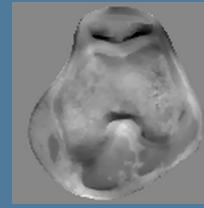
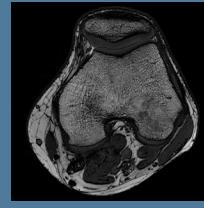
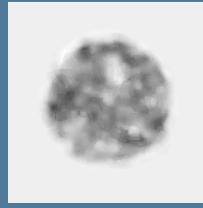
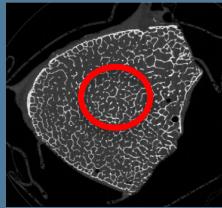


677 On the Feasibility of Quantitative Susceptibility Mapping for Trabecular Bone Volume Density Mapping at 3 T



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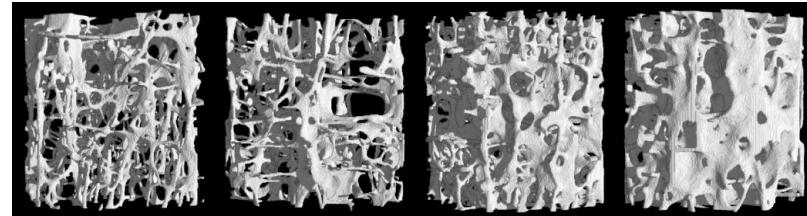
Declaration of Financial Interests or Relationships

Speaker Name: **Maximilian N. Diefenbach**

I have the following financial interest or relationship to disclose with regard to the subject matter of this presentation:

Company Name: **Philips Healthcare**

Type of Relationship: **Grant Support**



Trabecular bone imaging

- Trabecular bone imaging has a high clinical significance for predicting fracture risk in patients with osteoporosis [1]
- High-resolution trabecular bone imaging previously applied in many distal sites and in the proximal femur with very good correlation with failure load [2,3], but not possible in many skeletal sites (e.g. spine)
- R_2^* mapping has been previously proposed as an alternative for indirectly measuring trabecular bone density [4]

QSM for bone

- Quantitative susceptibility mapping (QSM) has been recently emerging for mapping diamagnetic and paramagnetic substances, primarily in the brain [6]
- Bone is diamagnetic and the magnetic susceptibility difference between cortical bone and water/fat can be captured using magnetic susceptibility measurements [4]
- Recent reports attempted to use QSM combined with ultra-short echo time (UTE) imaging for mapping the susceptibility of cortical bone [7, 8]

Research Question:

Can changes in the **trabecular bone** density be detected
by **Quantitative Susceptibility Mapping** at 3T?

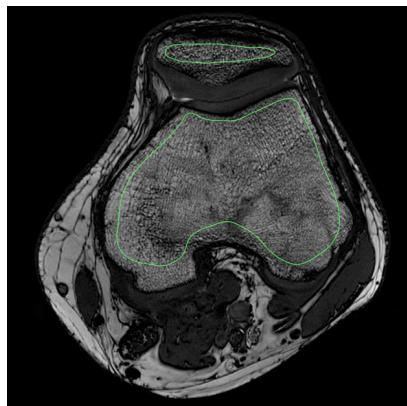
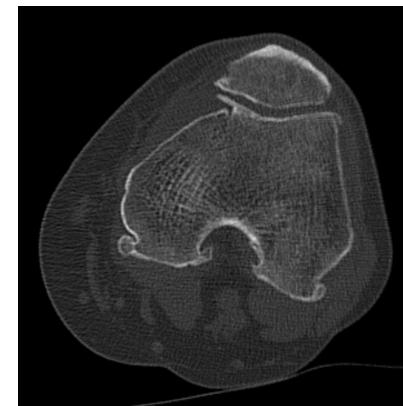
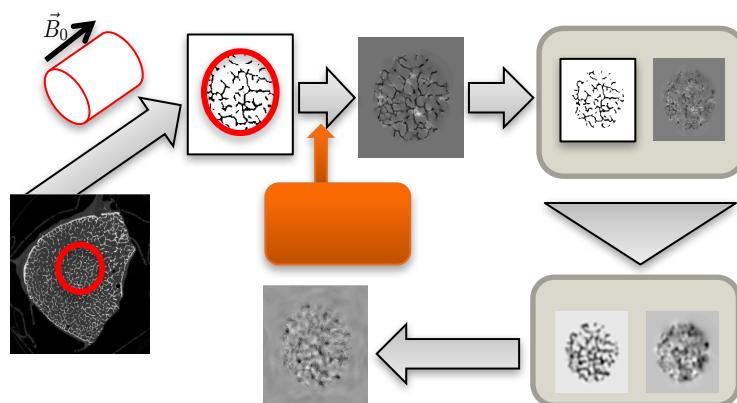
The research question was addressed by 2 methods.

