Carotids imaging at 7 Tesla using traveling wave excitation and local receiver coils

H. Kroeze[1], B. L. van de Bank[1], F. Visser[1], J. J. Lagendijk[2], P. Luijten[1], D. W. Klomp[1], and C. A. van den Berg[2]
[1]Radiology, UMC Utrecht, Utrecht, Netherlands, [2]Radiotherapy, UMC Utrecht, Utrecht, Netherlands

Introduction:

MRI of the carotid arteries and plaque formation at the level of the bifurcation in particular is important to assess the composition of high risk plaque and the associated risk of stroke. Many studies have been done at 1.5 and 3.0 T. Imaging at higher field strengths may result in substantial higher resolution which is important for the detailed assessment of plaque composition, e.g, the measurement of the fibrous cap, (micro-) hemorhage, macrophase infiltration and neo-vascularization (vaso vasorum) of the plaque. Carotid artery imaging does not (yet) belong to the current high quality imaging procedures. For carotid artery imaging it is required to use black blood image sequences to visualize the plaque. The relative homogeneous RF excitation profiles required for these sequences and the destructive RF interferences that occur at the high frequency of 300 MHz, impedes the use of large (homogeneous) excitation coils. Complex designs that require multiple transmit channels and complex RF shimming strategies are currently explored to overcome these technical hurdles.

In this study we used another more simple approach by using a quadrature patch antenna that uses the bore of the magnet as a wave guide enabling traveling waves to excite the spins in the human body while using local receiver coils for optimized signal to noise at the level of the carotid bifurcation [1] [2]. Using the traveling wave approach the problem of destructive RF interference is reduced, however, generating enough B_1 remains a challenge.

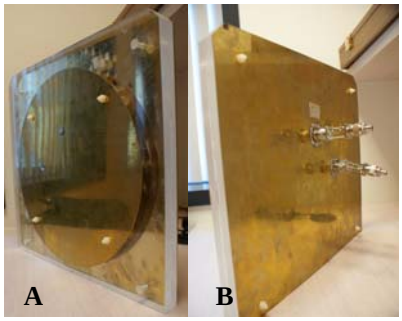

Fig. 1: The patch antenna.(A) front side (B) ground plane with connectors

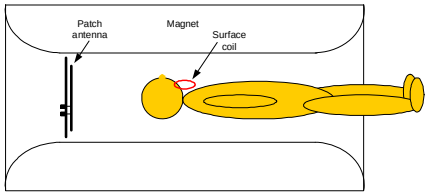

Fig. 2: The coil setup used for this study. The patch antenna is placed inside the RF-shield. A local receive coil was placed on the region of interest at the iso center of the magnet.

Methods:

The patch antenna was designed as shown in figure 1 (Ground plane = 420x420mm^2, substrate PMMA 30mm, patch ø350mm). The transmit antenna was placed at the end of the magnet bore inside the RF-shield of the scanner (fig. 2). The local receiver coils (ø50mm approximately) were placed on the neck of a healthy volunteer close to the left carotids. The two channel patch antenna was tuned, matched, and interfaced via home-built RF-switches.

Sagittal and transverse T1 weighted GRE images (fig. 3), were obtained from the carotids without any image normalization processing. A spin-echo sequence (fig. 4) was performed to determine whether the strength of the B1-field of the patch antenna is sufficient to enable spin refocusing.

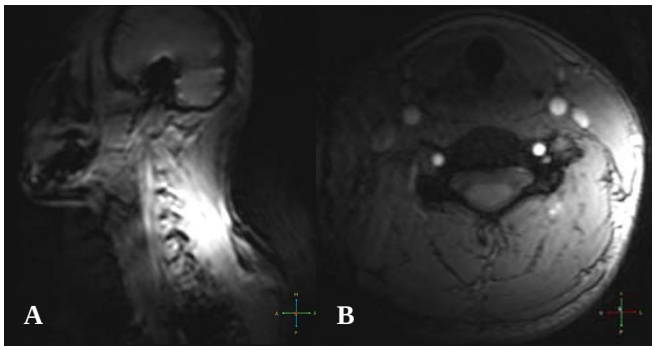

Fig. 3: Images obtained with the transmit patch antenna and local receive coil of the left carotid artery. (A) Sagittal image of the neck and head, the carotid is visible over a large area. (FOV = 250x250mm^2, slice thickness = 2mm, resolution = 2mm,TR = 6ms) (B) Transverse image of the neck. (FOV = 350x350mm^2, slice thickness = 1.2mm, resolution = 0.7mm,TR = 40ms).

Results:

The absence of black shades in the region close to the receiver coil in the GRE images illustrate the potential of using traveling waves to excite the spins with minimal destructive RF interferences at 7T (fig. 3). Even with the limited RF power that is available, sufficient B1 can be realized to obtain a spin echo image (fig. 4).

Conclusion/discussion:

The patch antenna design is a potential alternative for large body coil excitation at 7T. We have demonstrated successfully that it is feasible to image the carotid artery at 7T using a patch antenna as a transmitter combined with local receiver coils.

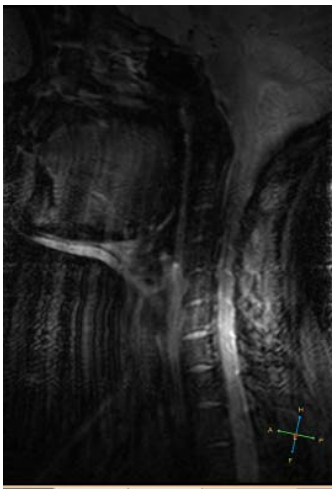

Fig. 4: Image obtained with a spin-echo at 7T while the patch antenna was used for transmit. The signal is received with a surface coil. Due to flow pulsation artifacts are visible. (FOV 250x250mm^2, slice thickness = 3mm, resolution = 1mm,TR = 3s).

References

[1] D.O. Brunner et al. "Travelling wave MR on a Whole Body system, 16th ISMRM, Toronto 2008

[2] C.A.T. van den Berg et al. "Using the natural resonant modes of the RF cavity for whole body excitation at 7 T", ISMRM workshop on Advances in high field MR, Asilomar 2007