

'MultiPaw': High throughput MR imaging of ex-vivo AIA mouse joints with injected SPIONs on a clinical 3T system.

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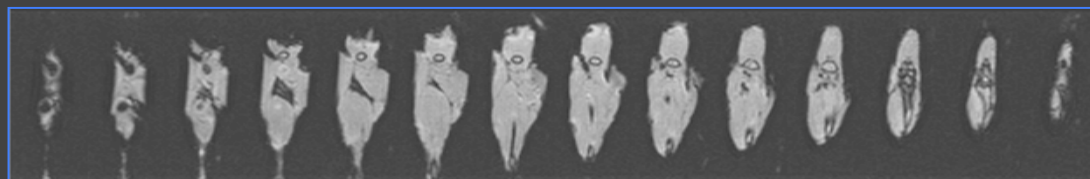
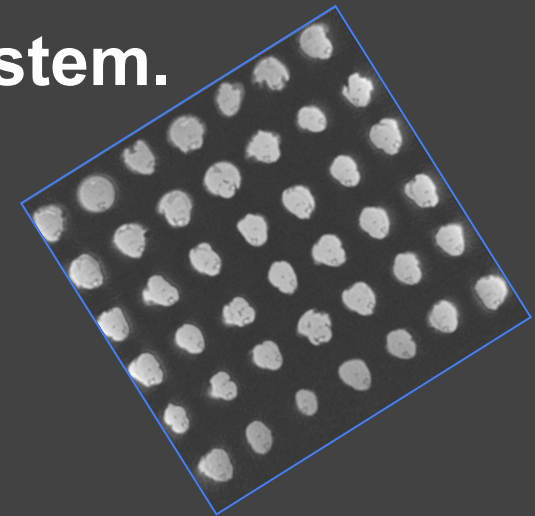
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Multipaw: high throughput ex-vivo at 3T

4348, monitor 38,

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Summary

- Introduction
- Methods
- Images
- Signal intensity
- Scores
- Conclusions – scan efficiency and diagnostic potential

Summary

Ex-vivo imaging of the A-PVA-SPION injected mouse knees (n=138) was carried out to investigate a 'MultiPaw' imaging protocol for optimizing small sample scanning at high -resolution in a clinical MRI system and to show the diagnostic potential using the difference Ultrashort Echo Time technique.

Particles

All particles described in this work are amino-PVA-SPIONs provided by EPFL/Uni Fribourg with or without coupled fluorophore dye

The superparamagnetic iron oxide nanoparticles were manufactured by an aqueous co-precipitation method.

(Chastellain M, Petri A, Hofmann H. J Colloid Interface Sci 2004;278(2):353-360).

The colloidal particles were further coated with a mixture of poly(vinyl alcohol) (PVA) and vinyl alcohol/vinyl amine copolymer. Surface derivatization of polymer-coated particles with a dye in a magnetic bed reactor.

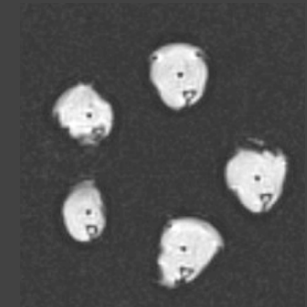
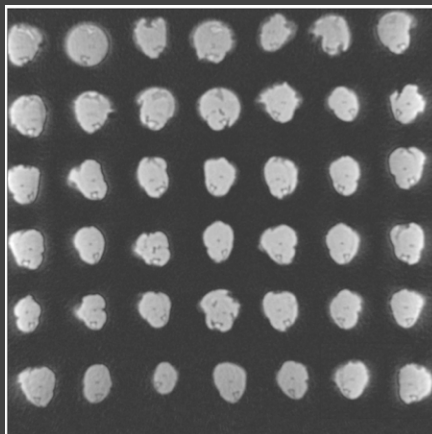
(Steitz B, Salaklang J, Finka A, O'Neil C, Hofmann H, Petri-Fink A. Bioconjug Chem 2007;18(5):1684-1690).

Methods

Signal intensity (SI) was measure and SNR - $SI/sd(\text{noise})$ calculated for 10 regions per coil group each 3 mm².

Compare the scan efficiency and image quantification potential in the two coil setups (Wrist and 4cm Loop).

