Correction of B_0 artifacts for *in vivo* Triple Quantum sodium MRI

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Introduction:

As shown by Hancu *et al*. [1], the use of a three-pulse (3P) RF coherence transfer filter in triple quantum (TQ) sodium MRI leads to reduced signal loss from B_1 inhomogeneities. The lack of a refocusing pulse in this approach, however, introduces a dependence of this signal on the inhomogeneities of the main magnetic field (B_0), which although less severe than that obtained from the flip angle dependence in the 4-pulse (4P) coherence transfer filter, it can still lead to unwanted signal loss. When field inhomogeneities are present, each of the individual coherences contributing to the TQ signal accrues different phases, leading to a signal loss that is equivalent to that seen in intravoxel dephasing, albeit with no explicit voxel size dependence.

Theory:

Because each coherence evolves independently, one potential approach to solve this problem would be to isolate each one of the four coherences giving rise to the overall TQ signal in the 3P scheme and “add them” together after an appropriate phase correction has been performed. This correction scheme is based on the observation that, before phase cycling, the signal from the 3-pulse coherence transfer filter can be shown to be [2]:

$$S(\tau,\delta,\theta,\Delta\omega_0,T_L,T_S;t) = M_0^{TQ} \sum_{m_1=-1}^{1} \sum_{m_2=-3}^{3} e^{i(m_1\varphi_1+m_2\varphi_2)} e^{i\Delta\omega_0(m_1\tau+m_2\delta)} A_{m_1m_2}(\theta,\tau,\delta,T_L,T_S;t)$$

where, A_{mn} functions depend only on the flip angle θ, the sequence’s timing parameters (preparation time τ and evolution time δ) and the relaxation properties of the object being imaged (long and short T_2 times, T_L and T_S, respectively). Because the dependence on the magnetic field inhomogeneity is fully contained in the exponential term, the TQ signal can be decomposed in four individual contributions that correspond to the 4 different coherences giving rise to the TQ FID in the 3P scheme. These contributions correspond to each of the possible of combinations of (m_1,m_2) in the equation above, i.e., (-1,-3), (-1,+3), (1,-3) and (+3,+3). Therefore, using a suitable phase cycling scheme, the individual coherences (A_{mn} coefficients) can be isolated, algebraically solved for and B_o corrected before recombination in order to obtain the final image.

Results:

The proposed approach for the correction of B_o inhomogeneity effects is demonstrated in figure 1 Here, a comparison between uncorrected (1st row, left) and corrected (1st row, right) TQ images from a homogeneous agarose phantom are presented. The TQ image exhibits a significant signal loss in the center of the object, due primarily to the destructive interference between the individual TQ coherences in the presence of the strong Z_2 inhomogeneity introduced by the agarose cylinder. The line in the images indicates the direction along which the line profiles in the plot (bottom row) were taken. Another demonstration of the proposed technique is presented in figure 2 where the same correction scheme is illustrated on a normal human volunteer. The use of this approach clearly alleviates the signal loss above the frontal sinuses (arrows).

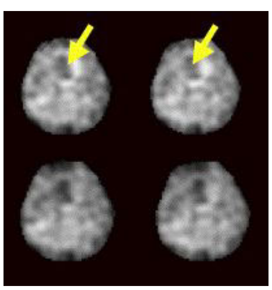

Figure 2: *A Demonstration of the B_o correction approach. (top) Uncorrected and (middle) corrected 3P, TQ images from a normal human volunteer. The data were acquired at 3.0T*

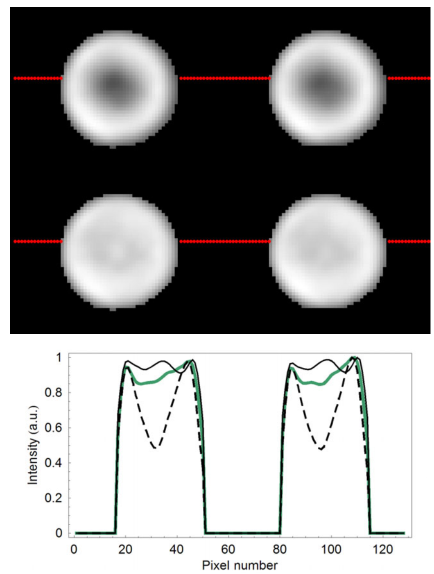

Figure 1: *B_o correction approach. (top) Uncorrected and (middle) corrected 3P, TQ images from an agarose phantom acquired at 3.0T. The line profile compares the signal intensity for the images (dashed and solid lines for top and bottom) alongside that of the single quantum image (thin line)*

Conclusions:

We have demonstrated that by acquiring the TQ coherences independently, it is possible to avoid the signal loss associated with the presence of strong B_o inhomogeneities when the 3P coherence transfer filter is used.

References:

[1] Hancu *et al*., MRM, **42**, 1146, 1999

[2] Tanase *et al*., JMR, In Press.