Improved Background Suppression for Intracranial 3D TOF MRA using Robust Fat Suppression with IDEAL at 3T

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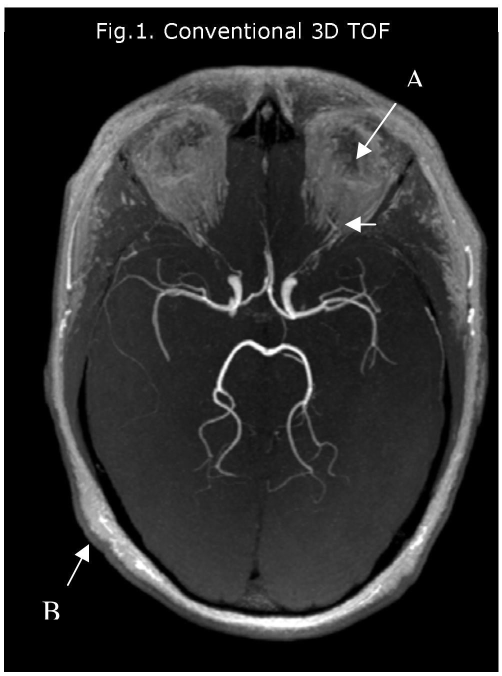
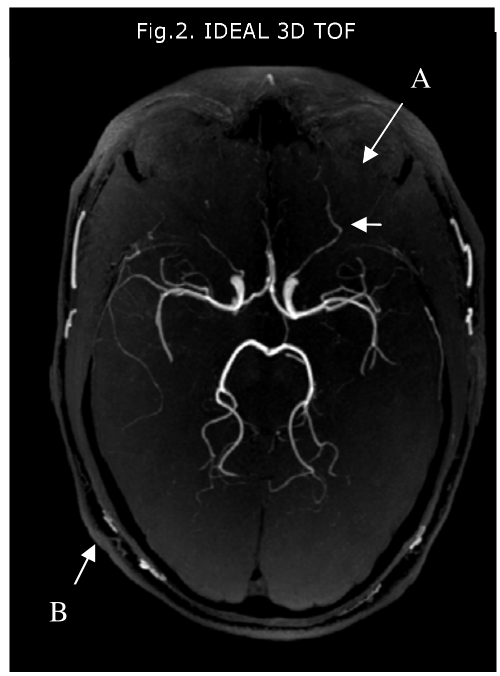
Introduction: Three dimensional time of flight (3D TOF) magnetic resonance angiography MRA (1) of the Circle of Willis has become a routine tool for neurovascular imaging. Although conventional 3D TOF is robust, high signal from extracranial short T1 tissues (particularly fat) compete with the signal from the in flowing arterial blood and can interfere with visualization of distal vessels, retrobulbar vasculature, particularly on maximum intensity projection (MIP) images. The IDEAL method (Iterative Decomposition of water and fat with Echo Asymmetry and Least-squares Estimation) [2] provides robust fat/water separation with greater signal-to-noise ratio (SNR) efficiency and less sensitivity to field inhomogeneity than chemical fat saturation [2]. The purpose of this work was to adopt IDEAL fat suppression for improved vascular visualization with intracranial 3D TOF MRA.

Methods: Volunteers were imaged under an IRB approved protocol on a 3.0T MRI scanner (v12.0 TwinSpeed, GE Healthcare, Waukesha, WI) using an 8-channel head coil. Conventional 3D TOF MRA of the Circle of Willis was performed with TE/TR 2.7/20msec, 22cm FOV, 1.0mm section thickness, 40 sections in a single excitation slab, a superior saturation band, flip angle 20°, acquisition bandwidth of ±41.67 kHz, with 512 x 224 pixel resolution for a 0.45 x 0.98 x 1.00mm voxel resolution. Imaging parameters were identical for IDEAL 3D TOF MRA, except three TE increments (2.2, 3.0 and 3.8ms) were used, with the selected TE values optimized to achieve the best possible SNR performance [3]. Both conventional 3D TOF and IDEAL-3D TOF used flow compensation with the readout gradient 1st moment nulled and a SENSE [4] based parallel acceleration method (ASSET) with an acceleration factor of 1.75. The total scan time for IDEAL-3D TOF was 5:16 minutes compared with 1:48 for conventional 3D TOF. For IDEAL 3D TOF separate fat, water, and recombined in–phase (water+fat) and out of phase (water-fat) images were reconstructed using an on-line reconstruction algorithm.





Results: Compared to the conventional 3D TOF MRA (Figure 1) IDEAL 3D TOF (Figure 2) has tremendously improved suppression of background signal. The improvement in retro-bulbar and subcutaneous fat suppression results in enhanced visualization of the ophthalmic arteries and extra-axial vessels. The combined back-ground suppression and signal averaging improves visualization of the distal and perforating intracranial vessels.

Figures 1 and 2: *MIP images of conventional 3D TOF compared to IDEAL 3D TOF in the same volunteer:* Retrobulbar fat (A) with relative high signal intensity due to short T1 obscures visualization of ophthalmic artery (small arrow). Improved fat suppression with IDEAL provides clear visualization of the ophthalmic artery (small arrow) as well as small subcutaneous external carotid artery branches (B). Close inspection of Fig 2. reveals improved visualization of peripheral and perforating vessels with the IDEAL 3D TOF technique.

Discussion: IDEAL 3D TOF provides improved background suppression, due to the fat-water separation. In addition, optimization of echo shifts produces the best possible SNR performance of the water-fat decomposition. The result is superior visualization of the extra-axial, central, distal and perforating branches. The improved vascular signal to the retrobulbar fat and subcutaneous tissues demonstrate the potential of this technique for non-invasive imaging of vascular lesions involving the orbits, temporal arteries, meninges or calvarium (e.g. hemangiopericytomas, temporal arteritis, dural vascular malformations). The single disadvantage of IDEAL 3D TOF over conventional 3D TOF techniques is the increased acquisition time from three separate TE acquisitions: approximately 5 versus 2 minutes for conventional 3D TOF. Although IDEAL is highly SNR efficient, the increased minimum scan time may be limiting for some clinical applications. Adaptation of the sequence to multiple echo acquisition or additional acceleration using 2D parallel imaging techniques could decrease acquisition time and/or increase volume of coverage.

Conclusion: IDEAL-3D TOF at 3.0T improves visualization of flow related signal by improving suppression of contributing background signal present in conventional 3D TOF MRA.

References: 1. Nishimura et al. MRM 4: 193-202, 1987. 2. Reeder et al. MRM 51:35-45, 2004. 3. Reeder et al. MRM 54:636-44, 2005. 4. Yu, H. et al. MRM 54:1032-39, 2005.