

Clinical Assessment of Standard and GRAPPA Parallel Diffusion Imaging: Effects of Spatial Resolution and Reduction Factor.

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INTRODUCTION – Standard single-shot EPI-based diffusion weighted imaging (DWI) has become commonplace in neurologic imaging (1), especially in evaluating for acute stroke (2), but suffers from poor spatial resolution and geometric distortion, compromising interpretation of small DWI lesions. Parallel imaging offers advantages for DWI in reducing readout time (via incomplete sampling of k-space), resulting in less distortion for given spatial resolution, and shortening echo time for a given b-value (with some preserved SNR) (3). This technique yields reduced susceptibility artifacts, increased spatial resolution, and reduced eddy current distortions (4,5). This prospective NIH funded study independently examined the effects of higher in-plane spatial resolution (192 vs. 128 square matrix) and acceleration factor (R=1 and R=3) upon diagnostic confidence and image quality. The main hypothesis was that parallel-imaging-enhanced DWI has relatively less distortion and improved resolution compared with traditional DWI, and improves lesion conspicuity and diagnostic confidence, and may reveal lesions in alternate vascular territories, thereby modulating therapy. Here we report the data of this trial.

METHODS – The study was approved by the local IRB and is HIPAA compliant. 48 patients (27 acute ischemic stroke, 11 intracranial hemorrhage, 7 acute hemorrhagic infarct, and 4 without DWI lesion), after signing written informed consent, were imaged with 4 separate diffusion-weighted sequences, acquired at the same imaging session on a 1.5T GE Signa scanner using two different acquisition matrices and reduction factors: (1) 128² @ R=1; (2) 128² @ R=3; (3) 192², R=1; (4) 192² @ R=3. Shared parameters for all scans included 5 mm slice thickness, with 1.5 mm gap, b=1000s/mm² (tetrahedral encoding), FOV 24 cm.

Diffusion images (isoDWI, B₀, and Trace ADC) were presented in blinded fashion and in random order to 3 neuroradiologists who rated the studies for overall image quality, susceptibility artifact, motion artifact, spatial resolution, subjective noise assessment, and lesion conspicuity (1 = much worse, 5 = to much better, and 3 = comparable to a "typical DWI scan"). Each reader was asked to select a most likely diagnosis and state confidence on a scale of 1-5 (extremely unlikely, 1, to extremely likely, 5).

RESULTS – Figures 1 and 2 show typical diffusion imaging scans for different matrix size and reduction factors, highlighting differences in technique upon perceived presence

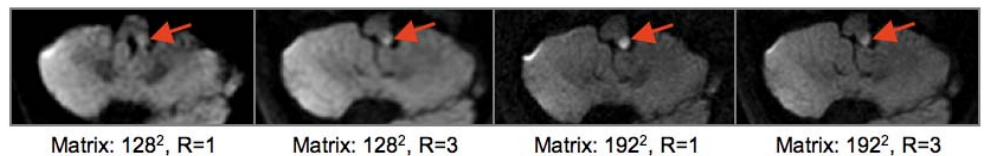


Fig. 1 – Representative diffusion images obtained with stated matrix size and reduction factor in a patient with left dorsal medullary infarct (red arrow). One of three readers graded the 128², R=1 and 128², R=3 scans as “No lesion”, but correctly graded the higher matrix size scans (192² R=1 and R=3) as infarct, highlighting the increased conspicuity of the lesion using a higher matrix size.

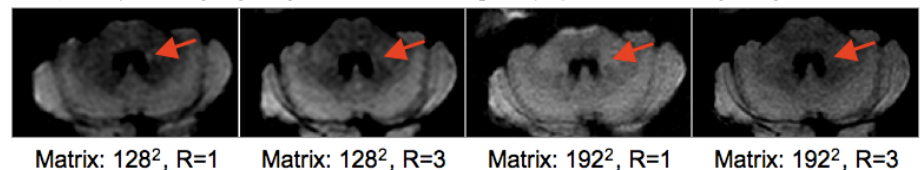
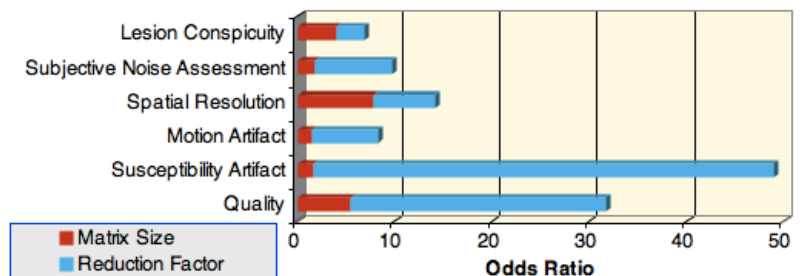


Fig. 2 – Diffusion images in a patient with right superior caudate body infarct (not shown), and tiny presumed left middle cerebellar peduncular infarct identified on Matrix = 128², R=1 image (red arrow), determined to be artifact on other DWI images, and standard MR sequences (not shown), altering diagnosis from “embolic” to “lacunar” infarct in 2 of 3 readers.



	Quality	Susceptibility Artifact	Motion Artifact	Spatial Resolution	Subjective Noise Assessment	Lesion Conspicuity
Reduction Factor	26.22382	47.39621	6.818963	6.424014	7.979687	2.771529
Matrix Size	5.526135	1.645034	1.435085	7.774999	1.781028	4.083381

Table 1 – Results of mixed-effects logistic regression with fixed factors of matrix size (128 or 192) and reduction factor (1 or 3) in the evaluated categories listed above.

of infarct. Table 1 shows the odds ratios for individual parameters. R=3 vs. R=1 had the greatest effect on susceptibility artifact and quality with odds-ratios of 47±15.5, and 26±7.3. Lesion conspicuity was not

decreased on the R=3 images despite reductions in echo time (and therefore reduced T2 shine through effect). Reduction factor had the greatest effect on overall image quality and geometric distortion. A higher matrix size was also preferred, regardless of whether or not parallel imaging was used.

DISCUSSION – Earlier studies have indicated that parallel imaging might improve diagnostic quality of DWI (4,6). However, it had not been investigated, thus far, whether higher matrix size or parallel imaging reduction factors individually or conjointly impact the diagnosis. In this prospective study, readers found that accelerated scans (R=3) had improved image quality and less susceptibility artifact compared with unaccelerated standard DWI, without adverse effects on lesion conspicuity, subjective noise assessment, or motion artifact. Of the imaging conditions studied, we believe R=3 accelerated 192x192 matrix scans offer the best imaging conditions for clinical DWI at 1.5T, and are preferred over either independently adjusted higher resolution or higher reduction factor.

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