Brain MR Imaging of Patients with Multiple Sclerosis at 3.0 Tesla: Dielectric Effect Artifact and Its Correction

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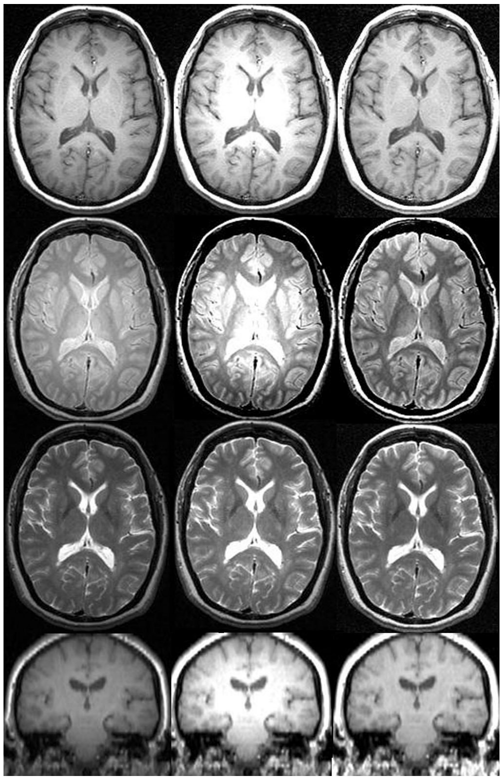
Introduction

MR imaging and MRI-derived measurements play an indispensable role in the diagnosis and monitoring of multiple sclerosis (MS). Currently, most MR imaging of MS patients is performed on 1.5 T systems. With the increasing use of 3.0 T scanners in clinical settings [1], one concern is the RF magnetic field (B_1) inhomogeneity at high field that results from RF penetration effects and standing wave effects [2, 3]. The B_1 inhomogeneity may result in signal intensity nonuniformity that can significantly interfere with image interpretation and measurements [4]. However, the appearance and correction of signal intensity nonuniformity on images of MS brain at 3.0 T have not been reported. We are conducting a study comparing 3.0 T with 1.5 T MRI for the evaluation of pathological changes in MS. Initial results regarding the appearance and correction of intensity nonuniformity are reported here.

Materials and Methods

Dual-echo fast spin echo images and conventional spin echo T1-weighted images (T1WI) of eight patients with MS were obtained on a 1.5 T scanner (Signa; GE Medical Systems, Milwaukee, WI), and 48 to 72 hours thereafter on a 3.0 T scanner (Signa; GE Medical Systems). These two sequences were studied because they are the most frequently used sequences in imaging MS patients. Scan parameters for the dual-echo sequence at 3.0 T were identical to those at 1.5 T (TR/TE1/TE2=4000/15/80 ms, ETL=8, NEX=1). The parameters for spin echo T1WI were also identical to those at 1.5 T (TR/TE=450/9 ms, NEX=2) except for a 30% longer TR (585 ms) at 3.0 T to maintain similar T1 weighting [1]. Other parameters for both sequences were: FOV=22 cm, matrix=256x192, thickness/gap=3/0 mm, receiver bandwidth =±15.6 kHz. A 20-cm-diameter spherical spectroscopic phantom (GE Medical Systems, Model 2152220) containing near physiological concentrations of common brain chemicals was also scanned at 3.0 T using the same protocol as for patients. Standard birdcage head coils were used.

Images from both scanners were visually inspected. After severe intensity non-uniformity was observed in the 3.0 T images, *N3*, a popular nonuniformity-correction algorithm that outperforms several other techniques [5], was utilized. However, it could not adequately correct the artifacts. Therefore, we developed a new nonuniformity correction technique. The new technique iteratively fits a multi-scale function to the 3D intensity in the dataset to estimate the global bias field and then remove the nonuniformity.



Before correction, regular Window setting	*Before correction, narrow Window setting*	*After correction, same narrow window setting*

Figure 1. *Dielectric effect artifact on brain MR images of MS patients obtained at 3.0 T. The artifacts are less recognizable at regular window setting, but rather obvious at narrow, optimal window setting for viewing gray/white matter near the brain surface. The shape and location of the brightness on coronal images (bottom row) reformatted from axial slices indicate that the highest B_1 field strength is at the center of the brain volume, rather than at the center of 2D slices. After application of our nonuniformity correction algorithm, the images appear homogenous at the same narrow window setting as for images in the middle column.*

Results

Images from 3.0 T showed dielectric effect artifact characterized by gradual signal intensity increase from the surface to the center of the brain volume. The artifacts were better appreciated with narrow window settings (Fig 1). The artifact was less recognizable on T2-weighted images (T2WI) of patients, but T2WI of the phantom at 3.0 T demonstrated artifacts similar to those from T1WI and proton density-weighted images. This may be explained by the much larger contrast between intracranial tissues on T2WI and the wider window setting used for viewing the brain images. None of the images acquired at 1.5 T showed similar artifacts. The artifacts at 3.0 T were corrected satisfactorily by applying our new, rapid nonuniformity-correction technique (Figs. 1, 2). The algorithm required four seconds to process 50 256x256 slices on a standard PC (1.6 GHz Athlon MP 2000+ processor, 2 Gb memory).

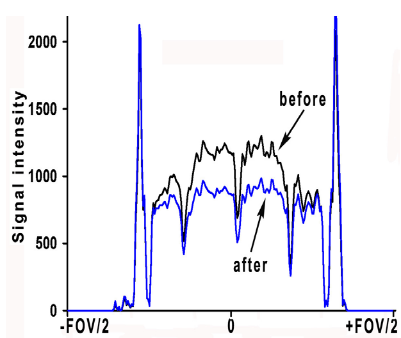


Figure 2. *Signal intensity vs. location of the pixels on the center horizontal line of the T1WI before and after correction in Fig 1. The curve of corrected image is flat compared with that before correction.*

Discussion and Conclusion

Brain MR images obtained at 3.0 T can be contaminated by dielectric effect artifacts, which are different in appearance from previously described shading artifacts at 1.5 T [6]. We have developed a new, platform independent, nonparametric algorithm that rapidly estimates and removes the intensity nonuniformity in 3D.

References

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