

Monitoring High Intensity Focused Ultrasound (HIFU) ablations in real time using interventional MRE

E. Breton¹, K. Kim¹, A. Gangi^{1,2}, J. Vappou¹

¹ICube Engineering Laboratory, CNRS-University of Strasbourg, FRANCE.

² Dpt. of Interventional Radiology, Hôpitaux Universitaires de Strasbourg,
FRANCE

1st Int. MRE Workshop, 28-29 Sept 2017, Berlin, Germany

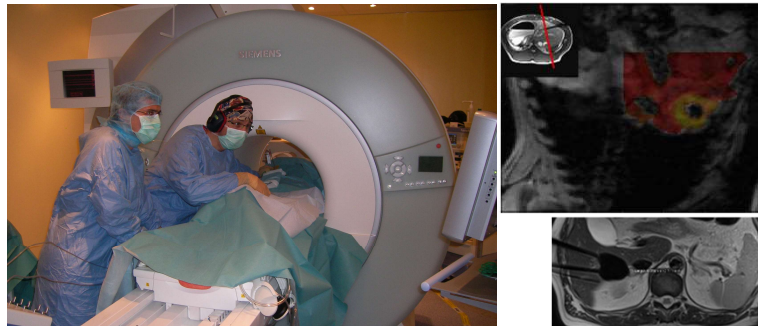
MRE at the ICube Laboratory (Strasbourg, FRANCE)



Interventional MRE



*Objective = Monitoring thermal
ablations in real time^[1]*



Biomechanical MRE

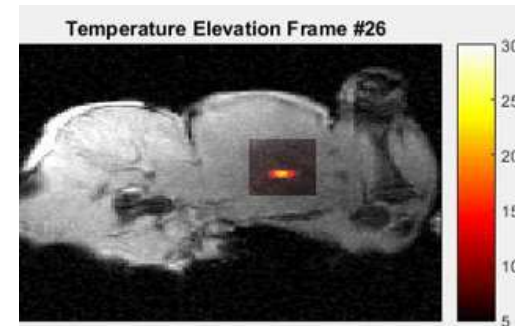


*Objective = Quantitative, biomechanical
characterization of soft tissues^[2]*



Monitoring MR-guided interventional procedures

- ✓ Gold standard = MR Thermometry



An additional biomarker would be helpful

Assessing tissue structural properties in real-time during thermal ablations

A new biomarker based on mechanical properties

Measured by MR Elastography

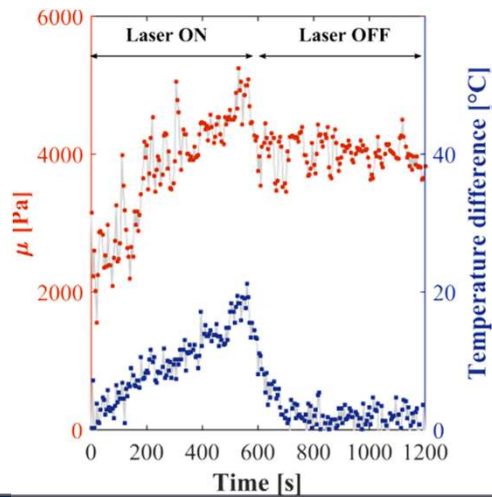
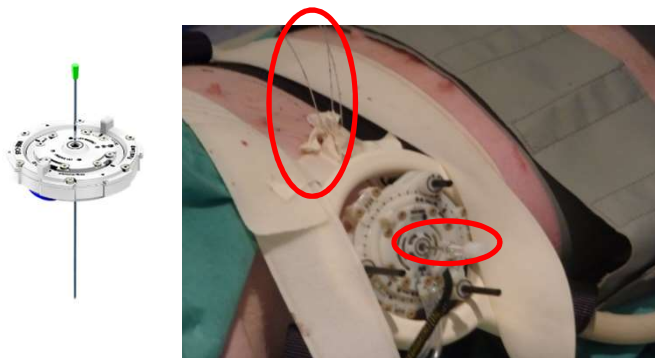


