Considerations for Parallel Imaging when using High Permittivity Pads in the Thighs at 3 T

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Target audience: Researchers interested in parallel imaging and/or RF shimming

Purpose: High permittivity materials have been introduced previously to correct transmit (B_1^+) inhomogeneities in the upper thighs at 3T [1]. However, due to reciprocity, this degrades the homogeneity of the body coil reception profile (B_1^-), which can introduce artifacts when using parallel imaging techniques that rely on body coil information for coil calibration. Post-processing methods have been introduced previously to correct for such wave propagation effects [2], but fail when the transmit and receive profiles of the body coil do not coincide. The aim of this work is to explore the effects of dielectric pads on the transmit and receive characteristics and image artefacts in the legs at 3 T when parallel imaging is used.

Methods: MR experiments were performed on a Philips Achieva 3 T TX MR system (Philips Healthcare, Best, The Netherlands) using a six-channel receive coil array for signal reception. Healthy volunteers (N=5) were scanned under a protocol approved by the institutional review board and signed informed consent was obtained.

B_1^+ maps were acquired using the DREAM method [3] at a spatial resolution of 5 × 5 mm^2 and a slice thickness of 10 mm. Additional low contrast, low tip-angle gradient echo (GRE) images were acquired in the same geometry using the body coil in transmit/receive mode to estimate the receive sensitivity profile of the body coil by taking the ratio of the B_1^+ map and the GRE image [4]. The body coil receive profile was then used to construct a body coil correction filter, after smoothing the profile by means of a polynomial fitting procedure.

Fast spin echo (FSE) acquisitions were performed as a multi-slice sequence using the following parameters: 1.5 × 1.5 mm^2 in-plane resolution; slice-thickness 3 mm; slice-gap 1.5 mm; TR/TE 600/10 ms, with 7 refocusing RF pulses; excitation/refocusing tip angle 90/180 degrees. Two-point Dixon fat/water imaging was performed using a 3D gradient echo sequence with the following settings: 1.4 × 1.4 mm^2 in-plane resolution; slice-thickness 10 mm; $TR/TE_1/TE_2$ 5.3/1.6/3.2 ms; tip angle 2.5 degrees. The data were undersampled in the A/P phase encoding direction by a reduction factor of 1.5.

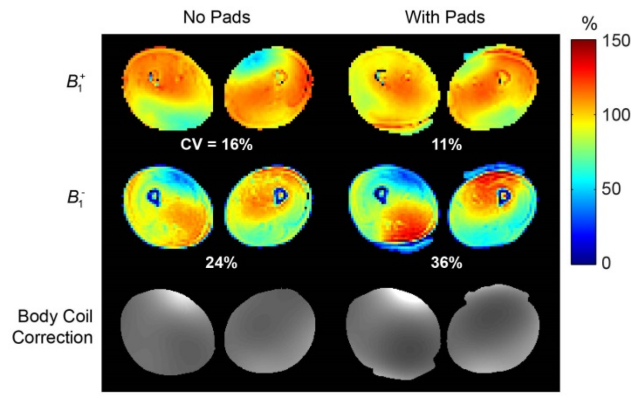

Fig. 1. Transmit (B_1^+) and receive (B_1^-) sensitivity of the body coil. The B_1^+ homogeneity (top) is improved by the dielectric pads while the B_1^- homogeneity (middle) is degraded. The receive profile is fitted to construct a correction filter (bottom).

Results: Figure 1 shows the characterization of the body coil transmit and receive profiles illustrating the degradation in receive homogeneity induced by the pads. The bottom row shows the correction filter which was derived from the receive sensitivity profile. Parallel imaging results are shown in Figures 2 and 3. As can be observed from the images, both the transmit and the receive profile are corrected when using dielectric pads together with the body coil correction filter: images with pads show substantially improved homogeneity compared to those without pads.

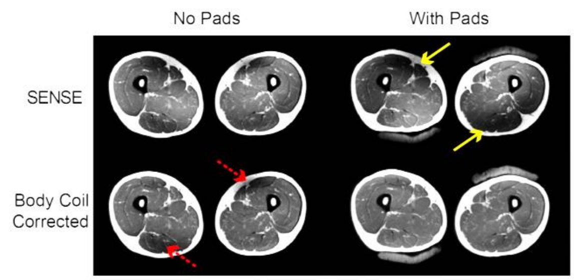

Fig. 2. FSE imaging results. The transmit non-uniformities (red) are corrected using dielectric pads, at the cost of enhanced receive non-uniformities originating from the body coil (yellow) resulting in artifacts when using a conventional SENSE or Roemer reconstruction. These effects can be corrected using prior knowledge of the body coil reception profile.

Discussion: Dielectric pads can improve the transmit homogeneity in the upper thighs, but this degrades the receive uniformity of the body coil for mirror symmetry reasons [4]. Receive inhomogeneities of the body coil are known to propagate directly into conventional SENSE or Roemer reconstructions which use image-based estimation of receive coil sensitivities [5,6]. However, since this systematic error is a common term among all array elements, these errors can be recovered by applying a body coil correction filter which is formed by the inverse of the body coil reception profile.

Conclusion: The use of dielectric pads substantially improves transmit homogeneity in the thighs. However, it compromises the receive homogeneity of the body coil. If uncorrected, this can degrade image quality when using parallel imaging techniques which rely on body coil information for calibration purposes. A correction procedure using prior knowledge of the body coil reception profile confirms this effect and restores image uniformity.

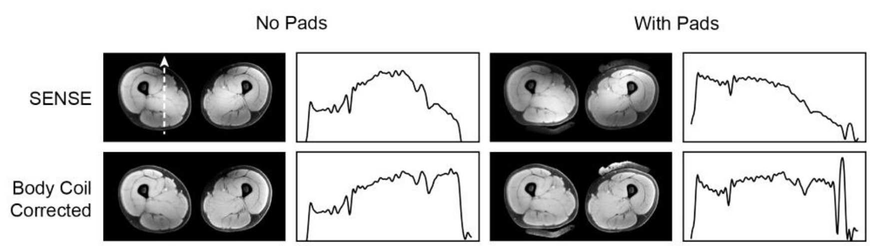

Fig. 3. Dixon water images using SENSE and the body coil correction method, without and with dielectric pads. Best image quality is obtained with dielectric pads and the body coil correction.

References: [1] Lindley et al., *Invest Rad 2014,* doi: 10.1097/RLI.0106; [2] Fuderer et al., *ISMRM 2004*, 2145; [3] Nehrke et al., *MRM 2012*, 68:1517–26; [4] Wang et al., *MRM 2002*, 48:362–9; [5] Roemer et al., *MRM 1990*, 16:192–225; [6] Pruessmann et al., *MRM*, 42:952–962.