Inter-Site Validation of the Pixel-Wise Method for Cardiac T2* Analysis in 50 Transfusion-Dependent Thai Thalassemia Patients

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Introduction: Currently cardiac T2* measurement is the most recommended tool to assess myocardial iron overload in Thalassemia patients [1]. The measurement can be separated into the magnetic resonance acquisition and post-processing-analysis processes. The acquisition part is well established given robust image quality in a single breath-hold time. Such acquisition can be categorized into the bright- and black-blood techniques [2]. The post-processing analysis part is also well recognized with some commercial available software. The analysis can be divided into two groups: the Region-Based (RB) and Pixel-Wise (PW) methods. There are current three accepted models for the RB method: the mono-exponential (exponential), mono-exponential with constant (offset), and mono-exponential with truncation (truncation) [3]. The choices of fitting models for the PW method, in contrast, are still open for further investigations. There are two objectives in this study. First, we investigated the inter observer variability of the reference site (CHLA, CA, USA) to our institute (Siriraj Hospital, Thailand) using the offset model on the PW method. The second objective was to compare the result of the offset to the exponential model with median report (MPS) method.

Materials and Methods: The measurement were performed on Thalassemia major patients (n=50, 24 males and 26 females, age 17.5± 5.9 years) who received regular transfusion and iron chelation therapy with age ≥ 10 years. The image were acquired on a 1.5T Philips Achieva XR system using a cardiac phased-array coil. A single mid-ventricular short axis slice was acquired on both bright- and black-blood techniques. The acquired images were analyzed locally and also transferred to process at the reference site using an in-house software developed with MATLAB software tool. All images data were fit to the offset model at the reference site and to the offset and exponential models at the local site. On both sites, Region of Interested had been defined manually from the partial interventricular septum region using the prior knowledge of a T2* color map to avoid partial volume effect and artifacts. The T2* results of the offset model from the reference (REF) and local (LOC) sites were reported using their mean. The MPS method was analyzed at the local site only. Bland-Altman plot was employed to analyze the agreement between two different T2* data sets. The coefficient of variation (CV) is utilized as the quantitative analysis of the closeness of the agreement.

Results: The Bland-Altman plots of the T2* values from both scanning techniques obtained by comparing the REF to the LOC and MPS methods were illustrated in Figure 1. The bright- and black-blood techniques had low bias (< 1 ms) on all comparisons. The inter-site variability of the offset model (REF *vs* LOC) showed reasonable values of CV on the bright- and black-blood techniques (7.9% and 4.0%, respectively). When comparing data from the REF to MPS method, the CV was still comparable to the offset model for the black-blood technique (4.4% *vs* 4.0%) but was higher for the bright-blood technique (13.3% *vs* 7.9%). Further investigation on the discrepancy of CVs for the bright-blood technique found that there was a data point that was significant different between two sites (the arrow lines in the upper row of Fig. 1). Such data was from a Thalassemia patient with severe iron overload heart. The images and their T2* maps of this case were displayed on Figure 2. The T2* value of the REF, LOC, and MPS methods on this patient for the bright-blood technique were 2.6, 4.7 and 6.1 ms, respectively, which were about 57% and 79% differences as compared to the REF method. The result from the black-blood technique on this case (the second row in Fig. 2), in contrast, presented a low variation between the reference and local sites that is about 1.3% (3.86 *vs* 3.91 ms) for the REF and LOC methods as well as only about 2.0% (3.86 *vs* 3.94 ms) for the REF to MPS method. The T2* values analyzed from the offset model, hence, can vary substantially at low T2* range for the bright-blood technique but still gave the robust result for the black-blood technique.

Discussion and Conclusion: In the study, for the black-blood technique, the CV of inter-site observer variability of the PW method using the offset model was similar to the previous report [4] from the conventional RB method using the exponential model (4.0% *vs* 4.1%) and also comparable as compared to the MPS method (4.0% *vs* 4.4%). Thus, the inter-site observer variability of both models was in good agreements. The results from the offset model for the bright-blood technique also had similar CV (7.9%) to the RB method (7.8%) [4] but higher CV (13.3%) when compared to the MPS method. The most different result was at low T2* range. This finding had also been report in the RB method and it had been suggested to employ the truncation model to minimize the effect [2]. This study also confirmed the characteristic of the offset model that tends to provide substantially low T2* value at low T2* range as compared to the result from the exponential or truncation models [2]. The offset model gave a substantially lower T2* value, due to the mathematic nature of the model (the higher the offset value from the fitting, the lower the T2* value obtained), while T2* was higher in the exponential model because of the spur T2* values, caused by blood flow artifact. The median of T2* values, as in the MPS method, then, should be utilized to minimize such the over-estimations In conclusion, the inter-site variability of the offset model on the PW method provided acceptable CV on the black-blood technique but higher CV on the bright-blood technique due to the discrepancy at low T2* range which can miss lead the result of iron clearance in the longitudinal study.

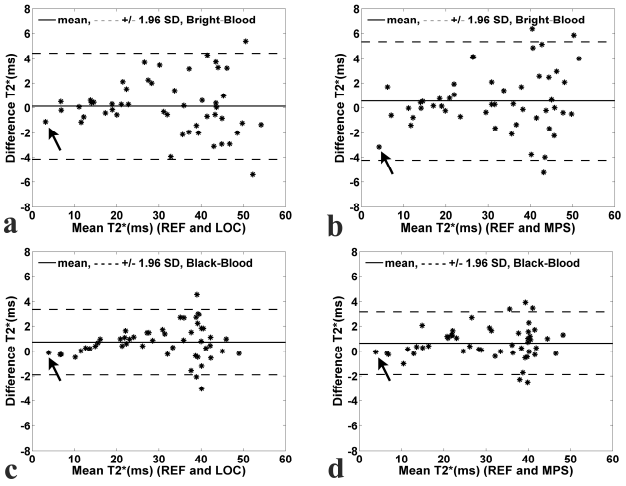

Figure 1. The Bland-Altman plots of the T2* values from both scanning techniques.

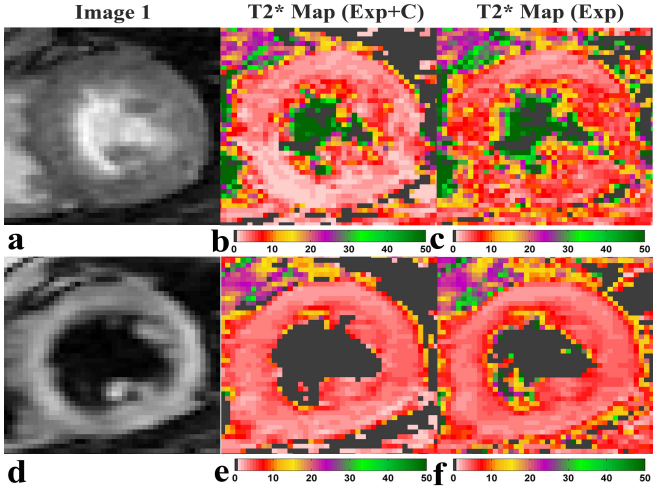

Figure 2. Cardiac and T2* map in msec of the bright- and black-blood techniques.

References:

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