Improvement in B1-Inhomogeneity Artifacts at 3 Tesla Using Dielectric Cushion

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Introduction: The advent of clinical MR imaging at 3T has been met with much anticipation. Basic MR physics predicts that doubling the main magnetic field strength from 1.5T will result in a gain in the signal-to-noise ratio (SNR). This increase in SNR can either simply be kept or it can be translated into improved spatial resolution, reduced acquisition time, or a combination thereof. Improved spatial resolution is particularly valuable in neuroimaging of the brain and spine, breast imaging, and magnetic resonance angiography. Reduced scan time is especially important in cardiac and body imaging. More specifically, reducing the acquisition time is valuable in motion sensitive applications and in the imaging of those patients whose limited breath-hold capabilities may lead to significant image degradation. However, this improvement in SNR is not without cost. This is manifested by increased T1 relaxation times, more pronounced susceptibility artifacts, and larger chemical shifts. In addition, 3T imaging is accompanied by a corresponding increase in the specific absorption rate (SAR) or deposition of RF energy in the patient [1-2]. Finally, B1-inhomogeneity artifacts, also called standing wave effects or dielectric resonances, can significantly degrade image quality, rendering examinations essentially nondiagnostic. To address this problem, dielectric or RF cushions have been developed in an effort to reduce such artifacts [3]. In this study, we investigate the quantitative and qualitative impact of a dielectric pillow on whole body imaging at 3T.

Materials and methods: The study was approved by our institutional review board and written informed consent was obtained. Twenty healthy male volunteers (mean body mass index ± standard deviation: 25.5 ± 3.4 kg/m^2) were scanned on a 3 tesla whole body system (Magnetom Trio, Siemens, Erlangen, Germany) using a dedicated body array coil for signal reception (USA Instruments, Aurora, OH). Identical imaging sequences were performed in the coronal and axial planes, with and without the use of a dielectric cushion. T2-weighted HASTE (TR/TE/FA/BW = 1000ms/81ms/136°/558Hz per pixel) and true-FISP (TR/TE/FA/BW= 3.41ms/1.7ms/50°/1502Hz per pixel) sequences were used for coronal imaging, each sequence performed with and without integrated Parallel Acquisition Techniques (iPAT), with an acceleration factor of 2 using the GRAPPA algorithm. Additionally, axial T2-weighted HASTE and true-FISP imaging without iPAT was performed.

The *quantitative effect* of the dielectric pillow (Radiofrequency Cushion, Siemens, Erlangen, Germany), namely the impact on SNR, was assessed by measuring signal intensities and their standard deviation in the liver and in artifact-free background regions external to the patient on corresponding images obtained with and without the pillow. Quantitative data was analyzed using a two-tailed paired Student's t-test.

The *qualitative effect* on perceived image quality was assessed by subjectively evaluating for the presence and severity of RF inhomogeneity artifacts by two independent readers in a side-by-side comparison with a 5-point DROC (differential receiver operating characteristics curve; 1 = image without pillow much better, 2 = image without pillow slightly better, 3 = images with and without pillow equal, 4 = image with pillow slightly better, 5 = image with pillow much better). In addition, the effect of the pillow on image quality was correlated with the volunteer's body mass index by calculating the Pearson's correlation coefficient.

Results and discussions: Mean hepatic SNRs were 50.7 with the cushion and 66.7 without the cushion for coronal HASTE imaging with iPAT. This difference was statistically significant ($p = 0.0008$). The same statistically significant decrease in SNR with the cushion was seen on coronal HASTE imaging without iPAT ($p = 0.001$). However, no significant change was seen on all other imaging sequences (coronal true-FISP w/wo iPAT, axial true-FISP wo iPAT, axial HASTE wo iPAT). Although the exact mechanism of this effect remains debatable, it is clear that a passive device such as the dielectric cushion cannot generate any RF energy itself. It is therefore reasonable to expect that in order to passively increase the signal in one location the signal would need to be reduced in other locations.

Qualitative analysis revealed an improved image quality on T2-weighted HASTE images, in both the axial and coronal planes, when imaging with the dielectric cushion (mean qualitative rank of 3.65 to 3.80 for reader 1 and 3.50 to 3.65 for reader 2; area under the DROC curve = 0.74 which is significant at the 0.05 level). This is mainly due to an improvement in image quality in the left hepatic lobe by decreasing the dielectric artifacts that commonly manifest in that region when imaging without the use of the cushion. No correlation was found between the improved image quality and the volunteer's body mass index. In addition, no significant improvement was seen on the true-FISP sequences.

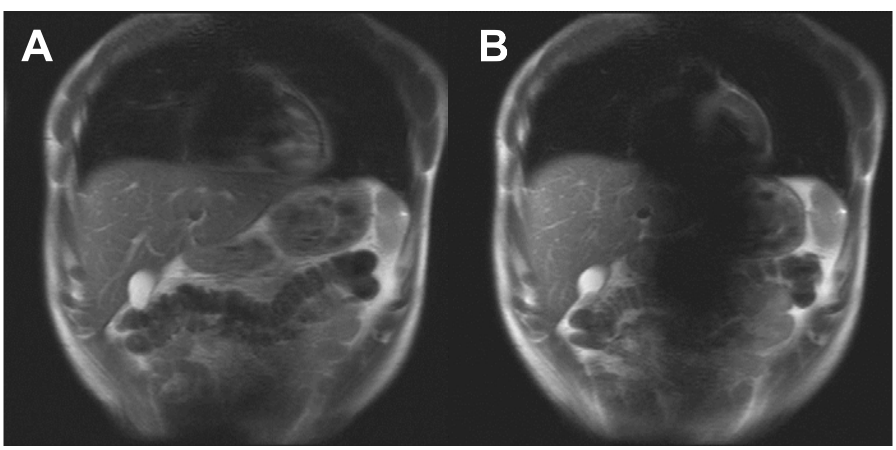

Figure 1: Coronal Haste imaging at 3 tesla with (A) and without (B) the use of a dielectric cushion. Substantial dielectric artifacts on image (B) obscure adequate visualization of the left hepatic lobe, the gastric antrum, and parts of the transverse colon.

Conclusions: We conclude that dielectric cushions improve image quality through decreased B1-inhomgeneity artifacts on T2 weighted- HASTE sequences but do not have a significant effect on T2 weighted true-FISP sequences. However, this improved image quality comes at a cost of reduced SNR.

References:
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