

# Buy One, Get Two for Free: Simultaneous Knee T2 Mapping and Morphological Analysis On Synthetic Images Using GRAPPATINI

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# Background

- Most commonly used contrasts to assess morphological joint abnormalities are [1]:
  - Intermediate-weighted TSE (IW)
  - T2-weighted TSE (T2w)
- Quantitative **T2 mapping** gained interest recently
  - Clinical Relevance: quantitative T2 is a good biomarker of early degenerative disease of cartilage and meniscus [2-4]
- The acquisition of both morphological and quantitative sequences is however **time consuming**, hindering their spread in clinical use.

[1] Huang M et al. Radiology 2014;273:S1-22.

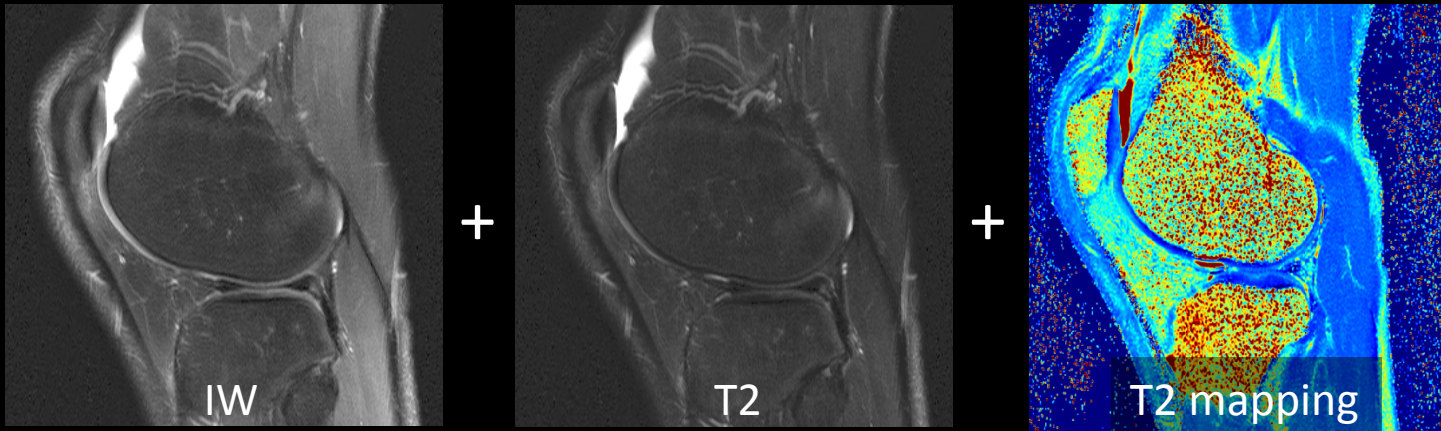
[3] Zarins ZA et al. Osteoarthritis Cartilage 2010;18:1408-16.

[2] Kijowski R, et al. Radiology 2013;267:503-13.

[4] Rauscher I et al. Radiology 2008;249:591-600.

