A Post-processing Method for Obtaining Accurate T2 Estimates from a Single Radial Fast-spin Echo K-space Data Set

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Abstract: A simple post-processing method to generate high-resolution T2 maps from a single radial fast-spin echo (RAD-FSE) k-space data set is presented. The method presented here is superior to an existing method, because it reduces significantly the T2 bias in smaller objects.

Introduction: T2-weighted imaging is a valuable method for the diagnosis of many pathological disorders. Information from T2-weighted images in terms of pathology is typically analyzed in a qualitative manner by the radiologist. Although the quantitative measurements of T2 values are reported to yield a more accurate diagnosis, T2 measurements are impractical for routine clinical use. In order to measure T2 values, several images at multiple TE points are needed. Thus, with conventional imaging techniques, the generation of high-resolution T2 maps requires long acquisition times (~ 10 min or more). Moreover, in regions of the body affected by motion there are problems due to motion-induced volume averaging or misregistration of TE images acquired in different breath hold periods.

Recently it was shown that high-resolution images at various effective TE (TE_{eff}) values can be generated from a single RAD-FSE k-space data set. As shown in Fig. 1a, this was done by using data acquired at a narrow TE range at the center of k-space (as far out as the Nyquist condition is satisfied) and all the radial data beyond this point[2,3]. With this methodology, most of the problems encountered with current T2 measurements are eliminated. The method is fast (data can be acquired in a breath hold) and since the TE images are generated from a single k-space data set misregistration problems are minimized. This method was used successfully to characterize malignant and benign lesions in the liver[3]. A problem with the post-processing method shown in Fig. 1a, however, is that T2 values for smaller objects are overestimated. This T2 bias may affect the diagnosis of pathologies in small lesions. In this work, we introduce a post-processing method that reduces this T2 bias considerably.

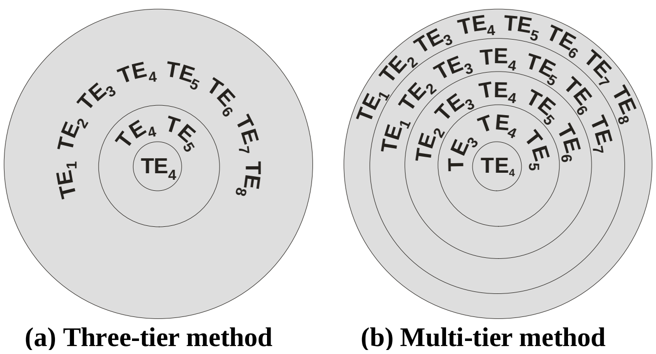

Fig. 1. Examples of the partial k-space data set corresponding to $TE_{eff}=TE_4$ for the "three-tier" and "multi-tier" methods.

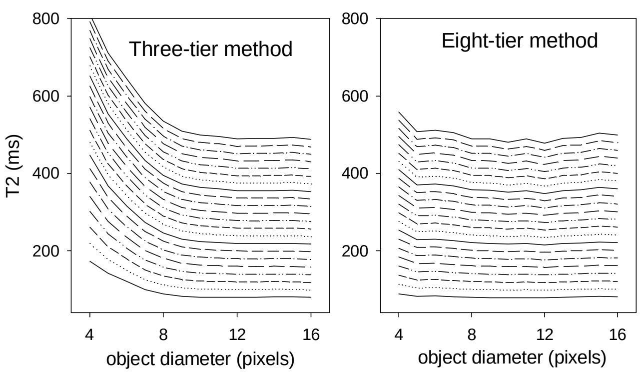

Fig. 2. Effect of the three-tier and multi-tier methods on T2 bias.

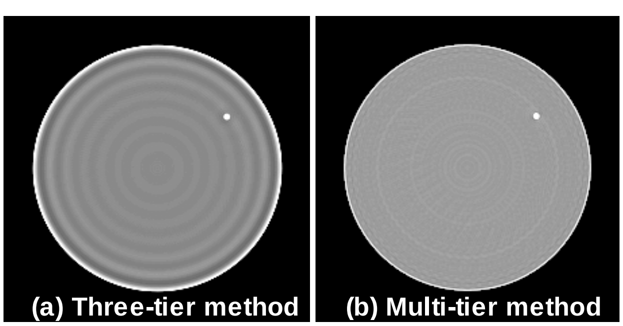

Fig. 3. Modulation artifact in the T2 maps calculated with the "three-tier" and "multi-tier" methods

Methods: For the evaluation of post-processing methods we used simulated k-space data where the intensity of the radial lines (views) was changed according to TE and T2. K-space data were simulated using the analytical expression of the Fourier domain for a circle. The parameters used in the simulations were ETL=8, number of views=256, number of sampled points along a view=256. Data at 8 different TE_{eff} values were generated covering a TE_{eff} range from 60 to 200 ms. Partial k-space data sets (as those shown in Fig. 1 for $TE_{eff}=TE_4$ for each of the methods evaluated in this study) were generated for each TE_{eff}. Images at the various TE_{eff} were reconstructed from the partial k-space data sets using filtered back-projection. Prior to filtered back-projection, the intensity of the missing k-space data points was calculated using linear interpolation. T2 maps were generated from the TE images by fitting the pixel intensities, *I*, to: $I = I_o e^{\frac{-TEeff}{T2}}$

Results and Discussion: As shown in Fig.1, in the "three tier" method we only use data at TE_{eff} and TE_{eff+1} in the center of k-space and then we include data from all TEs. In the "multi-tier" method, the number of views is progressively increased as we move from the center to the edge of k-space while ensuring that the average TE in each tier is as close to TE_{eff} as possible. Thus, the T2-weighting in the "multi-tier" method is extended to higher spatial frequencies.

The results of the simulations for objects of variable size and T2's are shown in Fig. 2. Both methods show good performance for large objects (i.e., the T2s obtained for large objects match the correct T2 values), however, the T2 bias for small objects is significantly reduced in the "multi-tier" method. Another error that is reduced with the "multi-tier" approach is the artifact caused by the discontinuities in k-space that occur at the Nyquist radii. This discontinuity causes a modulation with radial periodicity in the T2 map. Not only the modulation is less objectionable in the T2 map obtained with the "multi-tier" method (see Fig. 3), but also the T2 variance caused by the modulation is less.

Conclusion: A post-processing method for obtaining high-resolution T2-weighted images from a single RAD-FSE data set is introduced. The presented method significantly reduces the T2 bias of an existing method.

Acknowledgements: NIH (grant HL03528) and the American Heart Association

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