Original Research Article

Utility of T2-weighted MR imaging and DWI in differentiating benign and malignant liver lesions

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Abstract

Liver lesions represent a heterogeneous group of pathology ranging from solitary benign lesions to multiple metastases from a variety of primary tumours. Liver lesions may be cystic liver lesions or hypervascular liver lesions or liver tumours. For optimal patient management, detection and characterization of focal liver lesions (FLL) is critical.Magnetic resonance with diffusion weighted imaging (DWI)) is a non-invasive technique which could improve the diagnostic accuracy in differentiating between benign and malignant liver lesions by measuring their ADC values.Therefore a study design to evaluate the contribution of imaging science towards the diagnosis of focal liver lesions. Axial sections of DWI and T2WI are obtained in patients with focal liver lesions and the sensitivity, specificity and detection rates of both the sequences are compared individually and together.In this study we are studying characteristic features of liver lesions on T2 and DWI sequence and calculating apparent diffusion co-efficient (ADC) values of focal liver lesions.

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Keywords: apparent diffusion co-efficient,hepatocellular carcinoma,Focal liver lesions,receiver operating characteristic

Introduction

Liver lesions represent a heterogeneous group of pathology ranging from solitary benign lesions to multiple metastases from a variety of primary tumours. Liver lesions may be cystic liver lesions or hypervascular liver lesions or liver tumours. For optimal patient management, detection and characterization of focal liver lesions (FLL) is critical. In patients with non-cirrhotic liver most of the focal liver lesions are benign. Most commonly encountered benign lesions are cysts, hemangiomas, focal nodular hyperplasias (FNH), and hepatocellular adenomas (HCA). Whereas, in a background of chronic liver disease, the most common primary liver malignancies are hepatocellular carcinomas (HCC), and to a lesser extent intrahepatic cholangio-carcinomas (IHC).

Metastases are the most commonly encountered malignant lesions in non-cirrhotic liver.T2- weighted imaging is helpful in discriminating non solid lesions that contain fluid- cysts/ abscess or that contain vascular channels filled with blood- hemangioma from solid lesions[1]. Difference in the microstructure of the lesion helps us to characterize the features of tissue and lesion on DWI. Principle of DWI is based on changes in water molecule (proton) movement which will alter the coefficient of apparent diffusion (ADC) and signal intensity in DWI and ADC maps.USG guided biopsy of liver lesions is pretty accurate method to diagnose malignancy but this is an invasive and operator dependent investigation. Magnetic resonance with diffusion weighted imaging (DWI)) is a non-invasive technique which could improve the diagnostic accuracy

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in differentiating between benign and malignant liver lesions by measuring their ADC values.Contrast enhanced examinations have become a routine component of abdominal imaging, however the risk of contrast media side effects and high cost/benefit ratio remain an issue. Other drawback being not able to distinguish between hemangiomas and highly vascular metastases, even using dynamic examinations[2].

Presence of high cellularity is the cause of impeded or restricted diffusion which is noted in tissues with high cellularity, which commonly being tumors, abscesses, fibrosis and cytotoxic edema. In tissues with low cellularity or with disrupted cell membranes, as in cysts and necrotic tissues there is free or unimpeded diffusion. Diffusion of water molecules in the tissue is measured by DWI. It is otherwise known as **Stejskal-Tanner sequence** where a pulse sequence T2-weighted spin echo sequence and 2 strong motion probing gradients on either side of the 180º refocusing pulse[3,4].For high accuracy, DWI should be interpreted in conjunction with conventional sequences. It can be used as a reasonable alternative technique to contrast-enhanced imaging in patients with end stage renal disease and gadolinium-based contrast agents are contra-indicated[5].Although usage of DWI in other body parts is new, it is associated with very high rates in detection and differentiation of benign and malignant lesions. It can also be used to look for metastases/ dissemination in oncological patients before treatment and for follow-up after treatment of liver tumors. For predicting the response to therapy of malignant tumors also, DWI shows very promising results[6,7]. Therefore a study design to evaluate the contribution of imaging science towards the diagnosis of focal liver lesions. Axial sections of DWI and T2WI are obtained in patients with focal liver lesions and the sensitivity, specificity and detection rates of both the sequences are compared individually and together.In this study we are studying characteristic features of liver lesions on T2 and DWI sequence and calculating apparent diffusion co-efficient (ADC) values of focal liver lesions.

