A New Designed 36-Channel Neurovascular Coil at 3T

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Introduction: Multi-element neurovascular coils are preferred clinically in commercial MR systems due to their large coverage, high signal noise ratio (SNR) and capability of parallel imaging. Using a 3.0T whole body MR scanner, 8-channelcarotid coil [1], 8-channel birdcage-like head coil and 16-channel neurovascular (NV) coil are available for neurovascular imaging. However, the longitudinal coverage of 8-channel carotid coil is limited to extracranial carotid artery territories and 8-channel head coil is only suitable to image the intracranial vascular beds. Although the 16-channel NV coil is designed to cover both intracranial and extracranial carotid circulations, its SNR is not high enough for high resolution vessel wall imaging, particularly the extracranial carotid territories. In this study, we sought to design and construct a 36-channel neurovascular coil with a wide longitudinal coverage from the top of the head through the upper torso with dedicated extracranial carotid elements.

Methods: ***Coil Design***: In order to obtain a wide coverage and high SNR, the coil was constructed on an anatomically shaped former composed of three parts (Fig.1): a large posterior head-nape-back part with 23 channels, a pair of carotid parts with 8 channels, and an anterior neck-chest part with 5 channels. Of note, this coil has 36 coil elements, but our MRI system (Philips Achieva 3.0T TX, Best) only provides 32 receive channels. As such, we added four switches between some top head elements and nape elements. The switches automatically select the right elements to work in 3 different coil modes which are software selectable: 1) independent 16 channel head coil (mode 1, 16 elements covering the brain are activated). 2) carotid coil (mode 2, 12 elements around the neck are activated). 3) neurovascular coil (mode 3, all elements work except the 8 elements at the top head are activated). We applied a special structure that the overlap along the longitudinal direction was made greater than the overlap required to cancel the mutual inductance for the carotid part to minimize the valley in signal peaks [1]. Beyond that, all nearest neighbor decoupling was obtained with critical overlap where possible and next-nearest neighbors were decoupled using preamplifier decoupling [2] using very low impedance amplifiers. The coil design process includes the following steps: step 1: we made a dummy for the upper part of human body. In order to make the coil fit most of human subjects, we made the dummy a little bigger than the standard size; step 2: produced a clingy cover for the dummy with thin PVC foil and past the copper ribbon on the outer side of the cover; step 3: found the optimal overlap between neighbor coils and tuned all coils; and step 4: installed and adjusted the preamplifier decoupling circuit. ***Phantom Studies:*** SNR comparison with the clinical 16-channel NV coil, 8-channel carotid coil and 8-channel head coil was performed using a standard SNR testing sequence at our 3T MR imaging system. T1-weighted spin echo MR images (TR/TE/α=400ms/20ms/90°, SL=2mm, FOV=350mm×350mm) were acquired for a head-neck phantom. ***In Vivo Studies:*** Three acquisitions were performed on 3 volunteers with 8-channel carotid coil, 16-channel NV coil and 36-channel NV home-made coil respectively for comparison, including 3-station TOF covering from aorta to brain vessel, cross-sectional black-blood QIR 2D T1w images for extracranial carotid artery [3], and 3D **M**otion-sensitive Driven **E**quilibrium Prepared **R**apid **G**radient **E**cho (MERGE) covering the extracranial and intracranial carotid arteries [4].

Fig.1: three parts of 36ch NV coil (A) and the final appearance of the whole coil (B)

Results: In phantom studies, the new 36-channel coil showed 10% higher SNR than that of 8-channel head coil in the head region (714 vs. 654), on average 4 times higher SNR than that of 16-channel NV coil (772 vs. 158) and almost the same SNR as that of the 8-channel carotid coil in the neck region (751 vs. 772). In volunteer studies, 3-station TOF image (Fig.2) demonstrated the large coverage capability of this coil. Cross-sectional black-blood QIR 2D images acquired by 36-channel NV coil showed much higher SNR than the same acquisition by 16-channel NV coil (Fig.3) benefited from the dedicated carotid parts of the new coil. Large coverage 3DMERGE images acquired by new developed coil showed higher SNR and better delineation of carotid artery as compared to 8-channel carotid coil, especially in the distal internal carotid artery and intracranial carotid artery (refer to the red circle region of Fig.4).

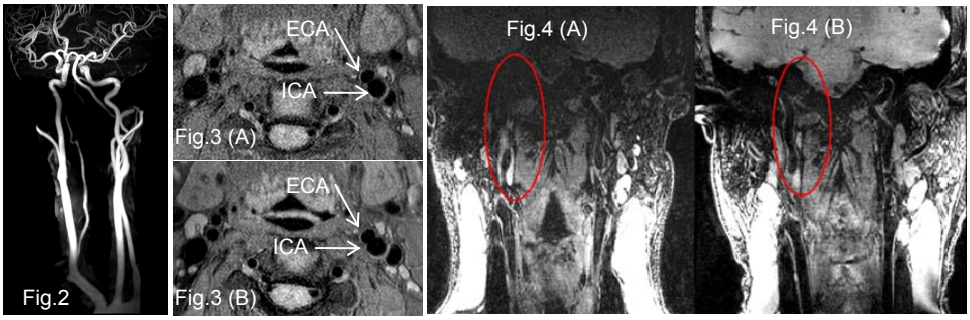

Fig. 2-4: Fig.2: 3-station TOF image by 36ch NV coil; Fig.3: Black-blood QIR images by 16ch NV coil (A) and 36ch NV coil (B); Fig.4: 3DMERGE images by 8ch carotid coil (A) and 36ch NV coil (B).

Conclusion: We have shown that the newly developed 36-channel NV coil provides high quality images for neurovascular imaging. It improves the performance over the current clinical 8-channel head, 8-channel carotid and 16-channel NV coils in the region from aorta to intracranial vasculature, which will be beneficial for neurovascular MRI and atherosclerosis screening. However, we found there is limited improvement for the SNR of the chest part at 3D MERGE images compared to 8-channel carotid coil. We will enlarge the anterior chest elements in future coil design.

Reference: [1] Balu N, et al. JMRI. 2009; 30(5): 1209-14. [2] Roemer PB, et al. MRM (1990), 16:2,192-225. [3] Yarnykh VL, et al. MRM. 2002; 48(5): 899-905. [4] Balu N, et al. MRM. 2011; 65(3): 627-37.