Wrist coil + 7 signal averages (42 samples) increases scan efficiency, gives higher signal homogeneity, all samples in same tune-up and easier regular sample arrangement than Loop coil + 1 signal averages (5 samples) (8+ groups)



Methods

A 3D T1 gradient echo sequence, called 'VIBE' throughout, (for iron oxide signal loss imaging and joint structure):

3D isotropic resolution of $310\mu\text{m}$, TR/TE 14.3/5.9ms and flip angle 12°

The whole examination for a single group (of 5 or 42 depending on the coil used) took around 20 minutes.

Images were also scored for the presence or absence of iron signal using the VIBE image and dUTE difference image showing positive contrast from regions containing iron oxide particles after subtraction of a second echo.

Methods

UTE sequence parameters (for iron oxide particle quantification and joint/bone structure):

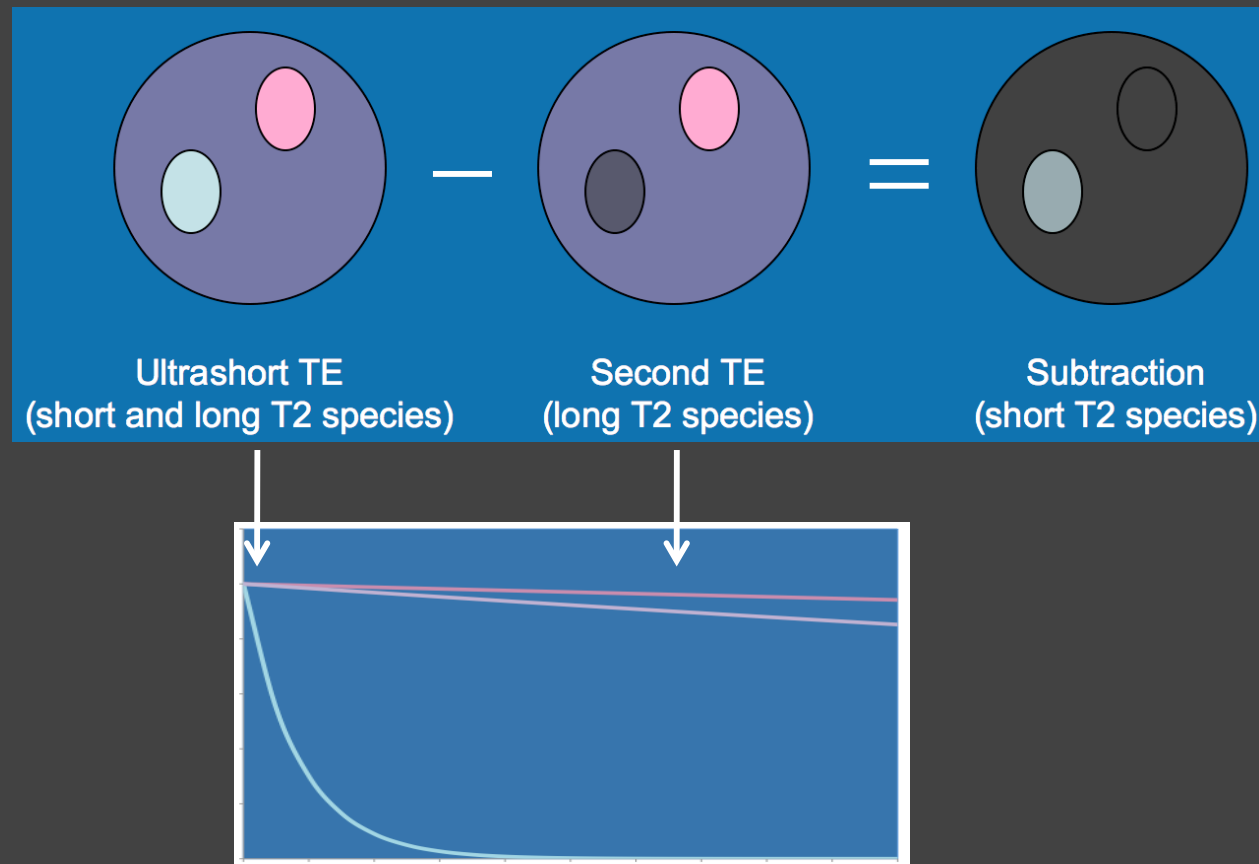
3D isotropic matrix of 512 and 90mm FOV (field of view) => 180 μ m resolution in all three directions