Material and methods

This was a prospective, observational study conducted at a tertiary centre for over a period of 2 years from September 2018 to August 2020. A total 50 patients of all age groups were included, who were detected with liver lesions on ultrasound abdomen and/or on computer tomography. Examination was done under Magnetom Vida Magnetic Resonance Imaging (3 Tesla).

Proper safety measures were taken. Postoperative and post radiation therapy patients were excluded from our study. Institutional Ethical Committee (IEC) clearance was obtained before conducting the study. Informed and written consent was obtained from all the patients.

MRI scan technique: Supine position with head positioned towards the magnet. Position the patient over the spine coil and place the body coil over upper abdomen. Securely tighten the body coil with straps to prevent respiratory artefacts. Give cushions under the legs for extra comfort. Centre the laser beam localiser over the xiphoid process of sternum.Planes and sequences used included: T2 Weighted Imaging (T2WI) in axial plane, diffusion weighted sequence (DWI) in axial plane, T1 2D or 3D gradient echo sequences (e.g. VIBE) if required with slice thickness of 3-4mm for axial, sagittal and coronal planes.

Data collection method and statistical analysis: Continuous variable like age and ADC were expressed as mean (standard deviation). The association of ADC with type of lesion (benign and malignant) using a chi-squared test. The mean differences in ADC between benign and malignant were compared using a student t-test. Receiver operating characteristic (ROC) curve of the ADC values used for differentiating benign from malignant lesions,. Accuracy of ADC Cut off value to differentiate benign from malignant lesions were assessed by Kappa statistic. A p value of less than 0.05 was considered as statistically significant.

Results

A total of 50 patients (75 focal liver lesions) were studied. Diagnosis on MRI was made with background of clinical context. Final diagnoses was reached in consensus with biopsy/ FNAC wherever applicable or clinical, laboratory, other imaging modality findings and follow-up.In our study, age range was of 28-78 years in which the maximum percentage of benign cases was seen in the age range of below 40 years (38%). Majority of the malignant lesions like metastases and HCC were seen between 51-70 years. One case of metastases from the osteosarcoma knee was seen in a patient of age 28 years.

Half of the patients diagnosed with cysts were seen in the age group of < 40 years. The mean

age for benign cases in our study was 38.2 years and for malignant cases was 56.9 years. In our study, there was a male preponderance (58.3%) when compared to females who accounted for (42.7%) of cases. Male: Female sex ratio is 1.3: 1.

Regarding gender distribution among individual abnormality in our study: There was male preponderance in HCC (88.9%), and metastases (62.5%) when compared to females

. Hemangiomas were seen more commonly seen in females. Multiple focal liver lesions were seen in 18 patients and all of them were malignant (100%). In 32 patients with single lesion, 6 (18.8%) were malignant and 26 (81.2%) were benign. 7 (14%) of patients had bilateral lobe involvement and all of them were malignant (100%). Out of 50 patients right lobe was involved in 38 (76%) cases, left lobe was involved in 5 (10%)cases.

Out of 50 patients 26(52.3%) had benign lesions whereas 24(48.7%) had malignant lesions. There were total 75 lesions seen in 50 patients. Out of the total 75 focal liver lesions seen in 50 patients, 49 lesions (65.3%) accounted to malignancy and 26(34.6%) were of benign nature.

Among the 75 FLL's, there were 18 HCCs, 34 metastatic lesions, 3hemangiomas, 8 simple cysts, 2hydatid cysts, 9 abscess,2 adenoma (Table-1). In 2 patients with single focal liver lesion were diagnosed as HCC due to the low ADC values and lack of compliance for contrast study. However they were diagnosed as focal nodular hyperplasia on histopathology.

