

Whole Body Three Dimensional Plaque Imaging

Y.-C. Chung¹, G. Mihai², O. P. Simonetti², S. Rajagopalan², and R. Jerecic³

¹Siemens Medical Solutions USA, Inc., Columbus, OH, United States, ²OSU Ross Heart Hospital, Columbus, OH, ³Siemens Medical Solutions USA, Inc., Chicago, IL

Introduction Atherosclerosis is a systemic disease. Angiographic approaches are “luminograms” and provide no data on vascular remodeling and plaque burden which are far more important determinants of risk in vascular diseases. Assessment of overall plaque burden with current 2D MRI approaches [1-3] has important limitations. Firstly, imaging is limited to selective anatomical regions (e.g., carotid arteries [1] and/or aorta [2-3]). These regions may not reflect the involvement of other vascular territories, which may be of greater importance depending on the patient. Secondly, 2D imaging with slice gaps or thick slice are commonly used to speed up image acquisition. The partial volume effect may reduce MRI’s sensitivity in detecting subtle plaque volume changes. Thirdly, image registration with 2D images is challenging in patient follow-up. We propose here an approach for high resolution 3D plaque imaging of the whole body (from carotid to femoral arteries) that can improve the quantification of plaque burden in patients with atherosclerosis.

Method Sequence: The technique is based on SPACE (a 3D turbo spin echo variant) with optimized T1 or T2 contrast [4-5]. ECG triggering and navigator gating are supported. When ECG triggering was used, acquisition was timed to systole for optimal blood suppression. The sequence was implemented on a 1.5T clinical scanner with 32 receiver channels (MAGNETOM Avanto, Siemens, Germany). **Imaging protocol:** Imaging was performed in 4 stations, each covering a specific section of vascular territory, using an appropriate imaging protocol based on SPACE. Station 1: carotid arteries – protocol from [6] (T2w) or [7] (T1w) was used with a 4-element carotid coils (Machnet BV, Netherlands). Station 2: thoracic arteries – protocol from [8] was used with two 12-element body and spine matrix coils. The coils were positioned high up to the chin to cover the arteries coming out from the aorta to the neck. Station 3: abdominal aorta – protocol similar to [9] was used using same coils as in (2) except that they are positioned to overlap with peripheral coils to cover the iliac arteries. Station 4: femoral arteries – protocol from [10] was adapted with the 16-element peripheral matrix coils (station covered by 8 elements). **Imaging:** The study was approved by the institutional review board. Four healthy volunteers and two subjects with risk factors for atherosclerosis were scanned. All coils were placed on the subjects before the scan. Fig. 1 shows the workflow. For patient comfort, carotid coils were removed when station 1 was finished. No breath-holding was needed.

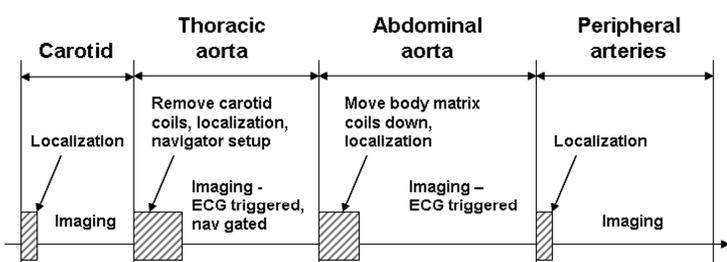


Figure 1 (UP). Workflow for whole body plaque imaging in an hour.

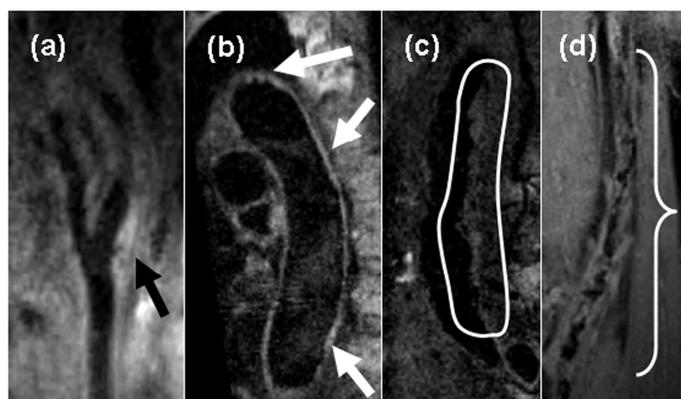


Figure 2 (RIGHT). Images from a patient with risk factor for atherosclerosis, known to have plaque in abdominal aorta. (a) plaque in carotid (dark arrow), (b) thoracic aorta, vessel wall surface shows irregularities/thickening, suggestive of plaque, (c) plaques at the abdominal aorta, and (d) plaque at femoral arteries.

Table 1. Scan time and coverage of the 4 station protocol.

Station	Avg eff. FOV / imaging FOV	Voxel size (iso)	Average scan time
Carotid	59 / 200mm	0.8mm	4:38
Thorax	289 / 350mm	1.2mm	12:29
Abdomen	338 / 450mm	1mm	16:44
Femoral	307 / 350mm	0.9-1mm	10:12

Results Table 1 shows the average scan times (localization excluded) and average effective coronal coverage for each station. The mean total scan time was 62min (max 66min). Excluding overlapped segments between two consecutive stations and the gap between station 1 and 2 (~20-70mm, dependent on coil positioning), the average vascular territory covered was 99.3cm (min 98cm). 18.3min (max 21.5min) was used for localization on average. SNR in the femoral arteries were comparatively low, probably due to the low coil density (covered by 8 elements only) and the need for high spatial resolution in that station. Fig. 2 shows an image set from one subject previously known to have abdominal and femoral plaque. The images showed that the subject also had plaque in other vessel segments. Fig 2b demonstrates that the technique can depict subtle vessel wall irregularities that may otherwise be obscured by partial volume effect in 2D imaging.

Conclusion The study showed, for the first time, that plaque burden imaging covering the whole body in an hour is feasible. Careful localization would minimize overlap and maximize anatomical coverage. Determinants of overall scan time include respiratory pattern for station 2 and heart rate for station 2 and 3. Localization time (~25% of total scan time) may be reduced by moving table technology. Use of 2 additional body coils (12-elements each) for station 4 would increase coil element density, and favors SNR and/or spatial resolution. 3T imaging can increase SNR. The approach provides an important tool to the understanding of plaque distribution in the whole body, and may also provide novel risk indices and potential surrogates to assess vascular response to drug therapy.

References [1] Underhill HR et al., Am Heart J 155(3):584, 2008. [2] Corti R, et al., JACC 46(1):106-112, 2005. [3] Lee JM, et al., Atherosclerosis 197(2): 951-958, 2008. [4] Park J et al., Magn Reson Med 58(5): 982-992, 2007, [5] Mugler JP III et al., Proc. 11th ISMRM, p.203, 2003. [6] Chung YC et al., JCMR 10(2) :426. [7] Chung YC et al., JCMR 9(2) :313. [8] Chung YC et al., Proc 16th ISMRM, p.927, 2008. [9] Mihai G et al., submitted to ISMRM 2009. [10] Zhang Z et al., Proc 16th ISMRM, p.520, 2008.