DIFFUSION-WEIGHTED MRI OF THE LIVER AT 3T MRI: EFFECT OF STEATOSIS ON ADC AT LOW AND HIGH B VALUES

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INTRODUCTION: Steatosis occurs in diverse forms of liver injury necessitating the ability to quantify liver fat. Nonalcoholic fatty liver disease (NAFLD) is the most common cause of chronic liver disease in the US affecting ~ 20% to 30% of the adult population [1]. Steatosis is considered to represent both a surrogate marker of and play a pivotal role in the development and progression of NAFLD and other liver diseases such as Hepatitis C (HCV) [2, 3]. The current gold standard to grade steatosis is biopsy (scale 0-3), which is invasive and limited by sampling error due to the heterogeneous nature of the disease [1]. The feasibility of using diffusion-weighted MR imaging (DWI) has been recently investigated as a diagnostic tool to more accurately and precisely characterize diffuse liver disease. This study aims to investigate the relationship of liver ADC at 3T with steatosis obtained with high and low b values.

METHOD AND MATERIALS: Eighteen subjects, 6 healthy volunteers, 4 patients with HCV and 8 patients with suspected NAFLD totaling 9 women and 9 men (mean age 49 years, range 23-80), underwent DWI at 3T with a breath-held EPI sequence (TR/effective TE =1800 ms /minimum, FOV=48cm, matrix=128×128, 2 NEX, ASSET Acceleration Factor of 2, 8/2 mm slices, 12 slices) using b value ranges: 1) 0-500, 2) 0-125 and 3) 125-500 and 3 gradient directions. All patients underwent liver biopsy within 1 month of MRI. ADC measurements were obtained from the right lobe of the liver at 3 levels - superior, inferior and at the level of the portal vein using a) 1.5cm diameter regions-of-interest (ROI) placed in the anterior and posterior right lobes avoiding vessels (total 6 ROIs), and also using a single large ROI occupying most of the right lobe including vessels at the same axial levels (total 3 ROIs). Median ADC values were calculated for the small and large ROI measurements. Histological analysis of steatosis grade was determined for the 12 patients based upon a biopsy sample. Differences in ADC by steatosis grade were assessed using the nonparametric Wilcoxon rank sum test with two-sided alpha= 0.05.

RESULTS: There were thirteen subjects with grade 0 steatosis (6 healthy volunteers and 7 patients) and 5 subjects with grade 1 or 2. ADC values based on high b-value data (125 and 500), derived from small and large ROIs were significantly lower among participants with steatosis grades 1 or 2 compared to those with steatosis grade 0 (healthy volunteers and patients with known grade 0), $p<0.04$ (Figure 1). This difference in ADC was significant for high b values (125-500), but not for low (0-125) or combined b values (0-500), Table 1 and Figure 2.

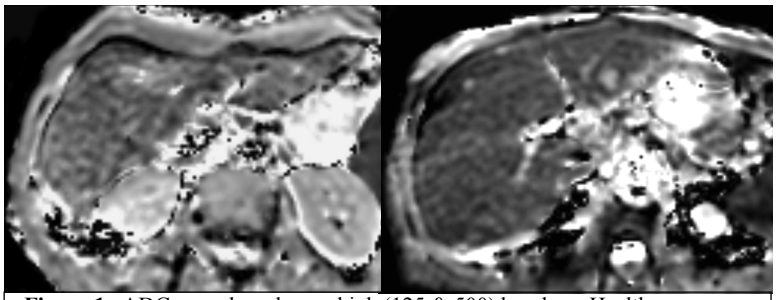

Figure 1. ADC maps based upon high (125 & 500) b-values. Healthy, non-steatotic volunteer (left) demonstrates higher ADC than the grade 2 steatotic NAFLD patient (right).

DISCUSSION: In this pilot study, liver high b value ADC measurements were significantly different between subjects without and with mild-moderate steatosis using small and large ROIs. Steatosis is the accumulation of fat in the hepatocytes, which may cause cell-swelling, which may explain restricted diffusion at the high b values. The effect of steatosis should be considered when evaluating liver disease with diffusion-weighted imaging. The relative influence of steatosis on liver ADC at low and high b values may be helpful in discriminating features of diffuse liver disease.

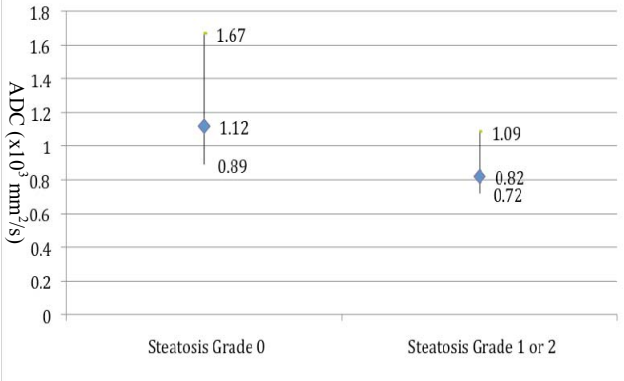

Figure 2. Distribution of right lobe liver average ADC in subjects with and without steatosis derived from high b values (125-500) for small ROIs.

Table 1. Median right lobe ADC in subjects without steatosis (grade 0) or mild to moderate steatosis (grade 1 or 2).

		Steatosis 0	Steatosis 1or 2	
Image	b values	ADC (range)	ADC (range)	p value*
SML	0-125	3.33 (2.44-5.00)	3.55 (2.78-4.85)	0.85
LRG	0-125	3.95 (2.51-5.74)	3.98 (2.80-5.23)	1.00
SML	*125-500*	*1.12 (0.89-1.67)*	*0.82 (0.72-1.09)*	*0.02*
LRG	*125-500*	*1.09 (0.97-1.70)*	*0.88 (0.73-1.21)*	*0.04*
SML	0-500	1.62 (1.47-2.17)	1.53 (1.24-1.81)	0.29
LRG	0-500	1.83 (1.40-2.32)	1.63 (1.36-2.10)	0.22

SML = ADC calculated from small ROIs; LRG = ADC calculated from large ROIs.

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