Table 1: Distribution of each focal liver lesion according to diagnosis

Diagnosis	No.of patients	No.of lesions	Percentage (per no.of lesions)
HCC	11	18	24.1
Mets	15	34	45.4
Abscess	9	9	12.7
Hemangioma	3	3	4.1
Simple cyst	8	8	10.6
Hydatid cyst	2	2	2.6
Adenoma	2	2	2.6
Total	**50**	**75**	**100**

Discussion

Liver lesions constitute major cause of morbidity. Detailed evaluation of pathologies under suspicion in USG has to be done with CT/ MRI. Benign lesions are found in younger age group and malignant lesions in elderly.Out of 75 FLLs (in 50 patients),74(98.6%) were detected by DWI and 73(97.3%) by T2WI. DWI was associated with significantly higher detection rate of all FLLs when compared to T2WI ($p < 0.001$).

DWI MRI significantly improved the detection of FLLs when compared T2WI. The lesions that were not picked on T2WI were retrospectively traced after examining the DWI sequences. The lesion not picked on DWI was a small simple hepatic cyst. These findings are comparable to Parikh et al[8]study wherein the number of malignant FLLs detected with DWI (62 out of 63 – 98.4%) was highly significant than those detected with T2 WI ($p < 0.001$). However, there was no significant difference between the T2 weighted imaging and DWI for the detection of HCCs alone. This result was different from Parikh et al. There was no significant difference determined between the use of T2 weighted imaging and DWI for the detection of benign hepatic lesions in our study. This result was different from a previous study [8]. In our study, 23 of 23 (100%) benign hepatic lesions were detected on T2 weighted images and 22 of 23(95.5%) on DWI. The lesion that was missed on T2WI was a small simple hepatic cyst. These findings were comparable to Yang DM et al[9]. There was no significant difference for detection rate with DW imaging between right and left liver lobes (100% and 98.1%, respectively). These findings are comparable to Parikh et al[8].

Missed lesions- On DW imaging.—1 FLL was missed on DW images (1 simple cyst).

T2-weighted imaging.—2 FLLs were missed on T2-weighted images and both were HCC in patients with pre-existing cirrhotic liver.ADC values were obtained for all 75 lesions detected

by DWI.(1simple cyst not detected on DWI was retrospectively traced after T2WI). The mean ADC value of the focal liver lesions in our study were as follows: simple cysts (1.37+/- 0.08 x 10^{-3} mm^2/s),hydatid cysts(1.11+/-0.11x10^{-3} mm^2/s), hemangiomas(1.12+/- 0.31 x 10^{-3} mm^2/s), abscess (1.04+/-0.11x10^{-3} mm2/s), adenoma (1.08 +/-0.41 x 10^{-3} mm^2/s), hepatocellular carcinomas (HCC) (0.68+/- 0.10 x 10^{-3} mm^2/s), metastases (0.65 +/- 0.11 x 10^{-3} mm^2/s). (Table-2)

Table 2: mean ADC for each type of focal liver lesion

Diagnosis	No. of lesions (n=75)	ADC (x 10^{-3} mm^2/s)	
		Mean	SD
HCC	16	0.68	0.10
Mets	34	0.65	0.11
Abscess	9	1.04	0.11
Hemangioma	3	1.12	0.31
Simple hepatic cyst	7	1.37	0.08
Hydatid cyst	2	1.13	0.11
Adenoma	2	1.08	0.41

Mean ADC values of malignant lesions were significantly lower than those of benign lesions: 0.65 x 10^{-3} mm^2/s V/s 1.1 x 10^{-3} mm^2/s respectively (P< .001). The ADC cutoff value 0.93 x 10-3 mm2/s was obtained by normal distribution (mean ± 2SD). With ADC cutoff of 0.93 x10^{-3} mm^2/s the sensitivity of 93.8%, Specificity of 92.1%, PPV of 95.8%, NPV of 88.9%, Overall accuracy of 99% was obtained. These findings are almost similar to the study done by **Reza Javadrashidet al[10].** The T2 signal cut-off value 0.87 x 10-3 mm2/s was obtained by normal distribution (mean ± 2SD). With T2 signal cutoff of 0.87 x$10^{-3}$$mm^2/s$ the Sensitivity of89.8%, Specificity of 92.3%, PPV of 95.7%, NPV of 82.7%, Overall accuracy of 93% was obtained. (Table-4)

Conclusion

MRI is an exceptional modality in detecting and characterizing the liver lesions. We inferred from our research that diffusion weighted imaging plays a significant role in separating benign from malignant liver lesions.Out of 75 FLLs(50 patients) 74(98.5%) were detected by DWI and 73(76.5%) by T2WI. And all 75 lesions were detected when both the sequences were used. DW imaging was associated with a significantly higher detection rate FLLs (p <0.001).