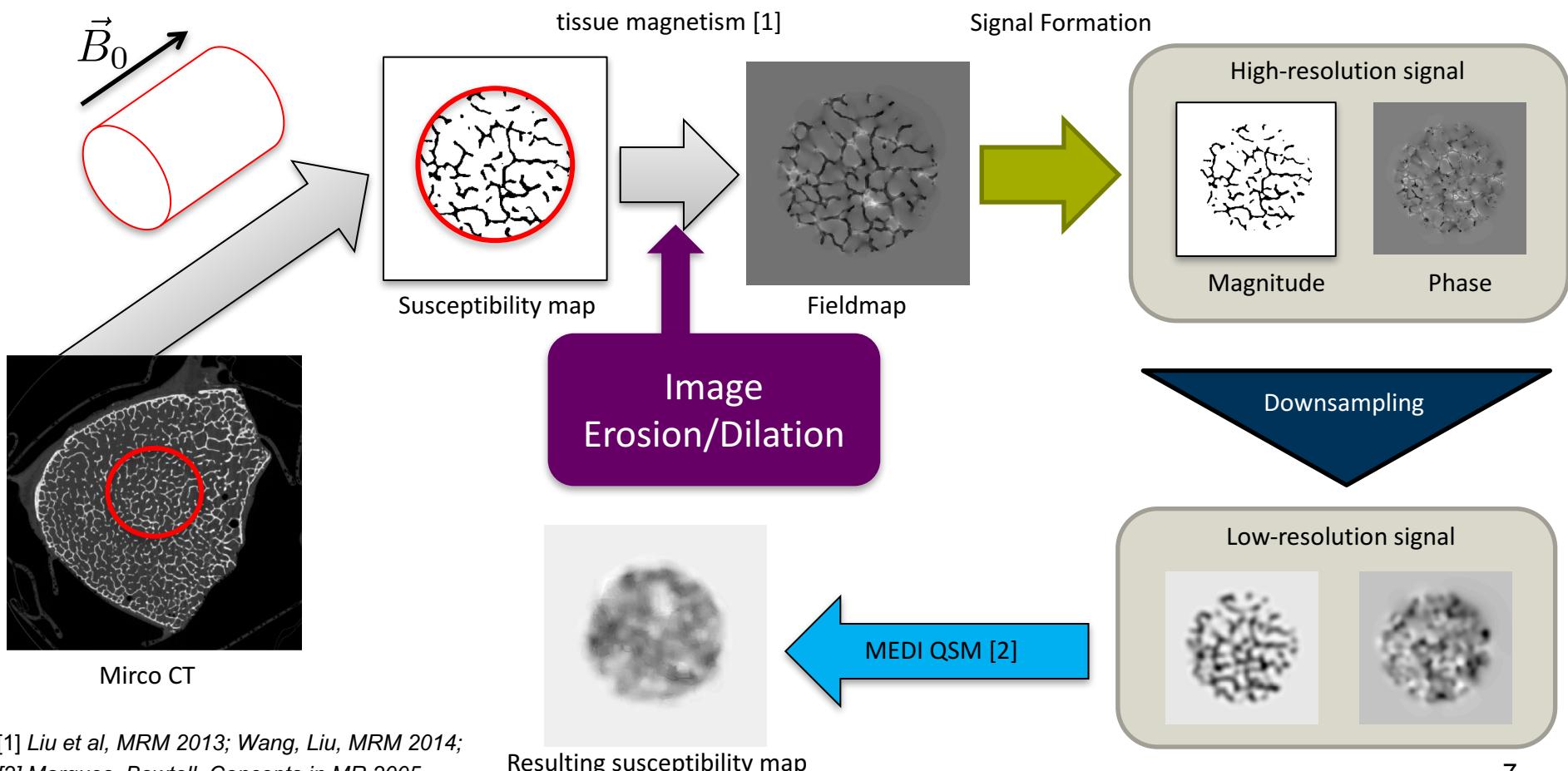
1.

