

# SWI POST PROCESSING TO ENHANCE CLINICAL UTILITY OF CONVENTIONAL 2D GRE IN THE PEDIATRIC NEUROIMAGING

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**INTRODUCTION:** Susceptibility Weighted Imaging (SWI) is an MR imaging technique that utilizes a gradient echo (GRE) acquisition together with phase post-processing to accentuate the paramagnetic properties of blood products, resulting in images very sensitive for the detection of intravascular venous deoxygenated blood and extravascular blood products [1]. SWI has been shown to be useful in studies of arterial venous malformations, occult venous disease, multiple sclerosis, trauma, tumors, and functional brain imaging [2]. A limitation of SWI is its requirement of a high resolution 3D GRE sequence, which can lead to acquisition times of up to 10 minutes for full brain coverage. Compared to the approximately 2-3.5 minutes of conventional 2D GRE scans acquired routinely at our pediatric hospital, the additional scan time needed for 3D GRE is unacceptable in our clinical setting. Our goal was to evaluate the utility of applying SWI's phase and magnitude post processing normally reserved for 3D GRE images to conventionally acquired 2D GRE images.

**METHODS:** Routine 2D GRE imaging was performed with the following parameters: TE/TR/FA = 15ms/650ms/20°, slice thickness = 5mm, 1mm gap, FOV = 18–24cm, rect FOV = 0.75, matrix = 384x168, BW=15kHz, and flow compensation. All exams were conducted using a 3T whole-body GE system and an 8-ch head coil. For the SWI processing, a phase unwrapped and high-pass filtered phase image was generated for each coil using a 2D Hanning window [1,3]. Next, a negative phase mask was generated for each coil, which was then multiplied by the magnitude image 5 times [1,3]. The final 2D SWI image was produced with a sum of squares over coils. The unwrapped phase image (weighted by the signal intensity of the coils) was also viewed to assess its ability to help differentiate between blood products and calcium. Processing was performed on 50 consecutive pediatric cases routinely performed at our children's hospital over a two week period, after which the resultant images were reviewed by an attending pediatric neuroradiologist (KY) and a neuroradiology fellow (SS). Direct comparisons were made between the conventional 2D GRE images and the 2D GRE SWI images; the inverted phase unwrapped images were used as complementary information. Each study was viewed in 3 installments, first viewing the conventional 2D GRE, then the SWI processed 2D GRE and 2D GRE phase unwrapped images (2D GRE Phase), and then finally, all 3 sequences in comparison. Each study was then assigned a categorization of 1 to 4 as follows: (0) No 2D GRE Findings, (1) No Change in Findings with 2D SWI, (2) More Conspicuous Findings with 2D SWI, (3) Additional Findings noted on 2D SWI images compared to conventional 2D GRE, or (4) Findings of conventional 2D GRE made less conspicuous after 2D SWI processing. Additional notes were made when: SWI processing resulted in visualization or improved visualization of basal ganglia mineralization; SWI resulted in worsened artifact; and when phase imaging suggested presence of calcium rather than hemorrhage, which was then confirmed by CT.

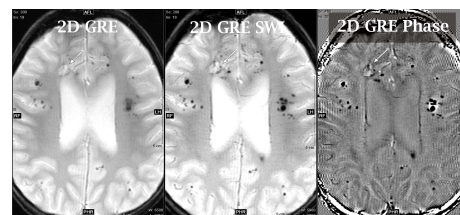
**RESULTS:** Of 50 cases reviewed, 14 studies had no GRE findings. Of the remaining 36 studies, 15 had more conspicuous findings on 2D SWI images than conventional 2D GRE, 16 demonstrated findings not seen on 2D GRE imaging, and no studies were completely unchanged after viewing SWI processed images, (fig. 1). Similar to SWI images normally acquired with 3D GRE, the conspicuity of blood products appeared to be increased (fig. 2) despite the lower TE used for 2D GRE (15ms for 2D GRE versus 20ms for 3D GRE). It was additionally noted that in cases of venous thromboses where 2D GRE clearly delineated asymmetric prominence of venous structures, detection of thromboses was more challenging on the 2D SWI images due to enhanced visualization of all venous structures (thrombosed and non thrombosed) (fig. 3). We also encountered several cases where incorporating phase images alongside the SWI images helped to distinguish calcification from hemosiderin, exploiting the different phase effects resulting from the differing magnetic susceptibility of calcium or iron containing structures (fig. 4). For the same reason, catheter lumen and their drainage holes were also more conspicuous after SWI processing, especially on phase images. This property may be useful in evaluating occluded / non functional catheters (fig. 5). In our 2 subjects with dental braces, SWI post processing resulted in images with more artifact than conventional 2D GRE (fig. 6).