With an ADC cut off value of 0.93×$10^{-3}$$mm^2/s$ the Sensitivity of 93.8%, Specificity of 92.1%, PPV of 95.8%, NPV of 88.9%, Overall accuracy of 99% was obtained. (Table-3)

Table 3: ADC cut off for identification of malignant and benign lesions.

The cut off of ADC for identification of malignancy is 932

ADC categories	Histopathology		Total number of lesions
	Benign	**Malignant**	
>932	24	3	27
<=932	2	46	48
Total	26	49	75

For that cut off

Parameter	Point estimate (%)	95% CI
Sensitivity	93.8	88.5-99.3
Specificity	92.1	86.3-98.3
Positive predictive value	95.8	91.3-100
Negative predictive value	88.9	81.8-96.0

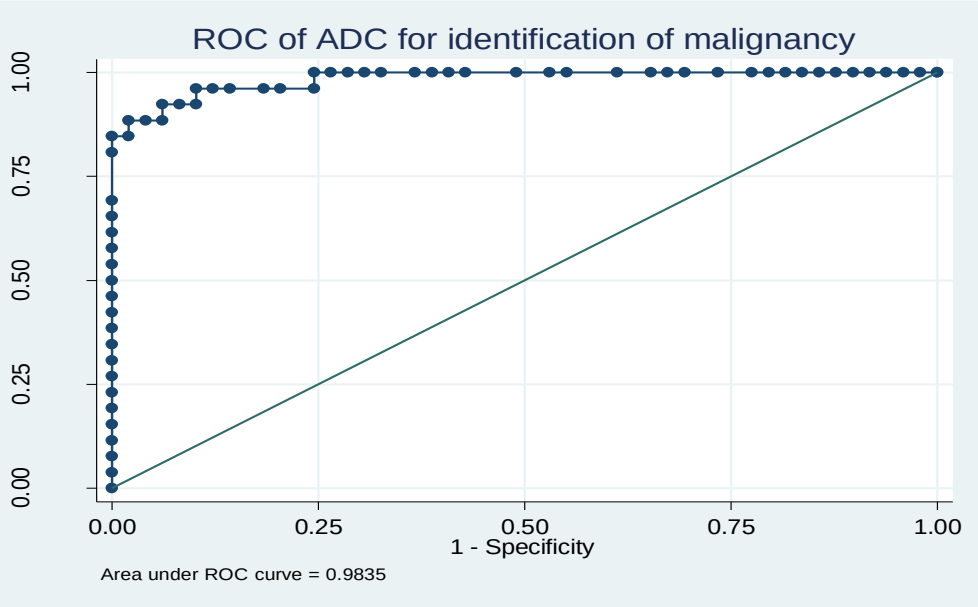

Fig 1:ROC of ADC for identification of malignancy

With T2 signal cut off of 0.87 x$10^{-3}$$mm^2$/s the Sensitivity of89.8%, Specificity of 92.3%, PPV of 95.7%, NPV of 82.7%, Overall accuracy of 93% was obtained. (Table-4)

Table 4: T2 signal cut off for identification of benign and malignant lesion

The cut off of T2 signal for identification of malignancy is 875

T2 signal category	Histopathology		Total number of lesions
	Malignant	**Benign**	
>875	5	24	29
<=875	44	2	46
Total	49	26	75

For that cut off

Parameter	Point estimate (%)	95% CI
Sensitivity	89.8	83.0- 96.7
Specificity	92.3	86.3-98.3
Positive predictive value	95.7	91.0-100
Negative predictive value	82.7	74.2-91.3

