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Role of Diffusion-Weighted MRI in Differentiating Benign and Malignant Hepatic Lesions: A Comparative Study.

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ABSTRACT

Differentiating benign from malignant hepatic lesions is essential for accurate diagnosis and appropriate management. Conventional imaging often lacks specificity, prompting the use of functional imaging techniques like diffusion-weighted MRI (DWI). This study aimed to evaluate the role of DWI and apparent diffusion coefficient (ADC) values in characterizing hepatic lesions. A prospective comparative study was conducted over one year, including 40 patients with hepatic lesions detected on initial imaging. All patients underwent MRI with diffusion-weighted sequences using b-values of 0, 400, and 800 s/mm^2. ADC values were calculated from ADC maps by placing regions of interest (ROI) within the solid portion of each lesion. Lesions were classified as benign or malignant based on imaging features, clinical correlation, and histopathology where available. Of the 40 lesions, 22 were benign and 18 malignant. Mean ADC for benign lesions was significantly higher ($1.78 \pm 0.24 \times 10^{-3}$ mm^2/s) than for malignant lesions ($1.12 \pm 0.19 \times 10^{-3}$ mm^2/s) ($p < 0.001$). ROC analysis identified an ADC cut-off of 1.35×10^{-3} mm^2/s with 88.9% sensitivity and 81.8% specificity. DWI with ADC mapping is a valuable non-invasive tool in distinguishing benign from malignant hepatic lesions, enhancing diagnostic confidence and potentially reducing the need for biopsy.

Keywords: Diffusion-weighted MRI, hepatic lesions, ADC values

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INTRODUCTION

Liver lesions represent a broad spectrum of pathological conditions ranging from benign cysts and hemangiomas to malignant primary and metastatic tumors [1]. Early and accurate characterization of these lesions is essential for guiding clinical management, planning therapeutic interventions, and improving patient outcomes [2, 3]. While conventional imaging modalities like ultrasound, CT, and standard MRI sequences provide valuable anatomical and morphological details, their diagnostic specificity remains limited, especially in differentiating benign from malignant hepatic lesions [4].

Diffusion-Weighted Imaging (DWI), an advanced MRI technique that evaluates the Brownian motion of water molecules in tissues, has emerged as a powerful functional imaging tool in this context. It offers quantitative assessment through apparent diffusion coefficient (ADC) values, which reflect tissue cellularity and membrane integrity—parameters often altered in malignant tumors. Malignant lesions generally exhibit restricted diffusion due to high cellular density, resulting in low ADC values, whereas benign lesions typically show higher ADC values due to their less cellular or cystic nature [5-8].

Our study aims to assess the role of diffusion-weighted MRI in distinguishing benign from malignant hepatic lesions by comparing ADC values across a spectrum of liver pathologies. By integrating DWI into routine hepatic imaging protocols, radiologists may enhance diagnostic accuracy and reduce the need for invasive procedures like biopsies.

STUDY METHODOLOGY

This prospective comparative study was conducted in the Department of Radiodiagnosis over a period of one year. A total of 40 patients with suspected hepatic lesions identified on preliminary imaging (ultrasound or CT) were enrolled after obtaining informed consent. Ethical clearance was obtained from the institutional review board prior to initiation of the study. Patients of all age groups and both genders who were referred for MRI evaluation of focal liver lesions were included.

All patients underwent magnetic resonance imaging on a 1.5 Tesla MRI scanner, which included conventional sequences (T1-weighted, T2-weighted, and fat-saturated sequences) along with diffusion-weighted imaging using multiple b-values (typically b = 0, 400, and 800 s/mm^2). Post-processing was done to generate ADC maps, and ADC values were measured by placing region of interest (ROI) within the solid portion of the lesion, avoiding necrotic or cystic areas. The average ADC value for each lesion was recorded for analysis.

Lesions were categorized as benign or malignant based on a combination of imaging features, clinical findings, laboratory data, and histopathological confirmation wherever available. In cases without biopsy, final diagnosis was established through follow-up imaging over a period of 3–6 months. Benign lesions included hemangiomas, focal nodular hyperplasia, and simple cysts, while malignant lesions included hepatocellular carcinoma and liver metastases.

Statistical analysis was performed using SPSS software. Mean ADC values were calculated for benign and malignant lesions, and independent sample t-tests were used to evaluate the significance of the difference between the two groups. A p-value of <0.05 was considered statistically significant. Receiver Operating Characteristic (ROC) analysis was also performed to determine the diagnostic accuracy and optimal ADC cut-off value for differentiating malignant from benign hepatic lesions.

