A 32-channel intracranial and extracranial vascular array for three dimension arterial wall MR imaging at 3T

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Introduction Accurate characterization and quantification of the intracranial and extracranial vascular diseases by magnetic resonance imaging (MRI) is desirable in identifying high-risk patients [1]. Due to the thin thickness of the vessel wall, the multi-channel head array [2] and neck arrays with high signal-to-noise ratio (SNR) and capability of parallel imaging are preferred in clinical examination. Since there is a lack of RF coil arrays [3] capable of large longitudinal coverage for the carotid arteries which are composed of the intracranial and extracranial vessels, intracranial and extracranial vessels are usually imaged separately in clinical examinations. In this work, a 32-channel intracranial and extracranial vascular (IEV) array was designed and fabricated for the whole carotid artery imaging at 3T. Both phantom and *in-vivo* experiments were carried out to evaluate the performance of the 32-channel IEV array.

Coil Design: The 32-channel IEV array was composed of two parts: 24-channel for the head and 8-channel for the neck. In the head part, 24 circular loops were arranged in four columns as shown in Fig. 1. The numbers of the loops were 1, 7, 7 and 9 from anterior side to posterior side respectively. The loops were designed to closely fit the head [2]. In the neck part, there are 3 rectangular loops overlapping with a butterfly-shape loop on each side [3-4]. All the elements were tuned to 123.2 MHz and matched to 50 Ω. Overlapping among the elements and low input impedance amplifier were used for element decoupling. **Phantom Studies:** Phantom studies were carried out to evaluate the performance of the IEV array. A spherical phantom with 175 mm diameter and a cylindrical bottle with 115 mm diameter and 200 mm length were employed to mimic the human head and neck. The spherical phantom was filled by 1.25g/L $NiSO_4 \cdot 6H_2O$ while the cylindrical bottle was filled by 3.75g/L $NiSO_4 \cdot 6H_2O$ and 5g/L NaCl. The phantom studies were performed on a 3T Siemens Trio MRI system. The SE sequence with following parameter was utilized: TR/TE = 300/15ms, FOV = 150×230mm^2, resolution matrix = 152×256, bandwidth = 260Hz/pixel. A noise scan was performed to acquire the noise covariance matrix by setting transmit power to zero. The covariance root sum of square (Cov-rSoS) [5] method was used to reconstruct the images. The SNR map was calculated based on reference [5]. ***In-Vivo* Studies:** The *in-vivo* experiments were performed in accordance with the institution's IRB regulations including informed consent. High resolution anatomical images were acquired to illustrate the performance of the 32-channel IEV array. T1-weighted 3D **S**ampling **P**erfection with **A**pplication optimized **C**ontrasts using different flip-angle **E**volution (SPACE) sequence was utilized [6], covering from extracranial carotid to brain vessel. The imaging parameters were: FOV = 180×180mm^2, ETL = 9, ESP = 3.58ms, resolution matrix = 256×256, slice thickness = 0.7mm (isotropic voxel size of 0.7mm^3), TR/TE = 926/25ms, bandwidth = 476Hz/ pixel, Averages = 2.

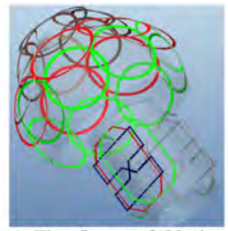

Fig.1 The figure of 32-channel IEV array.

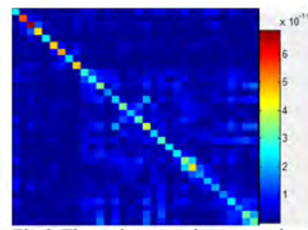

Fig.2 The noise covariance matrix of the IEV array

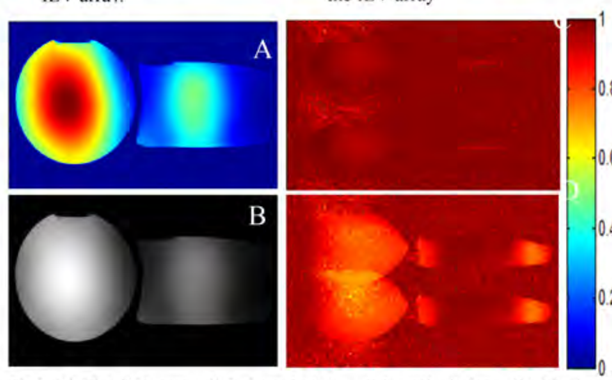

Fig.3 (A) The SNR map of 32-channel IEV array in sagittal plane. (B) The image of Cov-SoS. (C) and (d) 1/g-factor with reduction factor R =2 and 3.

Results The noise covariance matrix of the 32-channel IEV array was shown in Fig. 2. It can be seen that the mutual coupling between 24-channel head part and 8-channel carotid part is very small. The phantom image and corresponding SNR map in sagittal plane of the proposed 32-channel IEV array were shown in Fig. 3.The 1/g-factor maps with reduction factor R = 2 and 3 were also displayed in Fig. 3(C) and 3(D), which demonstrated that the parallel performance of the proposed 32-channel IEV array is very well. In volunteer studies, the vessel walls of major arteries such as extracranial and intracranial arteries with resolution 0.7×0.7×0.7mm^3 was shown in Fig. 4, which demonstrated the large coverage and high resolution imaging capability of the 32-channel IEV array.

Discussion/Conclusion This study demonstrates a 32 channel IEV array design by combining an 8 channel carotid array and a 24 channel head array in convenient fashion. Both phantom and in-vivo experiment results show that the proposed array is capable to provide a large coverage from carotid to brain vessels with high SNR to achieve high resolution vessel wall images. This would benefit arterial disease diagnosis. Future investigation will focus on coil configure optimization of the head/neck array to further improve image resolution with high SNR.

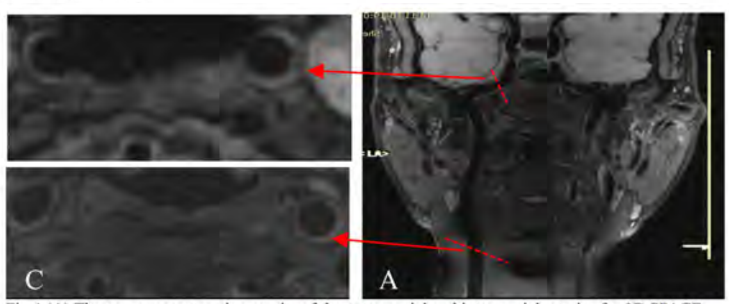

Fig.4 (A) The curve reconstruction results of the extracranial and intracranial arteries for 3D SPACE. (B) short axial of supraelinoid segment and (C) internal carotid artery.

Reference [1] Z.C.Zhou, et.al., ISMRM 2013, p.0877. [2]Wiggins GC., MRM (2006), 56(1), 216-223. [3] Y.Q.Zhang, et.al., ISMRM2012, p.2652. [4] X. Hu, et al., ISMRM 2014, p. 2543. [5] B. Keil et al., JMR 2013, 229, 75-89. [6] L. Zhang, etal., ISMRM 2013, p3610.

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