Numerical
Simulations

2.

In Vivo
Measurements



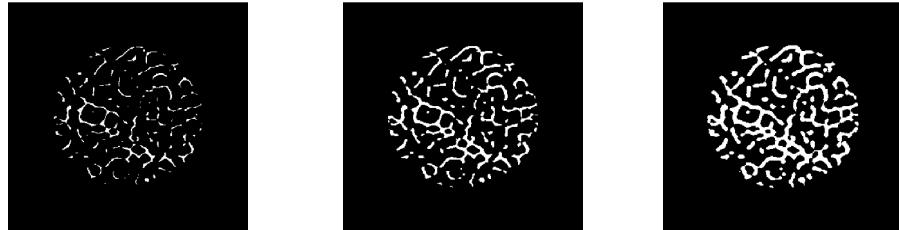


[1] Liu et al, MRM 2013; Wang, Liu, MRM 2014;

[2] Marques, Bowtell, Concepts in MR 2005

Erosion/Dilation Parameters

Neighborhood	3D 6-connected pixels
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Signal Formation Parameters

Number of echoes	6
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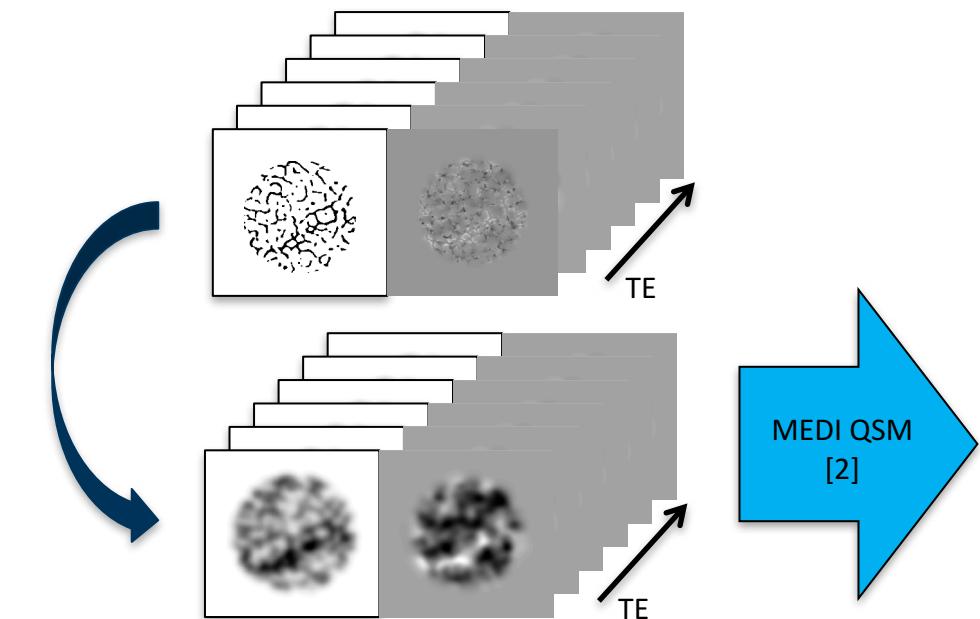
TE1/delta TE	1/3 ms
--------------	--------

Susceptibility difference inside/outside of cylinder	-3 ppm (chi bone -12ppm, chi water -9ppm)
---	--

Downsampling Parameters

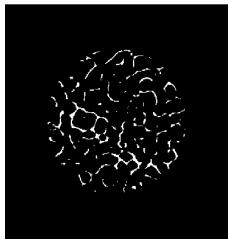
Resolution before downsampling	0.055 mm isotropic
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Resolution after downsampling	2 mm isotropic
----------------------------------	----------------

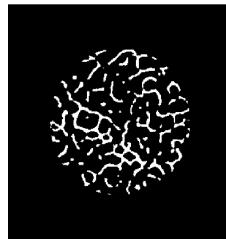


Bone volume : total volume (BV/TV)

