Submillimeter Spatial Resolution Contrast-Enhanced MRA of the Carotid Arteries Using Ferumoxytol in Humans

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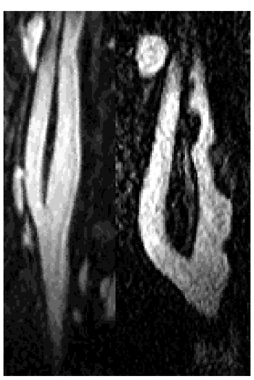
Introduction Current first-pass methods for CE-3DMRA of the CA suffer from limited spatial resolution (1). This problem can be overcome using nearly isotropic, very high-resolution MRA with ferumoxytol.

Materials and Methods Ferumoxytol (Advanced Magnetics Inc., Boston, MA), an iron oxide blood pool contrast agent with a plasma half-life of 14 hours (2), was used to obtain very high-resolution MRA of the extracranial CA. Studies were performed with IRB approval and informed, written consent. A dosage of 4 mg/kg diluted to 7.5 mg/ml was infused at 2 cc/sec. All studies were performed on a 1.5 T system (GE Medical Systems, Milwaukee, WI) equipped with TwinSpeed gradients and a 4-channel neurovascular coil and a 4-channel carotid coil. A series of 10 subjects (6 volunteers and 4 patients, 4 male/6 female, average age of 51.1) were studied. First-pass imaging was performed using a temporally-resolved TRICKS acquisition with the neurovascular coil. This was followed by an optimized very high-resolution 3DMRA sequence using the following parameters: TR/TE of 4.9 msec/1.4 msec, sampling BW of 83 kHz, FOV 26 cm, matrix size of 512x512, 1 NEX, and interpolated partition thickness of 0.8 mm. The in-plane spatial resolution was 0.5x0.5 mm. An axial 3D volume of 128 partitions covering the circle of Willis through the extracranial carotid bifurcation was acquired in approximately 5.5 min. In addition, a 3DMRA with lower in-plane resolution (1.0x1.0 mm) as well as a pre-contrast axial 2D TOF MRA with an in-plane resolution of 1.0x2.0 mm were acquired. We then changed to the carotid coil, and repeated the 3DMRA acquisitions at the aforementioned spatial resolutions. The volume location was centered on the bifurcation of the CA. In addition, we also acquired 3DMRA at an isotropic voxel resolution of 0.4x0.4x0.4 mm from 5 of the 10 subjects (3 volunteers and 2 patients). Multiplanar and maximum intensity reconstructions were performed. SNR of blood, muscle, and fat and CNR of blood relative to muscle and fat were measured in the source image of multiplanar reconstructions. Each source image was selected at level immediately before the carotid arteries bifurcated.

Results and Discussion No adverse events occurred. Very high-resolution MR angiograms showed improved delineation of the CA compared with first-pass images, steady-state images acquired at 256x256, and 2D TOF MRA. Oblique multiplanar reconstructions eliminated venous overlap and provided excellent delineation of the carotid bifurcations from a healthy and a patient volunteer with confirmed partial stenoses (Fig 1). The average SNR and CNR from all subjects listed in Table show that very high-resolution CE-3DMRA of the extracranial CA using ferumoxytol is feasible and can be useful in measuring the degree of stenosis.

Conclusion. Limitation of spatial resolution of current first-pass methods for CE-3DMRA of the CA can be overcome using nearly isotropic, very high-resolution MRA with ferumoxytol. The method has the potential to improve the accuracy and precision of measurements of carotid artery disease compared with current MRA methods.



		SNR			CNR	
Coil	**Matrix**	**B**	**M**	**F**	**B-M**	**B-F**
Neurovascular	256x256	55.5 ± 26.7	7.9 ± 2.7	24.6 ± 11.0	47.7 ± 24.4	30.9 ± 20.1
	512x512	15.2 ± 3.7	3.4 ± 0.8	8.6 ± 2.8	11.8 ± 3.0	6.6 ± 2.6
Carotid	256x256	211.3 ± 85.7	22.1 ± 7.1	121.4 ± 55.9	189.2 ± 86.9	89.9 ± 43.8
	512x512	69.2 ± 24.2	9.0 ± 3.1	47.3 ± 24.3	60.1 ± 25.4	21.9 ± 13.2

Figure 1. Shown are the right carotid arteries at isotropic resolution of 0.4x0.4x0.4 mm from a normal volunteer (left) and a patient with partially stenosed carotid artery (right). Also shown is the table that lists the average SNR and CNR and their standard deviations from all volunteers of 3DMRA data acquired with neurovascular and carotid coils at different in-plane spatial resolutions (B-blood, M-muscle, F-fat).

References (1) Butz et al, Acta Radiol 2004;45:164-170. (2) Ersoy et al, AJR Am J Roentgenol 2004;182:1181-1186.