Synopsis
Development of MR Angiography has provided a robust technique for the detection of stenoses throughout the body, but the modality still remains limited in the measurement of stenosis severity and morphology. TROTA is an extension of the 2D complex-subtraction MR-DSA method. The method yields 2D time-resolved targeted projection angiograms around the vessel of interest using a rotating slice-selective snapshot FLASH pulse sequence. These projection angiograms can be reformatted with similar techniques used in rotational x-ray DSA yielding three-dimensional pixel data. The data can be displayed using MIP, 3D rendering and multi-planar slice reformattting to accurately depict vessel morphology.

Introduction
Despite significant advances in the field of magnetic resonance angiography, many diagnostic applications are still limited by the ability of current techniques to accurately determine the severity of stenosis. Trade-offs must always be made between spatial resolution, temporal resolution and examination field-of-view. We propose a strategy similar to catheter angiography where initial contrast injections (or even non-contrast time-of-flight scans) are done to locate vessel narrowings and further targeted studies are performed to confirm and more accurately depict suspect lesions. The TROTA (Targeted ROTational Angiography) technique is a further development of 2D complex subtraction Gd-enhanced MRA(1). Projection reconstruction techniques similar to those used in rotational catheter x-ray angiography(2) are employed. The goal is targeted high-resolution MR imaging of suspect vessels which have been already identified.

Methods
Imaging was performed using a 1.5T clinical scanner (Magnetom Sonata, Siemens Medical Systems, Erlangen, Germany). A two-dimensional slice-selective snapshot FLASH sequences was used (TR=3.0, TE=1.8, FA=20, BW= 610 Hz/pixel, slice thickness=20mm, 20-40angles, 380msec/projection). An example rotation of the 2D slice around a targeted vessel in the neck is depicted in Fig 1A. Note that targeted imaging allows rapid imaging using a reduced-FOV. Severe fold-over artifacts may be present, without obscuring the targeted vessel. Phantom experiments were performed with intravenous tubing used to simulate a carotid artery/stenosis. Flow through the phantom was realized using a MR compatible injector (Medrad, Pittsburgh PA) with two syringes (saline, saline + Gd (T1\text{\textasciitilde}=50ms) Reconstruction was performed using complex filtered-backprojection and regridding algorithms. Three-dimensional rendering and slice reformattting was performed using VolView (Kitware, Clifton Park, New York)

Results
Representative source rotational 2D projection images are shown in Fig. 1B. After backprojection, images were available in the coronal, axial (Fig. 1C) and sagittal orientations. Axial reconstructions are shown at the levels indicated in 1B. Using the available three-dimensional data, targeted MIP and three-dimensional rendering was possible (Fig 1D).

Discussion
Everyday clinical decisions depend on the accurate measurement of stenosis severity. TROTA aims to improve spatial resolution through a targeted rotating acquisition. TROTA further enhances the superior temporal resolution of 2D-MR-DSA with the addition of isotropic high-resolution 3D reformattting. In the future, TROTA may provide 3D targeted angiograms with spatial resolution equivalent to catheter angiography.

References