Computing ADC for higher *b*-value using log-linear relationship between ADC and *b*-value

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Introduction: Diffusion weighted imaging (DWI) is a very sensitive imaging sequence for detecting various tissue abnormalities in brain. In clinical practice, *b*-values of 1000 sec/mm^2 or less are commonly used; however it has been reported that use of higher *b*-values improves disease visualization and detection[1]. DWI imaging with higher *b*-values is challenging because it suffers with low signal to noise ratio (SNR), distortion along with longer scan time. To overcome these difficulties computed DWI technique has been proposed by many researchers [2]. Computed DWI technique is a mathematical technique, which generates images of higher *b*-values by using at least two different lower *b* value ($b \leq 1000$) images. Here we report that we have observed ADC depends on *b*-values, on contrary to the previous assumption where it was considered constant for all *b*-values and computation of ADC corresponding to higher *b*-values was not possible. The aim of this study was to find the relationship between ADC and *b*-values for quantification of ADC corresponding to higher *b*-values using lower *b*-values with computed DWI technique.

Material and Method: A total of 15 patients with intracranial pathologies were included in this study retrospectively with the institutional ethical committee approval. All imaging were performed on 3.0T MR scanner. DWI was acquired using 11 *b*-values of 50, 100, 150, 200, 300, 400, 600, 800, 1000, 1500 and 2000 s.mm^{-2}.

In acquired images, ADC values were calculated using the mono-exponential model $S(b)=S_0(\exp(-b.\text{ADC}))$ with two different *b*-value; and the change (in percentage) between ADC values obtained from two consecutive *b*-values. For computed images, voxel-wise log-linear relation between ADC and *b* was calculated, and respective DWI maps were reconstructed using the relationship between ADC and *b*-value. ROIs were drawn on normal grey matter, white matter and pathologic tissues of both computed and acquired images to estimate the error between actual and computed ADC maps.

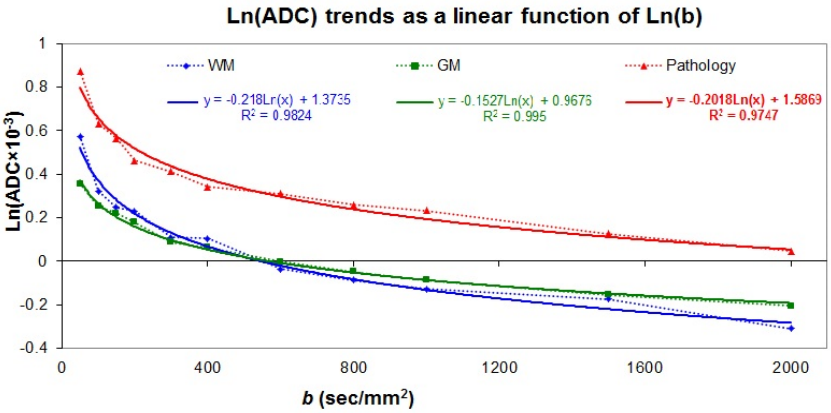

Figure-1: *Plot shows the variation of ADC w.r.t b-value in normal white matter, gray matter and pathologic tissue. Solid line shows the linear relationship between natural logarithmic ADC and b-values.*

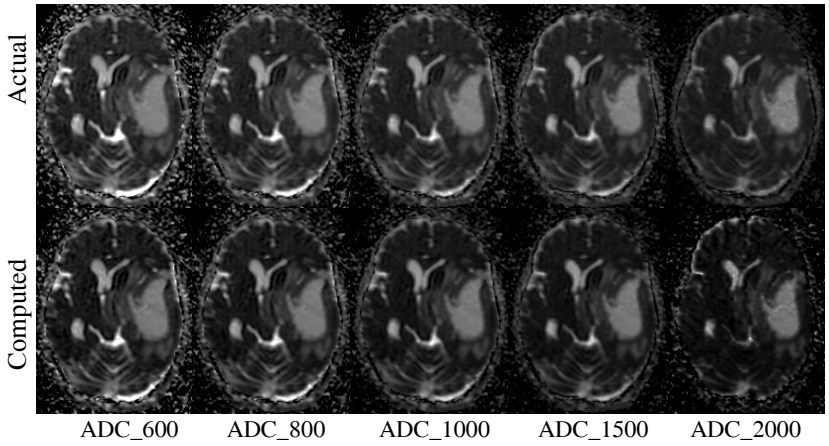

Figure-2: *Shows the actual and computed ADC maps of different b values.*

Results: We have observed a change of 7.65±3.27% between ADC values obtained from two consecutive *b*-values in acquired images. This observation supports our initial assumption that the ADC is not constant with respect to *b*-values (Figure 1). Our log-linear model fits well (R^2~0.9) in all the regions of brain except ventricles while generating computed DWI images. The error in reconstructed DWI images is ≤6%. No significant difference was observed between computed and actual ADC (Figure 2).

Discussion and Conclusion: Log-linear relationship was observed between ADC and *b*-values (Figure 1). Our initial investigation suggests that the ADC values corresponding to higher *b*-value can be computed using log-linear relationship derived from lower *b*-values ($b \leq 1000$). This will greatly reduce the scan time where multiple *b*-value images are obtained. Moreover, this computational method can also be manipulated to determine optimized *b*-values to obtain ADC maps for improving clinical diagnosis. Gradient nonlinearity could play a role in the observed behavior of ADC with *b*-values[3]; however it may not fully explain the log linear relationship between them.

References: [1] Blackledge MD, Leach MO, Collins DJ et.al. Radiology. 2011 Nov;261(2):573-81.[2]Ueno Y, Takahashi S, Kitajima K et. al.. Eur Radiol. 2013 Jul 25. [3] Malyarenko DI, Ross BD, Chenevert TL, Magn Reson Med. 2013 May 13. doi: 10.1002/mrm.24773