

Feasibility of Refocused Turbo Spin Echo (rTSE) for Clinical Noncontrast MRA

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Introduction: Flow-independent angiography is a type of noncontrast-enhanced imaging that relies on the NMR properties of tissue, rather than flow, to generate contrast. RARE-type sequences are capable of generating contrast between blood and surrounding tissue based on T_2 differences, but conventional RARE sequences have a non-zero first moment at the RF pulses and at odd echoes, and are therefore susceptible to flow-related artifacts and signal loss. An alternative technique, refocused turbo spin echo (rTSE) combines the increased signal provided by the 180° refocusing RF pulses of RARE and the better flow performance of the fully-refocused gradients and phase alternation of balanced SSFP [1]. Blood-background contrast is then provided by the T_2 differences between blood and background muscle tissue, with artery-vein contrast provided by the differing behaviors of the blood pools under rapid refocusing. Here, we demonstrate the feasibility of the rTSE sequence in patients in a clinical setting.

Methods: Data from 4 patients (2 male, age 65.5 ± 9.0) who were scheduled for peripheral runoff contrast-enhanced examinations was acquired to assess the efficacy of the rTSE sequence in the clinical setting. A Siemens 3-T Trio scanner (Siemens Medical Solutions) with peripheral MRA coils placed anteriorly and laterally and a spine coil placed posteriorly was used for imaging. Three stations were acquired in each patient, covering the lower vasculature from the aortic bifurcation to the ankle, except in one patient who was unable to tolerate the procedure and was removed from the analysis. For each station, the 3D sequence parameters were: TR/TE/Echo Spacing = 3000/230/3.4 ms, resolution $1.48 \times 1.48 \times 1.50 \text{ mm}^3$, acquisition time $5:21 \pm 0:35$ per station ($16:07 \pm 1:05$ total). Additionally, a 2D time-of-flight angiogram was acquired providing a standard against which to compare the rTSE images.

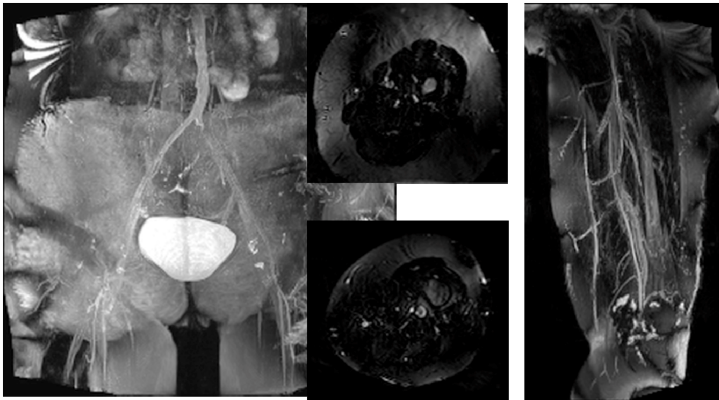


Figure 1. Thin MIP of upper station (left) with axial slices corresponding to MIP of thigh station (right).

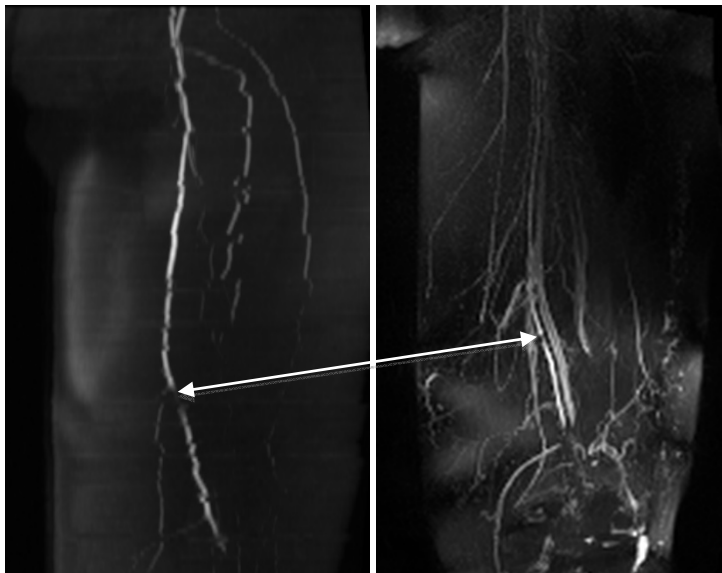


Figure 2. Thigh station depicting femoral stenosis on both TOF angiogram (left) and rTSE angiogram (right).

Results: Figure 1 shows rTSE images from the upper station of a 54 year old female patient depicting the aortic bifurcation and iliac arteries. Also shown are axial slices of the thigh showing the high contrast achieved between arteries and background muscle and the lesser contrast achieved between arteries and veins. Figure 2 compares an rTSE scan (right) with a TOF scan (left) of a 76 year old female. A stenosed section of the femoral artery was visualized successfully with both sequences.

Discussion & Conclusions: As patient size is, in general, larger than volunteer size, the aortic bifurcation was obscured in all three patients due to aliasing (Fig. 1, left); additional phase encodes in the anterior-posterior direction would alleviate this problem, at the cost of increased scan time. The femoral artery was well depicted in the thigh station of all patients, with sufficient contrast to visually separate the artery from the femoral vein and with sufficient resolution to successfully image a stenosis of the mid-thigh femoral artery. Imaging of the calf station was unsuccessful, due largely to a decrease in artery-vein contrast, which may be attributable to an increase in venous T_2 , which has been reported [2].

T_2 contrast is easily attained by TSE-style sequences; however an undesired fat signal is observed in this version of rTSE. Careful application of other fat suppression methods, such as spectral-spatial pulses, may mitigate this signal in the future. In these images, the synovial fluid in the knees appears bright due to its long T_2 . The application of an inversion pulse prior to excitation would allow suppression of this fluid based on its T_1 .

References:

1. Fielden SW et al. ISMRM 2009 #1877.
2. Brittain JH et al. MRM 38:343-354 (1997).