Interventional MRE

Provide radiologists with an elasticity map in real-time during the procedure

iMRE

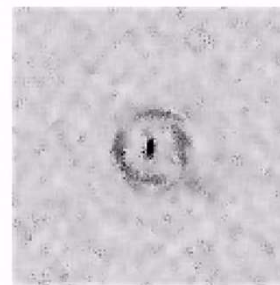
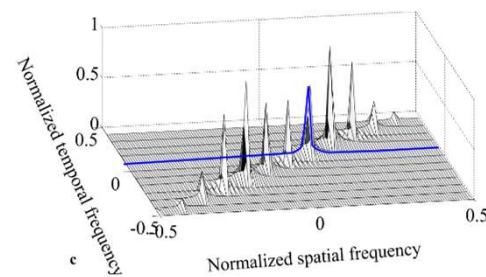
Monitoring percutaneous ablations (laser, RF, cryoablation)



Corbin et al.,
MRM 2015

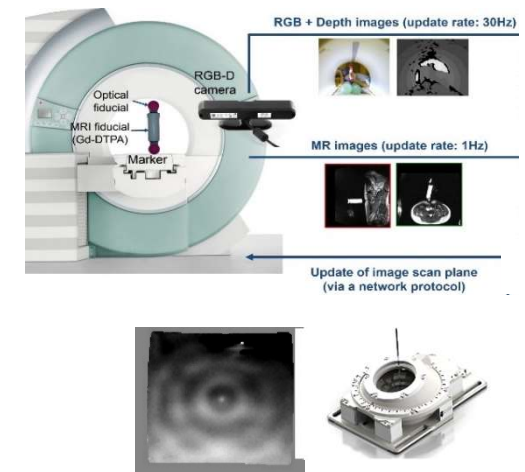
Corbin et al.,
ISMRM 2016

K-space interventional
MRE

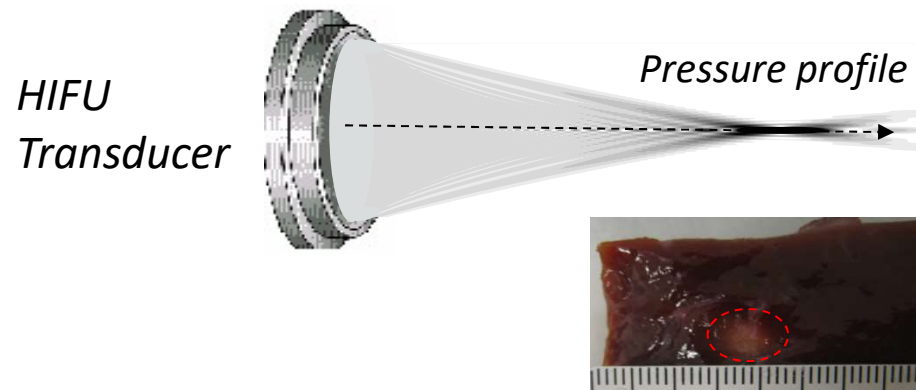


Corbin et al., Magn Reson Mat Phys
Biol Med, 2016

iMRE+ HIFU



High Intensity Focused Ultrasound (HIFU) therapy



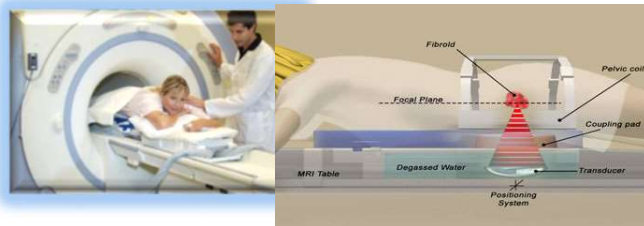
- ✓ Non invasive
- ✓ Non ionizing
- ✓ Requires guidance by imaging

