A 20 channel head/neck array for three dimensional arterial wall imaging at 3T

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Introduction Accurate characterization and quantification of the intracranial and extracranial vascular diseases by imaging techniques is desirable to identify high-risk patients [1]. Due to the thin thickness of the vessel wall, multi-element head/neck arrays with high signal-to-noise ratio (SNR) and capability of parallel imaging are preferred clinically. The longitude coverage of such arrays needs to be extended to include extracranial carotid vessels as well as intracranial arteries. Since the position of neck elements of the arrays would adjust to individual patients to maximize SNR, conventional decoupling methods such as inductive decoupling and overlapping array elements are hard to implement to decouple the head elements and neck elements. In this work, we propose an approach in convenient fashion to construct the 20-channel head/neck coil with extended longitude coverage and high SNR by combining a commercial 12-channel head array and a dedicated 8-channel carotid array. The coupling effects are compensated by accounting for the noise correlation matrix in the reconstruction method. Both phantom and *in-vivo* experiments were carried out to evaluate the performance of the 20 channel head/neck array.

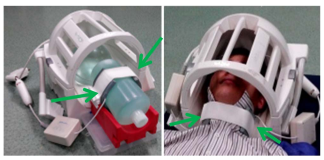


Fig. 1 Experiments Setup.

Methods ***Coil Design:*** The proposed 20 channel head/neck array consisted of a dedicated 8 channel carotid array [2] and a commercial 12 channel head array. The carotid array was fabricated on a pair of soft polymer collars which fit the neck closely (green arrows) as shown in figure 1 to increase SNR. There were three rectangular loops overlapping with a butterfly-shaped element on each collar. All the elements of the carotid array were matched at 123.2 MHz and decoupled by overlapping and pre-amplifiers. In order to further compensate the coupling effect caused by closely placing the carotid array and head array, the covariance root sum of square (Cov-rSoS) [3] reconstruction method was used. ***Phantom Studies***: Phantom experiments were carried out to evaluate the performance of the proposed head/neck array. A spherical phantom with 175 mm diameter and a cylindrical bottle with 115 mm diameter and 200 mm length were employed. 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 three orientation images of the head/neck phantom in Fig. 1 were acquired by using gradient recalled echo (GRE) image sequence with the following parameters: TR/TE = 500/4 ms, flip angle = 20º, FOV = 320×320 mm^2, slice thickness = 5 mm, 256×256 imaging matrix. The noise of each channel of the array was acquired by using the same sequence with none transmit power. The Cov-rSoS reconstruction method was employed to reduce the coupling effects on the SNR performance of the head/neck array [4-5]. The SNR comparison of the combined 20 channel head/neck array, 12 channel head coil array only and 8 channel carotid array only was carried out to evaluate the coupling effects. Pulsar tool box [6] was employed to estimate the parallel imaging performance of the 20 channel head/neck array. SENSE g-factor [7] maps were calculated based on the acquired raw data. ***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 proposed array.T1-weighted 3D **S**ampling **P**erfection with **A**pplication optimized **C**ontrasts using different flip-angle **E**volution (SPACE) sequence was utilized for black blood scans [8], covering from carotid to brain vessel. The imaging parameters were: FOV = 165×205×51.2mm^3, ETL = 39, ESP = 3.58ms, base matrix = 210×256×64 (isotropic voxel size of 0.8mm^3), TR/TE = 938/21ms, bandwidth = 751Hz/ pixel. Scan time was around 12min.

