# Optimization of Diffusion-Weighted Imaging for the Liver MRI at 3T: Usefulness for the Detection of Hepatocellular Carcinoma

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## Introduction

Diffusion-weighted imaging (DWI) has been widely adopted in the clinical practice [1]. It provides functional information, such as motion or diffusion of water molecules, and can be used for the detection and characterization of malignant or non-malignant lesions [1-3]. Although a 3T magnetic resonance (MR) system is beneficial for DWI because of its high signal-to-noise ratio (SNR), susceptibility and chemical artifacts occasionally reduce the image quality of DWI and interfere with imaging diagnosis on the body MR imaging (MRI) [2]. We have previously reported the optimization of the imaging parameters for DWI of liver MRI [4]. The optimized DWI could not only improve the image quality and spacial resolution, but also reduce artifacts [4]. In this study, we evaluated the utility of our proposed optimized DWI of liver MRI comparing with the conventional DWI which is widely used in the clinical practice.

## Materials and Methods

Fifty-two patients who have a risk of hepatocellular carcinoma (HCC) due to chronic liver disease (age range = 26 – 82, mean = 63.8 years, M:F = 33:19) were scanned on a 3T MR system using an 32-channel cardiac phased array coil and multitransmit RF technology. We scanned two different types of DWI as follows; optimized DWI (single-shot EPI; TR/TE = 6250/56 ms; FA = 90°; FOV = 380 x 299 mm; matrix = 112 x 173; slice thickness = 7 mm; slice gap = 1 mm; number of slices = 26; number of excitation = 2; free breath-hold; fat suppression = SPAIR; offset freq. = 250 Hz; SPAIR TR = 250 ms; inversion delay = 100 ms; EPI factor = 75; b-factors = 0, 500, and 1000 sec/mm$^2$; BW in EPI freq. direction = 4050.4 Hz/pixel; total scan time = 3 min 32 sec) and conventional DWI (single-shot EPI; TR/TE = 1877/55 ms; FA = 90°; FOV = 380 x 299 mm; matrix = 112 x 68; slice thickness = 7 mm; slice gap = 1 mm; number of slices = 26; number of excitation = 2; respiratory-triggered; fat suppression = SPIR; offset freq. =180 Hz; EPI factor = 25; b-factors = 0, 500, and 1000 sec/mm$^2$; BW in EPI freq. direction = 4438.5 Hz/pixel; total scan time = 1 min 42 sec ~ 3 min 24 sec). Qualitatively, the SNR of the normal liver parenchyma and lesion-to-nonlesion contrast-to-noise ratio (CNR) were measured using previously reported methods [5] after regions of interest (ROIs) were drawn on each DWI with a b-factor of 1,000 sec/mm$^2$ by one radiologist. In addition, the detectabilities of HCCs on two DWIs were evaluated using receiver-operating characteristic (ROC) curve analysis after two observers independently interpreted the images in a random order. The sensitivity, positive predictive value (PPV) and the area under the ROC curve (Az) of each observer were calculated, respectively. The SNR of normal liver parenchyma and lesion-to-nonlesion CNR of two DWIs were compared with the Wilcoxon signed-rank test. The sensitivity and PPV of two DWIs were compared using the McNemar's test. The diagnostic accuracy of two DWIs was nonparametrically compared by analyzing the mean Az values using the SAS %roc macro. The interobserver agreement for the evaluation of two DWIs was analyzed with the kappa statistic. The agreement in terms of kappa values was as follows: <0.40 = poor agreement; 0.41–0.75 = good agreement; >0.75 = excellent agreement. A $p < 0.05$ was considered to indicate a significant difference for each analysis.

## Results

A total of 109 HCCs were evaluated but metastatic tumor, hemangioma, cyst and post-treated HCCs were excluded from the analysis. There were no significant differences in the SNR of the normal liver parenchyma and lesion-to-nonlesion CNR between two DWIs (Table 1). The sensitivity and PPV of the optimized DWI in detecting of HCCs were significantly better than those of the conventional DWI ($p < 0.05$) (Table 2). In addition, the mean Az value of the optimized DWI was higher than that of the conventional DWI but there were no significant differences between two DWIs (Table 2). Interobserver agreements were good; the kappa values of the optimized and conventional DWIs were 0.512 and 0.585, respectively.

## Discussion and Conclusion

The optimized DWI could offer better spacial resolution without reducing the SNR of the normal liver parenchyma and lesion-to-non-lesion CNR comparing with the conventional DWI. In addition, the diagnostic performance of the optimized DWI was better than that of the conventional DWI. We suggested that our proposed optimized DWI should be advantageous for liver MRI to detect HCCs in the clinical practice.

## References

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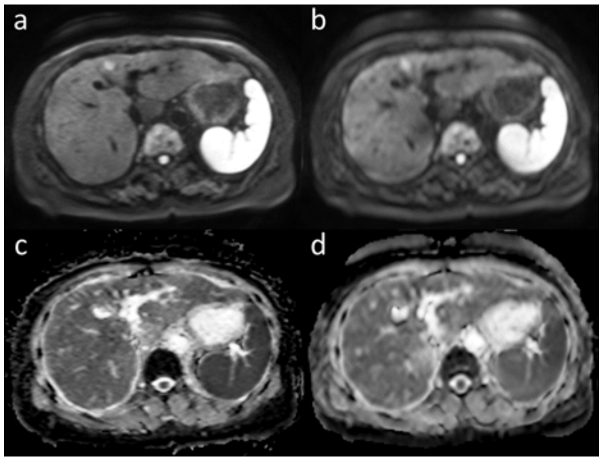


Figure 1. a) optimized DWI (b = 1,000 sec/mm$^2$), b) conventional DWI (b = 1,000 sec/mm$^2$), c) ADC map (optimized DWI) and d) ADC map (conventional DWI). The lesion in S4 of the liver showing hyperintensity on the optimized DWI is clearer than that on the conventional DWI.

**Table 1. Comparison of the SNR of the normal liver parenchyma and lesion-to-nonlesion CNR between optimized and conventional DWIs**

| | SNR (normal liver parenchyma) | | CNR (lesion-to-nonlesion) | |
|---|---|---|---|---|
| optimized DWI | 11.0 ± 4.8 | ] n.s. | 21.4 ± 17.7 | ] n.s. |
| conventional DWI | 11.0 ± 5.0 | | 20.1 ± 15.1 | |

SNR: signal-to-noise ratio, CNR: contrast-to-noise ratio

n.s.: The difference between two DWIs is not significant

**Table 2. Comparison of sensitivity, PPV and Az values between optimized and conventional DWIs**

| | | Sensitivity | | PPV | | Az value | |
|---|---|---|---|---|---|---|---|
| Observer 1 | optimized DWI | 56.9% | ] * | 98.4% | ] * | 0.933 | ] n.s. |
| | conventional DWI | 44.0% | | 87.3% | | 0.883 | |
| Observer 2 | optimized DWI | 45.0% | ] * | 98.0% | ] * | 0.838 | ] n.s. |
| | conventional DWI | 35.8% | | 95.1% | | 0.800 | |

PPV: positive predictive value

*: The difference between two DWIs is significant

n.s.: The difference between two DWIs is not significant