Improvements of 3DTOF MRA at 3.0T

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Introduction

With its higher SNR, 3.0T can be superior to 1.5T for high-resolution 3DTOF MRA [1]. Associated with the higher field strength is the increase in SAR, especially with magnetization transfer (MT). Also, the artifacts from the pulsatile flow are aggravated [2].
The problem of increased SAR can be addressed with power monitor design [3] and centric MT that applies MT pulses only during the acquisition of central *k*-space points [4,5]. Pulsatile flow artifact resulting from applying phase-encoding gradients in sequential view order can be reduced with non-sequential view orders such as elliptical centric (EC) [6]. However, EC view order increases the short-term average SAR with centric MT because the center of *k*y-*k*z space is acquired in a short time. A novel strategy of rearranging EC view order was developed to maintain the non-sequential nature of EC view order, while distributing the high SAR from the MT pulses throughout the entire scan.

Methods

A 3DTOF MRA pulse sequence was implemented with rearranged elliptical centric (REC) view order. In REC, the acquisition of all *k*-space views is divided into annular segments. The acquisition time of each segment is set equal to 10 sec to match the short-term average time of the power monitor [3]. Each segment is then subdivided into 3 blocks as illustrated in Fig. 1. The central views with MT are placed in the middle block of each segment. This strategy allows constant RF deposition in the 10 sec moving average window of the power monitor and, therefore, minimizes the short-term SAR. REC also offers the option of skipping the corners of *k*-space to reduce the scan time without sacrificing spatial resolution [7].
To compare the artifact intensity and vessel conspicuity with different methods, a healthy volunter was scanned on a GE 3T-94 VH/i scanner with the modified pulse sequence. The imaging parameters were selected based on a clinical 3DTOF MRA protocol at 3.0T with 38ms TR, 4ms TE, 25^o FA, ±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. When MT was applied, the MT pulse was active only during the acquisition of 30% of the data points in the center of *k*-space and the flip angle of the MT pulse was 670 degree. The scan time was 8:03 for two slabs with full *k*-space acquisition, and 6:21 with *k*-space corners skipped.

Results

Fig. 2 shows image comparisons of the techniques discussed in Methods, with identical window/level settings in each pair. Comparing (a) and (b) confirms the reduction of pulsatile flow artifacts with REC and the background suppression with MT. The artifact-to-signal ratio is 0.068 in (a) and 0.020 in (b). Comparing (c) and (d) demonstrates the improved visualization of small vessels with MT even though the scan time is shorter. The vessel-to-backgound signal ratio is 3.89 in (c) and 4.88 in (d). Comparing (e) and (f) shows no substantial degradation of image quality from scan time reduction by skipping *k*-space corners. The SNR is 81.9 in (e) and 89.9 in (f).

Discussion

This work demonstrates that REC view order can reduce the flow artifact while minimizing the short term average SAR of MT in 3DTOF MRA. This technique mitigates both drawbacks of MRA at higher field strength and reduces the imaging time. A further clinical study is underway. With REC, the *k*-space points are acquired in a series of rings, so it is compatible with the the RINGLET motion correction technique [8].

Acknowledgements

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References

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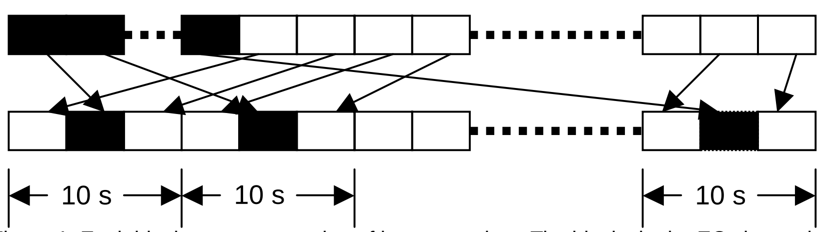

Figure 1: Each block represents a ring of k-space points. The blocks in the EC view order (top row) are re-arranged so that those with high SAR (solid) are distributed evenly throughout the entire scan.

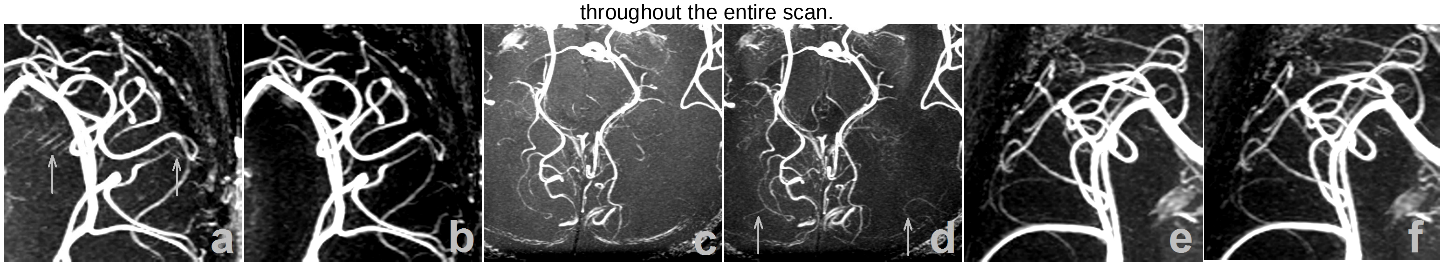

Figure 2 (a,b) Pulsatile flow artifacts (arrows) in conventional 3DTOF MRA (a) are reduced with REC, MT and skipping *k*-space corners (b).

Figure 2 (c,d) Small vessels not detectable in conventional 3DTOF MRA (c) are visualized (arrows) with REC, MT and skipping *k*-space corners (d).

Figure 2 (e,f) Image quality wih full *k*-space acquisition (e) is not substantially degraded when the corners of *k*-space are skipped (f).