# A 6 channel Array for micro-imaging of carotid plaque at 3T

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**Introduction:** Noninvasive imaging of carotid artery bifurcation, which is prone to plaque formation due to turbulent blood flow, is of great neurological interest, since carotid atherosclerosis is the leading cause of acute stroke. The vulnerable plaque has a thin fibrous membrane of less than 65μm, covering a large, possibly necrotic, lipid core. A necrotic core of the plaque can be on the order of 1mm$^2$. Since plaque components have sub millimeter dimensions, MR images with high spatial resolution and sufficient SNR are required to characterize the vulnerable plaque to determine the probability of rupture [1]. A resolution of about 50-300μm in-plane is desirable in most cases. Previous experimental results on different kinds of 1.5 T carotid coils [2] show that 6-channel coils give the highest SNR at the desired penetration level; in this case it is 3-4 cm away from the surface of the human neck. A six-channel surface coil was designed and built for 3T, which provides better than 200μm resolution with a sufficient SNR at the point of carotid artery bifurcation.

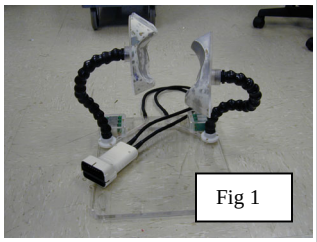
Fig 1

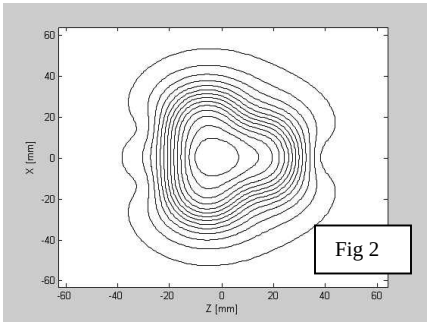

Fig 2

**Method:** The six-channel carotid coil consists of three 3" loops on each side of the head. The coils were laid on an anatomically shaped former, which ensures the perfect fit with neck and head (Fig 1). This also helps to achieve a better penetration. A flexible positioning device ensures close proximity to various neck sizes. Maps of the RF magnetic field were created to ensure sufficient coverage. Fig 2 shows an isocontour plot of $B_1$ amplitude in a plane parallel to the coil, but at a depth of 3.5 cm from the coil. The stepsize in the contours is 0.5 dB. The coils were overlapped such that there was good isolation (<-20db) between all coils. All elements were tuned and matched to 50Ω at 127.74MHz and were attached via cable trap baluns to half-wavelength cables to low input resistance pre-amps, which minimizes the interaction between any element and other elements not immediately adjacent thereto. A passive and an active decoupling circuits were connected to the coil, which detune the coil during the transmit pulse (Fig 3). These circuits also provide better patient safety. The coil was tested on human volunteers under appropriate IRB conditions. All studies were performed on a GE Healthcare Signa Excite 3.0T Whole Body Scanner (Waukesha, WI). Several techniques were used for evaluation, including black-blood techniques as well as contrast enhanced vascular techniques (Fig 4). Additionally, a 2D inner volume black blood based sequence with a 512×256 matrix, FOV 8×4 cm$^2$, 4NEX and 16ETL was used to evaluate very high resolution scanning. A standard 1RR double IR technique, FSEUNO was used to evaluate tissue contrast throughout the volume, with a TE= 68 ms, TR=1RR, 256×256, 4NEX, 10ETL.

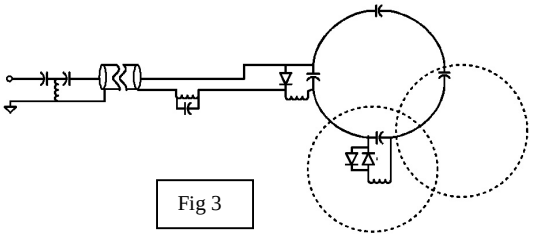
Fig 3

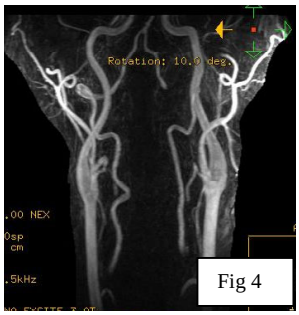

Fig 4

**Result and Discussion:** SNR comparisons at a depth of 3.5 cm, the average depth of the carotid bifurcation, show that the 6 channel coil performs with a factor of 1.6 better in SNR than a single 3 inch loop on each side of the neck. Three coils on each side of the head enable complete coverage of between 16-20cm FOV's, both superior and inferior to the bifurcation, which ensure that the coil does not need to be repositioned between different patients to account for patient size/shape variability. The contrast enhanced TOF technique shows good homogeneity and SNR in a 12cm through-plane region surrounding the bifurcation (Fig 4). Initial studies provide good visualization of the carotid wall with clear definition of the wall from the blood pool and surrounding muscular and fatty tissue. Fat saturation is consistent throughout the volume, therefore allowing for lipid versus tissue evaluation for high-risk plaques. Additionally, the lymph nodes, which surround the carotids, can also be seen (Fig 5). Fig 6 shows an ultra-high resolution image of the carotid, using the inner volume black blood technique, with an in-plane resolution of 160μm and 2mm through-plane resolution. The main advantages of this coil are high-resolution images with good SNR, good penetration and large enough Z-directional coverage. Furthermore, the placement of the coils are such that parallel imaging can be used to decrease imaging time in both the in-plane and through-plane directions, allowing for greater resolution in a relatively short imaging time.

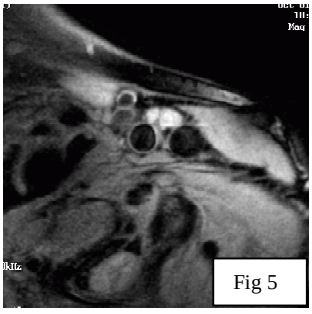
Fig 5


Fig 6

**Conclusion:** A 6 channel carotid array was built and tested. Since the area of interest is about 3.5 cm deep, a large number of channels does not pay off for SNR [2]. The present configuration with three 3 inch loops on each side was found to be the optimum, with a SNR increase of 1.6 over a single 3 inch loop on each side of the neck. Not only did the SNR benefit, but also the FOV is drastically increased over the 2 channel version. We are presently creating a flexible housing for better fit with a larger variety of neck shapes and sizes.

**Reference:** [1]: *Bruce A Wasserman, et al.* Radiology 2002; 223:566-573, [2]: *S. Mathew et al.* Proc ISMRM 12(2004), 1550