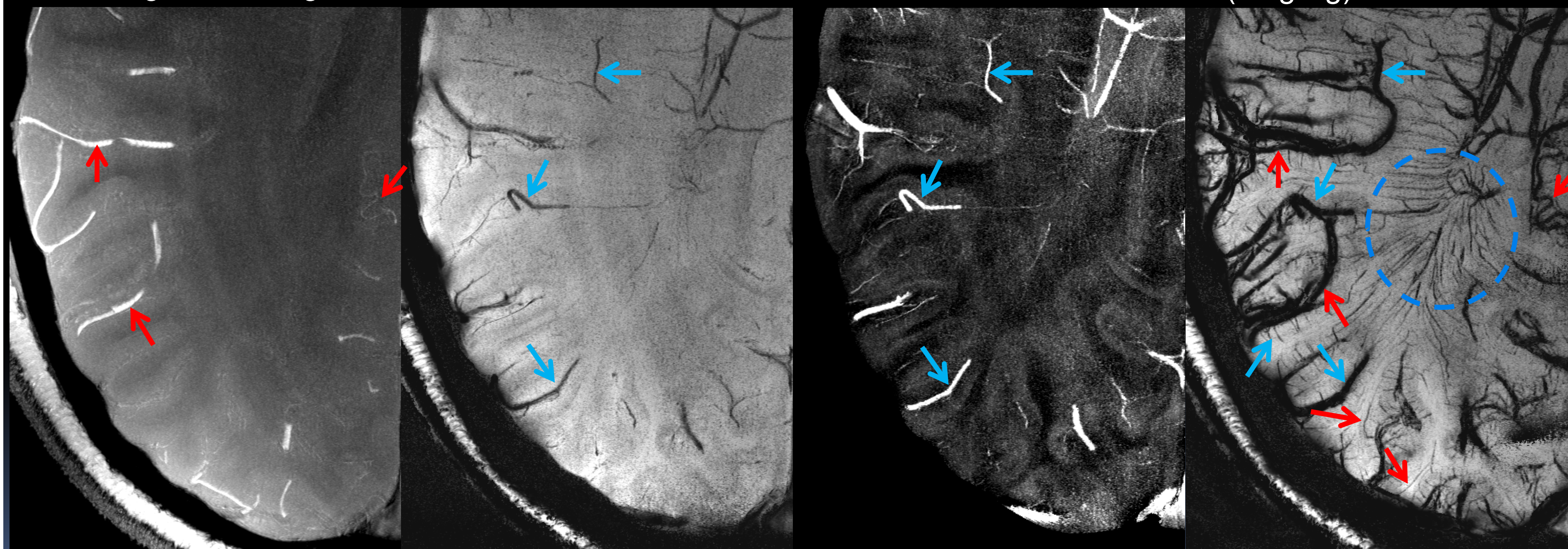
Differentiate Arteries from Veins

MIP of pre-contrast magnitude images

mIP of pre-contrast SWI data

MIP of pre-contrast QSM data

mIP of post-Ferumoxytol (3mg/Kg) SWI data



↑ : Artery

↑ : Vein

Effective Slice Thickness = 6.4mm

