Intensity correction at high field MRI by filtering of the reference scan

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Introduction

At high-frequency MRI (e.g., at 128MHz, 3T), dielectric effects lead to intrinsically non-uniform transmit/receive fields (see, e.g., [1],[2]). At these frequencies, the wavelength within the human body is comparable to its size. RF losses in the body also play an important role. These effects lead to image non-uniformity. This is particularly so in abdominal imaging.

Correction method

Several data-adaptive methods try to estimate a non-uniformity field from the image itself [3…8]. Yet, all these methods tend to have difficulties in handling images with large contrasts.

In our approach, this is solved by using a scan of very low contrast (a proton-density weighted scan). For that scan, the determination of a non-uniformity field is much easier. In practice, a non-uniformity estimate based on such an "easy" scan is applicable to all subsequent scans.

Whenever using the SENSE or CLEAR feature, a low-resolution 'coarse calibration' reference scan is done anyway, in order to relate coil-element sensitivity to a reference coil (usually the quadrature body coil, or QBC). This reference scan is designed to be almost purely proton-density weighted. Using this reference scan, the following procedure can be used for intensity correction:

1. During the planning of the diagnostic scans, a low-resolution density-weighted reference scan is done, acquiring images from both a synergy-coil array (if applicable) and from the QBC. This results in the image-sets S_i and Q, respectively.
2. By using homomorphic filtering [3], the image-set Q is uniformity-corrected into an image-set F.
3. The synergy-coil sensitivities are estimated by referring to that uniformity-corrected set F (rather than, as with default SENSE or CLEAR, by referring to Q). This results in sensitivity-estimates $s_i=S_i/F$. If only the QBC is used for acquisition, its "sensitivity" is estimated as $s_i=Q/F$.
4. The diagnostic scans are reconstructed by the SENSE or CLEAR method, using the knowledge of aforementioned sensitivities s_i. (In the simple case of one single coil element, this amounts to a division by s_1).

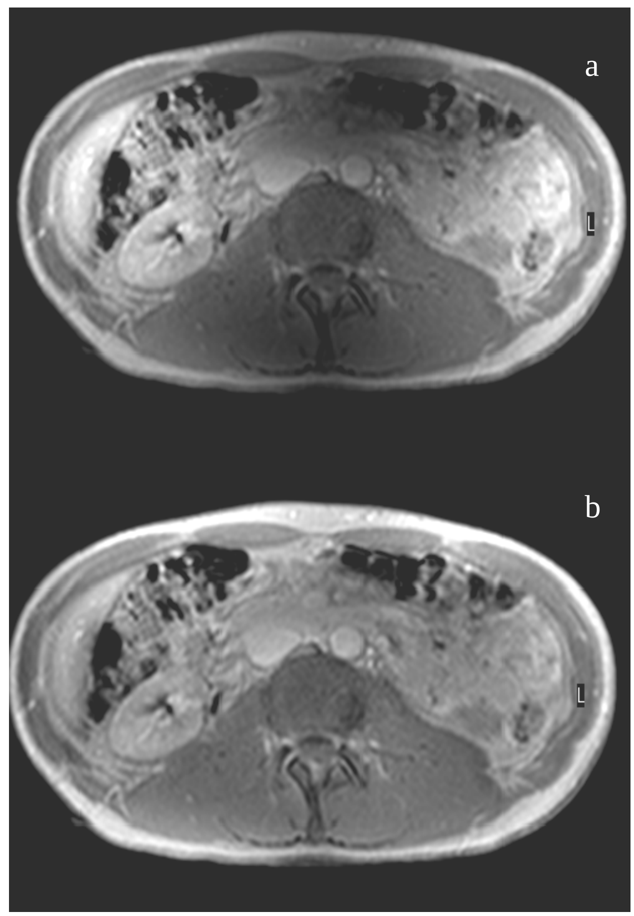
This procedure is called "Body tuned SENSE/CLEAR".

Results

The figure shows an example of an image by default CLEAR (a) and by bodytuned CLEAR (b). The image has been acquired on a 3T Philips Intera using a T1W FFE sequence (T_E=2.3, T_R=220, flip=80).

In the CLEAR image, the "dielectric dips" can be seen: in the central-anterior part of the abdomen and in the spine region. These are practically absent with bodytuned CLEAR.

A comparison study was done on 12 volunteers. Images were reconstructed with both standard CLEAR and with bodytuned CLEAR. The standard deviation of intensity over the liver was measured. In result: bodytuned CLEAR increased uniformity in all cases. In average, the relative non-uniformity (standard deviation over average) was 0.22 for standard CLEAR and 0.13 for bodytuned CLEAR.



Conclusion

Filtering of the reference scan is a relatively simple but effective method to reduce image non-uniformity for abdominal images at 3T.

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