# 3D-Orthogonal Phased Array Coil for High-Resolution and Low-distortion EPI Imaging of Monkey Brain at 3.0T

**Z. You[1], W. E. Kwok[1,2], M. Mukherjee[2], and M. Mancarella[3]**

[1]Department of Imaging Sciences, University of Rochester, Rochester, NY, United States, [2]Rochester Center for Brain Imaging, University of Rochester, Rochester, NY, United States, [3]Center for Visual Science, University of Rochester, Rochester, NY, United States

## Introduction

MR imaging of monkey brain are useful for modeling studies of diseases such as Parkinson's disease, AIDS and stroke [1], and for the better understanding of brain development [2] and brain functioning [3]. Due to the small size of monkey brain, high image spatial resolution is needed. Human used RF coils such as head coils and knee coils have large volume, and the signal-to-noise (SNR) may not support the desirable resolution for monkey brain imaging. Moreover, their coil geometry may prevent the use of stereotaxic needed in some studies. Single channel loop surface coils have been used to image monkey brain, but their signal coverage may be limited. Though there are dedicated coils for imaging monkey brain, such as in reference [4], the coil size is relative large and it may not provide the optimal SNR. Furthermore, the above coils may not be compatible with parallel imaging which is useful for EPI imaging to reduce susceptibility induced image distortion artifacts [5]. This aspect is especially important for fMRI, diffusion weighted imaging and DTI. The objective of this study is to design and construct a dedicated phased array receiver coil to provide high and uniform signal for monkey brain MRI, and to enable parallel imaging to provide EPI imaging with low distortion.

## Methods

The study was conducted on a Siemens Trio 3.0T whole body MR scanner. This dedicated phased array receiver coil for imaging the brain of rhesus monkey is hemispherical in shape, 11.5cm in inner diameter and 5.0cm in effective height, and is conveniently placed over the monkey head. It consists of 2 volume saddle coil elements and one circular loop coil element (Fig. 1a-c). The 3 coil elements are combined as in Fig. 1d. The saddle elements 1, 2 are concentric to the loop element, and so they are orthogonal to the loop element. The middle parts of the two saddle elements are put orthogonally. Therefore, the 3 elements in this volume coil are orthogonal to each other making it a 3D-orthogonal construction, and coupling among them can in theory be minimized to zero. In this design, the isolation between any 2 elements is better than -25dB without low-impedance preamplifiers. Each of the 2 saddle elements has a circular hole 5cm in diameter at the center top to allow for stereotaxic device attached to the monkey skull. The coil design with the hole also reduces the signal intensity at the center top providing a more uniform overall signal. Each coil element was constructed using 14-gauge copper wire. A 4 year-old rhesus monkey (4.1kg) was imaged under isoflurane anesthesia (Fig. 1e). Anatomic images were acquired using turbo spin-echo sequence. Diffusion-weighted images were obtained using single-shot EPI with b-values of 0 and 500, and GRAPPA with acceleration factor of 2 was also used to evaluate the compatibility of the coil with parallel imaging.

