Magnetic Particle Based MRI Thermometry at 0.2 T and 3 T

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This study provides insight into the advantages and disadvantages of using ferrite particles embedded in agar gel phantoms as Magnetic Resonance Imaging (MRI) temperature indicators for low-magnetic field scanners. The advantages of high-field MRI, like lower purchase and operation costs and the reduction of certain artifacts are well known. Nevertheless, the more open designs for the low-field scanners are better suited for MRI-guided interventional procedures and reduces claustrophobic issues for patients. In order to circumvent issues of toxicity and develop more biocompatible agents, in this study we use mixed magnesium-zinc $(Mg_{1-x}Zn_x)_yFe_{3-y}O_4$ ferrite particles as temperature contrast agents. In a recent work, we have shown that these mixed MgZn ferrites possess promising magnetic properties and, in moderate concentrations under 240 $\mu g/mL$, are much less toxic than other previously studied materials [1]. We compare the temperature-dependent intensity of MR images at low-field (0.2 T) to those at high-field (3.0 T). Due to a shorter T_1 relaxation time at low-fields, MRI scanners operating at 0.2 T can use shorter repetition times and achieve a significant T_2^* weighting, resulting in strong temperature-dependent changes of MR image brightness in short acquisition times. Although the signal-to-noise ratio for MR images at 0.2 T MR is much lower than at 3.0 T, it is sufficient to achieve a temperature measurement uncertainty of about $\pm 1.0^oC$ at 37^oC for a 90 $\mu g/mL$ concentration of magnetic particles [2]. In addition to the advantages listed above, we discovered a surprising benefit when using low-field scanners. The percentage changes of the temperature-dependent image intensities are larger for low-field scanners compared to high-field scanners. As a consequence, there are two potential advantages of conducting MRI thermometry at 0.2 T compared to 3.0 T. First, the temperature measurement itself can be more accurate, and second, the acquisition time can be shorter.

References:

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