MR- guided HIFU

- Preoperative planning
- Monitoring in real time
- Post-operative assessment



Objective: Using MRE to monitor HIFU therapy in real time

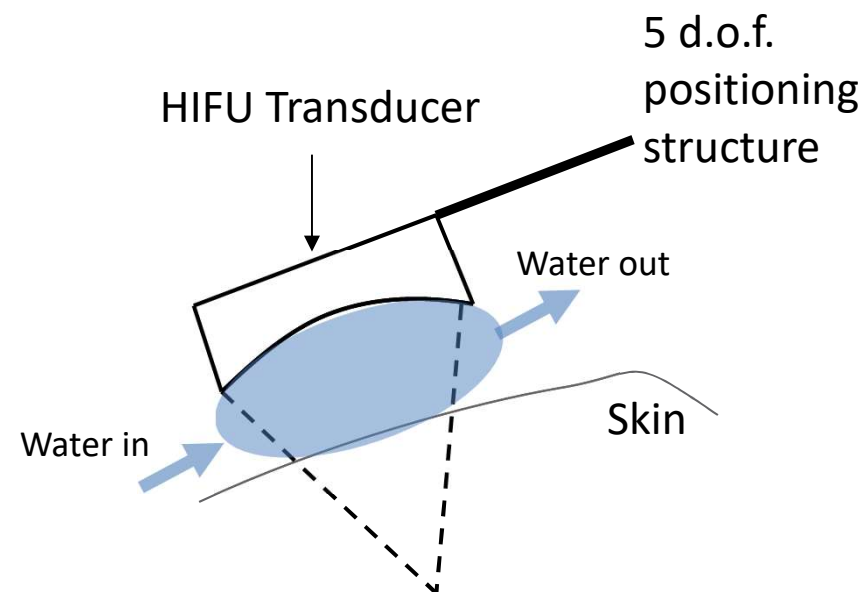


- Gynecology (Uterine fibroids)
- Urology (Prostate cancer)
- Neurology (Essential tremor, Parkinson's disease)
- Oncology (Brain, liver, bone, breast)

....

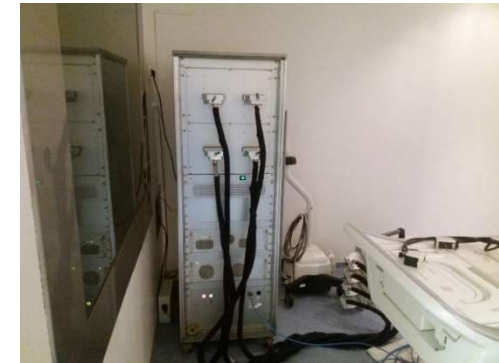
iMRE for HIFU therapy

Material and Methods

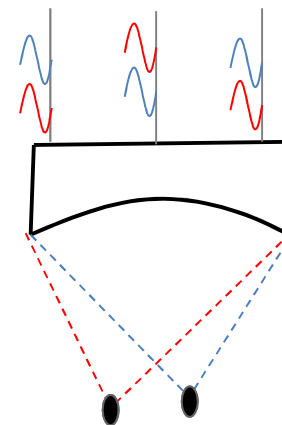


Transducer: Imasonic, France

HIFU system: Image Guided Therapy, France

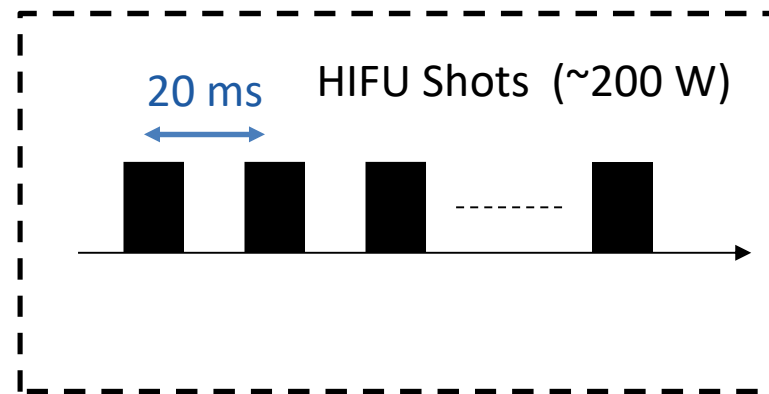


Electronic steering (256 elements, 1MHz)