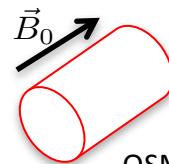
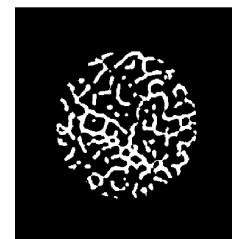
~ 0.08



~ 0.19

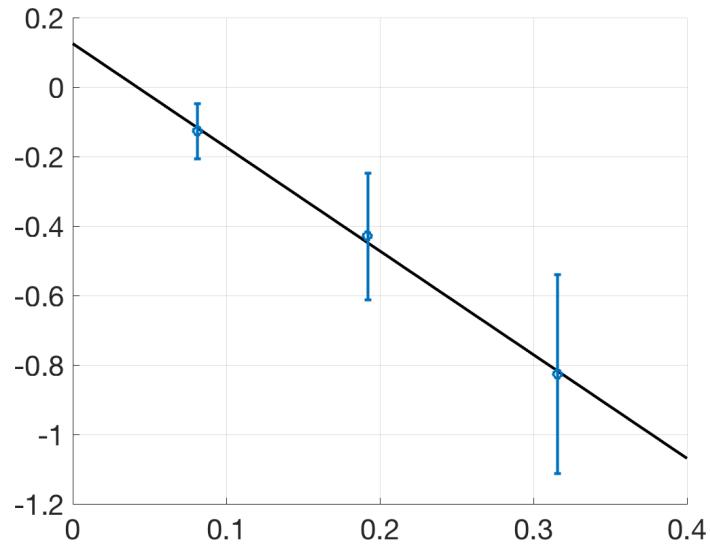
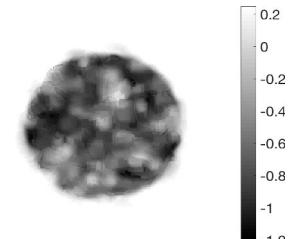
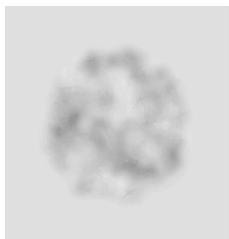


~ 0.32

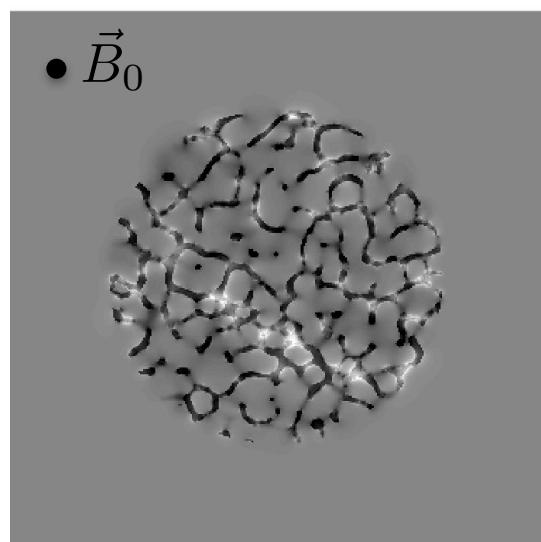
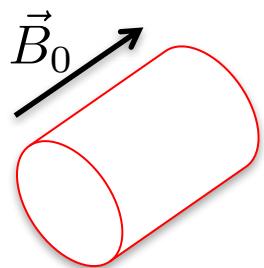
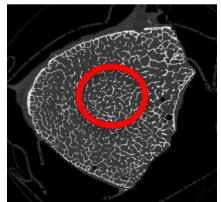


QSM mean susceptibility values inside the cylinder in [ppm]
(referenced to values outside the cylinder)

