Design of Multi-Elements Transverse Field RF Surface Coils

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Introduction. Several clinical MRI/MRS applications require a careful selection of the RF coil design to optimize the signal-to-noise ratio (SNR) in a particular region of interest (ROI). RF surface coils comprising two centrally positioned current elements, called figure-of-eight (FO8), have been described [1-3]. The FO8 design produces a B_1 field that, in the central region, is substantially a transverse RF field. It was previously found that, for particular geometrical conditions, the two elements FO8 coil shows a higher signal amplitude and a pronounced spatial selectivity, as compared with the standard circular loop coils [4-5].

Aims. We have studied the B_1 field distribution of square RF surface FO8 coils comprising a multitude of linear current elements positioned in the central region. Theoretical and experimental results show that, by carefully selecting the number/relative position of the current elements, it is possible to select a central ROI with improved B_1 spatial homogeneity.

Methods and Results.

The 3D B_1 field of FO8 coils and a square loop (SL) coil was simulated with a FEM software (HFSS, Ansoft). The multi-elements FO8 models comprised a number (n=2, 4 or 6) of parallel current elements centrally positioned at a given distance (2s=6, 10 or 15 mm) each other. As shown in Fig. 1, for the FO8 coils the simulated B_{1x} field component presents, in x-y planes parallel to the coil, a central region of high sensitivity, as compared to the standard SL. In this central region the B_{1x} spatial distribution of the FO8 coil can be optimized by carefully selecting the number and/or the separation of linear elements. In fact, Fig. 1 shows that the extension of the central region of high B_{1x} field increases as the number of linear elements varies from 2 to 6 (for a constant 2s=10 cm). Similar results (not shown) were obtained as the separation 2s increases from 6 to 15 mm for a fixed number (n=4) of current elements. To compare theory and experiments, SL and FO8 prototypes (2L=10 cm) tuned at 64 MHz were built on Plexiglas using adhesive copper strips (width=4 mm, thickness=100 μm) and tested on the workbench using a small pick-up solenoid. The FO8 prototypes matched the simulation dimensions (n=2, 4, 6; 2s=6, 10, 15 mm). Figure 2 shows a FO8 prototype with 6 elements (2s=10 mm).

Figure 3 shows the B_{1x} field distributions for the SL, the FO8 coil with 2 elements (2s=10 mm), and an optimized FO8 coil with 6 elements (2s=6 mm). An excellent agreement between theory and experiments was observed, both along the x and y axis. We note that the optimized FO8 coil shows an homogeneous B_{1x} region (within 20% variation) of about 4 cm. The B_{1x} homogeneity of the FO8 coil with 2 elements was 1 cm only. This B_{1x} homogeneity improvement is associated with a decrease of the maximum B_{1x} amplitude of about 1.6, with respect to the FO8 coil made by 2 elements. However, the maximum B_{1x} of the optimised multi-elements FO8 coil shows a significant improvement (about a factor 2) with respect to the standard SL coil.

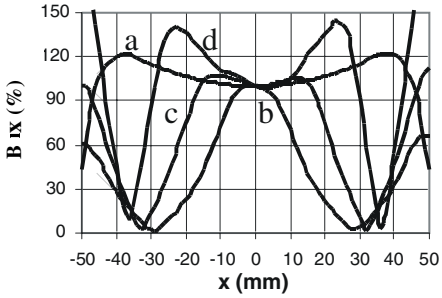

Fig. 1. The normalized simulated B_{1x} distribution along the x direction, at z=8 mm, for: SL coil (a) and FO8 coils with 2 (b), 4 (c) and 6 (d) linear elements at a constant separation 2s=10 mm.

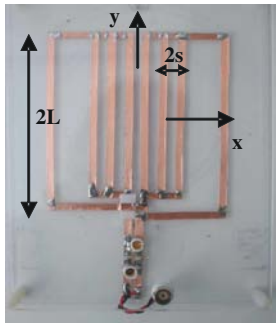

Fig. 2 . A 6-elements FO8 prototype (2L=10cm, 2s=10 mm).

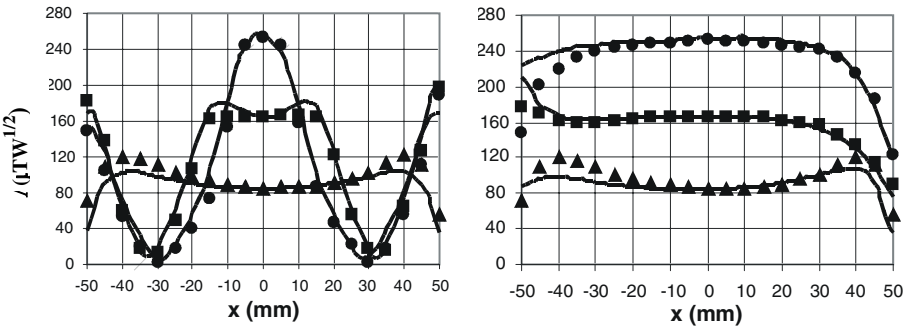

Fig. 3 The simulated (continuous line) and measured (symbol) B_{1x} distribution along the x (left) and y (right) directions (z=8 mm), for the: SL coil (triangles); FO8 coil with 2 elements and 2s=10 mm (circles); FO8 coil with 6 elements and 2s=6 mm (squares). The size of the coils was 2L=10 cm.

Conclusions. We have shown, theoretically and experimentally, that optimized multi-elements FO8 coils allows to select a ROI with better B_{1x} homogeneity. This novel coil design should be useful in clinical applications, as MRI/MRS of muscles and brain.

References. 1. Smith MA et al, MRI 4:455-460, 1986. 2. Seton HC et al, MAGMA 8:116-120, 1999. 3. Alfonsetti M et al., ESMRMB 2003 Proc., p.224. 4. Alfonsetti M et al., MAGMA 18(2):69-75, 2005. 5. Alfonsetti M et al, ISMRM Proc., Miami, USA, 2005, p.2503.