An Array Structure for Improved Endoanal Imaging

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Introduction: In MR imaging, the use of endocavitary receiver coils greatly improves the signal to noise ratio (SNR) of the area of interest and allows high-resolution images to be obtained. This has led to the development of endoanal coils [1-4] to assess morphological and functional disorders of the anal sphincter with specific applications in complex perirectal sepsis, faecal incontinence and congenital anomalies. These internal coil techniques are still in their infancy but are moving to become routine investigations because they provide invaluable diagnostic information in disorders of the anorectum and pelvic floor.

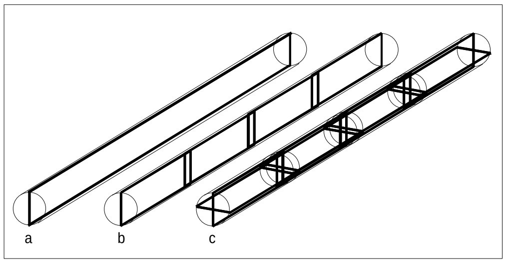

Fig.1 Endoanal coil structures

In order to cover the superior-inferior extent of the anal sphincter, a 10cm length of coil is required while a maximum coil diameter of 11mm ensures that there is no significant sphincter distension that might obscure pathology. These requirements and the limitation to a single channel machine, resulted in an extended-loop coil design (fig.1a) [1]. Such a design is inevitably a compromise, anatomical constraints taking precedence. The coil length is dictated by the field of view along the coil major axis, whilst optimal SNR at a typical ROI would suggest much smaller axial dimensions. We have investigated the SNR performance as a function of coil length. This suggested that an array of shorter elements should out-perform the existing 100mm single-element design. This approach has been demonstrated previously in the design of a prostate array coil [4].

Materials and Methods: Four 11x27mm rectangular loop coils were constructed from 1mm diameter copper wire (fig.1b). Each coil produced a loaded Q of ~150 when tuned to 63.7 MHz. Mutual inductance between adjacent neighbours was eliminated with an overlap of 2.5mm. The mutual coupling between next-nearest neighbours was found to be negligible with this geometry. The coils are set into 1x1mm slots machined into the surface of a 12mm diameter Delrin ™ rod. Each coil incorporates an actively-switched detuning circuit and is matched to a 50 ohm output impedance.

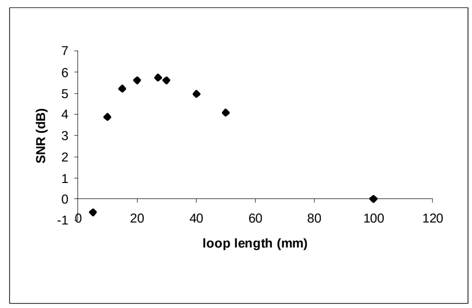

Fig.2 SNR v loop length

Results: Fig.2 shows the SNR at a distance of 15mm normal to the mid-point of the coil plane, obtained by Biot-Savart simulation assuming typical loading conditions, as a function of loop length. Bench measurement confirmed that an 11x30mm loop achieves >5db SNR gain over an 11x100mm loop. Fig.3a shows the transverse field uniformity produced by an extended loop coil, whilst Fig.3b demonstrates the improvement in field symmetry achieved by adding a second, orthogonal loop as shown in Fig.1c.

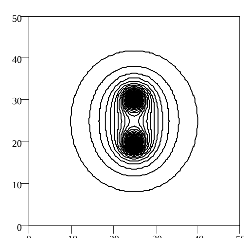
Fig.3a

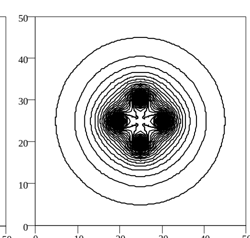
Fig.3b

Conclusions: As anticipated, the single channel extended loop loses efficiency as the length/diameter ratio increases. Using an anatomically prescribed diameter of 11mm, we have demonstrated, by simulation and direct measurement, that optimum SNR is achieved with loop lengths in the range 20-30mm.A practical array coil design, using 4, 11x27mm loops achieved a >5dB SNR gain over an existing 11x100mm single loop design. As well as eliminating nearest neighbour mutual inductance, adjacent coil overlap has the additional benefit of avoiding signal nulls in the y-z plane by ensuring a net y component of rf flux at all points. The number of coils may be extended by the addition of a similar array placed symmetrically, at 90° relative to the first, exploiting the intrinsic decoupling of this structure. The additional orthogonal array may be used to improve both SNR and the uniformity for proton imaging, or may be tuned to another frequency for spectroscopy/imaging without compromise to the original four-element structure.

References:

1. deSouza NM, Puni RK, Gilderdale DJ, Bydder GM. Magnetic resonance imaging of the anal sphincter using an internal coil. Magnet Res. Quart. 11; pp45-56; **1995**
2. Hussain SM, Stoker J, Kilper JW, Schouten WR, den Hollander JC, Lameris JC. MR imaging of the anal sphincter complex with an endoanal coil- normal anatomy. Radiology 197; pp671-677; **1995**
3. deSouza NM, Gilderdale DJ, Puni RK, Coutts GA, Young IR. A solid re-useable endorectal receiver coil for magnetic resonance imaging of the prostate: design, use and comparison with an inflatable endorectal coil. Proc. 3rd meeting, SMR, Nice, France, p187; **1995**
4. Gilderdale DJ, Coutts GA, deSouza NM. Design and development of an Endorectal Array Receiver Coil. Proc. 5th Sci. Mtg, ISMRM, Vancouver, BC, Canada; p1509; **1997**