SR-TurboFLASH measurements of renal perfusion: Comparison between 1.5 and 3T with and without parallel imaging

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Background

Renal perfusion measurements have been introduced to assess the impact of renal artery stenosis on the parenchymal blood flow and to determine the split renal function[1,2]. Most approaches are based on dynamic first pass imaging of a gadolinium bolus. To correctly trace the passage of the contrast agent bolus a temporal resolution of 1s is required. Rapid temporal sampling will, of necessity, impose restrictions on coverage and /or spatial resolution. Parallel imaging (PI) is one possible solution to increase the spatial coverage with unchanged temporal resolution, yet at the cost of the available signal-to-noise ratio (SNR). Recently introduced 3T scanners however, theoretically offer sufficient SNR for fast sampling with high temporal resolution, increase coverage and sufficient SNR. Therefore, the aim of this study was to intraindividually compare a fast saturation-recovery (SR) TurboFLASH (TFL) sequence with and without PI at 1.5T with SR-TFL with PI at 3.0T to determine the optimal sequence for renal perfusion imaging.

Material and Methods

After IRB approval, 15 healthy volunteers (15 men, 26-36 years) underwent three consecutive MR perfusion measurements for a total of 45 MR perfusion exams. Serum creatinine was determined in all volunteers to rule out renal disease. SR-TFL measurements were performed after the automated bolus injection of 7cc of Gd-BOPTA (Mulithance, Bracco) at 4cc/s through an antecubital 20G needle at 1.5T (Avanto, Siemens Medical Solutions) and at 3.0T (Tim Trio, Siemens Medical Solutions). The SR-TFL sequence applies a pulse train of three short π/2 pulses with constant amplitude and phase cycling in a phase angle of π/2 followed by a 10 mT/m spoiler over 1 ms to drive magnetization into saturation. All TFL sequences used a 192 x 160 Matrix interpolated to 384 x 320 with a voxel size of 2.9 x 2.3 x 8 mm³. A temporal resolution of 4 slices/s (1.5T no parallel imaging), 6 slices/s (1.5T, parallel imaging, GRAPPA factor 2) or 5 slices/s (3.0T with parallel imaging, GRAPPA factor 2) was achieved. TR and TE were minimized and ranged between (TR 168-280ms, TE 0.98-0.95ms) with a flip angle of 12° and a bandwidth of 900 Hz/pixel for all three sequences. The slices were prescribed in an oblique coronal orientation. Total acquisition time was 3:30 minutes. Additionally, a high-spatial resolution 3D MRA (0.7mm³, 19s scan time) was acquired after the first exam to rule out renal artery disease.

The SNR at baseline and at the maximal signal intensity of the kidneys and the aorta was measured according to a previously published dedicated method[3] which is also suitable for sequences using PI. The image quality (noise level, presence of disturbing artifacts, demarcation of the kidneys) was rated by two radiologists in consensus on a four point scale (4-very good, 3- good, 2-moderate, 1-poor). On an offline workstation regions of interest (ROI) were placed over the kidneys and signal-intensity-versus-time curves were obtained using dedicated software (MERZ Siemens Medical Solutions). The software uses a gamma variate fit to derive perfusion parameters on a pixel-by-pixel basis with automated motion correction, including: mean transit time (MTT), time to signal peak (TTP), maximal signal intensity (MSI), maximal upslope of the curve (MUS). The parameters were compared paired t-tests with the 1.5T TFL without parallel imaging as standard of reference.

Results

All measurements could be performed without problems. The SNR at baseline and at maximal signal intensity of the kidneys was significantly higher at 3T (baseline 15.3±5.4/ peak 84.5±32.6) than at 1.5T without (9.6±2.4/ 60.1±25) or with parallel imaging (9.3±2.3/ 56.7 ± 26.4).The TFL at 3.0T was rated best with a median of 4 due to the high SNR and the good demarcation of the kidneys throughout the entire measurement (Figure 1), even in the excretory phase. The more pronounced chemical shift artifact at 3.0T was not disturbing. The TFL at 1.5T without PI was rated with a median of 3, the TFL at 1.5 with PI with a median of 2, mainly due to the weak demarcation of the kidneys and markedly decreased SNR. Non-significantly different values for MTT and TTP were found for all three techniques. Solely, the MUS and MSI were significantly higher ($p < 0.01$) with the use of PI at 1.5T and 3.0T. A complete overview of the perfusion parameters can be found in table 1.

	TTP [s]	MTT [s]	MSI [A.U.]	MUS [A.U./s]
1.5T TFL without PI	11.1 ± 1.6	14.8 ± 2.2	399.7 ± 64.0	64.0 ± 11.7
1.5T TFL with PI	11.0 ± 1.4	14.6 ± 1.8	440.6 ± 123.3*	70.8 ± 19.9*
3.0T TFL with PI	11.2 ± 1.7	15.8 ± 2.1	553.9 ± 194.9*	91.0 ± 38.9*

Table 1 – TTP and MTT are independent of the technique used. MSI and hence also MUS are significantly higher (denoted with *) with the use of PI at 1.5T and at higher field strength.

Conclusion

The TFL sequence at 3.0T seems to be the favorable sequence for renal perfusion scans, as it directly converts the higher SNR into an increased spatial coverage with set high temporal and spatial resolution. The application of PI at 1.5T leads to markedly reduced image quality, while without PI only a limited spatial coverage is achieved. The perfusion parameters MTT and TTP are hereby independent of the technique used, while MUS and MSI depend on the technique applied.

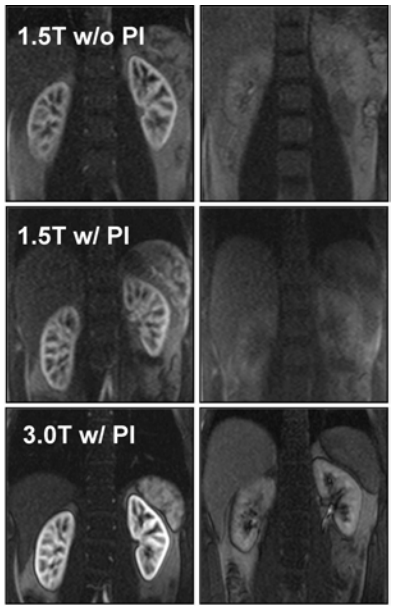
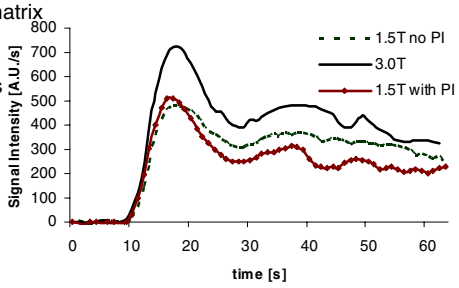


Figure 1 Exemplary images from the first pass of the contrast agent (left column) and of the excretion phase (right column) demonstrating the difference in the image quality and noise. While on the late phase images at 1.5T the kidneys are hard to mark off, they can be easily marked off in the late phase at 3.0T. Please also note that the image at 3.0T is much more homogenous and appears less grainy even though the same matrix and field of view was used for all three sequences,

Figure 2

The higher SNR at 3.0T also is also reflected in the signal intensity versus time curves. This also explains the higher MSI and MUS at 3.0T.



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