Liver T2* measurements: The best curve fitting model for ROI based method and Pixel based method .

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Introduction

MRI T_2^* is a noninvasive technique to assess liver iron content and showed strong correlation with liver iron concentration (LIC) [1,2]. Two major methods have been used to calculate liver T_2^*. ROI based method, the T_2^* is derived from an exponential curve fitting of mean signal intensity in selected ROIs of liver parenchyma in the region of regular biopsy [3]. Pixel based method, the T_2^* is obtained from mean T_2^* of all T_2^* pixels in liver excluding great vessels [3-5]. The curve fitting models for T_2^* estimation in both methods included mono-exponential, mono-exponential with a constant offset (Offset model), mono-exponential with late TE truncations (Truncation model), and bi-exponential [3-5]. The correlation of the T_2^* obtained from pixel based method and that of ROI based method was proved to be linear in some curve fitting models [3-5]. In addition, median T_2^* was found to be more robust compared to that of mean T_2^* in pixel based method [6]. Therefore, we aims to find the correlations between median T_2^* obtained from pixel based method and the T_2^* acquired from ROI based method across 3 different curve fitting models, mono-exponential, Offset, and Truncation.

Purpose

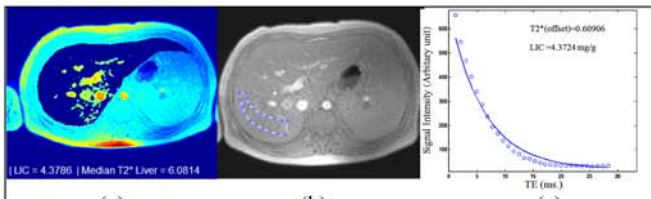
The purpose of this study was to compare the T_2^* measurements between ROI-based method and pixel-based method in three different curve fitting models.

Materials and methods

Fifteen β-thalassemia major patients (10 males and 5 females, mean age 26.27±14.01) who have received blood transfusion and chelation therapy were involved to this study. The study was reviewed and approved by a local institutional review board. Images were acquired on a 1.5 Tesla, Achieva, Philips, Netherland, MRI scanner with a SENSE torso 16 elements coil. The scanning protocol was multi-echo gradient echo sequence, TR 100 ms, 30 echo times (TEs 1.179-28.323 ms at 0.936 ms increment), flip angle 20 degree, slice thickness 10 mm, matrix size 90×120, FOV 350 mm, and NSA 1. Total acquisition time was approximately 15 seconds. Axial images at the slice through the center of liver of 30 TEs were acquired with single breath-holding. T_2^*s were calculated in two methods by two observers. ROI based method was performed by selecting a ROI near the posterior border of liver in homogenous area avoiding great vessels. Average signal intensity in the ROIs of 30 TEs was plotted against TEs and fitted for decay curves in three models, mono-exponential, Offset, and Truncation. For the pixel-based method, each pixel excluding great vessels in a selected ROI was fitted for pixel's T_2^* with the 3 fitting models. Median T_2^*s represented liver T_2^* were calculated from all T_2^* pixels. Segmentation to eliminate great vessels was done by fuzzy clustering algorithm (FCM). All analysis was performed on a PC using MATLAB R2011a (Mathworks, Natick, MA, USA), and IBM SPSS software V. 20. Inter and Intra-observers variations in each curve fitting model were evaluated by Intra-class correlation coefficient (ICC), percent coefficient of variation (% CV), and Bland-Altman plots were used to demonstrate the variations. Pearson correlation was applied to assess the correlation between T_2^* obtained from ROI based and that of pixel based methods. The differences of the T_2^*s between the 2 methods, ROI-based and Pixel-based, were evaluated by paired student 's t-test at 95% Confidence Interval (CI).

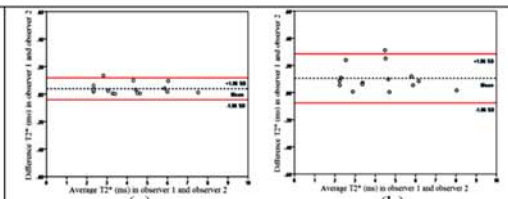
Results

The ICC demonstrated good agreement among T_2^* values estimated by two observers in both ROI based and pixel based methods (correlation coefficient=0.990-1). Based on % CV, Pixel based method provided less intra and inter-observers variation than those of the ROI based method in all curve fitting models, 0.94%-1.67%, and 1.65%-3.49% respectively. The Offset fitting model offered minimal %CVs of both intra and inter-observers variation in pixel based method, while the ROI based method only intra-observer variation was minimum. The minimal %CV of inter-observers with ROI based method was from mono-exponential fitting model. Figure 1(a) shows an example of median liver T_2^* (6.08ms.) obtained by pixel based method and a converted liver iron concentration (LIC) of 4.38 mg/g. Figure 1(b) shows a selected ROI of identical image data set for T2* ROI based analysis, and the fitting result with Offset model, T_2^*6.09 ms, in Figure 1(c). Figure 2(a) and 2(b), Bland Altman plots show variations of T_2^*s fitted by Offset model from pixel based method and ROI based method respectively. ROI based method shows remarkably greater variation. Pearson correlation between the 2 methods showed strong correlations in all fitting models ($0.993<r<0.997$) (P=0.01). Figure 3 shows an example of correlation between ROI based and pixel based methods in Offset curve fitting model (r=0.997). The T2*s obtained from ROI based and Pixel based methods were significant difference in almost every model except that of the Offset model.



(a) (b) (c)

Figure 1 (a). shows colormap of liver T_2^* with pixel based method fitted by Offset model (median T_2^*=6.0814 ms., LIC=4.3786 mg/g). Figure 1(b) a selected ROI in homogenous area of liver. Figure 1(c) shows result of Offset curve fitting model from ROI based method, T_2^*=6.0906 ms., LIC=4.3724 mg/g



(a) (b)

Figure 2. Bland Altman plots show variations of T_2^*s fitted by Offset model from pixel based method 2(a) and ROI based method 2(b).

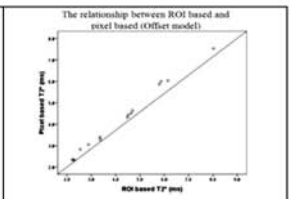


Figure 3. show a correlation between ROI based T_2^* and pixel based T_2^* fitted by Offset model.

Discussion and Conclusion

The liver T_2^*s measured by ROI based method showed greater variations than those of the pixel based method. This may be due to inhomogeneous deposition of iron in liver or smaller sampling numbers of data. However, there was no significant difference of the T_2^*s between the ROI based and pixel based methods when they were fitted with the Offset model (P=0.721) because the Offset term may absorb the error from artifact and noise. With this study, we assume that ROI based method with Offset curve fitting model potentially provided similar outcomes to those of pixel based method for liver T2* measurements.

References

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