

## Contrast-enhanced MR angiography: The evaluation of central K-space filling scheme in 3D turbo FLASH and 3D FISP

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**Purpose:** As a fundamental study for scan timing optimization, we evaluated the central k-space filling scheme of 3D turbo FLASH and 3D FISP, which used for contrast-enhanced MR angiography.

**Materials and Method:** The phantom consisted of 12 pairs of test tubes, 12 infusion lines and 12 10-ml syringes. In each pair of test tubes, as a standard tube, one was filled with a diluted Gadolinium chelate solution (2.28 mmol/L) and the other was empty. The standard tubes were included to compensate for the possible inhomogeneity of the magnetic field. Two concentrations (1.40 mmol/L and 3.15 mmol/L) of contrast solution were used for sequential filling of the vacant tubes. After installation of the phantom within the surface coil, sequential manual infusions of the 10-ml contrast solution into vacant test tubes were performed during scanning in coronal plane. The scans were obtained utilizing two pulse sequences: a 3D turbo FLASH and 3D FISP using a 1.5T MR scanner. The  $T_a$  was set to 30 seconds by the changing of the number of phase encoding in Z-axis. The time intervals of the sequential infusions were 2 seconds. In the first experiment, the sequential infusion started 3 seconds after the beginning of the scan and finished at 25 seconds. After replacing the vacant tubes, in the second experiment, a repeat scan was started with the sequential injection of 10-ml of contrast solution in every other second from 4 to 26 seconds. This experiment was performed using both lower and higher concentration contrast solutions. In the 3D FISP sequence, methods of experiment were the same as those of the 3D turbo FLASH sequence. The acquired images were processed by MIP technique. Subsequently, SNR of each tube was calculated and plotted (time-SNR graph). The time-sensitivity graph, which was the first derivative of the time-SNR graph, was also plotted to evaluate the sensitivity over data acquisition time. The same processing and measurements were applied to all four studies done by two contrast solutions in two pulse sequences. On the time-sensitivity graphs of both pulse sequences, parameters, such as the sensitive acquisition zone (SAZ) and the most sensitive point (MSP), were measured.

**Results:** The time-SNR graphs showed abrupt downslides along the time. Initially and terminally filled test tubes did not affect the shape of curves. In the time-sensitivity curve, the SAZs were measured as one-half (15 sec) of acquisition duration (30 sec) in both 3D turbo FLASH and 3D FISP sequences and in both lower and higher concentration contrast solutions. The MSPs were 3/8 point (11.5 sec) and 1/2 point (15 sec) of acquisition duration in 3D turbo FLASH and 3D FISP sequences, respectively, and was located at the center of each SAZs.

**Conclusion:** The central k-space filling scheme of 3D turbo FLASH and 3D FISP were different. Whereas 3D FISP fills central k-space at the half of acquisition time, 3D turbo FLASH used asymmetric filling scheme and fills central k-space at 3/8 of acquisition time. Therefore the knowledge of SAZ and MSP, which developed in this study, would be very important to get more accurate scan timing protocol in each pulse sequence.