50000 radial projections

Ultrashort TE (echo time) of 0.07ms, TR (repetition time) 9.6ms and flip angle 10°

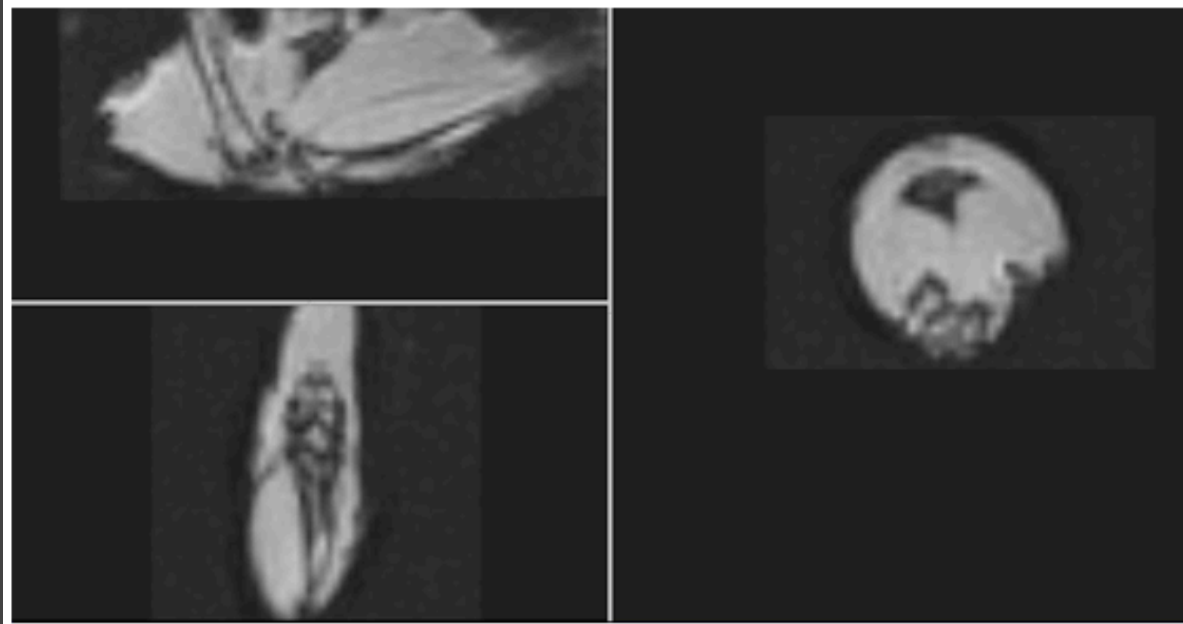
dUTE consisted of the acquisition and subtraction of two echo times (ultrashort UTE, and short TE2) leading to positive contrast from short T2 species and reduced signal elsewhere.

dUTE

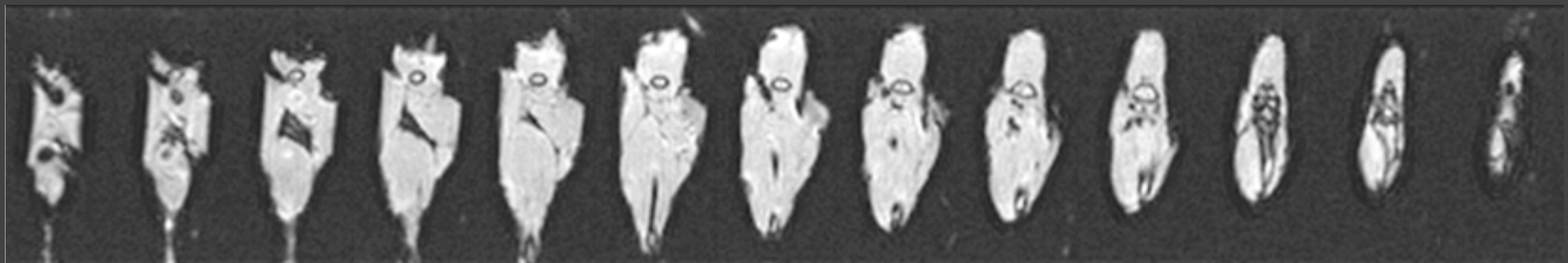


dUTE gives high-resolution 3D anatomical images with suppressed background, reduced artifacts and high iron contrast, and allows automatic quantification of iron oxide

