# MR Elastography of Radiofrequency Ablation Lesions

S. Maderwald[1], H. H. Quick[1], K. Uffmann[1], F. Vogt[1], M. E. Ladd[1]
[1]Radiology, University Hospital Essen, Essen, NRW, Germany

## Introduction

MR Elastography (MRE) has shown the potential to visualize tumors in breast tissue [1] due to tumor related local changes in tissue elastography. Minimally invasive techniques, such as radiofrequency ablation, produce local tissue denaturation due to increased tissue temperatures. This technique is used in cancer therapy for tumor ablation. It is, however, difficult to determine the exact size of the ablation lesion. In this study, we evaluated the potential role of MRE as imaging tool for visualizing the zone of necrosis against the background of differences in tissue elastography of heat ablated tissues and normal untreated tissue [2]. The liver of a pig including a RF ablation induced lesion was examined with MRE directly after ablation and subsequent euthanization of the pig.

## Methods

The experiment was performed on a fully anesthetized mini pig weighing 40 kg. One lesion was created in normal liver parenchyma under CT guidance using an RF applicator (Cool-tip, Radionics 910, Burlington, MA) with 3 cm distal tip exposure. Ablation time was 20 minutes with an energy of 100 W at 480kHz. Subsequent to successful RF lesion creation, the pig was euthanized. Imaging was performed on a 1.5 T SIEMENS Sonata system equipped with gradients capable of 40 mT/m maximum amplitude and a slew rate of 200 mT/m/ms. The key sequence of this elastography study was a modified phase contrast (PC) sequence. This PC sequence synchronized the motion sensitizing gradients (MSG) to the oscillation of the mechanical waves which were induced into the region of interest with a piezoelectric oscillator to visualize the mechanical waves in the tissue. Due to refractions and reflections of the waves caused by fat, rips, and the interface between different tissue types, waves could not be induced directly via excitation of the skin. Penetration of the mechanical waves into the liver tissue was realized with a plastic extender of 20 cm length that was fixed with one end to the piezoelectric actuator [3]. The other end was inserted into the pig through a surgical cut down enabling ventral access to the liver from the outside.

The shear modulus was determined from the wavelength inside the tissue using multiple phase offsets and motion encodings in all three spatial directions. For mechanical excitation, oscillation with a frequency of 100 Hz and amplitudes in the range of 300 to 500 µm were used. Phase images were acquired in transversal, sagittal and coronal orientations. The total scan time was approximately fifteen minutes per motion encoding direction. Parameter settings for the modified PC sequence were TR/TE 160/13.3 ms, flip angle 15°, FOV 280 x 244 $mm^2$, slice thickness 5 mm, BW ±240 kHz. The in-plane matrix varied from 64 x 64 to 256 x 256 interpolated. One to three MSG cycles with an amplitude of 30 mT/m were used. Two 6-channel phased-array surface coils were used for signal detection. Image postprocessing was performed on a PC equipped with a Pentium4 1.9 GHz processor using Matlab (R13. The MathWorks, Natick, MA).

## Results

Assuming a tissue density of 1000 $kg/m^3$ in both, the liver parenchyma and in the ablated tissue, the determined average elasticity value, represented by the shear modulus, was 13 kPa and 16 kPa for the normal and coagulated tissue, respectively. The differences of the wave patterns in the lesion compared to its surrounding area are clearly depictable in the phase images.

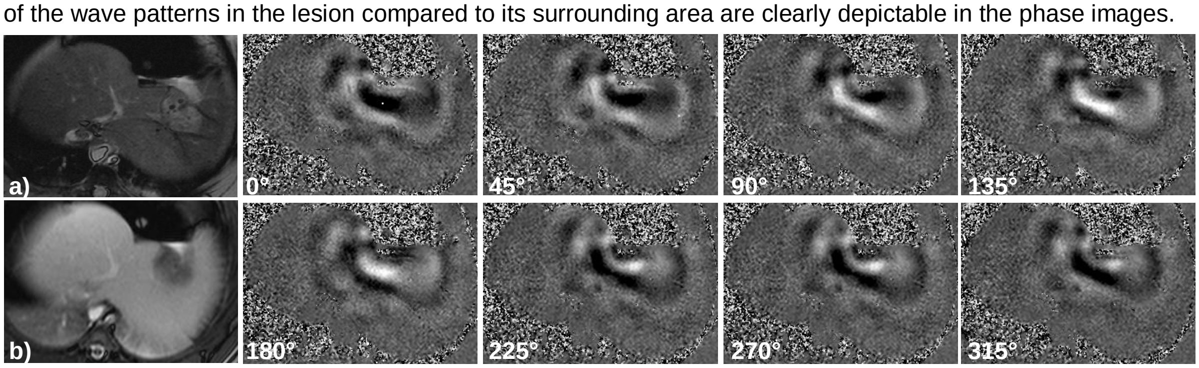


**Fig. 1:**
a) transversal magnitude image of the pig liver and (b), corresponding image of a T2 3D FLASH data set. In the corresponding phase images with different phase offsets (0°-315° step size 45°), the wavelength in the region of the lesion is longer than in normal tissue.

## Discussion

The present study demonstrates the potential for determination of RF ablation induced lesion size with MR elastography in the liver of a pig in situ. Largest obstacle still remains mechanical wave transmission into the liver from outside the body. Additionally, the effect of breathing motion on MR elastographic imaging in an in vivo setting has not been considered. If these hurdles can be overcome, MRE promises capability as monitoring tool for ablation therapy.

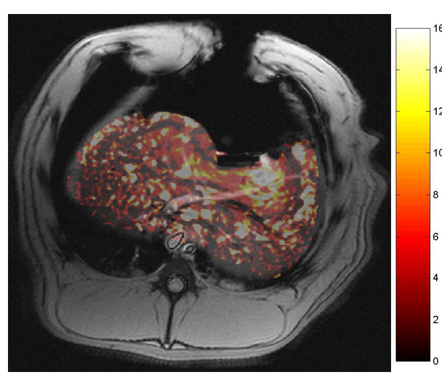


**Fig. 2:**
Image overlay of the shear modulus image onto corresponding MR magnitude image.

## References

1. Sinkus et al., Phys.Med.Biol. 45(2000)
2. Tao Wu et al.; Magnetic Resonance in Medicine 45:80-87 (2001)
3. Uffmann et al., Concepts of Magnetic Resonance (Magnetic Resonance Engineering) 15(4):239-254(2002)