Integration of Scan Time Reduction Techniques with Rearranged Elliptical Centric k-Space Acquisition for 3DTOF MRA at 3.0T

C. Lin[1], M. A. Bernstein[1], J. Huston III[1]

[1]Department of Radiology, Mayo Clinic College of Medicine, Rochester, MN, United States

Introduction

3DTOF is an important method for MRA of the head and neck imaging. Recently, improvements have been made in 3DTOF MRA with the increased SNR at higher field strength and the new techniques such as rearranged elliptical centric (REC) view order which provides MT background suppression and flow artifact suppression [1-3]. However, one of the remaining drawbacks for 3DTOF is the long scan time. For whole head coverage, a typical high resolution three slab 3DTOF MRA protocol at 3T can require more than 12 min. This work demonstrates that such long scan time can be substantially reduced with a combination of several techniques, while maintaining the image quality.

Methods

A relatively long TR of 38ms has been used in 3DTOF MRA to allow sufficient time of inflow to avoid saturation of blood signal. As shown in fig. 1, a shorter TR of 26ms causes a loss of blood signal and, therefore hampers the ability to detect small vessels. However, since the image contrast is dominated by central *k*-space views, longer TRs are necessary only for the central views to maintain image contrast, while shorter TRs can be used for outer views. To reduce the scan time, we vary the TR based on the *k*-space radius of the views, similar to VARIETE where variable TE is used for fat signal reduction [4]. Integrated with elliptical centric MT, the longer TR for the central views is obtained by adding the MT RF pulse and associated gradient spoiler. This technique is also combined with REC view order as shown in fig. 2. To further reduce scan time, views in the corners of *ky*-*kz* space are not acquired. Such technique can also be integrated with REC view order as previously reported [3]. It has been to shown to provide 20% reduction of scan time in 3DTOF MRA without sacrificing spatial resolution or contrast to noise ratio [3,5]. Finally, standard parallel imaging techniques like SENSE can reduce the scan time of 3DTOF MRA [6]. Higher SNR at 3.0T allows acceleration with parallel imaging while maintaining adequate image quality.

The combination of all these techniques allows substantial speed up of the 3DTOF MRA scan. To evaluate image quality with and without scan time reduction, five healthy volunteers were scanned on a GE 3.0T scanner with an 8-channel head coil using both the conventional method without MT and the new method which integrates scan time reduction techniques with REC view ordering for low SAR MT and flow artifact suppression. The imaging parameters for the conventional method were 38ms TR, 4ms TE, 25° FA ramp pulse, ±16kHz BW, 20x18cm FOV, 384x224 matrix, 1.4mm slice thickness and 32 slice per slab. The data set was reconstructed to 64 slices per slab and 512 matrix with zero-filling. For the new method, MT was applied only prior to the acquisitions of central 1/3 of total views after omitting the views in *k*-space corners, where an 8ms Fermi pulse with 670° FA was used, and the TR was 38ms for central 1/3 of views and 26ms for outer views. SENSE with an acceleration factor of 2 was used.

Results and Discussion

Fig. 3 shows the comparison of the conventional and the new 3DTOF MRA with and without parallel imaging from one of the volunteers. With integrated MT, the images acquired with new technique have less background signal. Signal loss associated with short TR shown in fig 1 is not observed with the new technique. A 40% reduction in scan time can be achieved without parallel image, or a 70% reduction if combined with parallel imaging. The average scores of overall image quality and vessel conspicuity of posterior arterial segments rated by a radiologist on a scale of 1 to 5 are listed in table 1. The overall image quality and large vessel conspicuity are the same for all techniques. For small segments, the vessel conspituity is superior with the new method than the conventional method. Even with the loss of SNR due to parallel imaging, there is only minor degradation in small vessel definition.

Integrated with previous work on low SAR MT background suppression and flow artifact suppression at 3.0T, the combination of scan time reduction techniques greatly improves the efficiency of 3DTOF MRA. With good sensitivity and wide coverage in less 4min, the method would allow the 3DTOF MRA to be used more frequently in clinical practice to survey the vasculatures. The improved efficiency can also be helpful in obtaining higher resolution. Although the new method has only been tested at 3.0T, similar advantages can be expected for 1.5T also.

References

[1] Bernstein MA *et al*, MRM 2001; **46**:955-962

[2] Lin C *et al*, MRM 2003; **50**:114-121

[3] Lin C *et al*, ISMRM 2004; poster 2573

[4] Lin W *et al*, MRM 1994, **32**(5):678-683

[5] Bernstein MA *et al*, JMRI 2001; **14**:270-280

[6] Gaa *et al*, Acta Radiol 2004 **45**(3):327-332

Figures

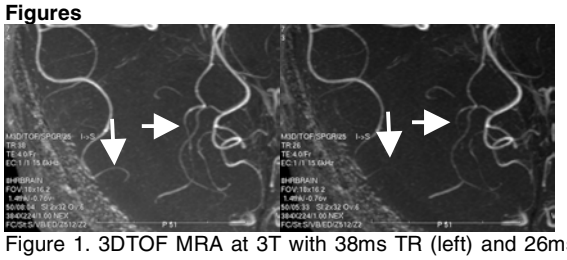

Figure 1. 3DTOF MRA at 3T with 38ms TR (left) and 26ms TR (right) demonstrate the loss of signal from small vessels marked by the arrows due to saturation.

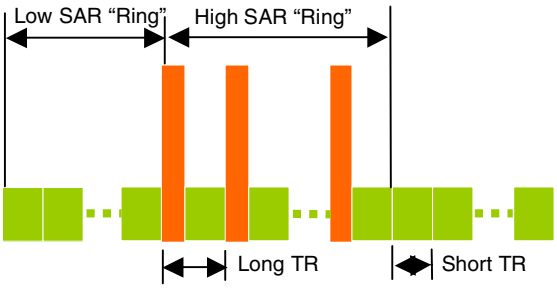

Figure 2. Each green block represents the acquisition of a *k*-space point, or a view, which has low SAR. Each orange block represents a MT sequence, which produces high SAR. With REC view order, consecutive views form a ring in *ky*-*kz* space and the low SAR rings for outer views and the high SAR rings of central views are interleaved to minimize the peak SAR. At the same time, the TR is longer for central views because of the MT sequence prior to their acquisition.

Figure 3. MIP images acquired at 3.0T with conventional of 3DTOF MRA in 12:06 (left), the new method w/o parallel imaging in 7:11 (middle) and the new method with parallel imaging in 3:41 (right). The grayscale settings are identical.

Table

	Image Quality Scores					Paired T-TEST (P<0.05)	
Method	Overall	P1	P2	P3	P4	P3	P4
Conventional	5.0±0.0	5.0±0.0	5.0±0.0	4.4±0.8	3.4±1.1	-	-
New	5.0±0.0	5.0±0.0	5.0±0.0	5.0±0.0	3.6±0.5	0.21	0.75
New w. SENSE	5.0±0.0	5.0±0.0	5.0±0.0	4.0±0.0	2.2±0.5	0.37	0.03

Table 1. Scores for the overall image quality and the conspicuity of posterior arterial segments (P1-P4) are averaged from five subjects. Statistical comparisons between the new methods and the conventional method are made for the results of P3 and P4.