**DISCUSSION:** Post processed 2D SWI images allow for increased sensitivity to blood products without requiring additional scan time. The resultant phase images have also added our ability to distinguish calcium

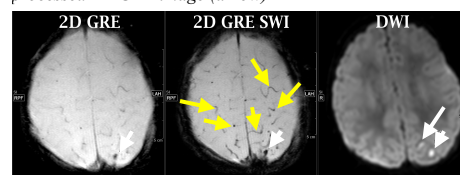
from hemosiderin.

This technique has some limitations in that

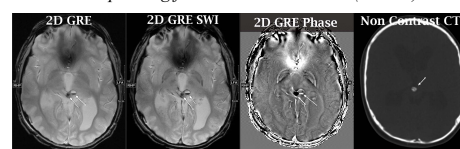
(1) with enhancement of additional normal venous structures on SWI post processing, pathologic venous structures may be less evident; and (2) braces or other metal-induced artifact may be worsened. However, we found that in over half of the cases, new pathologic findings were found or lesions became more conspicuous after SWI post-processing, leading us to conclude that this technique may be a useful adjunct to our daily clinical practice, especially at a pediatric setting where long scan times of 3D SWI are difficult to implement. Future work will aim to assess additional contributions can be gained by using SWI style minimum intensity projections of the 2D GRE data. **References:** [1] Hacke E.M. (2004) MRM 52:612-18. [2] Tong KA. AJNR (2008) Jan;29(1):9-17. Epub 2007 Oct 9. Review. [3] Reichenbach J.R. (1997) Radiology



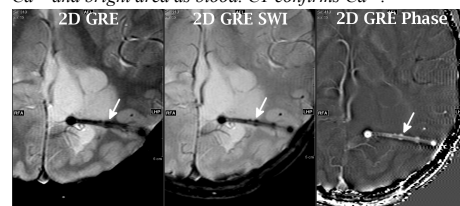
**Figure 2:** More conspicuous blood products seen on SWI processed 2D GRE image (arrow)



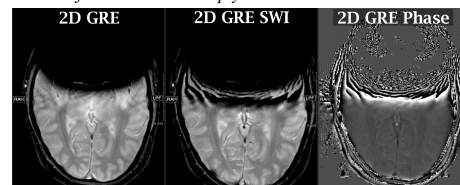
**Figure 3:** Left parietal venous thrombus (arrow) on 2D GRE is less prominent on SWI 2D GRE due to prominence of additional venous structures (yellow arrows). DWI shows corresponding focal ischemia and clot (arrows).



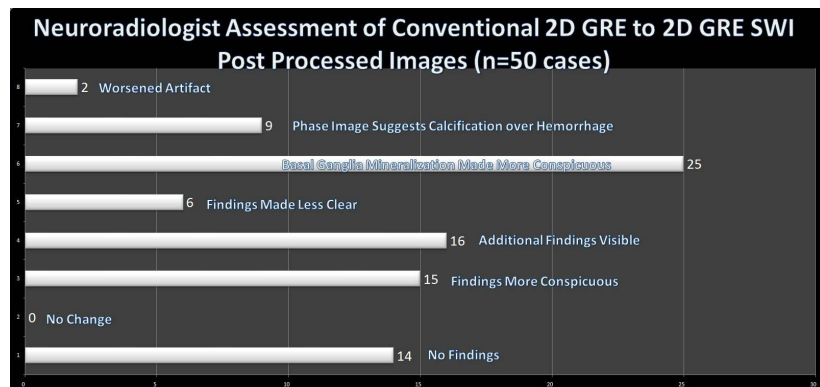
**Figure 4:** 2D GRE and 2D GRE SWI images focal dark lesion and adjacent dark fluid level in a pineal tumor. It is uncertain whether this is all hemorrhagic or there are Ca<sup>2+</sup> tumor components. 2D GRE Phase shows dark area as Ca<sup>2+</sup> and bright area as blood. CT confirms Ca<sup>2+</sup>.



**Figure 5:** 2D GRE SWI & Phase images demonstrate catheter features more sharply than 2D GRE.



**Figure 6:** 2D GRE SWI and Phase images demonstrate increased artifact compared to conventional 2D GRE in patient with braces.



**Figure 1:** Neuroradiologist assessment of contribution of SWI post processing of 2D GRE acquisition and Phase images to interpretation of conventional 2D GRE images.