Results ***Phantom studies:*** As shown in figure 2, the proposed array provided a wide coverage for intracranial and carotid arteries with high SNR. The SNR comparisons among the 20 channel head/neck array, 12 channel commercial head array and 8 channel carotid array demonstrated that the proposed array maintained similar SNR in brain and neck region by using the covariance root sum of square reconstruction strategy to compensate coupling among array elements. The minor SNR decrease is probably due to the impedance of each element deviated from optimal impedance to minimize the noise figure of the preamplifiers. Figure 3 showed the inverse g-factor maps under 1D acceleration with reduction factor 2 and 4. Maximum and mean g-factors were shown below the maps which demonstrated good parallel imagining capability of the proposed array. ***In-vivo studies:*** In volunteer study, Fig. 4 showed the vessel walls of major arteries such as extracranial and intracranial arteries, which demonstrated the large coverage and imaging performance of the proposed array

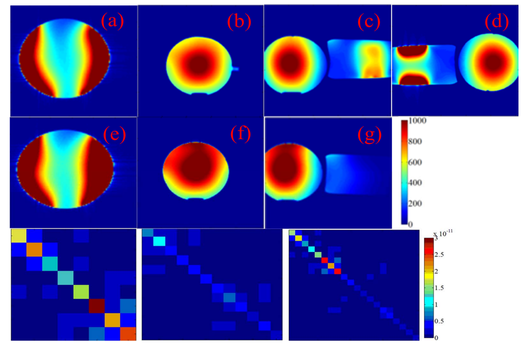
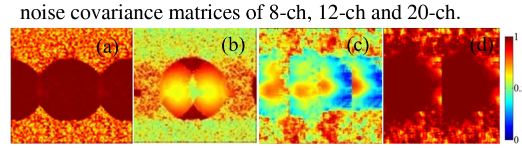


Fig. 2 SNR maps under the same scale.(a)-(d) Acquired by 20 channel head/neck array. (a) Transversal plane of cylindrical phantom, (b)-(d) Transversal/sagittal/coronal plane of spherical phantom. (e) Transversal plane of cylindrical phantom acquired by 8 channel carotid array. (f)-(g) Sagittal/coronal plane of spherical phantom acquired by 12 channel head array. The FOV and imaging matrix in (a) and (e) is 160×160mm^2 and 128×128. (Bottom) The noise covariance matrices of 8-ch, 12-ch and 20-ch.



1.007/1.05/2 1.142/2.03/4 1.03/1.78/2 2.09/9.72/4

Fig. 3 The inverse g-factor maps on transversal planes. The numbers under each map indicate the mean g-factor/ maximum g-factor/reduction factor, respectively. (a) and (b) correspond to the spherical phantom. (c) and (d) correspond to the cylindrical phantom.

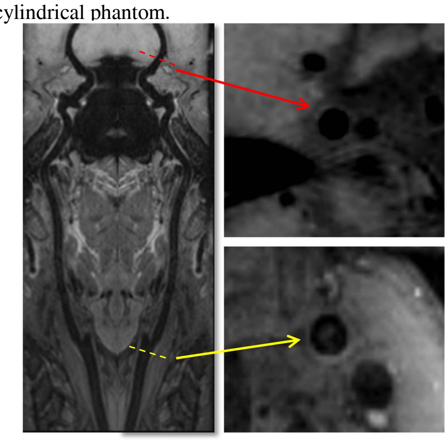


Fig. 4 (left) The curve reconstruction results of the extracranial and intracranial arteries for3D SPACE. (right) short axial of supraelinoid segment and interal carotid artery.

Discussion/Conclusion This study demonstrates a 20 channel head/neck array design by combining an 8 channel carotid array and a 12 channel head array in convenient fashion. The coupling effect of the array elements can be compensated by using Cov-rSoS reconstruction method. 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 and good parallel imaging performance, which will 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.

Reference [1] Z.C.Zhou, et.al. ISMRM 2013, p.0877. [2] Y.Q.Zhang, et.al. ISMRM2012, p.2652. [3] PB Roemer, et al. MRM (1990), 16:2,192-225. [4] Pruessmann, et.al. ISMRM2002, p.196. [5] MA Ohliger, et al. MRM (2004), 52,628-639. [6] Jim X. Ji, et al. Concepts in MR part B 2007, 24-36. [7] Pruessmann, et al. MRM 1999, 42:952-962. [8] L. Zhang, et al.ISMRM 2013, p3610.

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