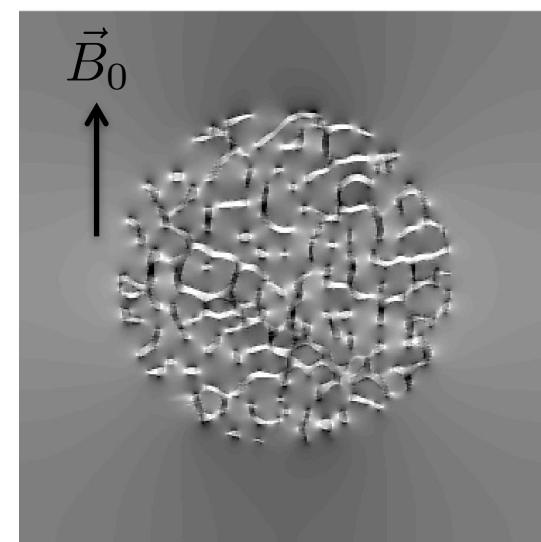
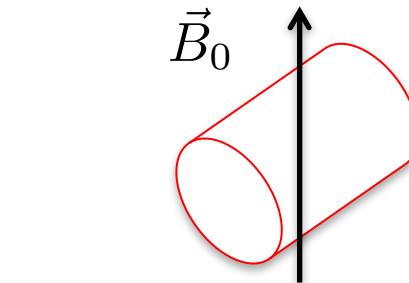
QSM susceptibility maps in [ppm]



Bone volume : total volume (BV/TV)



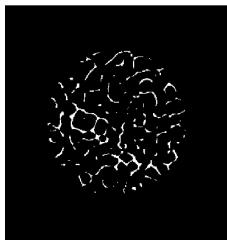
Fieldmap / [Hz]



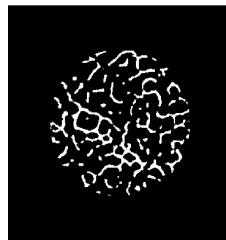
Fieldmap / [Hz]

Bone volume : total volume (BV/TV)

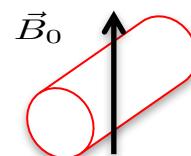
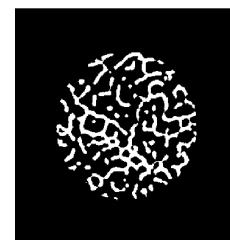
~0.08



~0.19

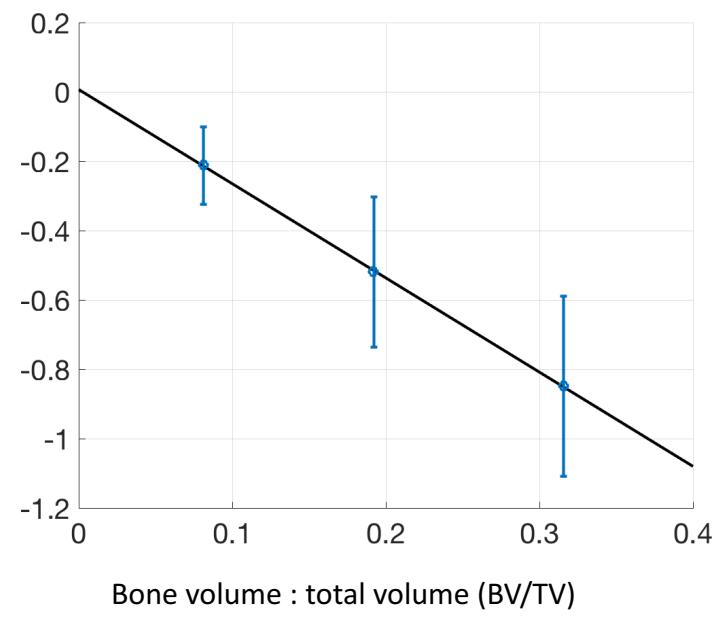
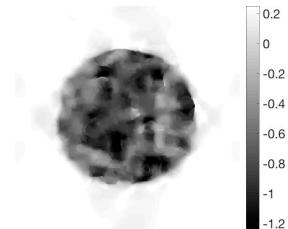
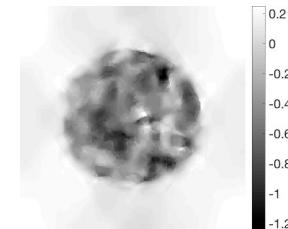
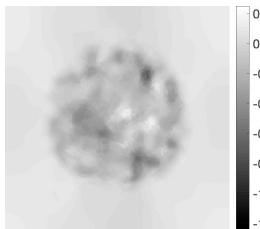