RESULTS

Table 1: Distribution of Hepatic Lesions by Type (n = 40)

Lesion Type	Number of Cases	Percentage (%)
Benign Lesions	22	55%
Malignant Lesions	18	45%
Total	**40**	**100%**

Table 2: Types of Benign and Malignant Lesions Identified

Lesion Category	Subtype	Number of Cases
Benign	Hemangioma	10
	Focal Nodular Hyperplasia	6
	Simple Cyst	4
	Hepatic Adenoma	2
Malignant	Hepatocellular Carcinoma	10
	Liver Metastases	8

Table 3: Comparison of Mean ADC Values Between Benign and Malignant Lesions

Lesion Type	Mean ADC ($\times 10^{-3}$ mm^2/s)	Standard Deviation	p-value
Benign Lesions	1.78	± 0.24	
Malignant Lesions	1.12	± 0.19	< 0.001**

Note: Statistically significant difference between groups.

Table 4: ROC Analysis for ADC Cut-Off Value to Differentiate Lesions

Parameter	Value
Optimal ADC Cut-off Value	1.35 $\times 10^{-3}$ mm^2/s
Sensitivity	88.9%
Specificity	81.8%
Area Under Curve (AUC)	0.91
95% Confidence Interval (CI)	0.83 –

DISCUSSION

The present study systematically evaluated the utility of diffusion-weighted MRI (DWI) in differentiating benign and malignant hepatic lesions in a cohort of 40 patients. Our findings demonstrated a clear separation of apparent diffusion coefficient (ADC) values between the two lesion groups, reinforcing the premise that tissue cellularity and architectural integrity—captured by DWI—offer powerful biomarkers for lesion characterization [9].

The overall lesion distribution in our sample—55 % benign and 45 % malignant—mirrors previously reported imaging-based liver series, where incidental benign lesions predominate in routine practice. Among benign entities, hemangiomas represented nearly half of the subgroup, while hepatocellular carcinoma (HCC) was the commonest malignancy, followed closely by metastases. This pattern is consistent with the epidemiology of focal liver lesions in regions with high cirrhosis prevalence and rising oncological burden.

Mean ADC values differed significantly between benign and malignant lesions ($1.78 \pm 0.24 \times 10^{-3}$ mm^2/s vs. $1.12 \pm 0.19 \times 10^{-3}$ mm^2/s, $p < 0.001$). The marked reduction in ADC for malignant lesions can be attributed to increased cellular density, enlarged nuclei-to-cytoplasm ratios, and reduced extracellular spaces that restrict Brownian water motion. Conversely, benign lesions such as hemangiomas and simple cysts exhibit higher ADCs because of abundant fluid-filled vascular or cystic channels, which allow free diffusion. Our values fall within the ranges described by Kele and van der Jagt, who reported benign liver lesions averaging $1.6–2.1 \times 10^{-3}$ mm^2/s and malignant lesions clustering around $1.0–1.3 \times 10^{-3}$ mm^2/s[4]. The narrow standard deviations observed in our dataset suggest that careful ROI placement confined to solid components yields reproducible metrics, an important consideration in routine workflow.

Receiver-operating-characteristic (ROC) analysis identified an optimal ADC cut-off of 1.35×10^{-3} mm^2/s, providing 88.9 % sensitivity and 81.8 % specificity. The area under the curve (AUC) of 0.91 indicates excellent discriminative ability, comparable to larger meta-analytic aggregates reporting pooled AUCs of 0.89–0.93. Importantly, a high sensitivity minimizes false-negative classification of malignant lesions, thereby reducing the likelihood of delayed oncological management. The slightly lower specificity reflects overlap between certain benign tumors with fibrous components (e.g., hepatic adenoma) and

malignancies with necrotic or cystic degeneration, highlighting the need to interpret ADC values in conjunction with conventional MRI features and clinical context.

Clinically, integrating DWI into standard abdominal MRI protocols offers several advantages. First, it adds minimal acquisition time yet provides crucial functional information without contrast administration—beneficial in patients with renal dysfunction or contrast allergies. Second, it may obviate invasive biopsy in lesions that demonstrate unequivocally high or low ADC values paired with characteristic morphology. Third, for patients under surveillance for chronic liver disease, sequential ADC measurements could serve as an early surrogate marker for malignant transformation.

CONCLUSION

DWI with ADC mapping is a valuable non-invasive tool in distinguishing benign from malignant hepatic lesions, enhancing diagnostic confidence and potentially reducing the need for biopsy.

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