# The GRAPPATINI sequence

Standard sequences



GRAPPATINI sequence

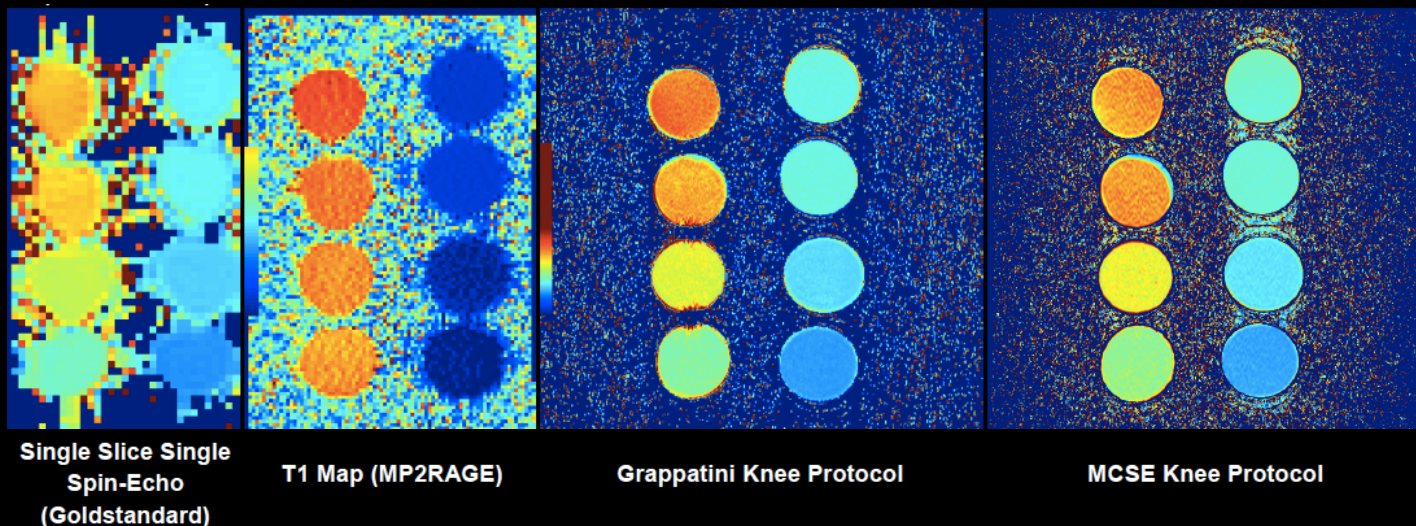


# Objective

- Validation of :
  - (1) **T2 values**
    - phantom experiment
  - (2) **image quality**
    - quantitative and qualitative assessment
    - 5 healthy volunteers
    - in comparison to the consecutive acquisition of morphological and quantitative sequences

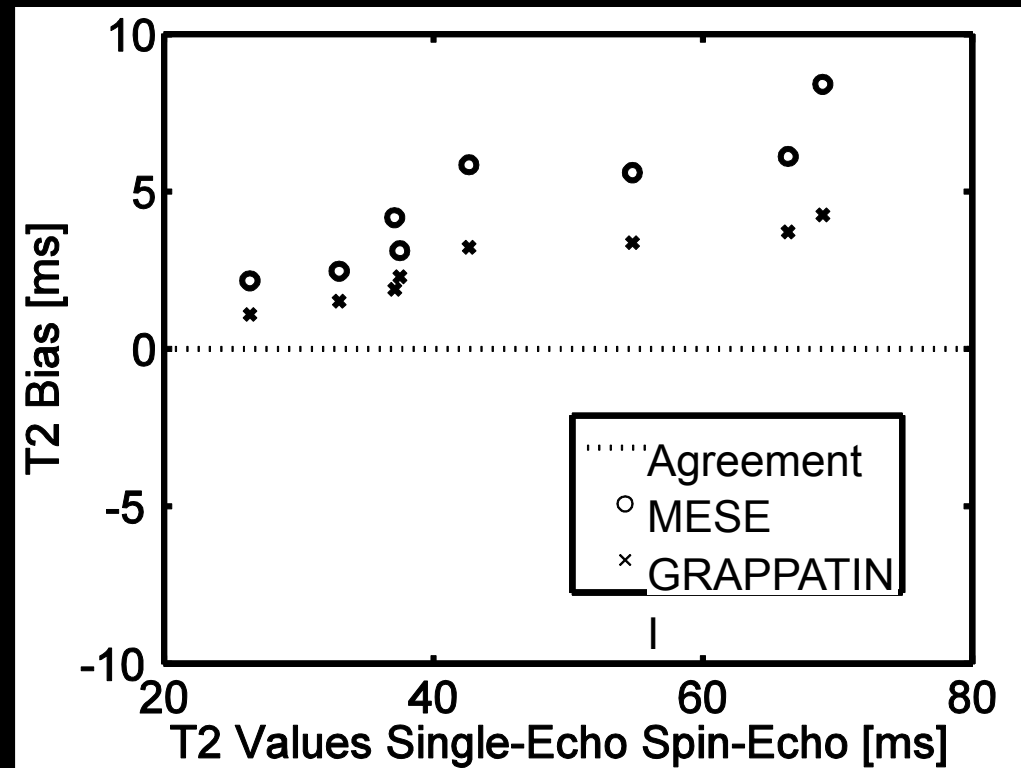
# 1) Phantom experiments – Methods

- Validation of the T2 estimation with GRAPPATINI
  - Phantom: Tubes filled with different concentrations of agar and gadolinium
  - Experiment: Same hardware and protocols (MESE and GRAPPATINI) used as in in-vivo experiments
  - Reference: Low resolution single slice, single spin-echo sequence



