Endoluminal MRI coils for mice rectal wall assessment

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Background and purpose: MRI is well suited to investigate human body and provide a good spatial resolution and contrast for the characterization and staging of lesions (1). Nevertheless, rectal wall assessment requires an even higher spatial resolution for visualizing different wall layers (2) (0.1-0.5 mm) in detail still within a limited acquisition time. Endoluminal coil is drastically increasing local signal-to-noise ratio (SNR) compared to external coils. The purpose of the research project is to assess mice rectal wall for lesion characterization and staging (colorectal cancer and inflammatory bowel disease) using MRI combined with confocal endomicroscopy and conventional endoscopy (4). In this abstract, endoluminal coils were built and assessed compared to volume coil to explore rectal region in mice.

Materials and methods: An endoluminal MRI coil (3) was designed and built for mice rectum investigation (figure 1) on a 4.7T Bruker Biospec system. The prototype (figure 1) has been designed with a length of 20 mm with an outer diameter of 2mm (coil + heat shrink coating). The circuit has been mechanically carved on both side of a FR4 epoxy substrate. Case A nonmagnetic capacitors were used for 50 Ohm matching (2x6.8 pF) and tuning (24.2 pF) at 200MHz resonance frequency for a series circuit. A PIN diode and two Choke inductors were used to actively decouple the coil during the RF transmission. The loaded and unloaded Q-factor were 44 51 respectively. The prototype was characterized on phantoms containing a solution of with 1,25g/L $NiSO_4$ and 5g/L NaCl The SNR was calculated and compared with SNR obtained with 32 mm inner diameter quadrature volume birdcage coil. Finally, in-vivo imaging was performed on healthy mice (c57 black6j). The coil was carefully inserted into mice rectum using sterilized lubricant K-Y gel and hold in position with medical adhesive tape (strap on the MRI bed). The rectum was investigated with axial T2-weighted 2D RARE and with T_1 –weighted 3D FLASH sequences.

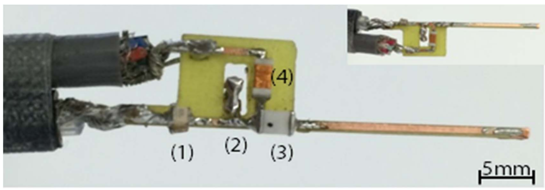

Figure 1 – (a) Photographs of endoluminal coil. The components for matching (1), tuning (2) and active decoupling (3) and (4) are welded on the substrate. (b) Backside of the coil.

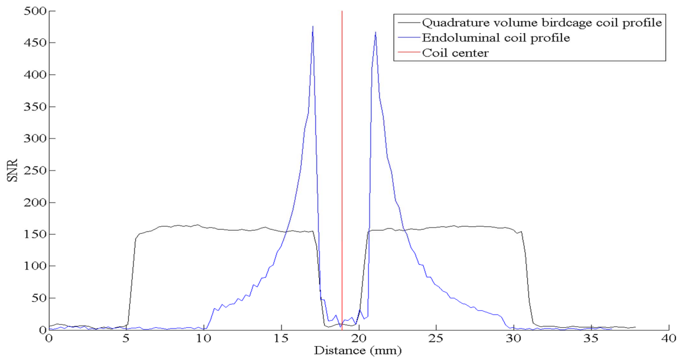

Figure 2 – Profiles comparison between quadrature volume birdcage coil and endoluminal coil on a water solution phantom.

Results: The preliminary results show the capability of designing endoluminal coils with dimensions compatible with an introduction on mouse rectum. The SNR comparisons performed on phantom (T_1 FLASH, TE=6ms, TR=15ms, pixel size=254µm, 254µm slice thickness and acquisition time=8min11s), shows a gain of 3.4 between the quadrature volume birdcage coil and the endoluminal coil with active decoupling circuit (figure 2). The SNR of the endoluminal coil is greater than the one with the body coil up to approximately 4mm from the center of the coil. Images acquired in vivo Show that with the volume coil it is not possible to well distinguish colon wall layers (figure 3a – T_1 FLASH, TE=4ms, TR=25ms, pixel size=78µm, 260µm slice thickness and acquisition time=11min31s) due to voxel size limitation. However, with the endoluminal coil, the gain in SNR can be used to increase spatial resolution and it is then possible to depict mice rectum wall layers (figure 3b - T_1 FLASH, TE=6ms, TR=26ms, pixel size=39µm, 260µm slice thickness and acquisition time=10min38s). Correcting for difference in voxel size, bandwidth and acquisition time, the SNR was found 4 times greater at the close vicinity of the coil.

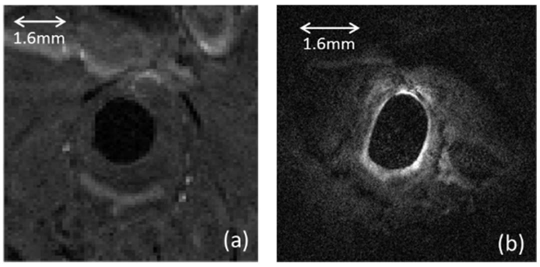

Figure 3 - Images obtain with (a) a quadrature volume birdcage coil and (b) with the endoluminal coil, $\boldsymbol{T_1}$ FLASH sequence. At the edge of the coil, the SNR is 4 times greater with the endoluminal coil.

Discussion: Endoluminal coils provide a higher SNR up to 4mm from the center of the coil compared with a quadrature volume birdcage coil. In fact, the endoluminal coil was inserted in a water tight cylinder but with relatively thick walls, that do not permit to measure SNR at close coil proximity. Hence, maximum SNR is underestimated. In-vivo experiments show an improved visualizing of rectal wall layers using endoluminal coil without acquisition time penalty. The combined signal reception of volume body coil with endoluminal coil could both allow a clear analysis of rectal wall still allowing an adequate examination in deep tissues far from the endoluminal coil.

Conclusion: This study shows the feasibility to design small endoluminal coils (2mm outer diameter) and to obtain very detailed images of mice rectum wall that were not accessible with volume coils. This work opens perspectives on mice trials using endoluminal coil to characterize colorectal cancer lesions and then, offers a possible way to better understand the pathology.

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