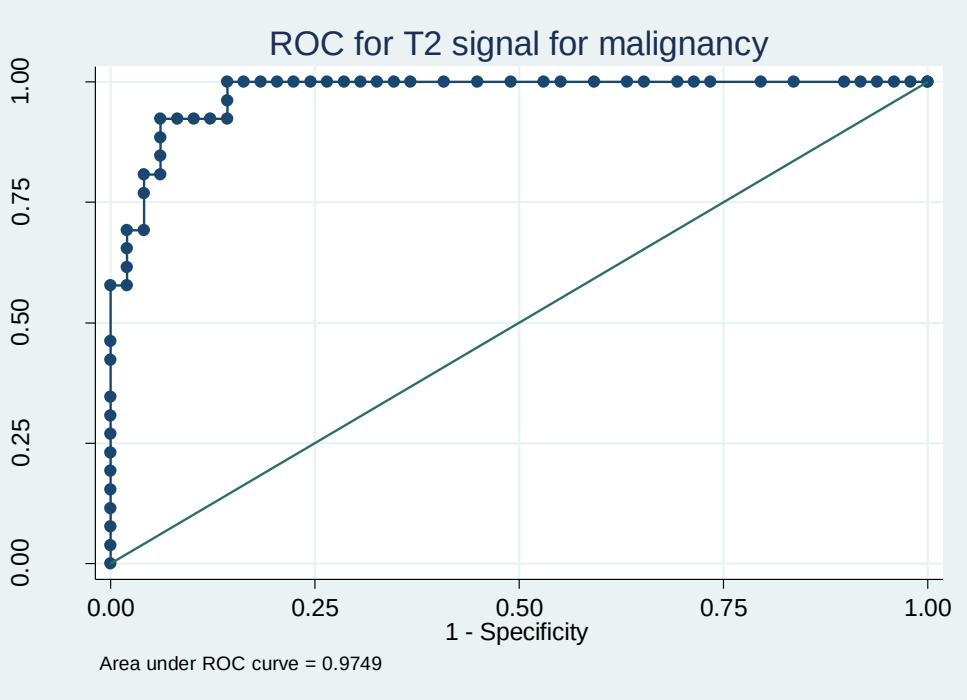

Fig 2:ROC for T2 signal for malignancy

In comparative ROC curve for ADC and T2 signal the P-value was 0.57. (Table-5)

Table 5: Comparison of ROC's of ADC and T2 signal intensity

Parameter	Area Under the Curve	95% CI of AUC	P value
T2	0.97	0.95-1.0	0.57
ADC	0.98	0.96-1.0	

Mean ADC values of malignant lesions were significantly lower than those of benign lesions: 0.65 x 10^{-3} mm^2/s V/s 1.1x 10^{-3} mm^2/s respectively (*P*< .001).The mean ADC value of the focal liver lesions in our study were as follows: simple cysts (1.37+/- 0.08 x 10^{-3} mm^2/s), hydatid cysts (1.11+/- 0.11 x 10^{-3} mm^2/s), hemangiomas (1.12+/- 0.31 x 10^{-3} mm^2/s), abscess (1.04+/-0.11x10^{-3} mm2/s), adenoma (1.08 +/- 0.41 x 10^{-3} mm^2/s), hepatocellular carcinomas (HCC) (0.68+/- 0.10 x 10^{-3} mm^2/s), metastases (0.65 +/- 0.11 x 10^{-3} mm^2/s)(Table-2)