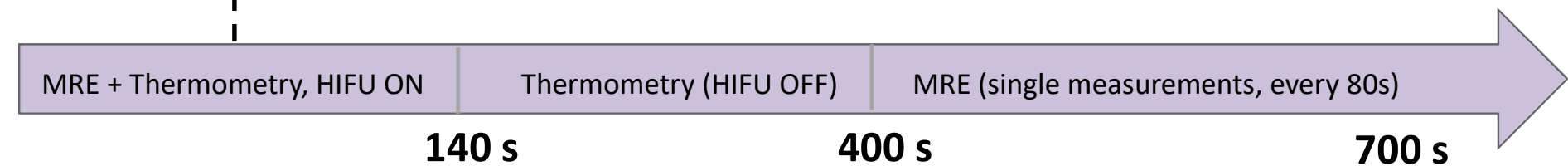


iMRE for HIFU therapy

Material and Methods



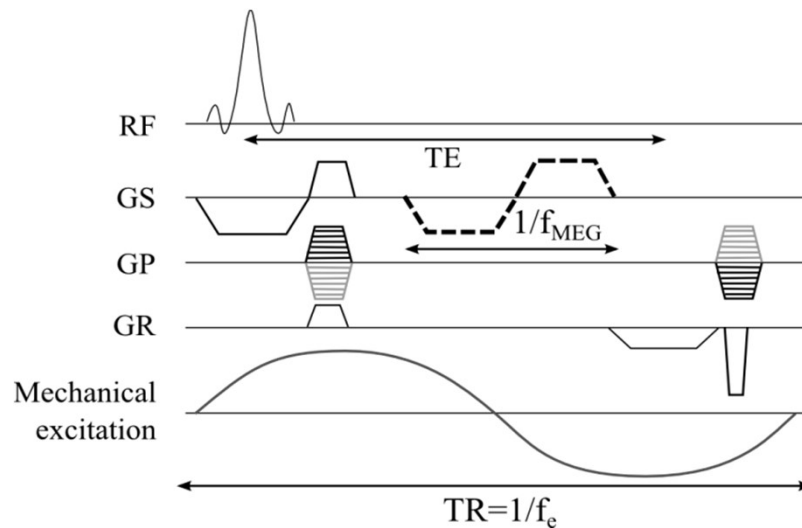
*Similar to methods proposed by
Wu et al. (2000) et Souchon et al.
(2008) on phantoms*