# 1) Phantom Experiments – Results

- MESE > GRAPPATINI > SSSE  
(stimulated echoes)



## 2) In vivo experiments – Methods

- Single-center prospective study, performed from September 2015 to January 2016
- **5 healthy volunteers** (3 males, age  $30.2 \pm 3.3$  years)
- 3T (MAGNETOM Skyra, Siemens Healthcare, Germany), 15-channel knee coil
- Acquisition of the **GRAPPATINI sequence**
  - Generation of additional synthetic contrasts with TE=34ms and TE=80ms
- Acquisition of **standard morphological TSE images**
  - IW (TE=34ms) and T2w (TE=80ms)

## 2) In vivo – Methods – MRI protocol

- 3T (MAGNETOM Skyra, Siemens Healthcare, Germany)
- 15-channel knee coil
- All sequences were acquired in the sagittal plane.

Sequence	Resolution	Number of Slices	TR	TE	Fat Suppression	TA
GRAPPATINI	0.4x0.4x3mm <sup>3</sup>	36	4880 ms	34 / 80 ms	On	6:22 min
<b>Total Acq. Time:</b>						<b>6:22 min</b>
IW - TSE	0.4x0.4x3mm <sup>3</sup>	36	3790 ms	34 ms	On	2:52 min
T2w - TSE	0.4x0.4x3mm <sup>3</sup>	36	3790 ms	80 ms	On	2:52 min
MESE	0.5x0.5x3mm <sup>3</sup>	36	1630 ms	$\Delta$ TE 13 ms	Off	7:09 min
<b>Total Acq. Time:</b>						<b>12:13 min</b>



## 2) In vivo – Methods – Analysis

- Comparison of synthetic morphological images versus conventional TSE images
    - **Quantitative analysis** : SNR, CNR
    - **Qualitative analysis** (2 radiologists blinded to employed sequence, Five-grade scale):
      - Global image quality
      - Image quality of each of the following anatomical structures: cartilage, menisci, cruciate ligaments, bone marrow, muscle, joint fluid, quadricipital and patellar tendons
      - Visual image contrast
      - Visual noise
      - Artifacts
- 2: first image significantly worse than second,  
-1: moderately worse,  
0: no difference,  
+1: moderately better,  
+2: significantly better

?



Synthetic Image (TE=34 ms)

?



Standard IW TSE (TE=34 ms)

## 2) In Vivo Experiments – Results

- **Quantitative Analysis**
  - No significant difference in SNR and CNR
  - **SNR** :
    - average SNR = 9.9 for both synthetic and conventional sequences,  $p=0.99$
  - **CNR** :
    - cartilage/fluid: 6.2 vs. 6.6,  $p=0.62$
    - meniscus/fluid: 11.3 vs. 11.6,  $p=0.81$

## 2) In Vivo Experiments – Results

- **Qualitative Analysis**

- No difference in **global image quality** or of any of the **anatomical structures** that were evaluated
  - average score of 0, 95%CI=[0; 0.4]
- **Artefact** scores were slightly higher for the synthetic sequences
  - average of -0.1, 95%CI=[-0.002; -0.6]
- **Visual noise** and **contrast** were slightly better for the synthetic sequences
  - average score of 0.1 for both, 95%CI=[0.002; 0.6]

# Limitations

- Number of included patients (volunteers)
- Implication in diagnosis imaging

# Conclusion

- T2 map, IW and T2w images can be acquired with one GRAPPATINI sequence in 6.22 min instead of 12.13 min (sum of the acquisition times obtained with the standard techniques)
- GRAPPATINI provides...
  - Accurate T2 values
  - Synthetic IW and T2w images quantitatively and qualitatively similar to conventional TSE images

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# Thank You



# The GRAPPATINI sequence

- **T2 Map Acquisition:**
  - 10-fold undersampled multi-echo spin-echo sequence (MESE)
- **T2 Map Reconstruction:**
  - GRAPPATINI [7]: Subsequent application of parallel imaging (GRAPPA) [5] and model-based reconstruction (MARTINI) [6]
- **Synthetic T2 weighted Images:**
  - Applying the forward signal Model to simulate TSE contrast with arbitrary echo-time TE

[5] Griswold, Mark A., et al. MRM 47.6 (2002): 1202-1210.

[6] Sumpf, Tilman J., et al. JMRI 34.2 (2011): 420-428.

[7] Hilbert, Tom, et al. ISMRM 22.4077 (2014).