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Susceptibility-weighted imaging of the brain: Does gadolinium administration matter?

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ABSTRACT

Objective: Susceptibility-weighted MR imaging (SWI) is usually obtained without administration of intravenous gadolinium (Gd). However, it is occasionally necessary to perform SWI after Gd is injected. The effects of Gd on SWI have not been systematically examined. The aim of this prospective study was to investigate whether performing SWI after Gd would influence the diagnostic image quality, parenchymal signal and vascular enhancement. An additional aim is to suggest potential future applications for Gd-enhanced SWI.

Methods: SWI was performed in 31 subjects before and after Gd administration. 17 cases were examined in a 1.5 T scanner and the remaining 14 were scanned at 3 T. The pre- and post-Gd images were analysed for signal changes in the cerebral grey matter (GM), white matter (WM) as well as for enhancement in the superficial and deep venous system. The visibility of the veins was graded on subtraction maps.

Results: The Gd-enhanced images showed no image quality degradation and no significant signal intensity change in the GM and WM as compared to the pre-Gd images ($p > 0.05$). After Gd-administration significant enhancement of the venous sinuses was noticed ($p < 0.005$), while the deep and cortical veins were poorly enhanced as confirmed by the calculated subtraction maps. The results showed no significant difference at variable MRI field strengths.

Conclusion: It is possible to perform SWI after Gd injection without information loss or signal change in the parenchyma. The most significant difference is the enhancement of the cerebral venous sinuses. Potential future applications are discussed.

1. Introduction

Susceptibility-weighted imaging (SWI) has been introduced to the clinical arena in the beginning of this decade [1,2]. This technique exploits the susceptibility differences between the tissues. It is thus extremely sensitive for parenchymal bleeds and calcifications, which are depicted as areas of signal loss. SWI can illuminate small vessels and veins in the brain, an advantage utilized for venous thrombosis, arteriovenous malformations and stroke. The two types of images most commonly used in clinical practice are the SWI and the reconstructed mini-IP (minimum intensity projection) images. Numerous excellent reviews of this technique and its clinical applications have been recently published [3–5]. SWI is traditionally performed without intravenous Gadolinium (Gd). In the daily clinical routine a radiologist might face a situation, when she/he decides to obtain SWI images after Gd has been already injected. However, it may be argued that the paramagnetic contrast medium could negatively influence SWI data, e.g. due to T2 shortening and additional signal loss.

The aim of this study is to clarify whether SWI after Gd-administration would degrade or significantly alter the image information regarding the: (1) signal change in the cerebral grey and white matter and the (2) enhancement of intracranial veins. (3) An additional aim is to suggest potential future applications for Gd-enhanced SWI.

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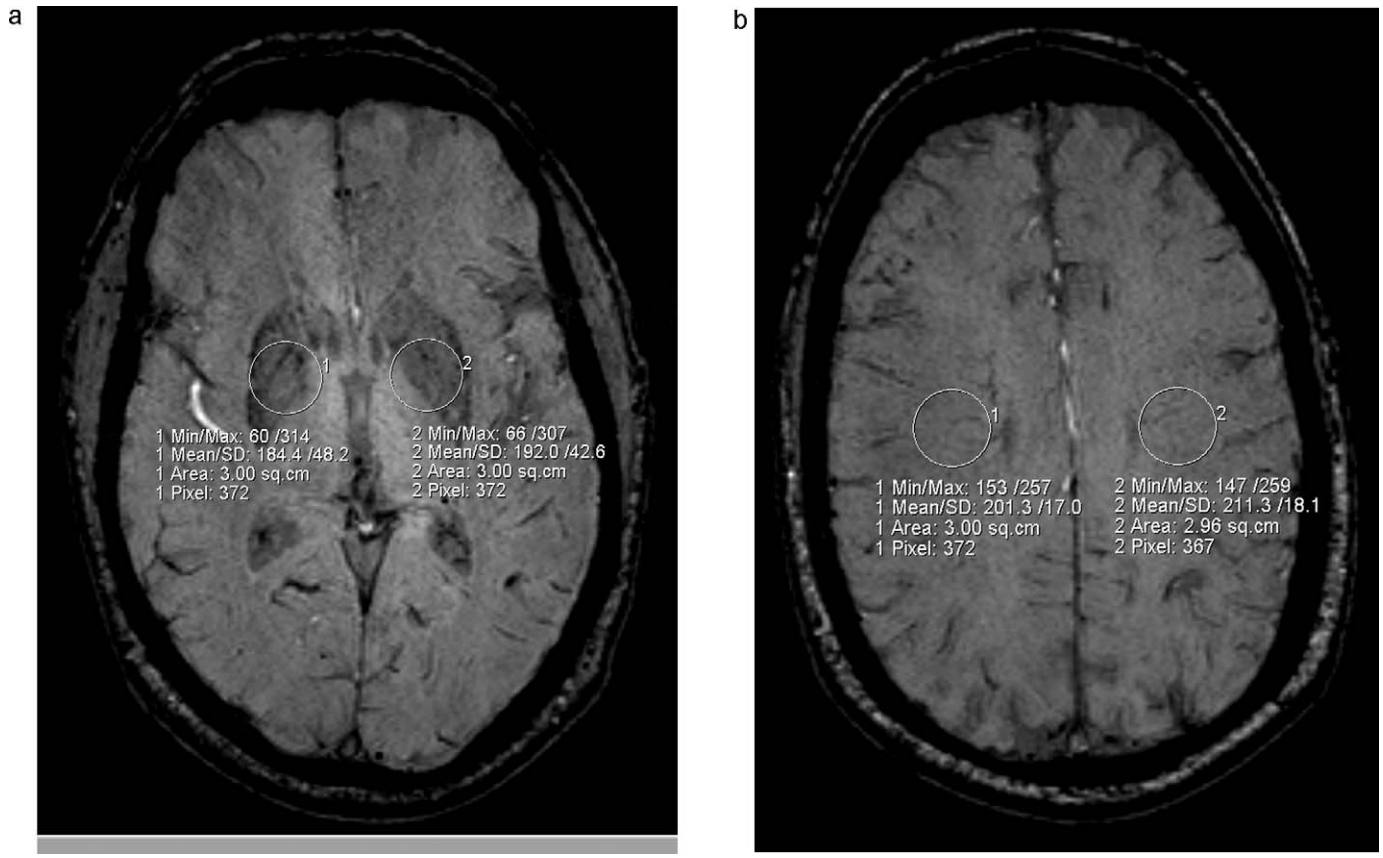

