Comparison of ASSETx1 and Corrected Power Images for T_2 Quantification

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Background: Measurements obtained using array coils are typically combined using the computationally simple root-sum-of-squares (RSS) algorithm. Alternative methods to combine array coils have been proposed. A recent study proposed using the optimal B_1 reconstruction method,[1] implemented by performing a standard parallel imaging reconstruction method (ASSET, GE Healthcare, Waukesha, WI) but without acceleration, i.e. using an R factor of 1 (ASSETx1). This method has been shown to improve the accuracy of T_2 measurements obtained when the signal-to-noise ratio (SNR) was low by reducing the mean background noise level.[2] Miller showed that computing corrected power images improved accuracy in T_2 measurements at low SNR.[3] Both these methods are independent and can be combined.

Aims: In this study we compared T_2 measurements obtained using RSS and ASSETx1, against RSS and ASSETx1 using Miller's algorithm. We acquired MR images with both high and low SNR.

Methods: A total of 11 Eurospin T_2 gel phantoms (Diagnostic Sonar, Livingstone UK) were imaged using an 8-channel brain coil on a 1.5T MRI system (HD, GE Medical Systems, Milwaukee, WI). The range of T_2 values was 52 to 223 ms. The images were acquired using a fast spin echo sequence in which separate images were acquired from each of the CPMG echoes. High SNR images were acquired at: TR = 7500ms, TE = [1-16] x 8.272ms, FOV = 21 x 21cm and slice thickness = 10mm. The same parameters were used to acquire low SNR images but with the slice thickness = 0.6mm. Low-resolution calibration scans were acquired for the ASSET reconstruction algorithm.

The same multi-channel raw data was reconstructed off-line using both the RSS and the ASSET algorithms.

T_2 quantification was performed using the Levenberg-Marquardt (LM) non-linear least squares algorithm to compute S_0 and T_2 using $S(TE) = S_0\exp(-TE/T_2)$. The data was also analysed using Miller's method which separates signal from noise by computing the corrected power image, $S_c(TE)^2 = S(TE)^2 - S_n^2$ where S(TE) is signal intensity at each echo and S_n is the average background noise. LM was then performed to compute S_0 and T_2 using $S_c(TE)^2 = S_0^2\exp(-2TE/T_2)$. Comparisons were made with the manufacturers stated T_2 relaxation times for the gels.

Results: The techniques are summarized using Bland-Altman method comparison statistics: bias and 95% limits of agreement. There was a systematic difference between the nominal T_2 for the high SNR measurements for both RSS and ASSETx1 with bias = -11 ms and 95% limits of agreement -24 to 1 ms. Therefore we used the RSS values at high SNR as the gold standard. Table 1 shows that at low SNR without Miller, ASSETx1 is both more precise and accurate than RSS. However, with the power correction applied both ASSETx1 and RSS are equivalent. There was no improvement when applying the power correction to the high SNR data.

Table 1 Low SNR T_2

	Bias (ms)	95% limits of agreement (ms)
RSS	33	(-26,69), range = 79
ASSETx1	-9	(-23,4), range = 27
RSS (Miller)	-16	(-25,-8), range = 17
ASSETx1 (Miller)	-17	(-25,-8), range = 17

Conclusions: The study tests proposed methods to improve derived T_2 values. At low SNR RSS has poor precision, whereas both ASSETx1 and Miller's algorithm applied to RSS improved both the precision and accuracy. Although Millers algorithm applied to RSS yielded the best results, ASSETx1 does not require a measurement of background signal intensity; which may be useful in small FOV measurements. There is a small further improvement in precision when applying the Miller method to ASSETx1 data.

[1] Roemer PB et al, Magn Reson Med 1990;16:192-225.
[2] Graves, 2007. J Magn Reson Imag (accepted)
[3] Miller, 1993. Magn Reson Imag;1993;11:1051-56