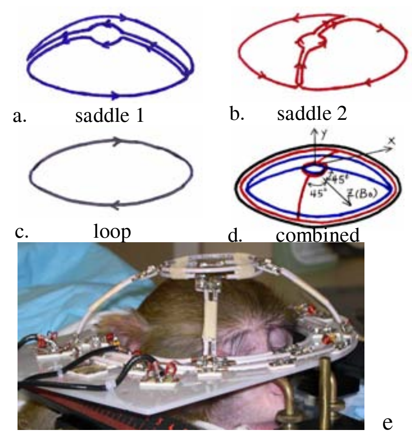



Figure 1. Diagrams and photo of the coil

## Results

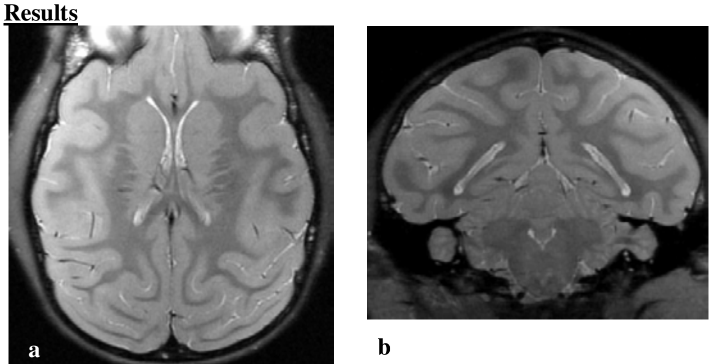
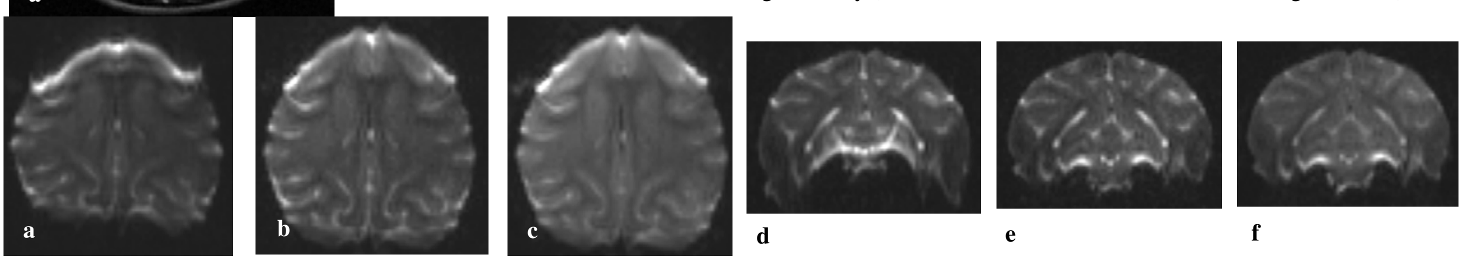



Figure 2. (Left) Axial (a) and coronal (b) high-resolution anatomical images obtained using turbo spin echo sequence with FOV 9cm, matrix 256x256, slice thickness 0.8mm, TR 4760ms, TE 12ms, turbo factor 15, 2 averages and 3:44 minutes. Detailed brain structures are observed in these images.

Figure 3. (Below) Axial and coronal EPI images obtained with FOV 12cm, matrix 128x128, slice thickness 2mm, TR 2900ms, and (a,d) no GRAPPA with minimum TE of 135ms, (b,e) GRAPPA and TE 135ms, and (c,f) GRAPPA with minimum TE of 90ms. Image distortion is significantly reduced using GRAPPA. By using the shorter TE allowed in GRAPPA imaging, signal in white and grey matters increase significantly (note the lower observable noise in those regions in c,f).




## Discussion & Conclusion

We have developed a dedicated phased array receiver coil for monkey brain imaging. It provides high and uniform signal to support high-resolution imaging. It is also compatible with parallel imaging which reduces susceptibility induced image distortion and reduces minimum TE in EPI. This is particularly important for fMRI, DWI and DTI studies. The new coil should be useful for monkey brain modeling studies of diseases, brain development and brain functioning. Its novel 3D orthogonal coil design leads to very low coupling among the coil elements. In addition, this design provides significant phase difference in the signals of the 3 coil elements, which is advantageous for parallel imaging [6]. This design concept may be adapted to human breast coils for horizontal field systems and human head coils for vertical field systems.

**References**

1. Lentz MR, et al. Radiology. 2005;235:461-468.. 2. Smirnakis SM et al. Nature. 2005;435:300-307. 3. Paton JJ, et al. Nature. 2006;439:865-870.
4. Bogdanov G, et al. ISMRM 2004, p1562. 5. Preibisch c, et al. Neuroimage. 2003;19:412-421. 6. Weiger M, et al. Magn Reson Med 2001;45:495-504.