Integration of an Inductive Driven Axially Split Quadrature Volume Coil with MRgFUS System for treatment of Human Brain

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Introduction: MRI guided focused ultrasound has demonstrated patient benefits in the non-invasive treatment of human brain disorders including essential tremors.(1) With the InSightec focused ultrasound system for the brain, a hemispherical transducer is used inside a commercial 3 Tesla MRI system. The transducer covers most of the upper skull area, so conventional volume head coils are not usable. Yet, there is a need for a local transmit/receive coil to ensure adequate B1 transmission and reception in the transducer. A coil array design has been proposed (2), but it involves many electrical connections that must cross the water membrane and does not address the transmit need. The purpose of this work was to design a novel coil that 1) has no wires or conductors crossing through the water membrane, 2) transmits preferentially into the desired imaging region of the brain, and 3) has high receive sensitivity.

Materials and Methods: A variation of a transmit/receive birdcage volume coil (3) was designed that is split along the Z axis. (Figures1, 2, 3) This allows half of the coil assembly to be located inside the acoustic treatment volume inside the transducer and immersed in acoustic coupling medium (usually degassed water). The other half of the volume coil assembly is outside the transducer and direct connected to the MRI system with RF drive cables. The upper half of the coil is inductively driven by the lower half by way of inductive center rings. This allows the upper half to be electrically isolated through the water membrane and have no cable connections into the acoustic treatment region. The upper coil assembly has the conductors in planes radial to the acoustic field and on boundaries of the transducer sections to have minimal interaction with the ultrasound field.

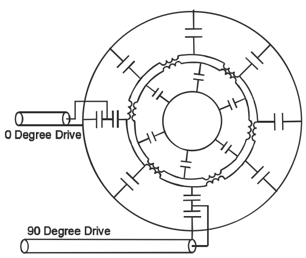

Figure 1.

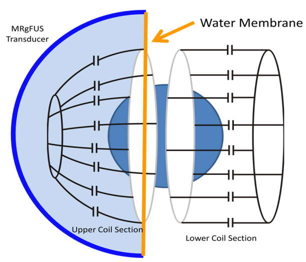

Figure 2.


Figure 3.

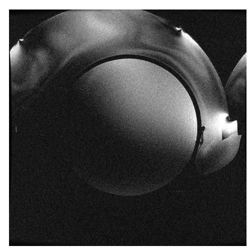
Figure 4.

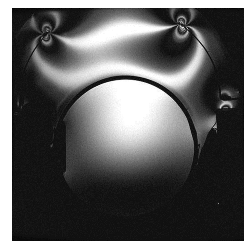
Figure 5

Results: Figure 4, interaction between the body coil and the transducer results in non uniform B1 in the middle of the treatment region. The body coil cannot make an adequate flip angle in this area and suffers from poor receive SNR**. Figure 5** uses the integrated volume coil, and shows significant improvement near the center of the phantom although some B1 non-uniformity remains. Beyond reducing the artifact from the body coil transducer interaction, the integrated split volume coil show a 300% improvement in SNR in the center of the phantom. This will significantly improve in the treatment planning phase as well as improving temperature monitoring accuracy during ultrasound thermal therapy treatments.

References:
1: W.J. Elias et.al. A Pilot Study of Focused Ultrasound Thalamotomy for Essential Tremor New England Journal of Medicine 2013; 369:640-648August 15, 2013
2: E. Minalga, R. Merrill, N. Todd, D. Parker, J.R. Hadley A 10-channel RF coil for use in magnetic resonance guided high intensity focused ultrasound of the brain. Proceedings of the 2013 ISMRM Annual Meeting, Salt Lake City UT abstract #0832.pdf
3: CE Hayes, WA Edelstein, JF Schenck An efficient, highly homogeneous radiofrequency coil for whole body NMR imaging at 1.5 T Journal of Magnetic Resonance 63, 622-628 (1985)