The Egyptian Journal of Hospital Medicine (October 2022) Vol. 89 (2), Page 6231- 6238

Diffusion Weighted Magnetic Resonance Imaging in Characterization of Different Pancreatic Masses

Islam Mahmoud Mahfouz*, Dalia Bayoumi, Salwa Mohamed Eteba
Department of Diagnostic Radiology, Faculty of Medicine, Mansoura University, Egypt
***Corresponding author:** Islam Mahmoud Mahfouz, **Mobile:** (+20) 01116175457, **E-Mail:** islammahmoud5262@gmail.com

ABSTRACT

Background: Diagnosis of variety of abdominal abnormalities could be easily done by diffusion-weighted magnetic resonance imaging (DWI) with apparent diffusion coefficient (ADC) quantification. Several studies have demonstrated that combining DWI with ADC measurement can aid in the detection and characterization of pancreatic masses. The objective of the current study is the evaluation of diffusion weighted imaging role as a non-invasive method in evaluation of pancreatic masses with histopathological correlation.

Patients and methods: The study included 59 patients performed at Radiology Department of Mansoura University Hospital. The patients were between the ages of 30 and 71 years. This research was carried out using a 1.5 T Philips Ingenia MRI scanner. All patients underwent history taking and MRI with DWI.

Results: Malignant lesions mean ADC was about 1.14 (SD 0.14) x 10^{-3} mm^2/sec. Mean ADC of benign lesions was about 2.38 (SD 0.73) x 10^{-3} mm^2/sec. With a cutoff point of 1.36 x 10^{-3} mm^2/sec for differentiating malignant from benign lesions, the benign lesions' ADC value was statistically substantially higher than the malignant lesions', with 95.8% sensitivity, 90.9 % specificity, and 94.4% accuracy.

Conclusion: Combining qualitative and quantitative examination of DWI and ADC results could assist to distinguish between malignant and benign pancreatic tumors. The evaluation of pancreatic masses can be aided by combining DWI with conventional imaging, which has been demonstrated to be an easy, non-invasive procedure.

Keywords: Diffusion weighted imaging, apparent diffusion coefficient, MRI, pancreatic masses.

INTRODUCTION

A tumor in the pancreas can be caused by a variety of benign and malignant disorders, some of which may be completely benign (mass forming chronic pancreatitis) or, more commonly, cancerous (like endocrine tumors as well as ductal adenocarcinoma), or to be of cystic type (like pseudocysts as well as cystic neoplasms) **(1)**.

Diffusion weighted imaging has yielded fruitful results in the evaluation of pancreatic lesions through quantitative analysis of mean apparent diffusion coefficient (ADC) values **(2)**.

Thus, ADC reflecting the freedom of water molecule motions serves to distinguish tissue regions of varying cellular density and stromal composition **(3)**.

The ADC map shows low signal intensity for tissues with water diffusion restriction while DW pictures show high signal intensity for these tissues; by computing the ADC value inside particular regions of interest, diffusion restriction can also be measured **(4)**.

This study aimed for the evaluation of diffusion weighted imaging role as a noninvasive method in evaluation of pancreatic masses with histopathological correlation.

PATIENTS AND METHODS

A total of 99 patients were included in this study, referred from the Surgical Oncology Department and Medical Oncology Unit at the Oncology Center Mansoura University (OCMU) and the General Surgical Department at Mansoura University Hospital, during the period from November 2019 to May 2022.

Patients were 35 males and 24 females, and their age ranged between 30 and 71 years. All patients underwent an appropriate history taking, followed by clinical examination and MRI with DWI.

Inclusion criteria:

- Both gender, males and females, were included in the study.
- Patients who agreed to participate in the study.
- Patients with a pancreatic mass, which was histologically proven following a true cut or fine needle biopsy/aspiration.
- Cases who were diagnosed comfortably upon clinical evaluation, laboratory studies and or follow-up radiological examinations.

Exclusion criteria:

- Patients who have a cardiac pacemaker.
- Patients who have metallic foreign body in their eye.
- Patients with severe claustrophobia to MRI examination.
- Patients with very bad general condition.
- Uncooperative patients with excessive motion.

METHODOLOGY

Magnetic Resonance Imaging:

All cases in this study were processed using the Philips Ingenia 1.5 T MRI scanner located in the Radiology Department of Mansoura University Hospital (with the same scanning parameters).

I. Patient preparation: Patients were instructed to avoid movement during the acquisition time. Before entering the examination room, the patient was

Received: 30/06/2022
Accepted: 06/09/2022

instructed to remove all metallic objects and all clothes containing metal. Irritable patients were reassured and informed about the examination. No sedation was used in any of the examinations. The patients were informed of the examination time as well as the importance of remaining motionless during the examination.

