A catheter-mounted magnetic resonance detector coil for biliary imaging: first in vitro images

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Background

Biliary strictures are a common digestive limitation. The incidence of biliary-epithelial carcinoma (CEC) is rising globally. CC has increased to become the commonest cause of death from a primary liver cancer in the UK. Despite advances in CT & MR technology, the current classification of biliary stricture type and location remains often difficult. This is particularly an issue in patients with primary sclerosing cholangitis, the commonest known predisposing factor for CEC. Even ERCP with brush cytology has a low sensitivity for neoplastic alteration. Traditional MR systems have an external detector to detect the signal into the scanner. However, the strength of the radio frequency signal and its phase is often found to be decoupled due to inhomogeneities.

A MR system in which the detection radio coil is closely apposed to the tissue of interest could improve the resolution of the images obtained and offer the ability to study tissue metabolism in vivo using MR spectroscopy (MRS). Our group has developed a prototype version of such a coil, designed such that it could be inserted into the biliary tree via an endoscope to improve tissue conspicuity.

Method

Images were acquired using a 1.5T GE Sigma scanner, using the main coil for excitation and the wrap-around microcoil probe for detection.

The imaging parameters for these experiments are described in Table 1.

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Experiment 1 – resolution testing

Scanning a resolution test sample produced images showing entire 10mm deep cuvettes, together with a similar depth of water phantom. Within the cuvette, the nylon bolt can be clearly seen. Resolution is adequate to discriminate individual bolts on the bolt (Figure 4).

Experiment 2 – uniformity testing

Figure 5b shows a sagittal view of the microcoil. The central dark area represents the RF coil. The signal is highly uniform along the length of the coil. Uniformity is apparent in the early images, where the coil is connected to the support. Two small defects can also be seen along the length of the coil, due to the lead conductors. These are either material artefacts or represent coil reception pattern. These defects cannot be seen running vertically, together with the support rod and co-axial wire.

Experiment 3 – ex vivo liver imaging

Imaging of porcine biliary tree revealed anatomical detail to a radius of more than 1.5cm, 360° along the length of the coil. Degradation is apparent in the early images, due to the coil conductors. These are sometimes seen running vertically, together with the support rod and co-axial wire. Branching bile ducts and blood vessels can be visualised in the images obtained.

Conclusion

The MR probe developed by our group can reliably produce images of a resolution of less than 1mm and field uniformity is excellent. The probe can demonstrate anatomical detail in meatal models. It is waterproof. Further work to enhance the utility of the probe is required, but the clinical and research potential is substantial.

Further microcoil projects

- Magnets project from 1.5T to 3T scanner
- Add magnetic resonance spectroscopy capability
- ‘Ex-vivo imaging of diseased central bile’
- Woodchuck, veterinary specimen
- Linkage of imaging, histological and cytological findings
- Integration of non magnetic duodenoscope (built)

References


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