A multi-coil multi-sample coil array for MR microscopy at 7T: Application to Mouse embryo development.

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Introduction. The mouse is the mammalian model of choice for the exploration of the molecular basis of disease and development. Manipulation of the mouse genome can result in unexpected phenotypic expression since multiple anatomic and developmental changes may result from a single genotypic change. Many phenotypes in development result in death of the mouse embryo prior to birth upon which the embryo is reabsorbed or aborted. MR microscopy can be used for screening fixed mouse specimens but the large number of specimens in the screen can prove a limitation due to scanner throughput.(1) It has been standard practice to reduce the time required for imaging multiple specimens by using a sufficiently large RF coil and imaging several animals at once. The time efficiency comes at a cost of signal-to-noise ratio per unit volume (SNRpuv) and optimal filling factor of the sample, the individual animal. Since SNRpuv varies inversely with the volume of the RF coil, signal strength can be substantially increased by reducing the coil size to that of the sample of interest. We developed a 4-coil RF array for imaging mouse embryos, which is designed to be used in parallel or serial image acquisition modes on a NMR spectrometer equipped with imaging gradients. The rationale for this design maintains a flexible acquisition system which may easily adapt to the demands of the imaging protocol.

Methods. The 4-coil probe and acquisition apparatus was developed on a Bruker Avance 7T/89 mm wide-bore spectrometer with imaging gradients (Bruker Instruments, Billerica MA, USA). The multi-coil imaging probe contains 4 Alderman-Grant volume coils of 5.2 mm inner diameter and 11 mm in length placed at the vertices of a square 3 cm on edge, and is built on a standard narrow bore NMR probe body. The probe can be operated in either a parallel mode using multiple receivers or with a GaAs and PIN Diode switching unit to move transmit and receive signal pathways between selected coils.(2) Individual TR switches and separate preamps are used to maintain channel isolation (> 60 dB) and signal quality in both operational modes. Imaging methods used a standard gradient echo sequence and standard multi-slice, multi-package features of the control software. A gating TTL pulse controls the diode switch for each imaging slice advance when using the array in serial mode. In parallel mode, no such switch advance is needed since the switches are all pass.

Results. We obtained comparable SNRpuv 2D and 3D images to single coil techniques with 4 times increased specimen throughput using standard gradient-echo and spin-echo techniques. Figure 1A shows single plane large FOV taken in parallel mode. Figure 1B shows a representative slice from a 3D data set from one sample (8.5 day mouse embryo) in one coil. Figure 1B data was taken on a single transmit, single receiver channel NMR system, in serial mode. (Analogous to multi-slice methods in serial mode acquires data on one coil per phase encode or NEX.)

Conclusions. We have developed a multi-sample multi-coil array RF coil capable of handling four embryos. The system can operate in parallel or serial mode and operates with multi-receiver spectrometers in parallel mode. The transmitted RF and received MR signal pathways allow variable gain in transmission and reception on each coil to allow for differences in coil performance due to sample variations. The flexibility of this design enables the experimenter to determine the optimal configuration for the imaging protocol at hand.

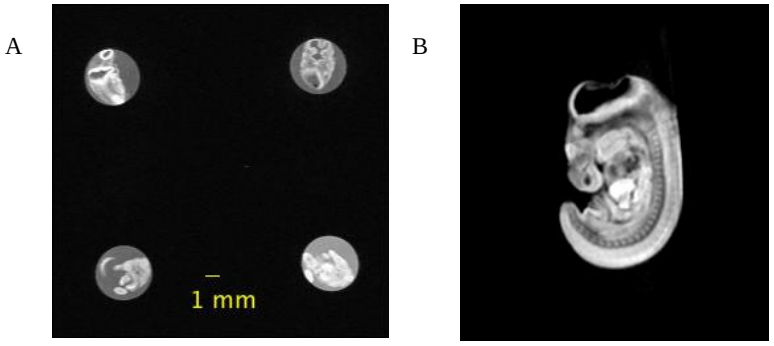

Figure 1. (A) A scout gradient echo image (TR/TE = 5/50 ms, Flip angle = 30 degrees, FOV = 4 cm) showing the arrangement the 4 coils arranged in the multi-coil probe. (B) A single mid-sagittal slice of a 3D 1024x512x512 data set over a FOV of 30 mm x 20 mm x 20 mm. The resolution of the image is 30 microns acquired using a 3D RARE with 4 echoes. The specimen is suspended in Fomblin™ (Solvay Solexis Inc., Thorofare NJ, USA), to reduce magnetic susceptibility distortions and highlight optimal internal contrast.

References.

1. N.A. Bock, N.B. Konyer, R.M. Henkelman, "Multiple-Mouse MRI",Magnetic Resonance in Medicine **49** (2003) 158-167.

2. H.D. Morris, A. S. Chesnick, "Strategies for multi-sample MR imaging: Applications to Mouse Phenotyping via MRI", Proceedings of the ISMRM **9** (2001) 201.