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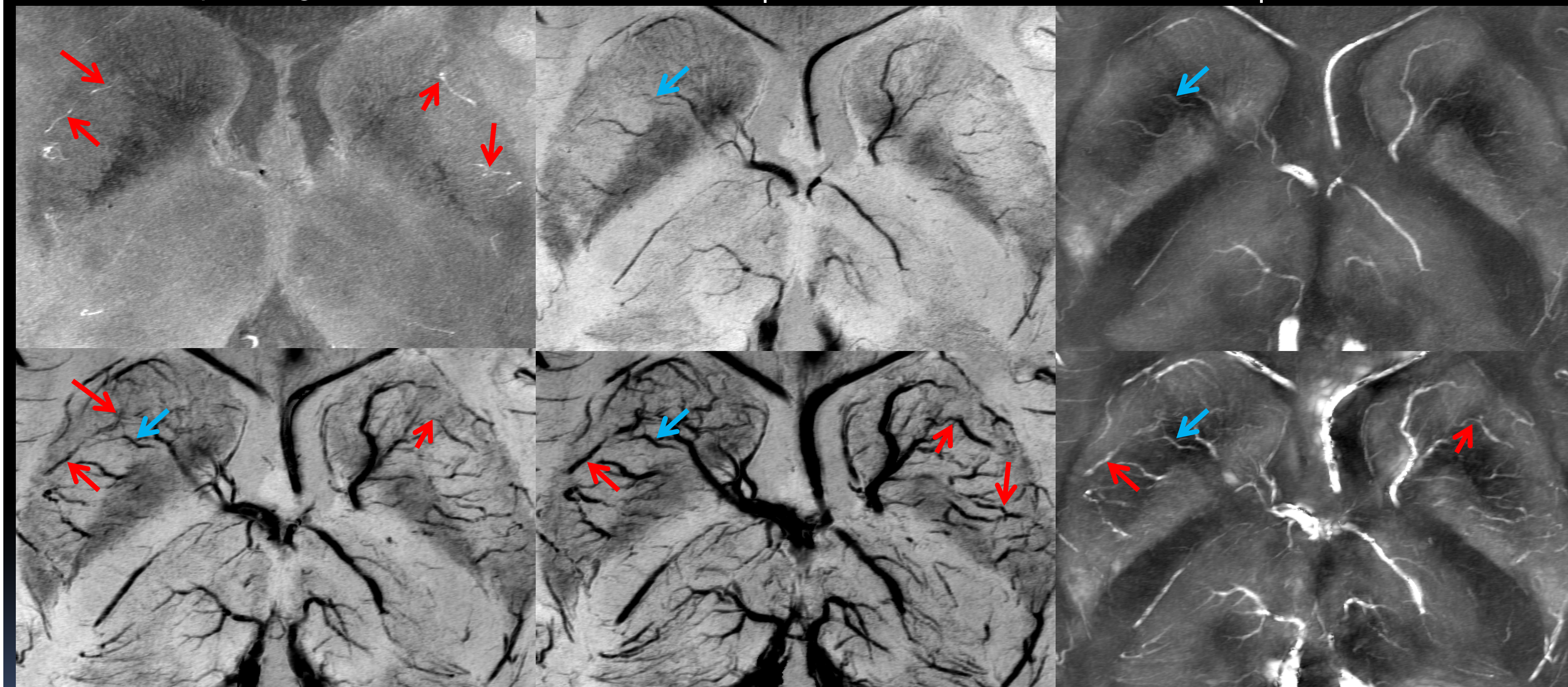
MIP of pre magnitude | mIP of pre SWI | MIP of pre SWIM



mIP of post-2mg/kg SWI | mIP of post-4mg/kg SWI | MIP of post-2mg/kg SWIM

↑: Artery ↑: Vein

B_0=7T, TE=8ms, Voxel size: 0.1094x 0.1094x1.25mm^3.
Effective slice thickness = 5mm.