~0.32

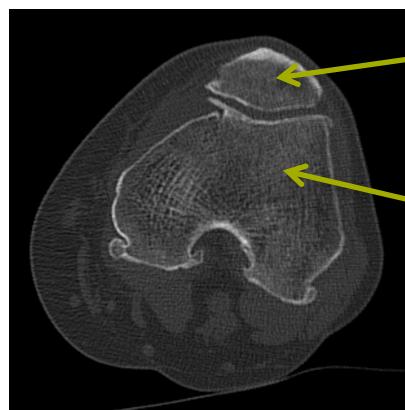


QSM mean susceptibility values inside the cylinder in [ppm]
(referenced to values outside the cylinder)

QSM susceptibility maps in [ppm]



2. In Vivo Measurements in the Knee

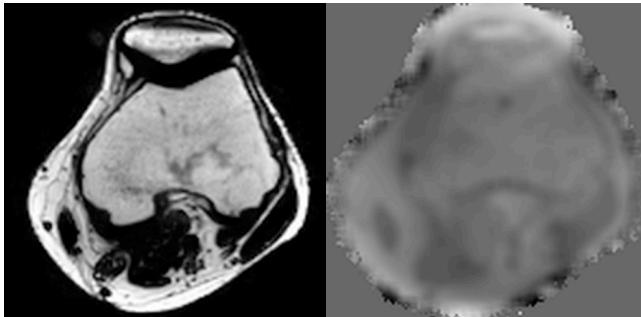


CT image

Patella

Femur

Low resolution scan



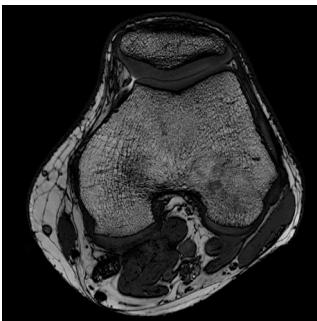
Low resolution scan parameters

Type	Gradient echo
Readout	Monopolar
Number of echos	12 (3 interleaves a 4 echos *)
TE1/delta TE	1.7/0.9 ms
Voxel size	1 mm isotropic



QSM

High resolution scan



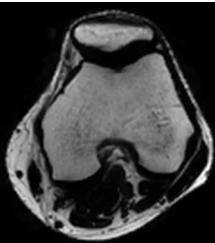
High resolution scan parameters

Type	Balanced SSFP with 2 phase cycles
TE	3.4 ms
Voxel size	[0.3, 0.3, 0.9] mm

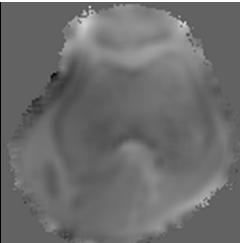


Bone volume :
total volume
(BV/TV)

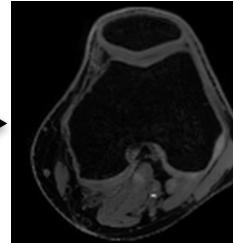
Magnitude



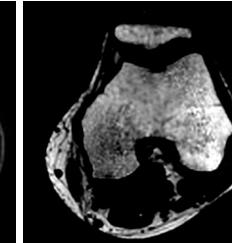
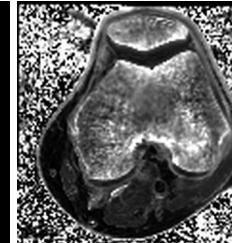
Phase



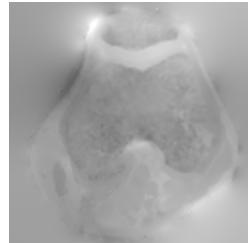
Water



Fat

 R_2^* 

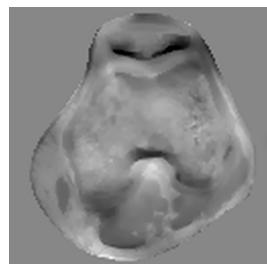
Fieldmap



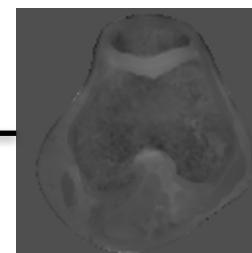
Graphcut-based
water fat
separation[1]

ISMRM water-fat
toolbox[2]