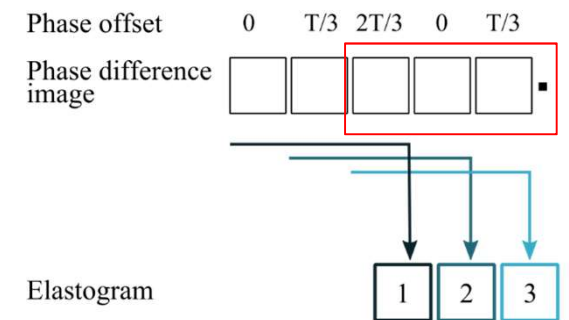
HIFU ablation

iMRE for HIFU therapy

Material and Methods



Spoiled, interactive GRE sequence
3 phase shifts
Fractional encoding

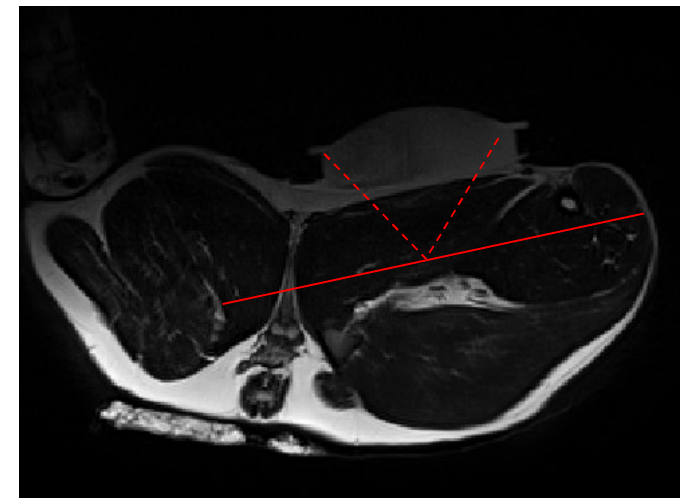
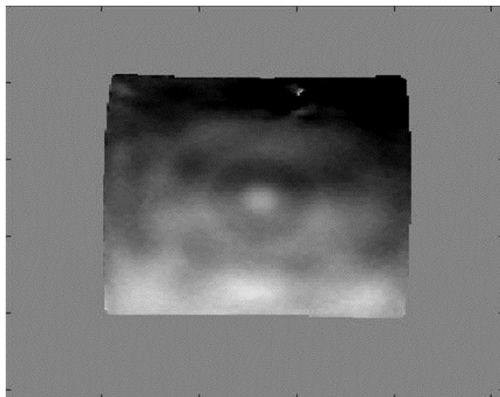
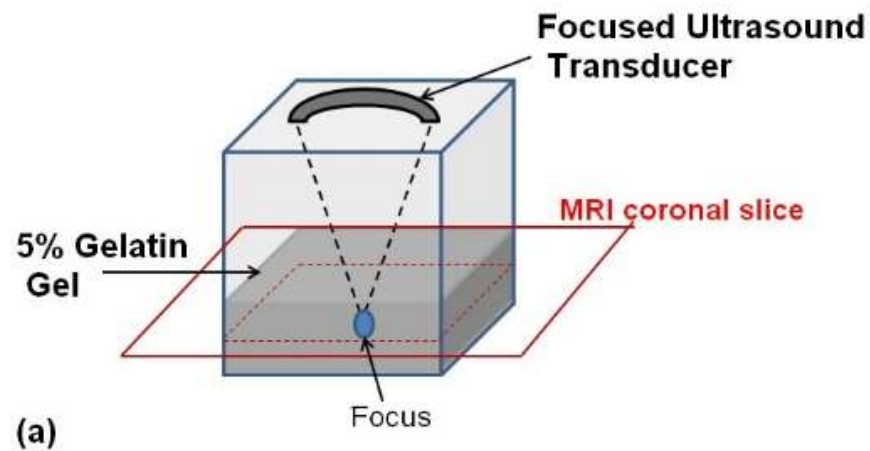


Sliding Window
+Harmonic analysis
+LFE algorithm
+Simultaneous
MRE+Thermometry (PRF)