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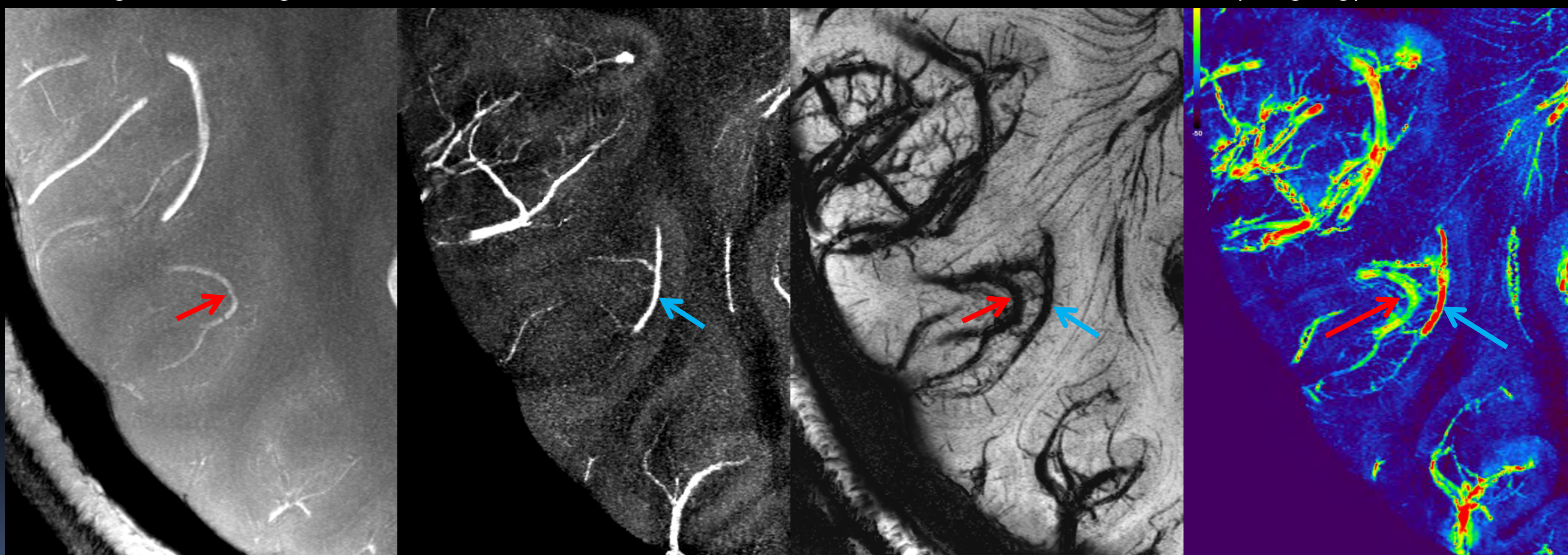
Differentiate Arteries from Veins

MIP of pre-contrast magnitude images | MIP of pre-contrast QSM data | mIP of pre-contrast SWI data | mIP of post-Ferumoxytol (3mg/Kg) SWI data



↑ : Artery   ↑ : Vein   Effective Slice Thickness = 6.4mm

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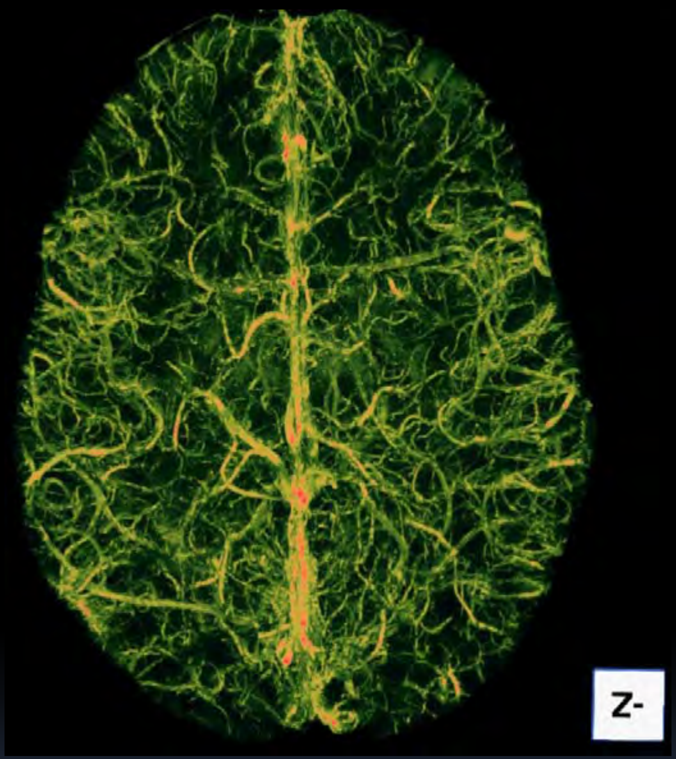
Conclusions

- We have demonstrated the feasibility to generate ultra-high-resolution MRAV using USPIO-enhanced SWI.
- Using a combination of pre-contrast magnitude, SWI, QSM and the difference between the susceptibilities of arteries and veins, we are able to separate arteries and veins.
- This could represent a powerful new tool in detecting microvascular abnormalities not visible on conventional MRA.



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