II. Technique: The patient lied supine, head first on the MRI table and a surface coil was used. Scanning was performed from the lung bases to the iliac crest.

III. T2 weighted pulse sequences: Axial T2-weighted image (1250/80) TR/TE with an 18 cm field of view, 256 x 256 matrix, 2 mm section thickness, and 1 mm section gap made up the first imaging.

IV. Diffusion weighted MRI: Utilizing single shot spin echo planar imaging (SS-EPI) in the axial plane, diffusion weighted images were produced. Diffusion was produced using the following parameters: slice thickness = 5 mm; interslice gap = 1 mm; FOV = 25 cm; repetition time (TR) 2745 ms; echo time (TE) 75 ms; matrix, 256 256; acquisition time = 50 sec. ' In the axial plane, three b-factors of 0, 500, and 1000 mm2/sec were achieved.

Image analysis:

When compared to normal pancreatic tissue, signal characteristics on DWI and ADC maps were reported as being hyperintense for bright signals and hypointense for those with low signal intensities. The lesions were detected using DWI. Then, with b values of 500 and 1000 mm2/sec, the DW images match the ADC maps.

We determined whether the lesion is restricted or unrestricted in diffusion. We defined a lesion as visually restricted if it appeared hyperintense with low signal intensity on the corresponding extracted ADC map image in comparison to the surrounding normal parenchyma.

ADC calculation:

By tracing the region of interest over the lesions, we were able to determine the mean ADC value of the discovered lesions. It was manually positioned to make sure it was smaller than the actual lesion and that it did not include nearby healthy tissue.

Ethical consideration:

The study was approved by the Institutional Review Board of the Faculty of Medicine, Mansoura University. Every patient signed an informed written consent for acceptance of participation in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

Data collected and encoded using Microsoft Excel software. Data were then imported into Statistical Package for Social Sciences (SPSS version 22.0) software for analysis. Qualitative variables were presented in the form of frequencies and percentages, while quantitative variables were presented in the form of means and standard deviations. The Kolmogorov-Smirnov test was used to determine whether the data were normal. The normal distributed quantitative data were compared using Student's t-test. Statistical significance was considered at p-value $\leq$0.05.

RESULTS

According to the diffusion results, ***table 1*** shows that 84.7% of the lesions showed restricted diffusion pattern while the remaining lesions showed non-restricted pattern in 15.3% of the cases.

Table (1): diffusion results distribution of the participants.

Diffusion	n=59	%
Non-restricted	9	15.3
Restricted	50	84.7

Table 2 shows that the mean ADC value in the detected lesions was 1.40 (SD 0.62) x 10^{-3}mm^2/s and the reported range was between 0.820 and 2.99 x 10^{-3}mm^2/s.

Table (2): Mean ADC value among studied cases.

Variable	n=59
ADC(x10^{-3} mm^2/sec) Mean ± SD (Minimum - Maximum)	1.40 ± 0.62 (0.820 - 2.99)

Table 3 shows that the mean ADC of the malignant lesions was about 1.14 (SD 0.14) x 10^{-3} mm^2/sec. In benign lesions about the mean ADC was about 2.38 (SD 0.73) x 10^{-3} mm^2/sec. In comparison to the malignant lesions, the ADC value of the benign lesions was statistically substantially higher.

Table (3): Comparison of mean ADC between malignant and benign lesions.

Variable	Malignant	Benign	test of significance
ADC (x10^{-3}mm^2/sec) Mean ± SD	1.14 ± 0.14	2.38 ± 0.53	t=11.23 p<0.001 *

