Enhanced detection of abnormalities in pediatric neuroradiology using high-resolution susceptibility weighted imaging

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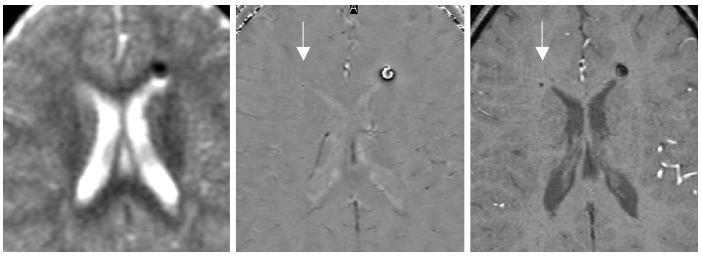
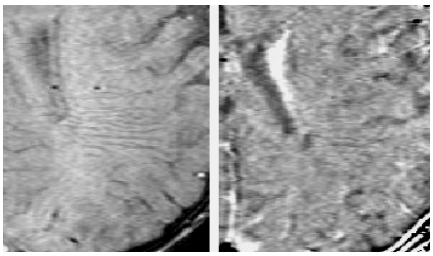
Purpose: The aim of this study is to evaluate the diagnostic potential of high resolution susceptibility weighted imaging (SWI) in cases of children with vascular malformations and phacomatosis. SWI is based on susceptibility-induced phase contrast and is sensitive not only to the oxygen content of intravascular blood but also to breakdown products, such as hemosiderin, and calcifications due to increased signal dephasing [1].

Patients and Methods: We studied children with suspected malformations (multiple cavernomas: 12 month old girl, Sturge-Weber syndrome: 5 month old boy, tuberous sclerosis: 5 year old boy) on a 1.5 T MR unit (Vision plus, Siemens) using a standard head coil. Conventional MRI consisted of pre and post contrast T1- and T2-weighted SE sequences, FLAIR and susceptibility sensitive EPI with a slice thickness of 6 mm. 2D TOF-MR angiography (arterial and venous) was performed in cases with vascular malformations. A high-resolution, T2*-weighted 3D gradient echo sequence with first-order flow compensation and rf spoiling was used for SWI (TR 67 ms, TE 40 ms, flip angle 25°, FOV 256 mm, 512 matrix) with an in-plane resolution of 0.5 x 1 mm² and a slice thickness of 1.5 mm. Magnitude and phase images were reconstructed from the raw 3D data sets and minimum intensity projections (mIP) were performed over 4–7 sections. To increase the visibility of the vessels and abnormalities, a phase mask was constructed from each original phase image. This mask filter was multiplied with the corresponding magnitude image.

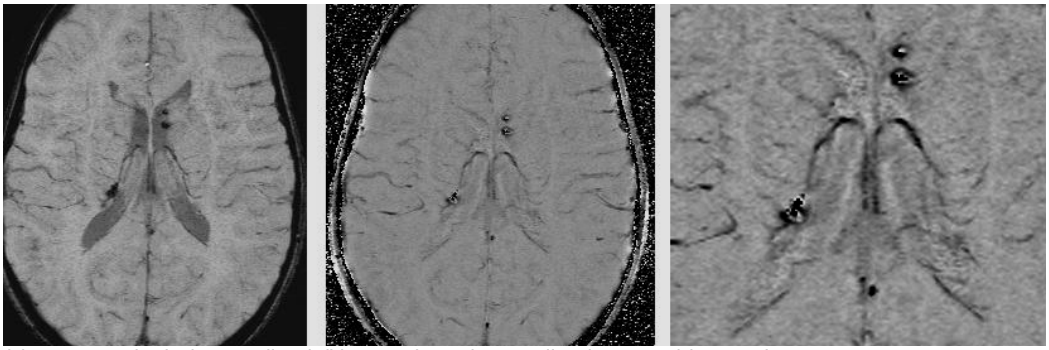
Results: Highly detailed information about the veins was obtained in all patients with SWI. In the patient with **multiple cavernomas** (Fig. 1) 3 cavernoma-like lesions were detected by the standard sequences, 4 cavernoma by the single-shot EPI sequence, and 9 lesions by SWI. The smallest lesion detected by SWI was 1–2 mm. The typical sign for a cavernoma was a bright rim around the hypointense lesion in the phase images which is caused by hemosiderin. In the case with **Sturge-Weber syndrome** early diagnosis was only possible using SWI. Distinct abnormal structures of deep venous vessels were seen in the occipital lobe on the left side with SWI (Fig. 2), whereas conventional imaging was without pathological finding. In a follow-up MRI typical strong enhancement of the cortical surface on T1-w images was present and a prominent deep collateral venous system was observed using conventional TOF-MR-venography. In the patient with **tuberous sclerosis** the subependymal nodules could be differentiated with detailed information using SWI. Typical calcifications of the subependymal hamartomas could be visualized clearly and more lesions were detected by SWI which is optimal for showing the calcifications because of the magnetic susceptibility differences of calcium and brain.



(a) EPI (b) SWI Magnitude (c) SWI Phase
Fig. 1 Cavernoma



(a) Magnitude (b)- Phase
Fig. 2 Sturge-Weber-Syndrome



(a) SWI Magnitude (mIP 5 slices) (b) SWI Phase (mIP 5 slices) (c) SWI Phase
Fig. 3 Tuberous sclerosis

Discussion: High-resolution susceptibility weighted imaging combines detailed spatial resolution with the ability to detect susceptibility differences in small lesions. In cases with vascular malformations it enhances the visibility of vascular abnormalities to a greater extent than conventional methods and helps to detect pathology earlier like in our patient with Sturge-Weber syndrome. In patients with tuberous sclerosis SWI helps to characterize subependymal hamartomas and to differentiate subependymal hamartomas from germinal matrix hemorrhages. Due to its intrinsic high sensitivity SWI can be recommended for special cases in pediatric neuroradiology.

References

[1] Haacke EM et al. Magn Reson Med. 2004 Sep;52(3):612-8.