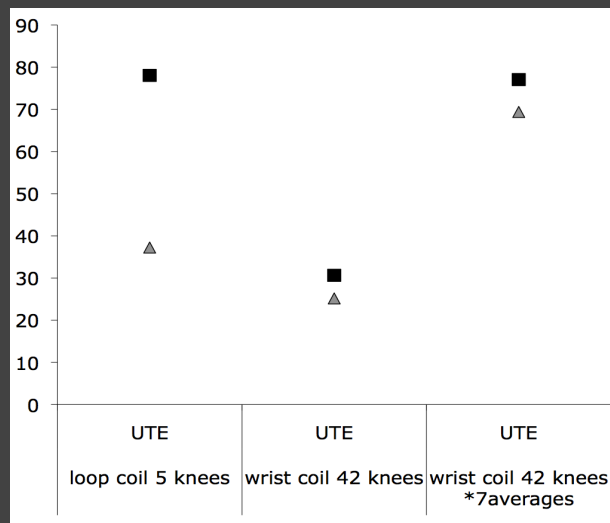
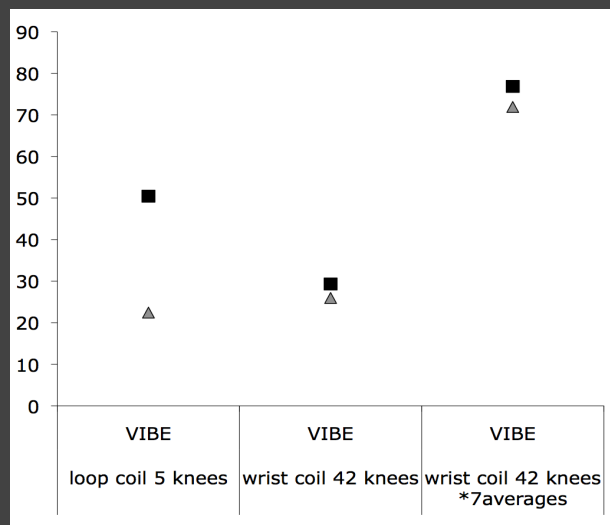
Images



VIBE images showing anatomy of the knee in 3 orthogonal planes and a series of coronal images.