~ 1 elastogram/2 s

iMRE for HIFU therapy

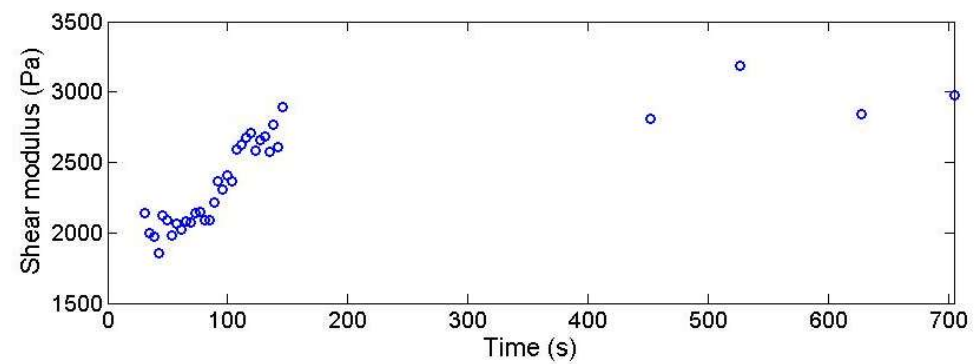
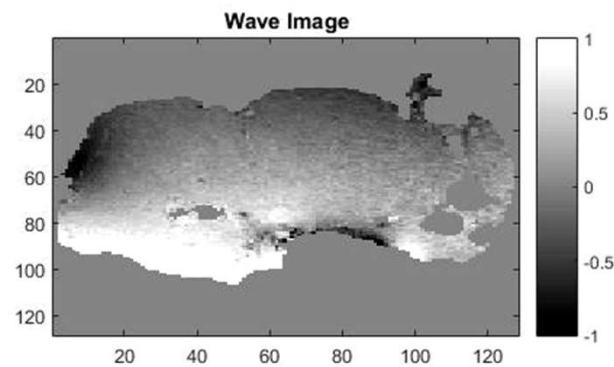
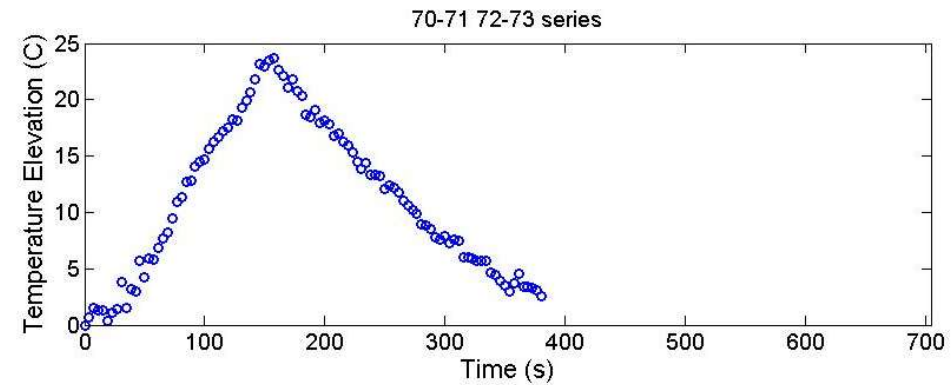
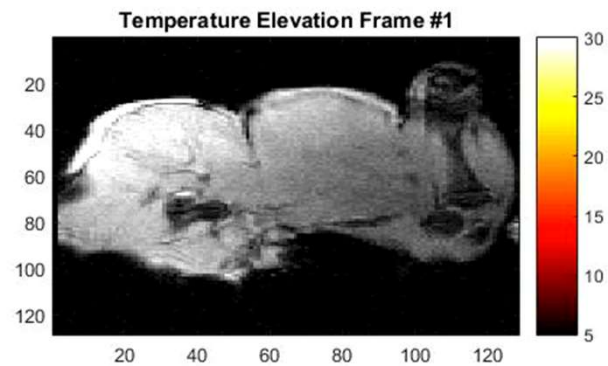
Results on Phantom & In vivo Setup



$$f_{\text{exc}} = 50 \text{ Hz}; f_{\text{msg}} = 90 \text{ Hz}; P_{\text{max}} = 220 \text{ W}$$

iMRE for HIFU therapy

Results



Conclusion

- Use of HIFU for both wave generation and heating simultaneously
- Feasibility demonstrated in vivo on muscle tissue
- Elasticity: interesting biomarker for assessing structural damage during HIFU therapy
- Ongoing work: comparison with thermal dose & histology
- Ongoing work: ultrasound dosimetry for MRE without damage

THANK YOU FOR YOUR ATTENTION!



Elodie Breton

Kisoo Kim

Afshin Gangi

Jonathan Vappou