Intensity correction for high resolution imaging using a transmitter/receiver surface coil

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Introduction. Dedicated surface coils (SC) are widely applied to detect NMR signals because they achieve higher signal-to-noise ratios (SNR).

However, the inhomogeneous SC sensitivity profile (B_{lxy}) results in images with a very high signal near the coil which decreases far from it. These signal intensity variations affect dramatically when image segmentation or standing waves investigation are of interest. When the same SC is used in the single-coil mode, as both transmitter and receiver, the inhomogeneity effects in transmission and reception are different, and the image presents a dual dependency on B_{lxy}. We present an image processing algorithm for correcting SC sensitivity profile operating in the single-coil mode based on the Biot-Savart law. This post-processing algorithm improves significantly the image quality.

Methods. Image signal intensities, ignoring random noise, is given by the expression:

$$I(x,y) = M_{xy}(x,y).\ B_{lxy}(x,y) \qquad (1)$$

where $M_{xy}(x, y)$ represents the transversal component of the tissue magnetization, and Blxy (x, y) is the magnitude of the SC sensitivity profile.

With an homogeneous radiofrequency excitation and a receive-only SC, the image intensity decreases with distance because of the inhomogeneous $B_{lxy}(x, y)$. Various algorithms have been devised to correct SC images by dividing out an estimate of the $B_{lxy}(x, y)$ [1,2].

However, if the SC is used in the single-coil mode, the inhomogeneous $B_{lxy}(x, y)$ provides a spatial distribution of flip angles within the sample in transmission. Therefore M_{xy} (x, y) also depends on the inhomogeneous B_{lxy} (x, y) as it is a function of the flip angle (a(x, y)) for a given sequence.

In a spin-echo experiment, the $M_{xy}(x, y)$ at any point in a uniform phantom is given by the expression:

$$M_{xy}(x, y) \propto \sin^3[\alpha(x, y)] \qquad a(x.\ y)\ a(\ B_{lxy}(x, y) \qquad (2)$$

With the knowledge of the sequence and its dependence on the flip angle, the image intensity can be corrected by estimating both influences, B_{lxv} (x, y) and a(x. y). In our algorithm, the $B_{lxy}(x, y)$

induced by the SC was modeled using the Biot-Savart law with a proprietary software. The SC was simulated as a polygon formed by straight wire segments [3].

Results. Several inductively coupled, series-tuned SC of different dimensions have been designed. Previous phantoms images were acquired on a Bruker BIOSPEC-BMT 47/40 using spin-echo sequence, and the signal intensity variation observed in the original image was remarkably decreased by using the algorithm. This image processing has been used to measure the size of rabbit knee cartilage. No appreciable changes in tissue contrast were noted in the corrected images.

Conclusion. The method described in this paper allows to eliminate the effect of the intensity spatial dependency when a SC is used as transmitter and receiver. The correction improved visual interpretation of the images without contrast modification.

References

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