

Safety and Initial Results with a Dedicated Human 7T Eye Coil

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Introduction

This study was performed to implement and safety test a dedicated third party coil at 7T. A dedicated, receive only eye coil was built and interfaced with a commercial 7T scanner to be used in combination with a separate transmit head coil for excitation. When using third party coils, especially at ultra high fields, validation of compatibility and safety are essential. It is even more crucial in eye imaging to avoid heating of the orbit, which has limited cooling abilities. Imaging of the human eye is becoming increasingly important in the assessment and diagnosis of ocular diseases. With the advantage of higher signal, and higher resolution compared to conventional field strengths, ultra high field MRI is rapidly emerging as a promising, non-invasive, clinical imaging tool for special purposes. Most human ultra high field systems currently focus on brain applications with well characterized coils. Research and clinical applications demand the use innovative coils for imaging other parts of the body.

Methods

Imaging was performed at 7 Tesla (Philips, Achieva) using a transmit head coil for excitation (Nova Medical) and a dedicated 4cm eye coil for receive (Rapid MR International LLC). A 16 channel receive interface box was used to connect the coil, with unused channels appropriately terminated. Safety components were built into the system through malfunction circuitry in the interface box, as well as active and passive decoupling of the eye coil. Initial installation and safety testing followed instruction of the MRI manufacturer, and included dedicated decoupling, heating, B1 and B0 tests. Phantom studies were performed to check for B0/B1 disturbances from cable currents and ferrous components. Coil sensitivity and SNR measurements were also performed on phantoms. During unlikely, but worst-case scenario coil placements (touching transmit coil, rotated compared to standard positioning), the temperature on the receive coil surface was measured while imaging a phantom. Additionally, animal studies were carried out to measure temperature increases during high level SAR excitation, as a model for human eye imaging. Fiber optic temperature sensors (Luxtron) were placed at key locations in and around the eye of a pig head (Figure 1). Temperatures were recorded over a period of approximately 2 hours, during which a TSE sequence with a maximum number of refocusing pulses to achieve maximum allowable SAR (3.2W/kg) was used. Pig and dog specimens were used for further coil behavior, positioning, and initial sequence testing.

Results

The coil passed all vendor specified tests. B0 and B1 maps showed homogeneity throughout most of the imaging region of the coil, with some disturbances in B0 indicating limited ferrous components and cable currents. Signal drop off of the coil is as expected for a 4 cm surface coil, with SNR values in the range of 20-50. No abnormal behavior was observed in any phantom temperature studies, with temperature increases on the coil surface limited to 0.3°C. Tissue heating as a result of high RF power was non-significant, with temperature increases in the same order of magnitude as recording fluctuations and error (Figure 1a/b). After successful safety validation, initial human sequence testing showed high quality images, as illustrated in Figures 2.

Discussion

This established a detailed process on how to validate and assess safety of dedicated third party coils. After phantom experiments, we used pre-clinical models to assess safety under clinical conditions and comparable tissue interfaces. Initial human testing was intensely monitored after completing a stringent safety assessment. This approach is readily achievable for in-house safety testing of third part coils and should become site specific SOP. 7T MRI with a dedicated eye coil was shown to be safe and can provide exciting improvements in image quality.

References

- [1] Bert RJ, Patz S, Ossiani M, et al. Acad Radiol 2006;12:368–378.
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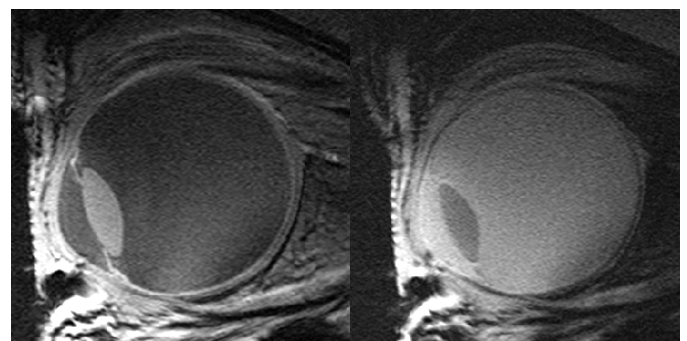
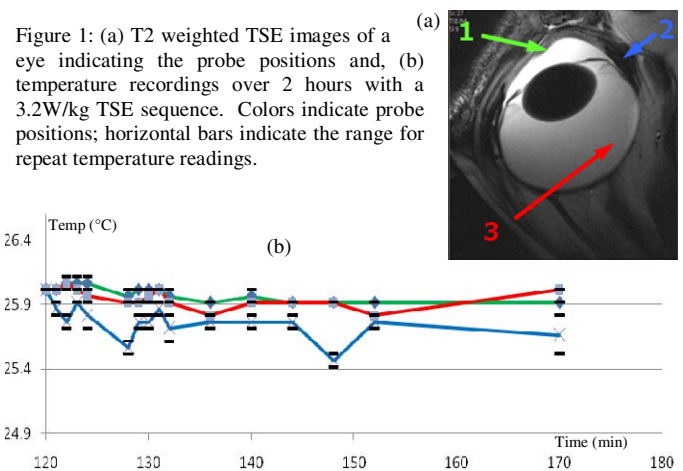


Figure 2: T1 and PD weighted sagittal views of the human eye (3D-SPGR, FA 20° and 3° respectively, TR/TE=10/2.6ms, 0.15x0.25x1.0mm³, 12 repeats.