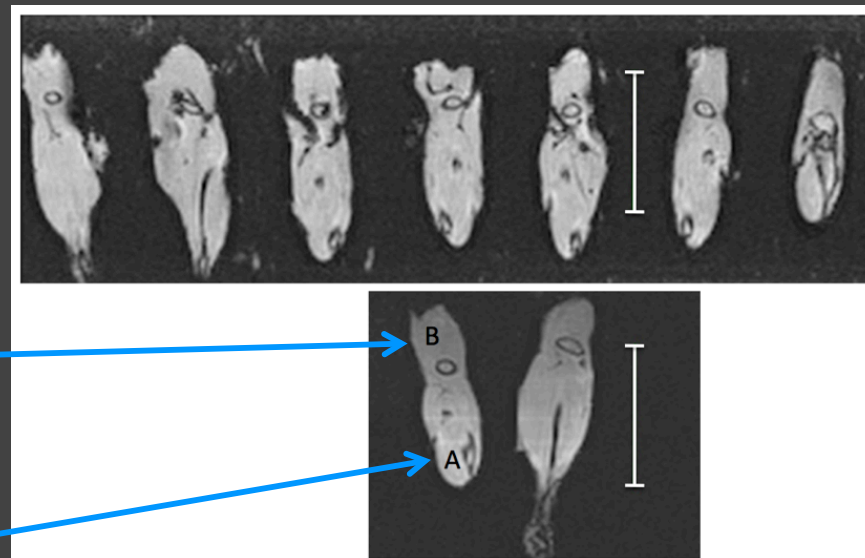
Signal Intensity and Homogeneity



△ mean snr 'remote' signal region

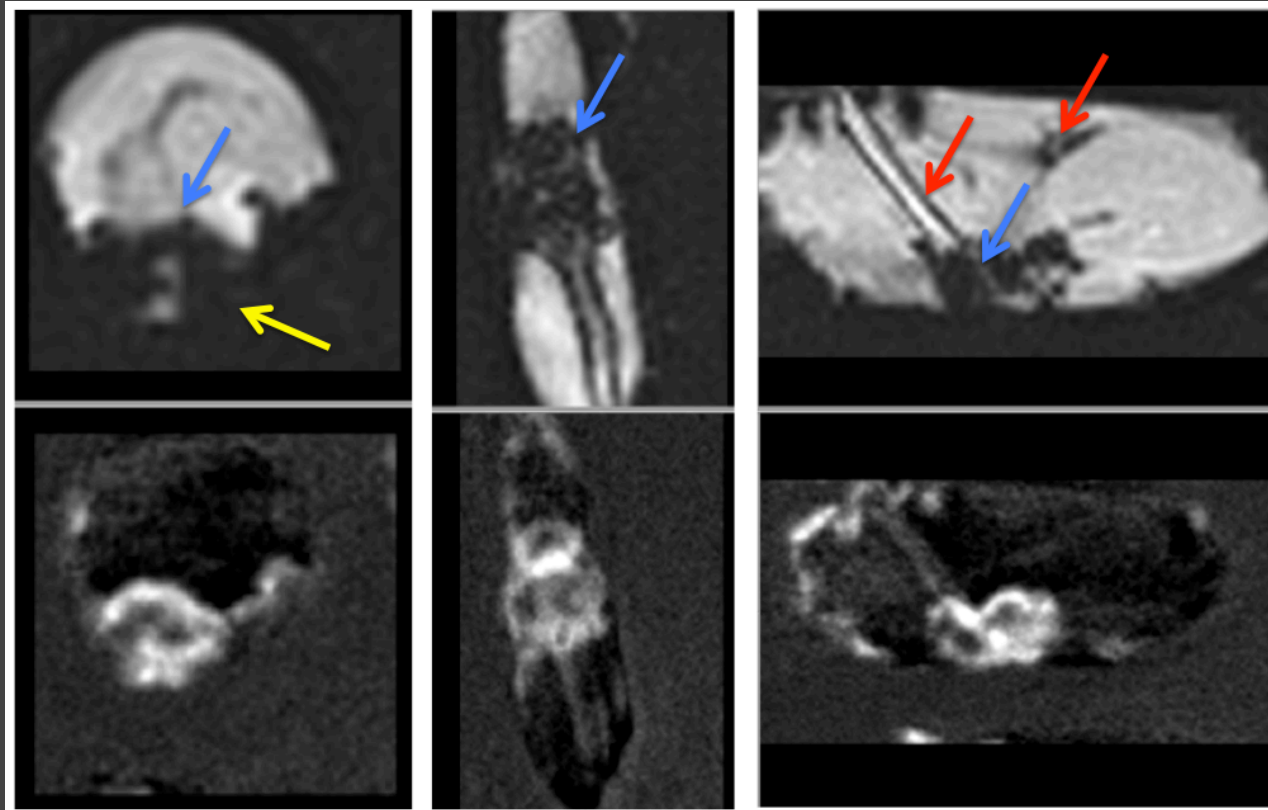
■ mean snr 'peak' signal region

SI theoretical max and actual max over whole sample