Susceptibility Map



Relative Difference Field



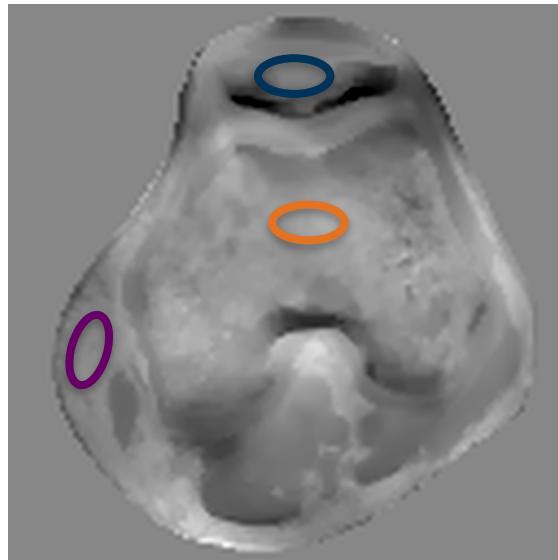
Field-to-
Susceptibility
Inversion[4]

Background Field
Removal[3]

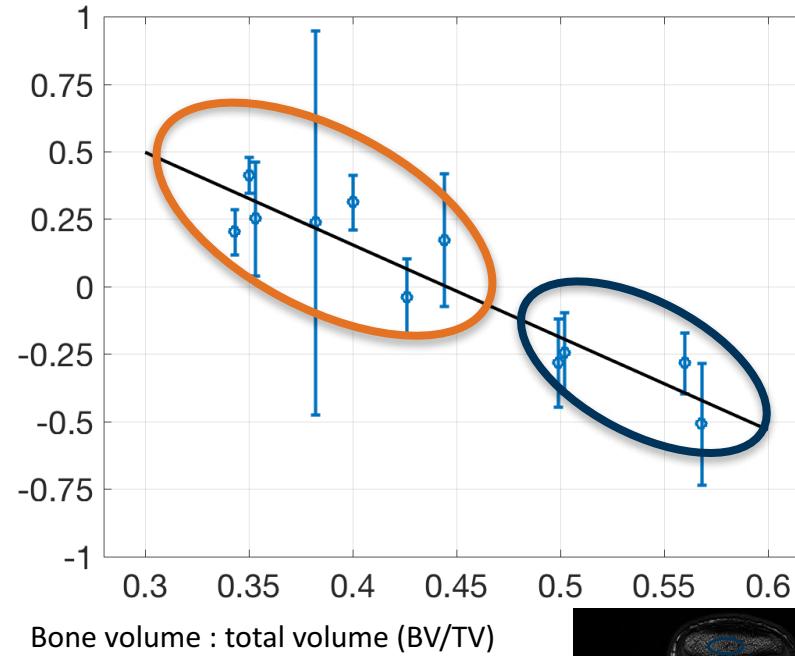
Morphology-Enabled
Dipole Inversion

Projection onto Dipole
Fields

MEDI toolbox[5]

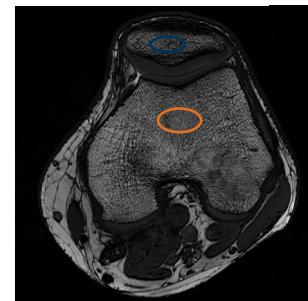


QSM susceptibility values in [ppm]
(referenced to fat ROI values)



ROI analysis:

- ROIs are selected in regions without red bone marrow
- ROI values are referenced to fat ROI values



Limitations:

- Effect of regions with zero MR signal (cortical bone) on QSM.
- Susceptibility of bone was previously reported between -12 to -8 ppm [3].
- Only an empirical threshold was used to obtain the BV/TV inside the knee [4].
- Need for robust susceptibility referencing.

Summary:

Can changes in the **trabecular bone** density be detected by **Quantitative Susceptibility Mapping** at 3T?



Preliminary results hint at **linear relation** between **BV/TV** and **mean susceptibility** in **trabecular bone**:

- A 10% difference in BV/TV resulted in a ~0.3 ppm susceptibility increase.
- Observed range of values are of the order what is currently measured in brain QSM. [1]

Acknowledgements



Thank you!

Funding:
Philips Healthcare