Clinical comparison between PADRE and SWI for susceptibility weighted MRI

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Introduction: Image contrast that utilizes local differences in tissue susceptibility has been explored in many applications, such as neuro-degeneration, stroke and vascular malformations [1]. SWI [2] is a post processing technique that combines phase and magnitude information from a susceptibility-sensitive MR sequence. Central to the SWI algorithm is creation of a mask from phase data, which is then used to enhance the magnitude image [2]. SWI has been commercialized by Siemens. Recently, an alternative algorithm for susceptibility weighting has been proposed, Phase Difference Enhanced (PADRE) [3,4]. The two techniques differ in how the phase mask is created. In SWI, a negative phase mask is used, while the PADRE mask includes both positive and negative. PADRE is available as a research tool on Philips MR platforms.
Purpose: The aim of the study was to investigate whether clinically equivalent information is obtained from SWI and PADRE.
Methods: Eight patients with hemorrhagic lesions underwent MR examinations on Siemens Skyra 3T and Philips Achieva 3T. On the Siemens system, the vendor-recommended gradient-echo (GRE) sequence was used, and standard SWI processing was performed. On the Philips system, two MR sequences were used and subsequently processed with PADRE: one GRE sequence adapted to be similar to the Siemens sequence, and one PRESTO sequence [5]. The TE of PRESTO is more than double that of GRE, giving large enhancement of susceptibility effects, but also making it sensitive to bulk susceptibility and motion artifacts. Sequence parameters are given in Table 1, while image examples are given in Fig. 1.

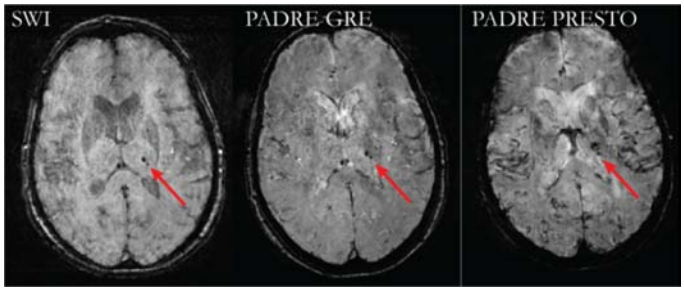

Figure 1. Example of the corresponding slice from the three different datasets. Two small hemorrhagic lesions in the thalamus are seen in all images (red arrow).

	SWI	PADRE GRE	PADRE PRESTO
TR(ms)	27	27	29
TE(ms)	20	20	46
α°	15	15	10
Res.(mm^3)	0.8×0.8×1.5	0.8×0.8×1.5	0.8×0.8×1.5
Slices/ori*.	75/TRA	75/TRA	75/TRA
Post-proc.	SWI	PADRE	PADRE

Table 1. Relevant parameters for the different imaging techniques. *Slice orientation, TRA denoting axial slices.

Patient data were anonymized prior to analysis. To quantify the image contrast, the same thirty small lesions were delineated in the post processed images for all three techniques. Regions of interest were also placed in adjacent normal appearing white matter and a contrast index, CI, was calculated as $CI = (S_{lesion}-S_{NAWM})/S_{NAWM}$, S being the signal intensity. The areas of the lesions were recorded. In order to evaluate the diagnostic usefulness of the images, three MR-experienced observers graded the overall diagnostic quality of each dataset on a scale 0-4. In this context, all hemorrhagic lesions present in each patient were counted, allowing for comparison of number of lesions detected in the three different datasets for each patient.
Results: Fig. 2 shows CI per dataset for the delineated lesions. Paired t-tests show significant differences between CI(SWI) and CI(PADRE PRESTO) and between CI(PADRE PRESTO) and CI(PADRE GRE), with CI(PADRE PRESTO) being largest. Fig. 3 shows the area measurements for the three techniques, where all differences were significant in paired t-tests. Lesions were generally largest for PADRE PRESTO, likely due to its long TE. Visual grading scores was similar between SWI and PADRE GRE, while in general lower for PADRE PRESTO, due to its larger artifact burden. In no case did the observers visual grading score differ by more than one unit. For the number of lesions, the interobserver variation was larger than differences between the imaging techniques.
Conclusion: Both PADRE and SWI are useful diagnostic tools, giving comparable diagnostic information. Significant differences in CI and lesion area were observed between the techniques. The PRESTO image sequence enhances susceptibility differences, but also increases artifact levels.

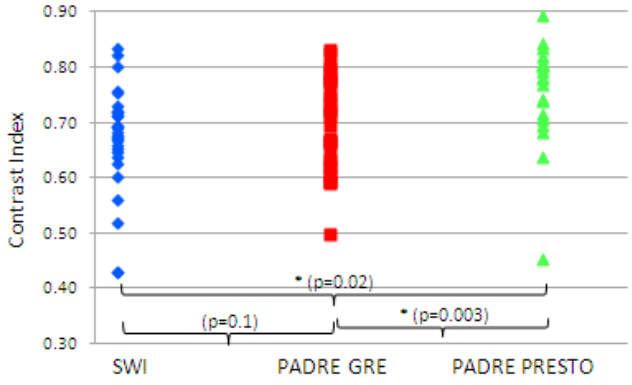

Figure 2. The CI for the lesions delineated in the postprocessed images. Paired t-tests show significant differences (p>0.5, denoted by *) for two of the three pairs.

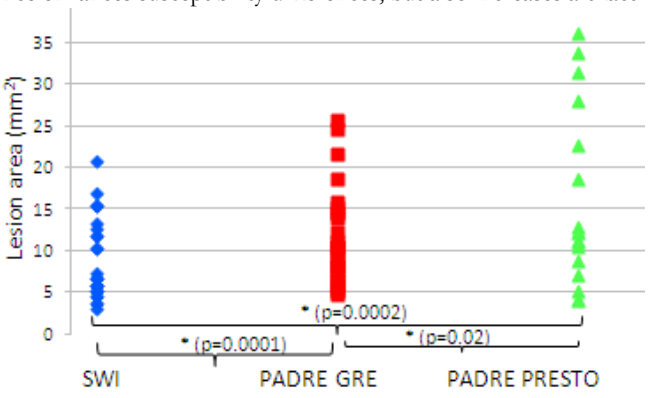

Figure 3. The lesions areas were significantly different (p>0.05, denoted by *) for all three pairs.

[1]Mittal S. et al, AJNR 30 p.232 (2009) [2]Haacke E. et al., MRM 52 p.612 (2004) [3]Yoneda et al., US patent US 2011/0304330 A1 [4]Yoneda T. et al., Proc. 17th ISMRM, 2764 (2009) [5]Liu et al., MRM p.764 (1993)