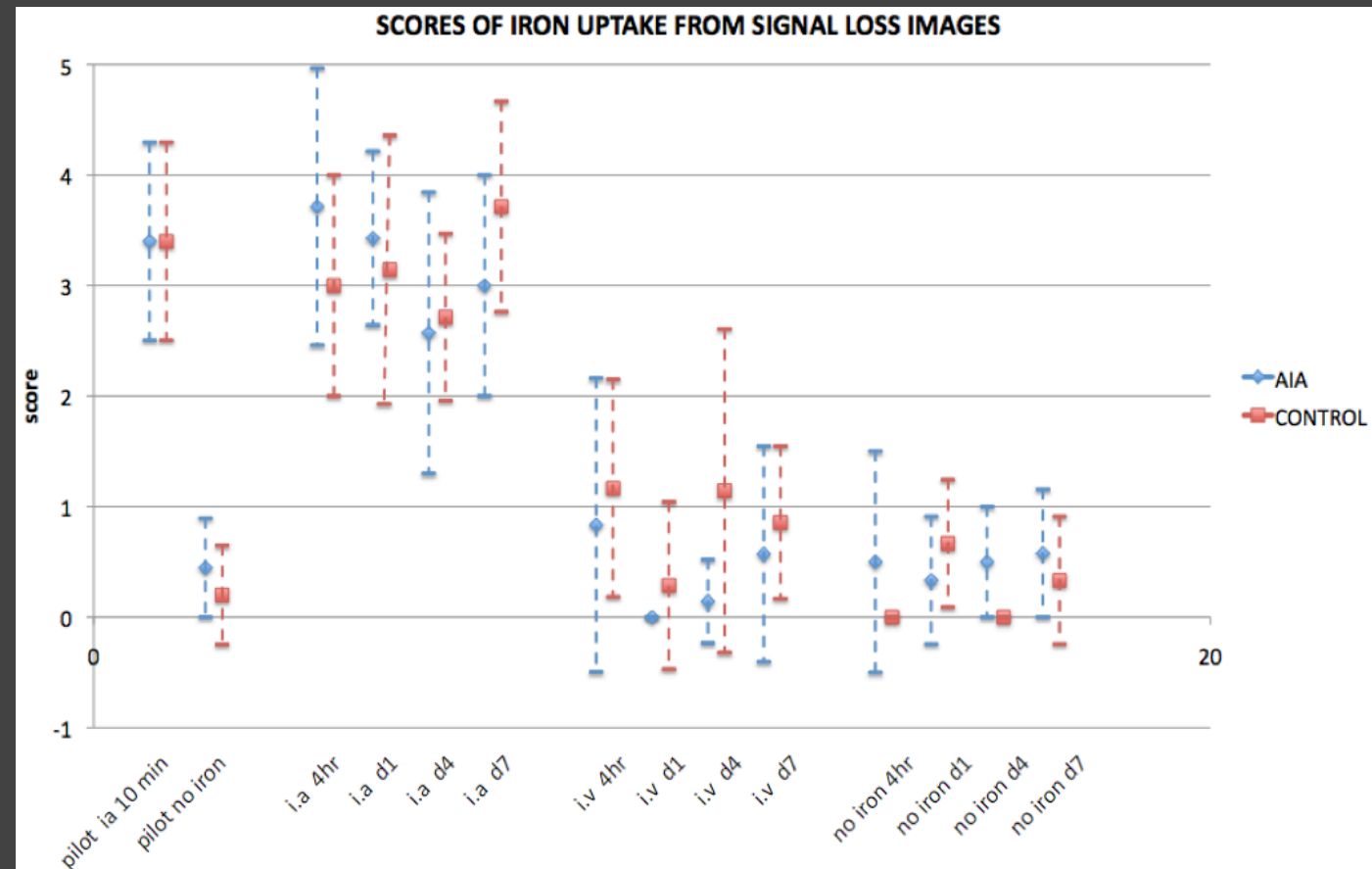
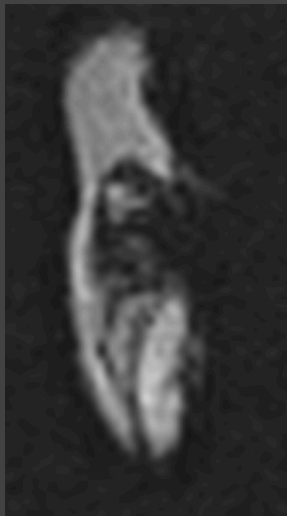
Images showing signal homogeneity in wrist coil (top) and loop coil (bottom). The bar represents 15 mm. A and B represent the 'peak' and 'remote' signal regions mentioned throughout.

