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Relaxation efficiency of cell internalized Gd-HPDO3A

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Introduction: Owing to its superb spatial resolution (< 100 µm), MRI is the technique of choice for cellular tracking. To be visualised, the cells have to be labelled with a suitable probe prior their transplantation. The minimum amount of Imaging Probe to be internalised for allowing cell visualisation is dependent upon its ability to affect the T1 of water protons, which, in principle, may be influenced by its intracellular compartmentalisation. The aim of this study is to compare the relaxing efficiency of a Gd(III)-based agent internalised into a given cell line by pinocytosis (localisation into endosomes) or by electroporation (localisation into cytosol).

Methods: The internalisation of Gd-HPDO3A (ProHance®, Bracco Imaging) into a rat hepatocarcinoma cell line (HTC) was carried out by pinocytosis (the cells were incubated for 16-24 hours in culture media containing the Gd-complex) or by electroporation (an electric pulse is applied to a cell suspension containing the Gd-complex in order to induce the membrane permeation). T1 of water protons were measured on the resulting cellular pellets at 0.5 T and 25°C on a Stelar Spinmaster spectrometer. MR-images were acquired on a Bruker Avance300 spectrometer (7 T) equipped with a Micro 2.5 microimaging probe.

Results: The localization of the imaging probe was assessed by acquiring Confocal Microscopic images of HTC cells labelled with the fluorescent Eu-HPDO3A analog. Interestingly, the relaxation efficiency of Gd-HPDO3A internalised by pinocytosis shows a drastic decrease upon increasing the amount of complex entrapped into endosomes (Figure 1). A significantly higher efficiency was observed for Gd-HPDO3A entrapped by the electroporation route.

The time dependence of longitudinal magnetization has been analyzed according to a theoretical model,[1] allowing the assessment of the residence lifetime of water protons in the various compartments (endosomes, cytosol, extracellular).

Conclusions: The obtained results show that the relaxing efficacy of an imaging probe internalised into cells is dependent on the peculiar internalisation route. When the probe is confined into endosome vesicles, its efficiency can be markedly quenched by the slow exchange of water protons between endosome and cytosol compartments. Conversely, upon entrapment in the cytosolic compartment via the electroporation route, the presence of only one membrane to be crossed makes the internalized agent more efficient for visualising cells by MRI.

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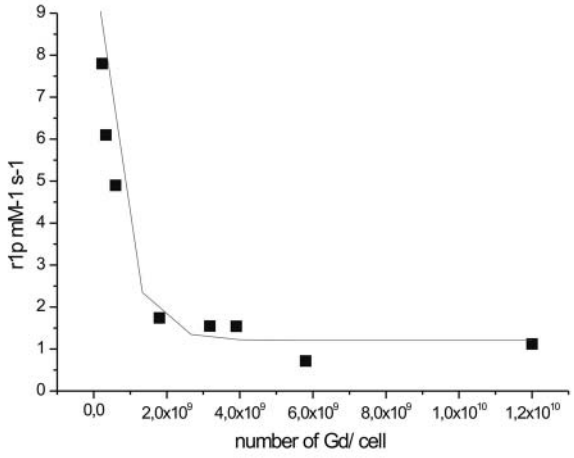

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Multi-loop coil for intravascular MRI

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Introduction: Intravascular single-loop coils could be used for high resolution vessel wall imaging[1,2,3]. However, they suffer from a poor field homogeneity which could be improved by innovative coil designs. Such inhomogeneity is caused by non-radially symmetric magnetic field distributions around the coil. In this study, a catheter-based multi-loop coils were built to improve the homogeneity. The coil architecture is numerically approximated by a fixed number of discrete current elements. Using a computer simulation (Mathimatica™), the position of the elements is optimized to generate maximum radial symmetry of the magnetic field. In-vitro experiments confirm the theoretical suppositions and calculations of the magnetic field distribution.

Methods: Four balloon-mounted coils: single-loop (SL), double-loop (DL), triple-loop (TL) and quadruple-loop (QL) were built. The wires architecture has been achieved by varying the conductors position to search for an optimised coil performance. For each coil, the calculated wires architecture was mounted on a commercial 5 French (1.7mm) angioplasty catheter (inflated balloon diameter 5mm, length 40mm). A second concentric balloon was build on the top of the inner balloon to reduce the motion-arifacts. The imaging double-balloon catheters, which can be inserted through a 10 French (3.3mm) sheath, were constructed in our laboratory.

To assess signal homogeneity and penetration depth, all catheters initially were scanned in a cylindrical phantom containing 1.25 g/l $CuSO_4$ solution. All investigations were carried out in a 1T Siemens scanner. The phantom images were generated using a FLASH sequence with 256*256 matrix, 4mm TS, 60^0 FA and 11/641ms TE/TR.

