A 12-Channel Neurovascular Coil for Parallel Imaging and Spectroscopy Imaging Applications at 3.0 Tesla

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Synopsis: The development of high field MRI systems allows parallel imaging applications to take advantage of the higher intrinsic SNR and lower geometry factor (g) provided by the higher magnetic field strength [1]. However, designers who work on high field RF array coil designs often meet new challenges, for examples, imaging inhomogeneity due to dielectric/wavelength effect, stronger coupling between a coil element and its environments, components heating issues, etc… In this paper we present a 12-channel head-neck-spine-cardiac array coil that has overcome these obstacles and provided high quality neurovascular parallel imaging and spectroscopy imaging applications at 3.0 Tesla.

Introduction: A RF coil design that has been well tested and proven to be successful at 1.5T may find itself not appropriate when being used on 3.0T MRI systems. Image shading often occurs to a RF array coil due to increasingly significant dielectric/wavelength effect at 3.0T. Coil elements couple more strongly to their environments, for examples, RF cables, DC lines, circuit boards, etc., at 3.0T than do they at 1.5T. In addition, heating problem associated with coil decoupling circuitries and cables also become more severe at 3.0T. These make the design of a 3.0T RF coil, especially, a multi-functional comprehensive array coil, more challenging. In this paper, we present a new three-section, 3.0T, 12-channel neurvascular (NV) coil that provides high quality head, neck/c-spine, vascular from the circle of Willis to the aortic arch and single-channel spectroscopy imaging applications. The 3.0T 12-channel NV also makes parallel imaging feasible for all the imaging modes except the single-channel spectroscopy mode.

Methods and Materials: The 3.0T 12-channel NV coil, as shown in Fig. 1, consists of three sections: head, anterior neck-torso and posterior neck-torso sections. Eight shaped loop coils are distributed along the outer circumference of a head coil former. The adjustable anterior neck-torso section has two loop coils with its neck portion being a flexible piece and wrapping around the anterior neck of a human. A similar design, i.e., two loop coils with their neck section wrapping around posterior neck, is also used for the posterior neck-torso coil. Both geometric overlap and preamplifier decoupling are used to isolate the adjacent coil elements. The isolation for the next nearest neighbor coils and the coils facing each other is solely depended on preamplifier decoupling. Although the twelve coil elements of the NV coil can be used simultaneously as twelve individual channels on a 16-channel MRI system, it is designed primarily for a 3.0T 8-channel MRI scanner and to operate in three imaging modes: head, full FOV vascular and single-channel spectroscopy modes. For the head mode, the eight head loop coils are selected while the four torso coil elements being turned off using active decoupling circuitries. In order to use all the twelve coil elements of the NV coil to optimize its performance for full FOV vascular imaging, the eight head coil elements, with each of their next nearest neighbor coil pair being combined through a quadrature (QD) combiner, are first converted into four QD output channels. This combining scheme, i.e., 90^o combine of the next nearest neighbor coil elements, provides the best SNR and uniformity for head imaging with the four combined channels without sacrificing parallel imaging capability. The four QD-combined head channels plus the four torso channels forming eight outputs for the full FOV imaging mode. The four QD-combined head channels can be further combined through two 45^o combiners and then through another 180^o combiner to become a single output channel for spectroscopy imaging of head. In addition, the position of the anterior torso coil can be adjusted to allow the anterior torso coil to image the heart. Volunteer images were obtained using the 3.0T 12-channel NV coil on a GE Excite II 3.0T 8-channel MRI scanner.

Results and Discussions: Figure 2 shows a T_2-weighted axial head image obtained with FSE sequence (TR=5000 ms, TE=81.3 ms, FOV=22 cm x 22 cm, slice thickness=5 mm, matrix=512 x 512 and NEX=1). Figures 3, 4 and 5 show, respectively, a T_2-weighted sagittal neck/c-spine image with fat saturation, a 2D TOF carotid image and a high-resolution 3D TOF carotid image. ASSET images with reduction factor of 2 for a diffusion-weighted head image (with phase encoding in the anterior-posterior direction) and a 3D TOF angiographic image (with phase encoding in the left-right direction) are also illustrated in Figure 6 and 7, respectively.

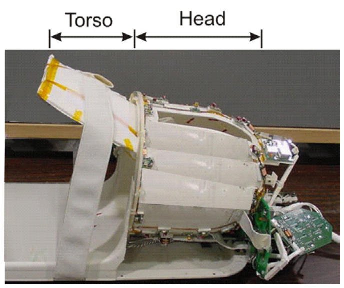

Fig. 1. The 3.0T 12-channel NV coil.

Fig. 2. 512x512 resolution.

Fig. 3. Neck image w/ FatSat.

Fig. 4. 2D TOF carotid.

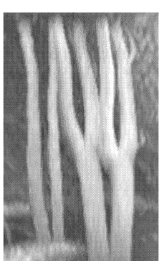

Fig. 5. Hi-Res. 3D TOF carotid.

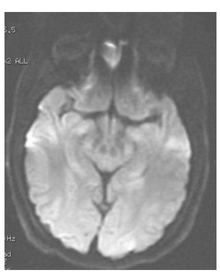

Fig. 6. ASSET w/ R=2 DWI.

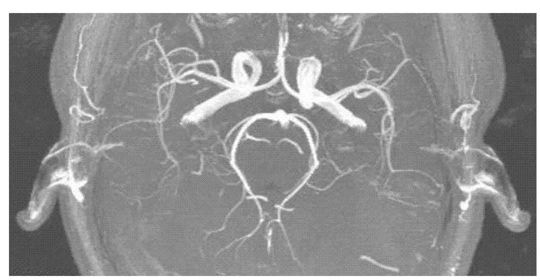

Fig. 7. ASSET w/ R=2 3D TOF image.

Conclusions: The 3.0T 12-channel NV coil, with an improved neck section, has shown its potential of producing high quality head, neck/c-spine and vascular images and also demonstrated its parallel imaging capability in both the anterior-posterior and left-right directions. The adjustable anterior torso coil provides an additional option for cardiac imaging. The optimal performance of the 3.0T 12-channel NV coil can be revealed when it is used on a 16-channel MRI scanner.

References:

1. Wiesinger, F., et. al., Proc. 12th ISMRM, p323, 2004.

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