Images – SPIONs VIBE cf dUTE



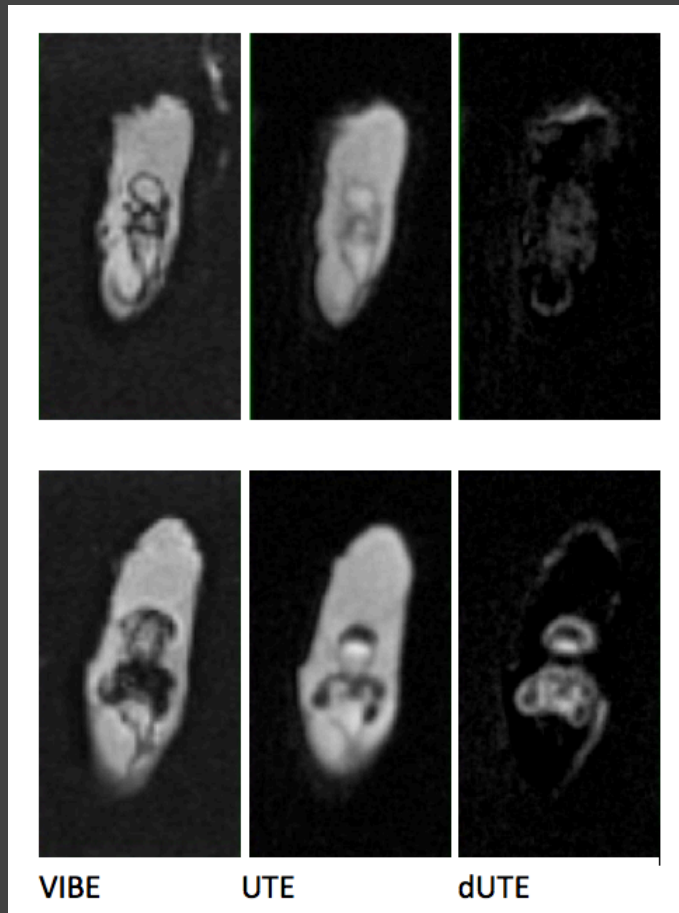
Seven days after intra-articular injection in an AIA mouse knee, showing 3 orthogonal reconstructions of signal loss (VIBE) and positive contrast dUTE. Difficulties in distinguishing **A-PVA-SPION signal (blue)** from other **hypointense regions (red)** and **sample edge (yellow)** on VIBE. Clear regions shown on suppressed background on dUTE.

Scores - VIBE



Comparison of scoring of magnitude of iron uptake from signal loss VIBE and positive contrast dUTE. Horizontal axes categories are route of injection of A-PVA-SPIONs (intra-articular or intra-venous) and time after injection of sacrifice. Blue are knees with AIA, red are control left knees. Error bars are 2 standard deviation.

