Improved lesion detection in regions with strong susceptibility using iShim-WBDWI as compared to 3D-Shimming WBDWI

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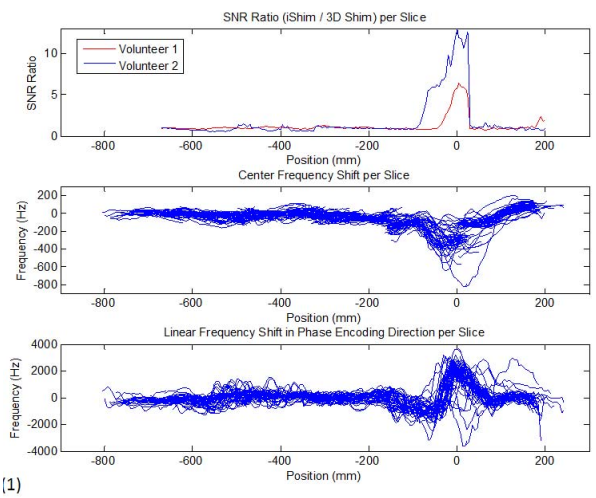
Target audience: Clinicians who are interested in whole-body DWI and researchers who are interested in advanced shimming technique

Purpose: Whole-Body DWI (WBDWI) allows the detection and characterization of focal lesions and distal metastases. However, geometric distortions and signal drops in areas with strong susceptibility, such as the neck, still pose a challenge for accurate diagnostis on whole-body DWI images - in particular at 3T[1,2]. The aim of this study was to compare a recently developed sequence integrated slice-by-slice shimming technique (iShim-WBDWI) with conventional volume-selective 3D shimming (3DShim-WBDWI).

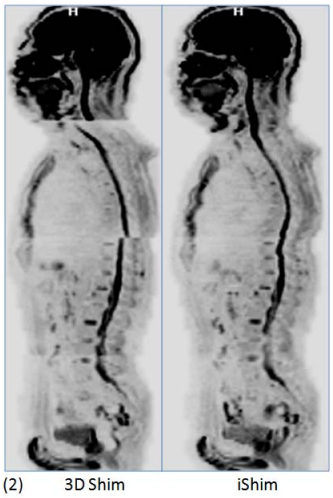
Methods: Fifty-seven patients with diffuse disease (29 multiple myeloma patients and 28 lymphoma patients) were examined in a 3T scanner (MAGNETOM Skyra, Siemens). The MRI protocol included 3D-Shim-WBDWI and iShim-WBDWI (prototype sequence) with identical scan parameters (transversal scan with 35 slices per bed position, voxel size is 3.75 mm × 3.75 × 5.00 mm, TE/TR is 60 ms / 4160 ms) and interleaved inversion recovery fat suppression. The patients gave written consent, and the study was approved by the local ethics committee. For each WBDWI scan, the 'broken spine' artifact was evaluated on a five-point scale (1: apparent through 5: no artifact) for all patients. The number of lymph nodes and bone lesions were counted in the neck region. The SNR was acquired and calculated from 2 volunteers with different body size using a pseudo-replica method[3,4], and the mean SNR for each slice, as well as the mean SNR ratio (SNR_{iShim} / SNR_{3DShim}) was reported as a function of position from pelvis to head region.

Results: The 'broken spine' artifact average score is 4.56 for images acquired with iShim-WBDWI, whereas the average score is 2.56 for 3DShim-WBDWI exams. In the neck region, the total number of lymph nodes detected by iShim-WBDWI and 3DShim-WBDWI were 3339 and 1699, respectively (the lymph node across different slices is counted separately); Visual inspection of iShim and 3DShim DWI images side by side showed that all the multiple myeloma lesions in throat, abdomen and pelvis regions were observed in both techniques, while 24 of 72 lesions observed by iShim-DWI in the neck region were not shown in 3DShim-DWI images, and all lesions observed in 3D Shim were also shown in iShim-DWI images (the myeloma lesions across different slices is counted separately). As shown in Fig. 1, with iShim-DWI, large SNR improvement is obtained in the neck region, and SNR performance is similar in other body regions as compared to the 3DShim-DWI technique.

Discussion and Conclusion: Slice-by-slice review of all WBDWI images reveals that the conspicuous lesions in the neck region cannot be detected with conventional 3D Shim WBDWI due to the signal loss. Compared to 3DShim-WBDWI, iShim-WBDWI (Fig. 2) shows largely improved image quality and thus improved detectability of lymph nodes and bone lesions in the neck region. By dynamic adjusting the center frequency and phase gradient defined for each slice (Fig. 1), the susceptibility artifacts have been largely reduced with iShim WBDWI. This dynamic shimming change is consistent with the SNR improvement in the body region. In conclusion, iShim greatly enhances the image quality of WBDWI, allowing for more accurate evaluation of distal metastasis.



(1)



(2)

Figure (1): SNR ratio of iShim / 3DShim, center frequency and phase gradient shift as function of position from pelvis to head. Center frequency shift and linear frequency change in phase encoding direction are from all patients.

Figure (2): Sagittal view of 3D Shim and iShim data with identical scan parameters for the single patient.

Reference: 1. Padhani AR, et al, Radiology 2011;261(3):700-718; 2. Lee SK, et al, Magn Reson Med 2014;71(5):1813-1818; 3. Robson PM, et al, Magn Reson Med 2008;60(4):895-907; 4. Wiens CN, et al, Magn Reson Med. 2011;66(4):1192-1197;