# In-Vivo Multiple Mouse MRI using Parallel Receive-Only Coils on a 3.0 T Clinical Scanner for Molecular Imaging Research

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**Introduction:** In-vivo multiple mouse MRI (MMMRI) has the potential to accelerate the development and preclinical testing of novel molecular imaging agents for the diagnosis and monitoring of cancer in patients. Clinical scanners have been used effectively to image mice in preclinical research, and its use facilitates easy translation of imaging protocols to clinical research. With their large volume of homogenous magnetic field, clinical scanners can also provide a suitable platform for MMMRI without the need for software or hardware modifications when equipped with parallel imaging capabilities. Clinical scanners are now available with up to 16 parallel receiver channels and soon up to 32 channels, providing the potential for up to a 32-fold increase in mouse imaging throughput. One way to realize this potential is to utilize a parallel receiver coil array comprised of multiple close-fitting coils around each mouse. [1] A multiple mouse handling and support system which reduces stress on the animals and shortens the preparation time is equally important for increased throughput[2] in dynamic MRI, targeted contrast screening and longitudinal studies. We report here the construction and performance of a 2-coil and 4-coil MMMRI parallel coil array for simultaneously imaging two and four mice in a 3.0 T clinical scanner along with an animal support system using non-conducting leads to eliminate RF interference for in-vivo imaging. A dual mouse MRA dynamic imaging with a G6 dendrimer agent is shown to demonstrate the system.

**Methods:** Each identical coil element was built using a simplified split-half turn (SHT) saddle coil design[3], a modification of the Alderman-Grant resonator, constructed with 1/8" 3M copper foil tape on a 38 mm OD cylindrical acrylic tube with an optimal size for full mouse imaging (77 mm length). Coupling between receiver elements was reduced by lowering the impedance measured at the end of each ¼ wavelength transmission line to 10 ohm. The coil elements were mounted in a plastic housing with holes spaced 48.3 mm apart in to make a horizontal 2-coil and a square 4-coil array (Figure 1). Coupling between coils is minimized by rotating adjacent elements by 90º. Each element was tuned to the frequency of the scanner (127.8 MHz) with a load in place. When used for in-vivo mouse imaging, the coils are tuned with a representative mouse load once and used without further adjustments. Anesthesia was applied either by IP injection, or using an isoflurane gas vaporizer through a 6-way flow splitter and vacuum scavenger. The mouse platforms were equipped with individual respiratory sensor pads and fiberoptic temperature sensors (FISO Technologies, Quebec) which were interfaced to an MP150 acquisition unit (Biopac, Goleta, CA) with multiple differential transducers and amplifiers units. Heating was provided by circulating heated Fluorinert FC-77 (3M, St. Paul, MN) through tubing wrapped around the coils. Gd-dendrimer contrast agents were administered through tail IV injection at a dose of 0.05 mmole/kg either manually or with a PHD-2000 multiple-syringe injector (Harvard Apparatus, Boston, MA).

Imaging was performed on a Philips Intera 3.0 T clinical scanner (Philips Medical Systems, Best, The Netherlands). Relative sensitivity and element isolation of the 2-coil and 4-coil arrays were measured from 2D T1-weighed FFE images on Gd-doped water phantoms. SENSE performance of the 4-coil array was measured on fixed mice and Gd-doped water phantom with T1-weighed 2D and 3D FFE sequence (TR 8.9 ms, TE 2.8 ms, FA 30º, FOV 8.0x 4.0cm, MTX 512x326, scan 50%, ST 0.6 mm, 256 overcontiguous slices, SENSE S3, NSA 1, scan time 2:18 min) The same 3D sequence without SENSE (84 overcontiguous slices, 1:45min/shot) was run every 2 min in the simultaneous dynamic contrast enhanced MRA on two live mice.

2-coil mouse array | 4-coil mouse array | 4-coil array internal | Slices from 3D T1-weighed FFE with 4-coil array

Figure 1. The 2-coil and 4-coil receive-only mouse arrays and slices from an artifact-free 3D SENSE (P1xS3) reconstruction.

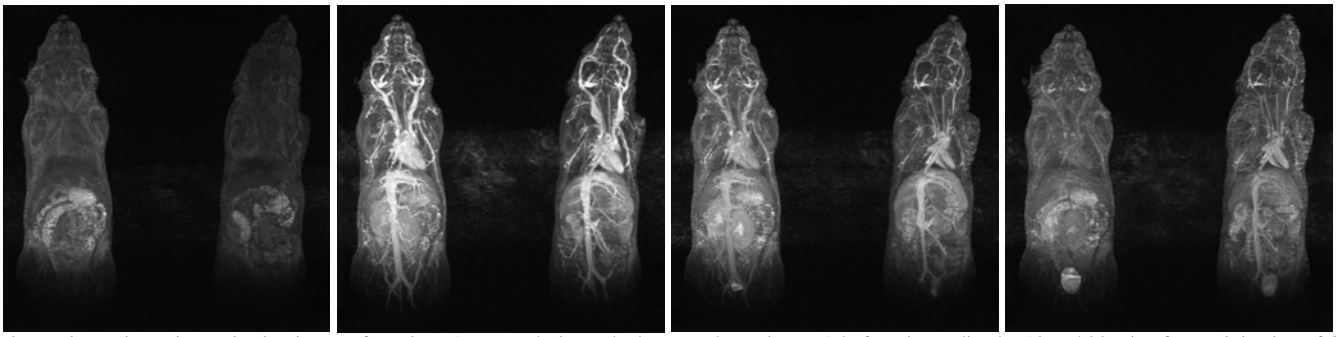

Figure 2. Maximum intensity projection images from 3D T1W FFE during a dual mouse dynamic MRA before, immediately, 10 and 20 min after IV injection of G4 (left) and G6 (right) dendrimer agent showing different distribution and clearance rates.

**Results and Discussions:** Images of Gd-doped water phantom obtained from each coil showed a relative signal to noise ratio (SNR) of 0.80 in the 2-coil array, and 0.76 in the 4-coil compared to images from an isolated coil. This translates to a factor of 1.79 and 3.45 increased imaging throughput for the 2-coil and 4-coil arrays, respectively, in order to obtain the same SNR as in the single coil image. The isolation between elements in the 2-coil array was -17 to -24 dB while those for the 4-coil array were slightly reduced at -14 to -20 dB between adjacent coils and -8 to -14 dB between diagonal elements. To prevent ghosting, it is necessary to increase FOV and matrix size when imaging multiple mice versus single mice resulting in longer scan times. To maintain the same temporal resolution as in the single mouse, SENSE can be used to reduce the phase and slice encoding steps or the NSA can be reduced. Figure 1 shows slices from a 3D T1-weighed FFE acquire with SENSE factor of 3 in the slice direction. Dynamic MRA acquired with the 2-coil array (Figure 2) with NSA of 1 demonstrates performance that closely matches that of a single mouse coil with NSA of 2. Further improvement in temporal resolution can be achieved with SENSE but the effect of motion artifacts is yet to be determined.

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