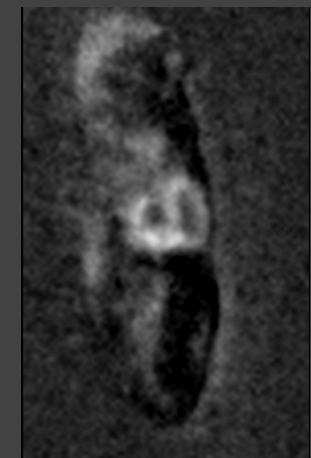
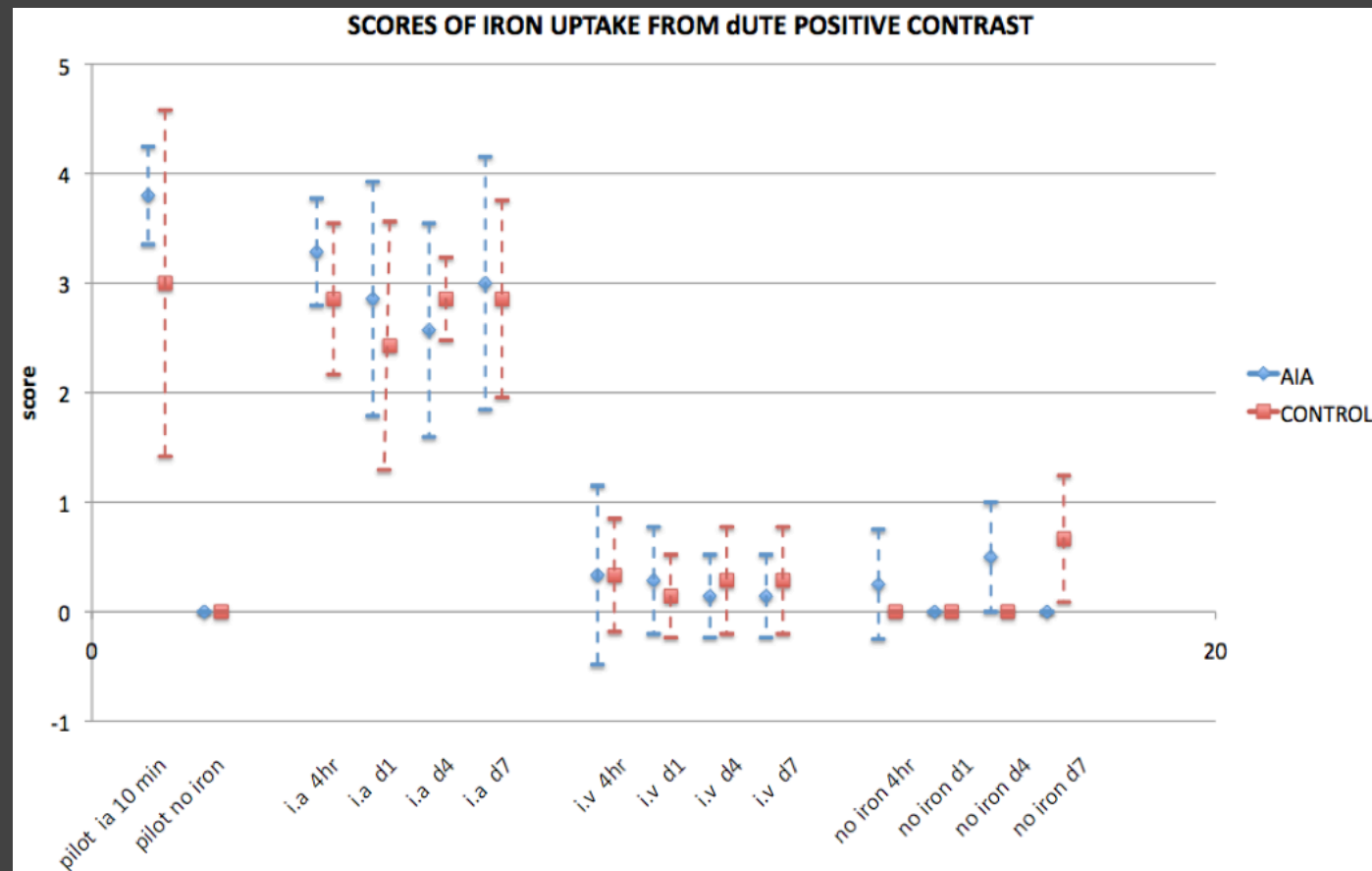
Images – dUTE SPIONs



The diagnostic potential of images showing control knees (no A-PVA-SPIONs, top) and knees dissected 4 hours after intra-articular injection of A-PVA-SPIONs (bottom).

VIBE image with A-PVA-SPIONs shows black signal from both iron and bone compared to the dUTE image which only has white signal in the region of iron uptake.

Scores - dUTE



Comparison of scoring of magnitude of iron uptake from signal loss VIBE and positive contrast dUTE. Horizontal axes categories are route of injection of A-PVA-SPIONs (intra-articular or intra-venous) and time after injection of sacrifice. Blue are knees with AIA, red are control left knees. Error bars are 2 standard deviation.

Scores

The standard deviation of the scores is lower in the dUTE images compared to the VIBE images (though not significant, n=6 per group, 12 groups)

AIA knee: 0.56 (dUTE), 0.80 (VIBE)

Control: 0.46 (dUTE), 0.75 (VIBE)

The mean score for the 'non SPION' cases (ideal score zero) is also lower with the dUTE 0.31 for VIBE and 0.11 for dUTE (p=0.1)

Conclusions

Multipaw increases scan efficiency and signal homogeneity

IV dose is too low to observe/quantify – further studies are needed for diagnostics, but quantification principle and potential are demonstrated

Artifactual signal loss on VIBE images, particularly behind the knee, gives overestimate of iron score

Only intra-articular iron is bright on dUTE, with all other tissue signals suppressed

Iron remains in place over the timescale (7 days)

Acknowledgements



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- Thank you
- Questions?



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