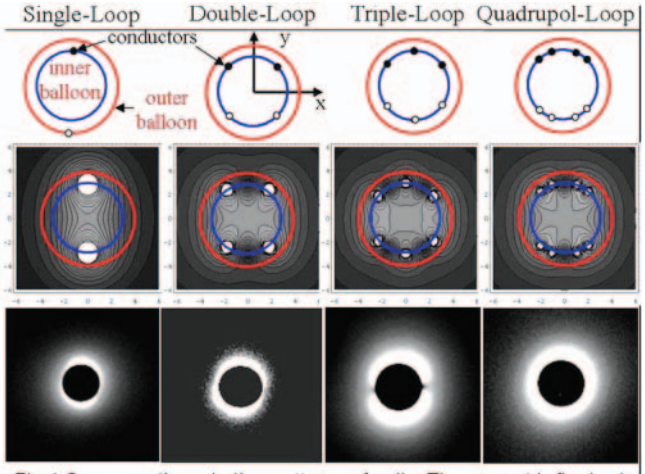

Fig 1:Cross-section winding patterns of coils. The current is flowing in opposing directions and represented symbolically by∘and•(top row). Cross-section field patterns: Mathematica™ simulation results of the four coils (middle row). In-vitro transversal images using four different coils (bottom row).

Results: Using an optimised conductor position for all coils (Fig-1, top-row), the calculation of the magnetic field distribution result in in-homogeneity less then 10% for QL which is about 40% better than SL coil. Fig-1 (middle-row) shows the magnetic-field distribution for each coil, the higher the number of loops the better the field homogeneities. The measured SNR in MRI images of the phantom confirm these results as shown in Fig-1 (bottom-row).

Discussion: We demonstrate that multi-loop coil can be used to improve the radial homogeneity of the MR-signal for a high resolution intravascular wall imaging. The signal variation is reduced as the number of loops increased. Obtained simulations are in good agreement with experimental results. Quadruple-loop coil permits the imaging of longer vessel segments and optimised radial signal homogeneity with less signal reduction.

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A four channel transmit receive microstrip array for 7.05 T

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Introduction: An increased SNR or imaging efficiency over large volumes has been achieved by the development of phased arrays[1]. These arrays have been limited to lower field strength because of more complicated decoupling and the lack of body resonators for homogeneous transmit pulses at higher fields. The recently introduced transmit/receive microstrip array[2,3,4] has demonstrated the possibility of overcoming these limitations. This abstract shows our application of the basic microstrip concept for 7.05T(300MHz). It is shown that there is no substantial coupling between the individual coils, although there is no physical overlap of the coils or additional preamplifier decoupling used.

Methods: The four channel array was built for a proton frequency of 300MHz. The maximum useable inner diameter of the array is 85mm. Each of the single coils is arranged at 0,90,180 and 270 degree positions around the center and has a size of 90mmx75mm(Fig.1,2). The microstrip-coils have a 3mm thick PTFE plate as the dielectric medium between the groundplane and the conductor loop and an additional shielding loop (all made of adhesive-baked copper tape). Decoupling of neighboring coils was achieved with an additional capacitance. A shield trap was added to each coil to prevent cable coupling. The whole array was surrounded by a 80µm thick copper foil. In order to achieve a homogeneous transmit profile, a phase shifter was placed in front of each coil for the correct phasing, and the array was connected to a four way power splitter. The imaging experiments were performed on a single channel 7.05T Bruker Biospec.

Results and Discussion: All four coils could be tuned and matched unloaded and with saturated NaCl-solution. No resonance peak split was observed. The average transmission between neighboring and opposing coils was measured to 29.6 and 18.6dB respectively (Fig. 3). The Q_0/Q_L ratio was 253/88 with a 85mm diameter 6g/l NaCl-solution phantom. Imaging experiments confirmed the good isolation and showed a relatively homogeneous transmit profile (Fig.4,5).

Conclusion: We have shown that for 300MHz the microstrip coil design is an interesting alternative to traditional loop arrays. The advantages of the array are the large usable diameter due to the relatively small thickness of the coils and simple decoupling of the four channels without overlap or active decoupling circuitry.

References:

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Acknowledgements: Funded by the Deutsche Forschungsgemeinschaft(Ha 1232/13-3) and the Alexander v. Humboldt Foundation(Wolfgang Paul Award).

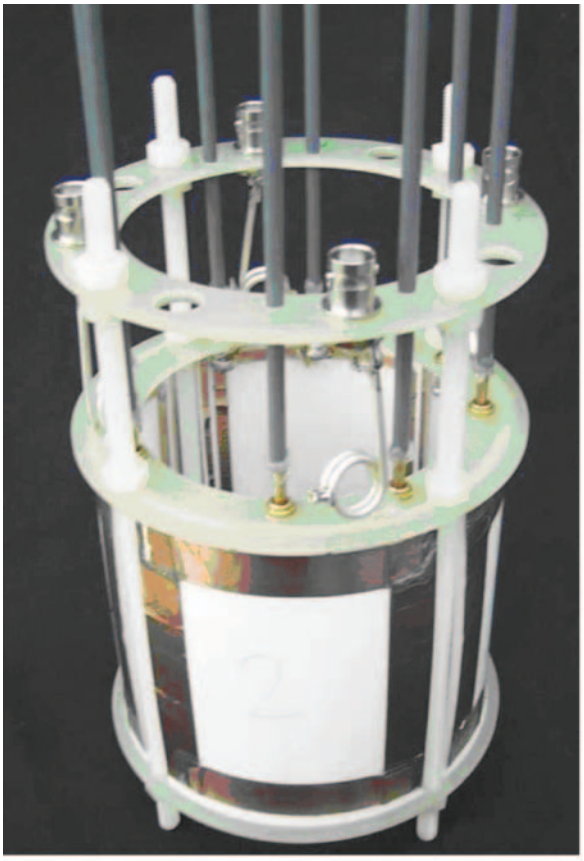

Fig. 1: The 4 channel microstrip array