

# Initial experience with volumetric MRI-guided High-Intensity Focused Ultrasound ablation in breast cancer patients

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## Introduction

Several studies have shown that it is feasible to perform MR-HIFU ablation of breast cancer<sup>1</sup>. However a limited efficacy was reported, which has hampered adoption in clinical practice. Additionally, respiration has been shown to cause significant field fluctuations in the breast, during proton resonance frequency shift (PRFS) MR Thermometry resulting in large temperature errors<sup>2</sup>. In this study, we present preliminary results from an ongoing clinical study, which has been designed to assess safety and treatment accuracy of MR-HIFU in patients with breast cancer using a novel dedicated MR-HIFU breast platform with a lateral sonication approach. An optimized PRFS-based sequence with a correction method for respiration was used for MR thermometry for the breast.

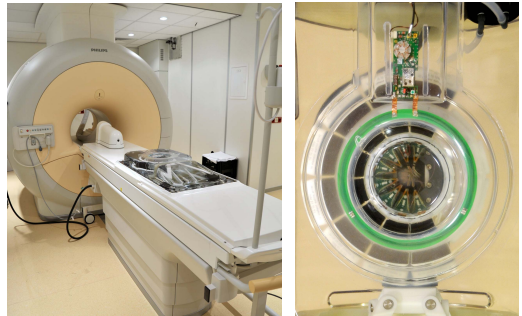
## Methods:

In this prospective clinical trial, ten female patients with pathologically proven invasive breast cancer after large-core needle biopsy will be included. Patients are treated according to a treat-and-resect protocol and surgery is performed between 48 hours and one week after MR-HIFU treatment. The tumor tissue is partially ablated, to be able to use the remaining tissue for tumor staging. After MR-HIFU ablation, thermal dose predicted volumes will be compared to necrosis at histopathology. MR-HIFU ablation is performed using a dedicated MR-HIFU breast system (Sonalleve Breast MR-HIFU, Philips Healthcare, Vantaa, Finland) in a standard 1.5-Tesla MRI scanner (Achieva, Philips Healthcare, Best, The Netherlands). The system consists of a water-filled table top with a breast cup in the center of the table, which is surrounded by eight separate 32-element focused ultrasound modules. A lateral sonication technique is employed to target the breast and MR-HIFU ablation is performed using a volumetric ablation technique.

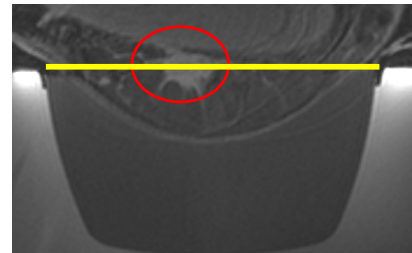
The PRFS-based MR thermometry sequence was optimized for breast tissue (TR/TE 76/30 ms, FA 30 °C) and has 4 slices, a dynamic scan duration of 2.4 seconds, and a voxel size of 1.67x1.67x5.0 mm<sup>3</sup>. A look-up-table-based multibaseline approach is used for the correction of respiration induced field fluctuations<sup>3</sup>. A dynamic contrast-enhanced MRI is performed for planning purposes with the Gadolinium injection at least 30 minutes before the first sonication. After surgical resection, histopathological analysis is performed using H&E staining.

## Results:

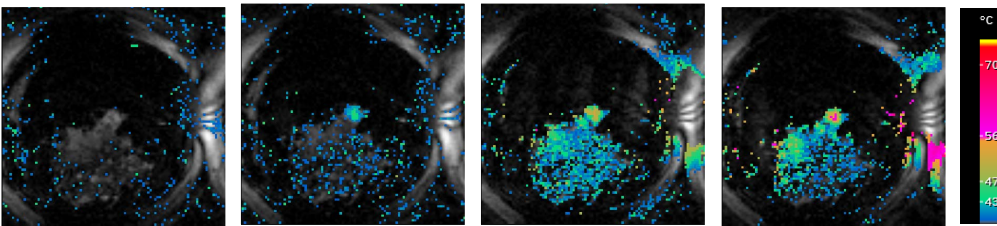
At the moment of writing this abstract, two patients have been included in the study. MR-HIFU ablation was performed under conscious sedation with the patients placed in prone position on the MR-HIFU breast platform. In the first patient, one sonication of 6 mm in diameter was performed using an acoustic power of 100 Watt. After 11 seconds, a peak temperature of 55°C was reached. Then, due to patient movement, errors in the MR thermometry caused the system to abort the sonication. After surgical resection, no tissue damage was found at histopathology. In the second patient, the quality of the optimized MR thermometry sequence was evaluated in 50 dynamics based on a voxel-by-voxel analysis. The temporal standard deviation was found to be 9.90°C before and 1.86°C after applying the multibaseline correction method. Three subsequent sonications of 6 mm in diameter, all at the same location inside the breast tumor, were performed with an acoustic power of 50, 60 and 70 Watt and a duration of 24.6, 14.9 and 22.1 seconds, respectively. The patient experienced no pain during or after treatment, and no redness or skin burns were observed. Histopathologic analysis showed an area of tissue necrosis inside the tumor with a diameter of approximately 6 mm.



The left picture shows the dedicated MR-HIFU breast platform before the MRI scanner. The right picture shows a close-up of the 8 transducers around the breast cup.



T1-weighted image of the first patient just before sonication. The anterior part of the tumor below the yellow line was reachable for the transducers.



The dynamic MR thermometry images during the sonication in the first patient. A maximum of 55°C was reached after 11 seconds.

## Discussion:

We present preliminary results of MR-HIFU ablation in breast cancer patients using a novel and dedicated MR-HIFU breast platform. In the first patient, we experienced difficulties to perform breast ablations due to problems with patient positioning and movement. Although the tumor was very close to the pectoral muscle, it was technically feasible to reach it using the lateral sonication technique. However, the thermal dose was not high enough to cause tissue necrosis. In the second patient, the PRFS-based optimized MR thermometry sequence proved to be very accurate with a temporal standard deviation of 1.86°C after correction, which is comparable to results obtained in volunteers<sup>4</sup>. Three sonications were performed, leading to tissue necrosis in the tumor as observed during histopathological analysis. The lateral sonication approach appears a promising alternative for MR-HIFU treatment of breast cancer.

## References

1. Schmitz 2009, J Magn Reson Imaging; 2. Peters 2009, J Magn Reson Imaging; 3. Hey 2009, Magnetic Resonance in Medicine; 4. Deckers 2012, FUS 3<sup>rd</sup> International Symposium

## Acknowledgements:

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