New array coil for HIP imaging in vertical field systems

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INTRODUCTION

Since the introduction of vertical field systems many RF coils have been developed for kinematic studies of large joints. Open, vertical field systems have the unique geometry to allow for such studies, but are limited in the hip due to the lack of an adequate coil design, largely due to the orientation of the DC magnetic field (in the AP direction). RF coils have to be designed that generate RF magnetic field in the coronal plane of the patient. It is the purpose of this investigation to find a coil geometry that has optimum SNR and sufficient uniformity over the hip joint to perform diagnostic imaging in a vertical 0.7T system

METHOD

A delrin positioning device was developed that would accommodate RF coils to be placed anterior and posterior to the patient's hip. The device consists of 2 rectangular paddles as shown in Fig.1 The 2 paddles are of equal size and have a cavity to house the RF coil array. The top paddle can move vertically with respect to the bottom one, for a maximum of 13 inches. The top paddle is also attached to the 2 poles via a hinge, such that it can be placed at an angle with respect to the bottom. The initial coil design was a combination of 2 perpendicular butterfly coils in the bottom, as well as in the top, as shown in Fig 2. The dimension of each butterfly wing was 2.25 inch by 7 inch with a 1.5 inch separation between the wings. The preliminary results with this coil were somewhat disappointing, so we increased the size to butterflies wings of 3.34 by 10.33 inch with a 1.95 inch separation. All coils had low noise integrated preamplifiers, noise figure 0.35 dB, with low input impedance of about 3 ohms for better decoupling between anterior and posterior halves. Baluns were implemented as well after the preamps to prevent standing waves on the cable shields that would otherwise degrade the Q and cause coupling between upper and lower halve. As can be seen on the circuit diagram in Fig 3, active PIN diode decoupling was implemented on one paddle of each butterfly, as well as a passive blocking network on the second paddle to improve decoupling from the transmit coil during the transmit pulse. The 2 butterflies in the posterior halve had an isolation of < -25 dB via perpendicular positioning of the 2 elements. Similar results were obtained for the anterior halve. Isolation between anterior and posterior halve was depending on the size of the patient, but was always < –15 dB. In areas where the conductors of different coil elements cross, gaps in the copper conductors lowered the parasitic capacitance between the traces as can be seen in Fig 1.

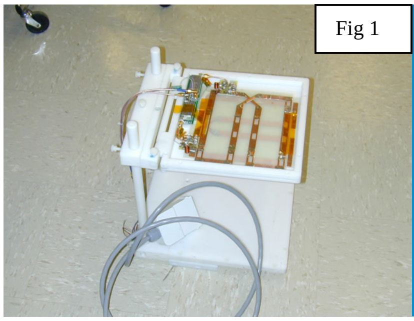
Fig 1

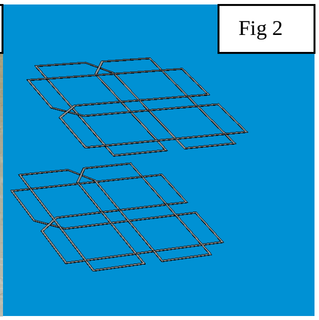
Fig 2

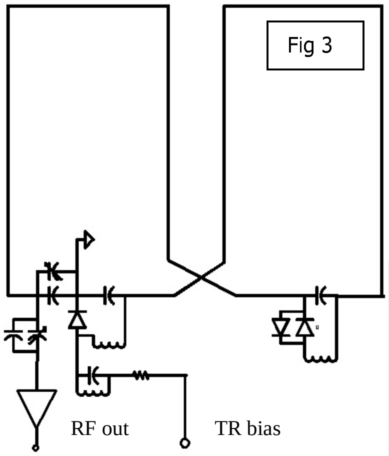
Fig 3

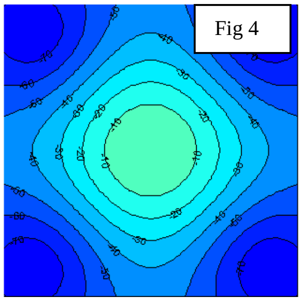
Fig 4

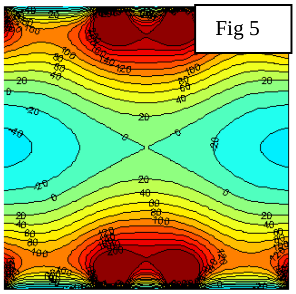
Fig 5

RESULTS

The field profiles in a 20 cm FOV of the bigger coil is shown in Fig 4 for the coronal plane in the center of the large coil, where anterior and posterior halves are separated by 8 inches. Isocontours are in multiples of 10% deviation from center. Fig 5 shows the axial plane, in which again the separation of coil halves is 8 inches, but in this case isocontours are in multiples of 20% deviation of center. It is clear from the coronal plot that there are 4 distinct low sensitivity spots, but they are away from the hip joint (center). The uniformity is good enough over a 10cm FOV to cover the hip joint. Biot Savart has been used for these calculations due to the low frequency of 30 MHz. Fig 6 shows an axial scan through the hip joint with a 24 cm FOV and 4 mm slice thickness. It is a fast recovery FSE sequence with a TR of 4500 and TE of 84 ms, 20 kHz bandwidth, 256^2 matrix with 4 NEX. In Fig 7 we see a coronal scan through the Hip joint. In this case the FOV is 28 cm with a 4 mm slice width. It is a standard spin echo sequence with TR of 567 and TE of 9 ms, bandwidth of 12.5 kHz, 256 by 192 matrix and 3NEX. In the latter we can see that the low sensitivity spots identified in the coronal field plot from fig 3 are not really a problem, since they reside outside the region of interest. Fig. 8 is a sagittal FSE; TR/TE 2667/32 with ETL 13; FOV 19cm^2 with matrix of 320 x 288; 20.8kHz bandwidth; slice 3.5mm/0.2mm gap. Note the presence of a nondisplaced labral tear (arrow).

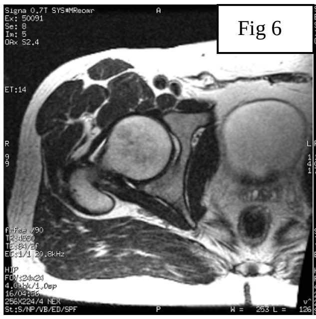
Fig 6


Fig 7


Fig 8

DISCUSSION and CONCLUSION

Increasing recognition of the clinical importance of hip labral and chondral lesions has placed a greater demand on MRI for providing accurate, noninvasive detection, thus preserving arthroscopy as a therapeutic tool. Reproducible detection of these lesions requires an in plane resolution of less than 600µ, which was not achievable with standardized body flex coil designs, but is achievable with this new coil design. Additional study of hip rotation will allow for assessment of the mobility of these flap tears and additional capsular abnormalities.