Fig. 1. Selection of the regions of interest (ROI size; 1 cm^3) in the SWI images.

2. Materials and methods

From January to June 2010, 31 adult subjects were prospectively studied; 17 were scanned in a single 1.5-T MRI (Magnetom Avanto, Siemens, Erlangen, Germany) and 14 individuals in a single 3-T scanner (Magnetom Verio, Siemens, Erlangen, Germany) equipped with a 12-channel head coil. The included subjects were scanned for clinical indications according to the routine guidelines in our institution. In all subjects, Gd-administration was clinically indicated. SWI was performed before and after intravenous administration of Gadobutrol 1.0 M at a concentration of 0.1 mmol/kg body weight. A signal-to-noise ratio of 1.0 was achieved in both scanners. For the 1.5 T the SWI parameters were; TR 49 ms, TE 40 ms, voxel size 1.1 mm × 0.9 mm × 1.8 mm, flip angle 15, number of averages 1, acquisition time 2 min:59 s. For the 3-T scanner the parameters were as follows; TR 28 ms, TE 20 ms, voxel size 1.1 × 0.9 × 1.8 mm, flip angle 15, number of averages 1, acquisition time 2 min:59 s. The SWI- and mini-IP images were generated automatically by the scanner software.

Exclusion criteria were (1) venous sinus thrombosis, (2) hemodynamically decompensated intracranial stenosis or occlusion of a major anterior circulation artery, and (3) extensive white matter or basal ganglia damage or infiltration.

2.1. MRI data analysis and postprocessing

2.1.1. Signal changes in the brain parenchyma

The pre- and post-Gd SWI- and mini-IP-images were analysed separately for signal intensity changes in normally appearing brain parenchyma. For the grey matter regions-of-interest of 3 cm^3 were placed in the lentiform nuclei on both sides. The white matter was represented by regions-of-interest in the centrum semiovale of 3 cm^3 bilaterally (Fig. 1).

2.1.2. Signal changes in the venous system

The pre- and post-Gd images were assessed for the signal intensity values in the venous structures only in the mini-IP images, for better inclusion of the venous structures. For the venous sinuses: a ROI was placed on the superior sagittal sinus at the level of the bodies of the lateral ventricles. For the deep venous system, ROIs were positioned in the internal cerebral veins. The cortical veins were not quantified with ROIs due to their extremely small size.

The placement of the ROIs was chosen in consensus by two experienced radiologists (EM and GF with a 16 and 12 years experience respectively). Using the software package provided by the manufacturer of the scanner (Leonardo-Workstation, Siemens, Erlangen, Germany), the ROIs in the GM and WM as well as of the venous system were copied from the pre-Gd to the post-Gd images to insure that the same anatomical location was quantified. The proper location was again verified visually, and corrected manually if necessary.

2.1.3. Subtraction maps

For further analysis subtraction maps were obtained using the same software package. Subtraction of the pre- from the post-Gd images was done for the SWI images. The visibility of the venous sinuses, the cortical veins and the deep venous system, was graded as follows: 0 = not visible, 1 = poor, 2 = fair, and 3 = good. The same two radiologists (EM and GF) independently graded the visibility of the veins. The interobserver variability was statistically tested. The subtracted images were further post-processed to yield