1H MRS in the Human Calf with a Spatially Selective RF Surface Coil

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Introduction. Proton MRS studies [1-2] are often performed with a simple circular or rectangular RF surface coils. For example, MRS in the calf of an adult volunteer would require an RF coil of about 8-12 cm in size to cover the full depth of the muscles. However, the standard RF coil presents a RF B1 field distribution with a maximum at the coil plane and a progressive decrease along the coil axis, that can be deleterious in terms of SNR and selectivity when the tissue of interest has a given thickness and is localised at a specific distance from the coil plane. Transverse field RF surface coils have been used for MRI applications and they are characterised by a RF field distribution with a sharp B1 peak located at some distance along the coil axis [3-6]. This feature makes the use of transverse field RF coils of potential benefit for MRS applications requiring spatial selectivity. Recently, the SNR advantage of the transverse field coil for proton MRS was demonstrated with phantoms.

Aims. In this work, we have numerically investigated the dependence of the RF spatial selectivity along the z-axis of RF transverse field and standard circular loop coils of various diameters. To test the *in vivo* efficacy of the transverse coil, we have measured the SNR along the z-axis by means of 1.5 T proton MRS spectra acquired in the resting calf on an adult healthy volunteer.

Methods. To compare the B1 spatial distributions of a transverse field coil made by two current elements, connected with a figure-of-eight (FO8) geometry [4-6], and standard circular loop (CL) coils we used Biot-Savart modelling. To fully cover the human calf a RF coil of about 10 cm in diameter is required. The RF field distributions of a FO8 coil of 10 cm in diameter and CL coils of diameter equal to 2.5, 3.8, 5, 7.5, 10 cm were simulated (Fig. 1). For practical testing, a FO8 coil prototype (dia=10 cm) made by two linear current elements (copper strips of 5 mm width) with separation 1cm and a CL RF coil (diameter 2R=10 cm) were built. These coils were tuned at 63.87 MHz, and MRS data were acquired in the presence of the resting calf of a male volunteer (body weight 80 kg) using a 1.5 T GE SIGNA LX 9.1 scanner. To quantify the MRS signal amplitude and the spatial distribution in the calf, ^{1}H PRESS spectra (TE=26 ms; TR=1500 ms; NEX=8; FOV=16 cm) from a voxel (8x8x4 mm^3) centrally positioned along the z-axis (A/P direction) were acquired. Axial scout images (Fig. 2) were used for the accurate positioning of the voxels.

Results. Figure 1 shows the simulated normalised B1 amplitude along the coil z-axis. The small size CL coil (dia=2.5 cm) presents the maximum B1 field amplitude within a narrow region close to the surface (z<5 mm) and a rapid decrease at deeper positions. However, because of the small coil diameter, the region of B1 sensitivity will be effective only in a very small area of the calf muscle. With such small size coil, to fully cover the calf muscles area, a phased-array design would be required, making the hardware complex and expensive. Increasing the CL diameter (dia>2.5 cm) increases the VOI, but the normalized peak B1 field decreases rapidly. On the contrary the FO8 coil of diameter 10 cm exhibits a sharp B1 peak located at some distance (z=5 mm) from the coil plane, and the peak B1 value is larger as compared to the medium-large size (dia>2.5 cm) CL coils. The pronounced A/P spatial selectivity of the FO8 coil with respect to the CL of equal diameter is shown in the scout images of Fig. 2. Typical *in vivo* PRESS spectra obtained at about A/P=22 mm within the human calf are reported in Fig. 3. We observe for both the FO8 and CL coils the presence of two ^{1}H peak components, corresponding to the muscle (peak at 4.7 ppm) and fat (peak at 1.5 ppm) tissues. The normalised area of each ^{1}H peak component (PRESS amplitude) measured along the A/P direction for the FO8 and CL coils is shown in Fig. 4. The PRESS amplitude in the muscle tissue component (Fig. 4A) shows that the FO8 coil allows an higher value (up to a factor 4.5) within a narrow region of width 20 mm and centred at about 12 mm from the coil plane. We also found a more pronounced PRESS amplitude decrease for A/P>20 mm using the FO8 coil, as compared to the CL coil. As shown in Fig. 4B, the signals due to the fat tissues obtained with the FO8 and CL coils are very similar, being localised in a very narrow region (about 10 mm) close to the coil plane.

Conclusions. We have shown that the FO8 coil of diameter 10 cm allows in the calf of volunteers an improved 1H PRESS SNR along the A/P direction within a well localized depth from the surface. These features should be of benefit in clinical MRS studies of human muscle metabolism and also in brain metabolites quantification [1-2].

References. [1] Tofts PS et al, In: Tofts PS, Editor Wiley; 2004. p. 299-339. [2] Meyerspeer M et al, Magn Reson Med 2003;49:620-625. [3] Seton et al, MAGMA 1999; 8:116-120. [4] Alfonsetti M et al, MAGMA 2005;18(2):69-75. [5] Alfonsetti M et al, Meas Sci Technol 2006;17: N53-N59 [6] Alfonsetti M et al, Proceeding ISMRM, Vol. 13, p.2503, Miami, USA, 2005.

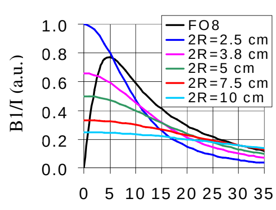

Figure 1. Normalized B1 field distribution along the coil z-axis for circular figure-of-eight (FO8) surface coil (2R=10 cm, 2s=1 cm) design and CL coils with different diameters.

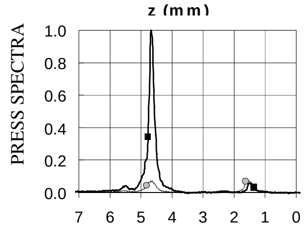

Figure 3. Proton PRESS spectra obtained in the resting calf of a male volunteer with the FO8 (squares) and CL (circles) coils at about 22 mm from the coil plane.

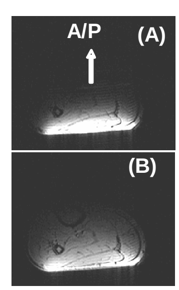

Figure 2. Scout axial images (TE=2 ms; TR=64 ms; flip-angle=30°; slice thickness=5 mm; FOV=15 cm) obtained with the FO8 (A) and CL (B) coils in the resting calf of a male volunteer.

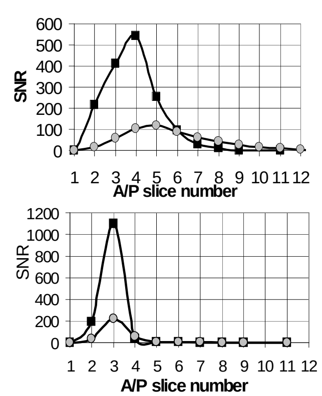

Figure 4. Normalized muscle (A) and fat (B) proton PRESS SNR along the A/P direction measured in the calf of a male volunteer using the FO8 (squares) and CL (circles) RF coils. The RF coil is positioned at A/P=0 mm.