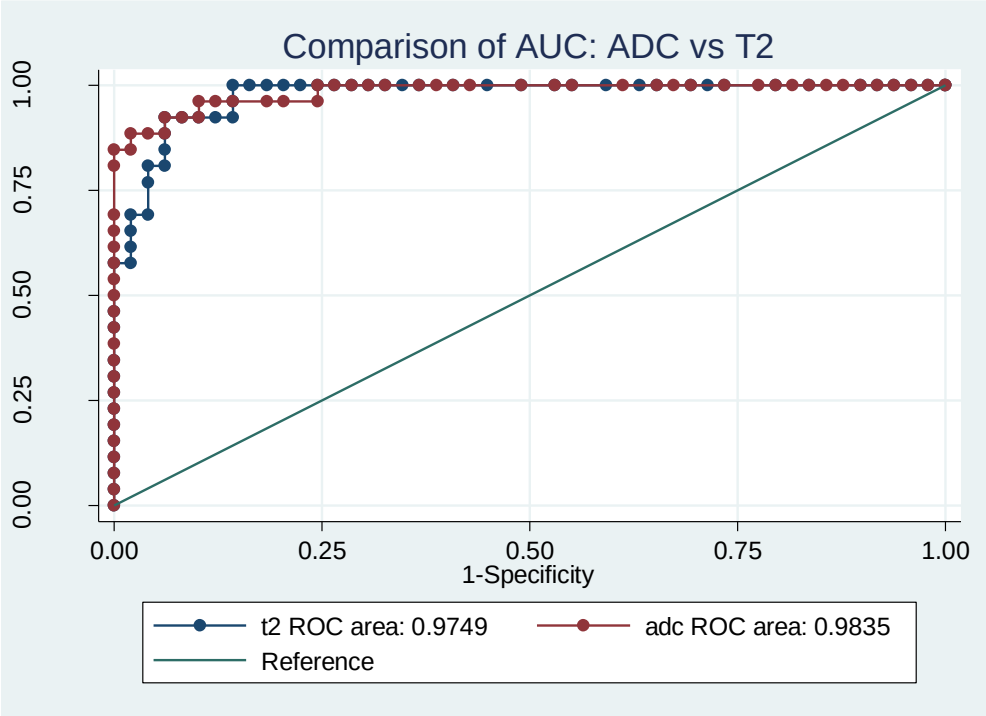

Fig 3:Comparison of AUC:ADC vs T2

Case-1

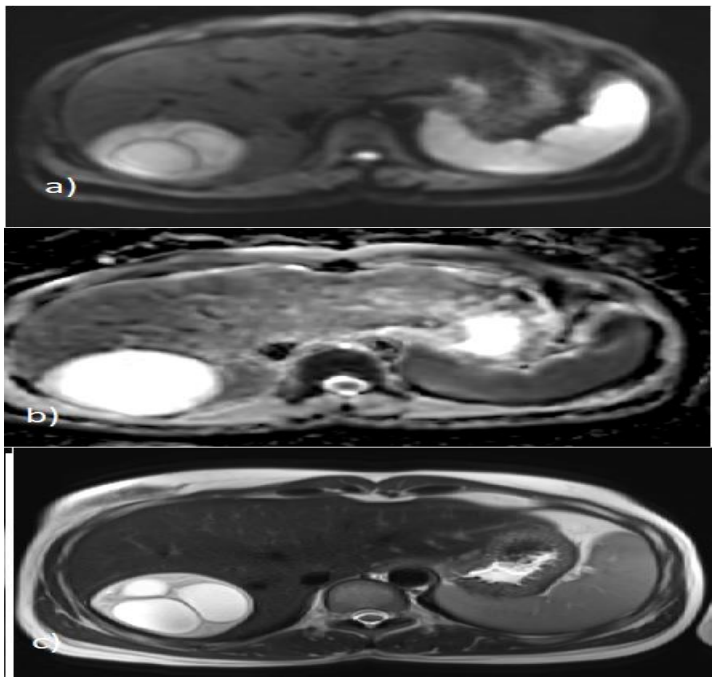

Fig 4: MRI abdomen showing a hydatid cyst in liver; a) & b) Axial DWI and corresponding ADC images showing a large hyperintense lesion in the right lobe of liver with no diffusion restriction. c) Axial T2W images showing loculations with hypointense septations.

