A susceptibility matched endorectal coil design suited for the MRS examination of the rectal wall

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Target audience*:* Clinicians or physicists interested in MRS (Magnetic Resonance Spectroscopy) examination of the bowel with an endoluminal coil.

Purpose

Prostate Endorectal Coils (PEC) are usually surrounded by a balloon inflated with air meant to prevent coil migration or to unfold the coil in the case of loop coils (PEC, Medrad). The migration of clinical Colorectal Endorectal Coils (CEC) is prevented by the organ itself (with the collapse of the colon[1]), nevertheless CEC are usually built with a plastic casing around an in-plane loop thus inducing an air cavity[2]. In both cases, a magnetic susceptibility effect will therefore occur at the air/tissue interface between the coil and the surrounding medium. Colorectal cancer induces metabolic changes that can be assessed using proton Magnetic Resonance Spectroscopy (1H-MRS) [3]. Though, spectroscopy is very sensitive to B_0 magnetic field inhomogeneities. In order to reduce B0 inhomogeneities, a homemade endorectal coil using Ultem™ (i.e Polyetherimide: $C_{37}H_{24}O_6N_2$) as a solid support was built. The MRS acquisitions performed with this susceptibility-matched endorectal coil were compared to those acquired with and with an endorectal coil without any susceptibility matching material.

Methods

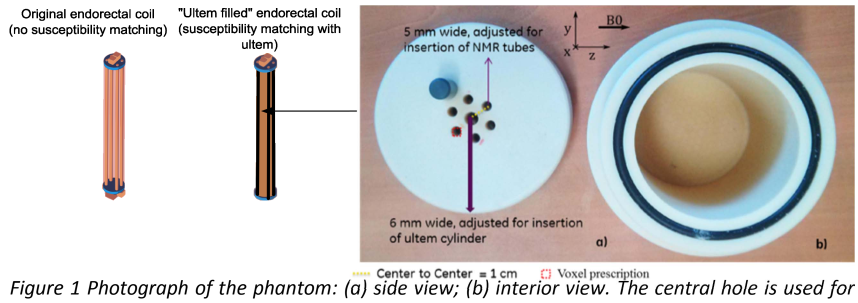

Figure 1 Photograph of the phantom: (a) side view; (b) interior view. The central hole is used for the insertion of the endorectal coil. Six 5mm outer diameter NMR tubes can be placed every 60° around the center.

A cylindrical phantom enabling the insertion of the endorectal coil at the center and of six 5mm-diameter NMR tubes was built. The NMR tubes were filled with different metabolite solutions containing Choline, Creatine or Lactate at 50 mmol/L (Figure 1). The interior of the phantom was filled with water to embed the tubes and coil. A proton MRS acquisition was performed using a PRESS sequence (TE /TR = 35/ 1800 ms, Bandwidth =5KHz, number of sampled data points = 4096, number of accumulations = 128 accumulations and acquisition time = 72 s). The MRS voxels' volume inside each NMR tube was equal to 4×4×4 mm^3, which corresponds to the minimum volume that can be prescribed using a standard PRESS sequence on the MR scanner in clinical mode.

The axis of the phantom was first aligned with the magnetic field. The acquisitions were then repeated for each individual metabolite with both coils keeping the position of the phantom and the shim parameters identicals. The measurements were then performed for different horizontal phantom angulations: 15°, 30°, 45° from the B0 magnetic field keeping the same shim corrections.

Results

		Lactate FWHM (Hz)	Choline FWHM (Hz)	Creatine FWHM (Hz)
0 °	Susceptibility matched endorectal coil	2.6 ± 0.1	3.6 ±0.1	3.7±0.2
	Original endorectal coil	3.8± 0.2	5.0±0.1	6.0 ±0.2
15°	Susceptibility matched endorectal coil	5.5	6.1	6.3
	Original endorectal coil	7.6	9.6	12.7
30°	Susceptibility matched endorectal coil	17.1	9.3	8.5
	Original endorectal coil	25.9		
45°	Susceptibility matched endorectal coil	21.5		
	Original endorectal coil	34.9		

Table 1 : FWHM measurements for spectra acquired with either an Ultem™ matched endorectal coil or original (air filled) endorectal coil for each metabolites. The measurements were repeated 4 times at identical positions for a 0° angulation. For 15°, 30°, 45° angulation of the phantom measurements were acquired once.

For a 0° angulation, FWHM was decreased by using the susceptibility matched endorectal: a 32% decrease for Lactate, 28 % for Choline and 38% for Creatine. For a 15° angulation, FWHM was decreased by 28% for Lactate, 37% for Choline, 49.7% for Creatine. For a 30° angulation: FWHM was decreased by 34% for Lactate. For a 45° angulation: FWHM was decreased by 40%.

Discussion : When the patient is in supine position, the first part of the bowel (until left colonic flexure) is not completely aligned with B0. The resultant angle between the colon and the B0 magnetic field (horizontal direction) increase the susceptibility effect therefore, theoretically, the susceptibility-matched coil would yield an even greater decrease in FWHM in *in vivo* conditions. When the phantom angulation is increased, the FWHM decrease yielded by a susceptibility matched endorectal coil is even more effective. Further measurements are needed to acquire statistical confidence on these results. Furthermore, the study was performed with a fixed voxel's volume and at a definite distance. Larger voxels prescribed further away from coil would be less exposed to the susceptibility effect since the susceptibility effect is more important at the interface.

Conclusion : The use of a susceptibility-matching material as a solid support for an endorectal coil results in a significant reduction in the FHWM of the spectra acquired with that coil. This approach is believed to be promising for *in vivo* acquisitions of 1H-MRS spectra of the colon, which, to our best knowledge, has not been attempted until now. Nevertheless, the heterogeneity of the bowel tissues (fat, vessels,…) will lead to larger FWHM and *in vivo* experiments will thus be required to confirm these results.

Acknowledgments: This work was performed within the framework of the LABEX PRIMES (ANR-11-LABX-0063) of Université de Lyon, within the program "Investissements d'Avenir" (ANR-11-IDEX-0007).

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