

# AN EIGHT-ELEMENT PHASED ARRAY COIL FOR CAROTID ARTERY IMAGING AT 3 TESLA

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## Introduction

Carotid artery disease due to plaque buildup at the bifurcation may lead to stroke. [1-3]. Accurate characterization and quantification of the plaque composition and morphology by imaging techniques is desirable to identify high-risk patients. Due to the small size of the plaque, carotid plaque imaging requires high resolution. Commercially available carotid coils used in clinical trials applications are usually 4-element designs (2 elements for each side).[4]. However, its penetration depth, coverage and signal-to-noise ratio (SNR) are sometimes insufficient in cases when the neck is short and/or the internal carotid arteries are deep within the neck. In this work, we propose an eight-channel receive-only phased array coil for use at 3T. The coil consisted of three overlapping loops and one butterfly element per side. We characterize this prototype and show first in vivo results. Preliminary comparison with commercially available carotid coils found that the SNR of the new design is 30% higher than commercial 4-element coils in most cases.

## Methods

**The design:** The proposed receive-only eight channel phased array (8PA) carotid coil (see Figure1) was designed for use at 3T (MAGNETOM Tim Trio, Siemens, Germany).The 8PA coil consisted of two sets of four elements layed out in a rectangular shape. The overlap between three adjacent elements in the transverse orientation minimizes mutual inductance [5]. A butterfly element is placed along the longitudinal orientation to improve penetration of the coil. The transverse and longitudinal overlaps minimize the coupling between the neighboring coil pairs. Flexible printed circuit board (PCB) was fabricated by etching the pattern of conductive loops on elastic plate. The proper capacitors were selected to provide tuning and matching at 123.2MHz. The coil was coated with soft polymer foam for flexibility when it fits to the neck. The design enables it to be positioned on both sides of the neck and held in place with a soft collar. The proposed design was tested on both phantom and volunteers. A cylindrical plastic bottle to match the dielectric properties of the human neck was placed inside the Siemens MRI Trio 3T scanner in the place where the subject's head usually lies. The proposed bilateral 8PA coil was briefly compared to a commercially available carotid coils with 4 elements (Machnet, Netherland) on water phantoms placed in the scanner. The spin-echo sequence with the following imaging parameters were used: TR(msec)/TE(msec)/echo train length/Slice Thickness/Matrix/ Pixel Bandwidth=300/15/1/5/256×256/130. The image slices (FOV=200×200mm<sup>2</sup>) were acquired with identical imaging parameters under the condition that the carotid coils were placed at the similar position of the phantom. And the SNR and g-factor maps [6] were also calculated from both coil transverse images with gradient-echo (GRE) sequences with the parameters: TR(msec)/TE(msec)/echo train length/Slice Thickness/Matrix/Pixel Bandwidth/FOV/Flip Angle=100/3.01/1/5/192×192/401/ 200×200/10. The seven volunteers (three patients and four healthy persons) with informed consent in accordance with our institution's human subject policies participated in the study on bilateral carotid artery imaging. All the volunteers were scanned with the proposed coil and Machnet coil using the same super-resolution protocols (i.e. turbo spin echo sequences). The images reconstructed by the SoS (sum of square) algorithm were acquired using three turbo spin echo (TSE) sequences that allow image acquisition of T1w, T2w and VFL (Variable FLip angle) T2w without iPAT (Integrated Parallel Acquisition Technique) to verify performance improvement of the designed coil relative to Machnet carotid coil.

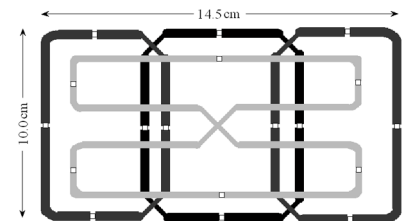


Fig.1. Schematic of one set of 8PA coil

## Results

**Coil performance evaluation:** The SNR map of 8PA coil is calculated from coil images with 60 measurements under GRE pulse sequence (see Figure 2). Noise correlation matrices of the designed carotid coil with (8PA) or without (6PA) butterfly elements are given in Figure 3. With the increased number of channels, the value of the coupling between different channels doesn't increase. And mutual coupling coefficient is always less than 0.3. The g-factor map of the GRAPPA method with R=2, 3, and 4 is shown in Figure 4.

**Volunteer study:** The study was IRB approved. As can be seen in Figure 5, the vessel wall and surrounding tissues visualization drastically improves by the application of the designed 8PA carotid coil. And the reconstructed images by our developing 8PA coil have substantially increased the received signal strength and have higher SNR and spatial resolution in comparison with Machnet 4PA carotid coil.

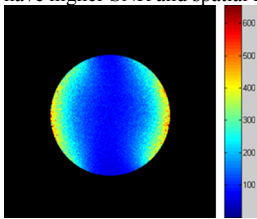


Fig.2. The SNR map of the designed 8PA coil

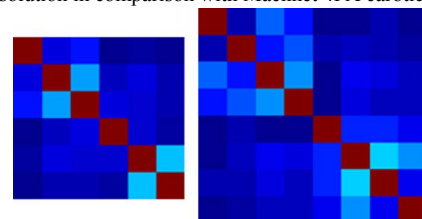


Fig.3. Noise correlation matrices of 6PA (Left) and 8PA (Right) coils

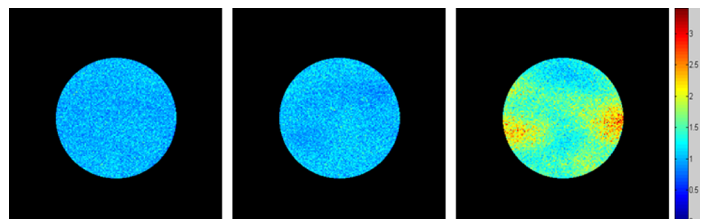


Fig.4. From Left to Right: g-factor map of GRAPPA with R=2, 3, and 4

## Discussions and Conclusion

This study demonstrates that the novel designed bilateral 8PA carotid coil can be used for in vivo MR imaging of the carotid arteries with SNR and spatial resolution improvement at 3 Tesla in comparison with Machnet carotid coil. And the 8PA coil with butterfly elements compared to the 6PA coil without them doesn't increase mutual coupling between different channels. Moreover, our proposed 8PA coil can be used in GRAPPA with the accelerated factor R=2 or 3. The performance comparisons including SNR, g-factor, penetration depth, spatial resolution, and coverage between the proposed 8PA coil and Machnet 4PA carotid coil will be done in further studies. The proposed 8PA coil provides dramatic improvement in the vessel wall visualization of carotid artery imaging and may lead to better detection of small atherosclerotic plaques.

## References

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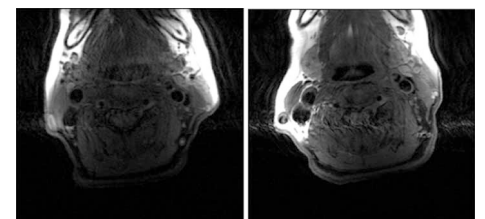


Fig.5. T1w images of (Left) Machnet 4PA coil and (Right) the designed 8PA carotid coil