Case-2

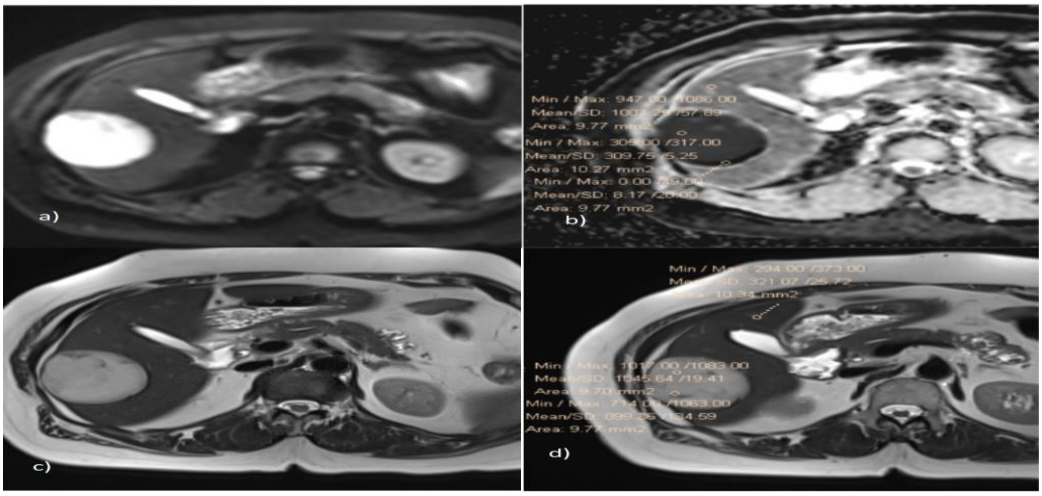

Fig 5: MRI abdomen showing focal liver lesion; a)&b) Axial DWI and corresponding ADC images showing heterogeneously hyperintense lesion with corresponding low ADC values in the right lobe of liver. On ADC map, it shows b value of 0.3 × 10^{-3}mm^2/s.c)& d) axial T2W image showing heterogeneous hyperintense signal with T2 signal of 0.7 × 10^{-3}mm^2/s.

Case-3

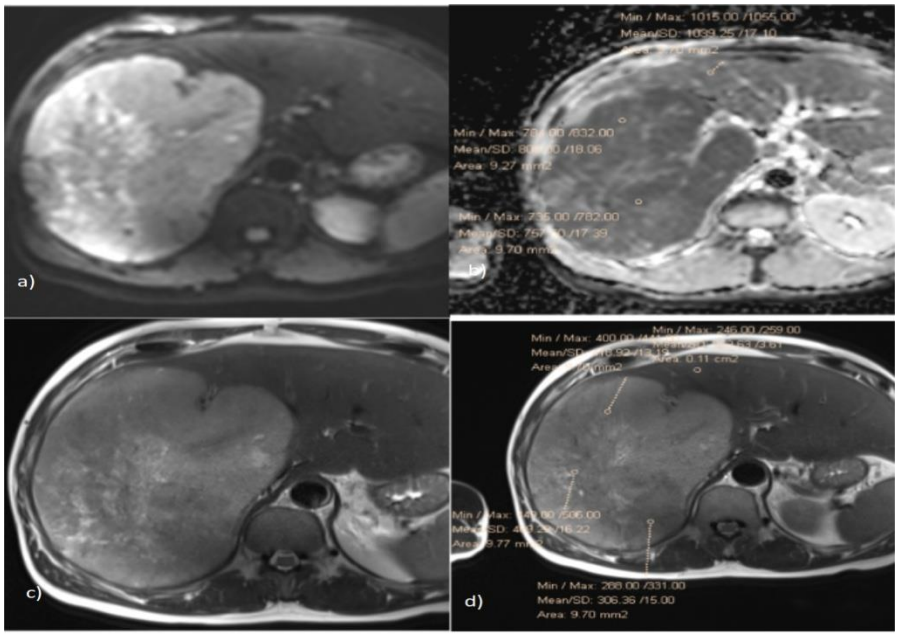

Fig 6: A 65-year-old man with HCC, a) &b)Axial DWI and corresponding ADC map showing areas of diffusion restriction with low b values of 0.7 x 10^{-3} mm^2/s.; c) & d)Axial T2W image showing heterogeneously hyperintense signal and T2 signal of 0.5 × 10^{-3}mm^2/s.

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