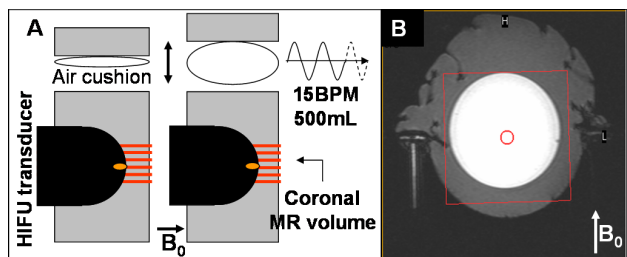# Online phase-collection based correction of MR thermometry for breast HIFU ablation: evaluation under various respiratory motion susceptibility conditions in phantom.

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Introduction

High intensity focused ultrasound (HIFU) should be an efficient technique to treat tumor in the breast under real time temperature monitoring. Whereas a dedicated platform was developed for this application (1), MR temperature remained problematic under in vivo respiratory condition because of large variation of magnetic field degrading the precision of temperature (2). The proposed online phase-collection based correction of non gated MR temperature was tested in a home made respiratory mimicking phantom under various HIFU power conditions.

Figure 1. Schematic view of respiratory perturbation simulated home made phantom; **A:** 3% agar-3% silicate gel (grey) was positioned in the area of a 256 elements HIFU transducer (black) which focal point is placed in the center of the transducer (orange ellipse); Air cushion was positioned on the gel without contact between and other gel with same composition stuck on; variation of air in the cushion via an MR compatible respirator device offered possibility to modify amplitude and frequency of displacement of the upper gel; 6 slices MR acquisition was done during HIFU session under respiratory simulated condition or not; **B:** 3D FFE T1weighted image assessed the position of the focal point; red square figured out the positioning of the MR temperature acquisition centered on the focal point position (red circle).

Material and Methods Under breathing conditions, although no apparent motion can be detected on the anatomical images, phase vary periodically masking a temperature increase. Therefore, phase-collection based correction started with a 20 dynamics learning step during which the all images were collected; During the second step, in a non heated region of interest, the standard deviation of MR temperature, calculated by difference of the current phase image with each collected phase image should be found minimum to select the correct collected phase image, used as reference image in the calculation of temperature following the proton resonant frequency shift (PRF) method. An home made phantom was built in order to simulate respiratory conditions: 3% agar-3% silicate gel was used as detailed in the figure 1. An air cushion with a piece of same gel positioned on permitted to create cyclic perturbations of local magnetic field with various frequency and amplitude. The same HIFU protocol consisting in a fixed time and power application was applied after 120s of acquisition at the focal point without simulated respiration and without any correction: variation of temperature at focal point served as reference standard and was compared to the condition with respiration perturbations and phase atlas based correction. The MR thermometry imaging was performed simultaneously with the HIFU application using a segmented gradient echo-echo planar imaging (GRE-EPI) sequence. 6 slices were acquired each 2.1s; echo train length of 19, binomial water selective RF pulses, TR = 50 ms, TE = 25 ms, flip angle = 35, matrix = 128 x 128, FOV of 128 x 128 mm^2, in-plane spatial resolution of 1 x 1 mm^2 and slice thickness of 5 mm. Average and standard deviation (SD) of MR temperature over the all dynamics were systematically mapped. Differences between temperature variation at the focal point under correction and simulated respiration, and referenced evolution were also compared with condition without correction.
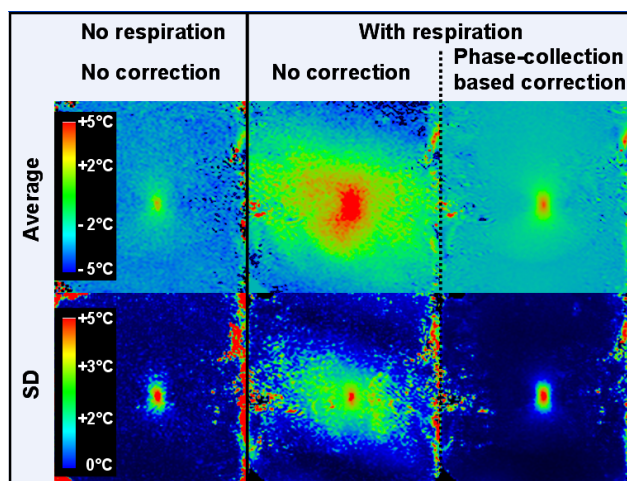

Figure 2. Typical temporal average (First row) and standard deviation (SD, Second row) of temperature maps of two 50W–60s HIFU ablation procedure session without (Left) and with respiratory simulated perturbation (Right). MR temperature data are compared without (No correction) and with phase-atlas based correction. Local perturbations oversized the focal point, whereas application of phase-atlas based correction gave similar results as no perturbation condition.

Figure 3. Typical temporal evolution of temperature at the focal point; Data for 3 main conditions are reported: No respiration/No correction (in black) taken as evolution of reference, With respiration/No correction (dashed line, in black) and With respiration/With correction (in red) for the same 50W–60s HIFU.

Results Without any perturbation, SD of temperature in a non heated area was found around 1°C whereas with phase atlas based correction, it improved to 0.5°C (Figure 2). Under simulated respiration, SD deviation of temperature was 3°C and 0.5°C respectively without and with proposed correction. After a 50W-60s HIFU application, a systematic increase of temperature of about +15°C was found (Figure 3). Differences with reference evolution curve at the focal point showed systematic improvement of the SD from 3.3°C to 0.8°C.

Conclusion Using a dedicated novel breast HIFU platform, MR temperature guided HIFU ablation was significantly improved using the phase-collection based correction. Further in vivo studies will be the next step.

References

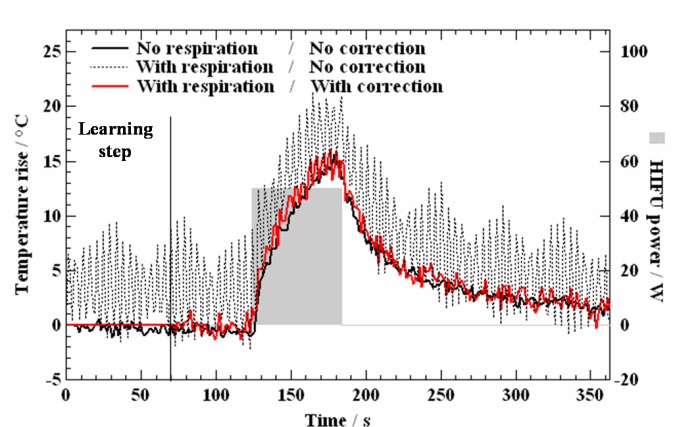(1) Moonen CTW, Mougenot C. Philips Research Book Series, 2006; 6:183-200 (2) Sprinkhuisen S et al. 6th Interventional MR meeting 2006.