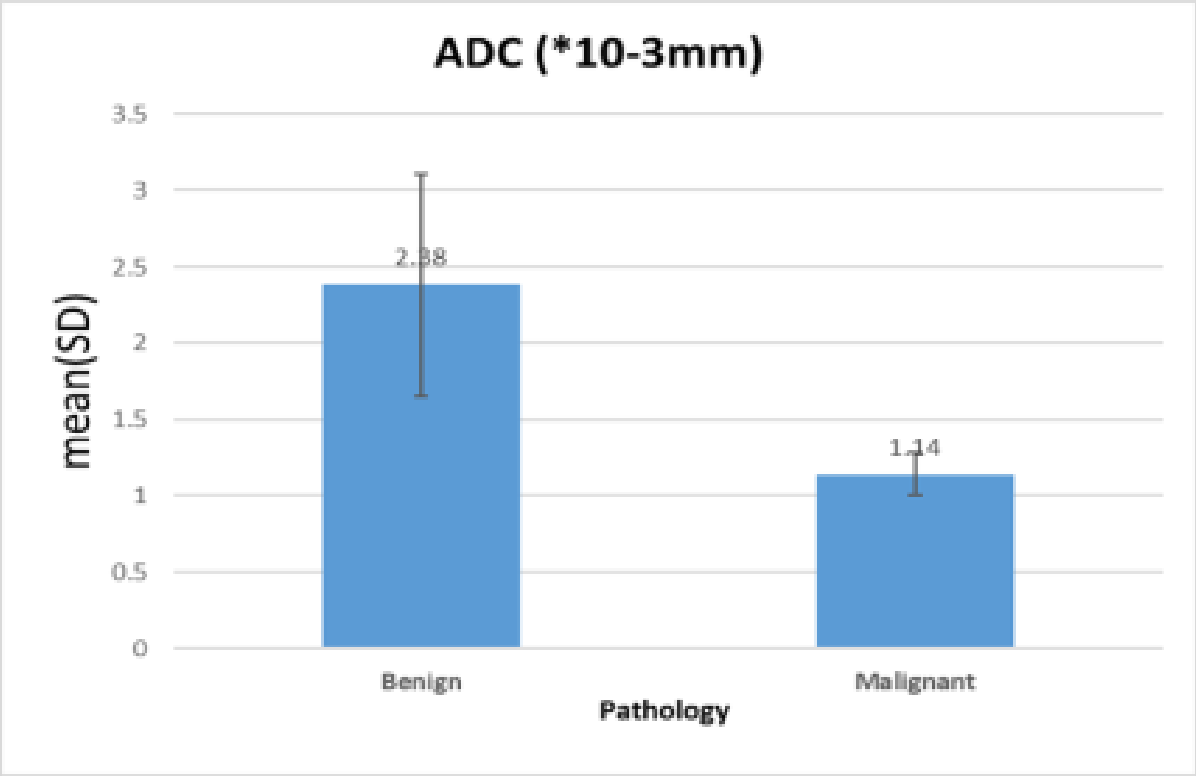


Figure (1): Comparison of mean ADC between malignant and benign lesion.

Table 4 demonstrates that the optimum ADC cut off point for separating malignant from benign lesions was 1.36 x 10^{-3} mm^2/sec, with 95.8% sensitivity, 90.9% specificity, and 94.4% accuracy.

Table (4): Validity of ADC in differentiating malignant from benign lesions:

Variable	AUC (95% CI)	Cut off point	P value	Specificity %	Sensitivity %	NPV %	PPV %	Accuracy %
ADC (x$10^{-3}$$mm^2$/s)	0.919 (0.766-1.0)	1.36	<0.001*	90.9	95.8	83.3	97.9	94.9

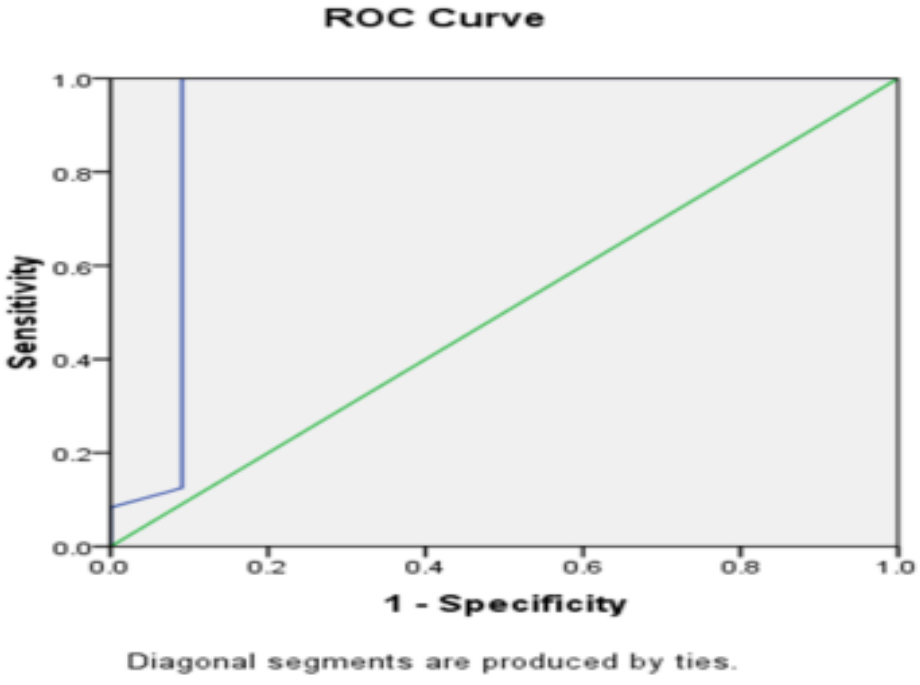
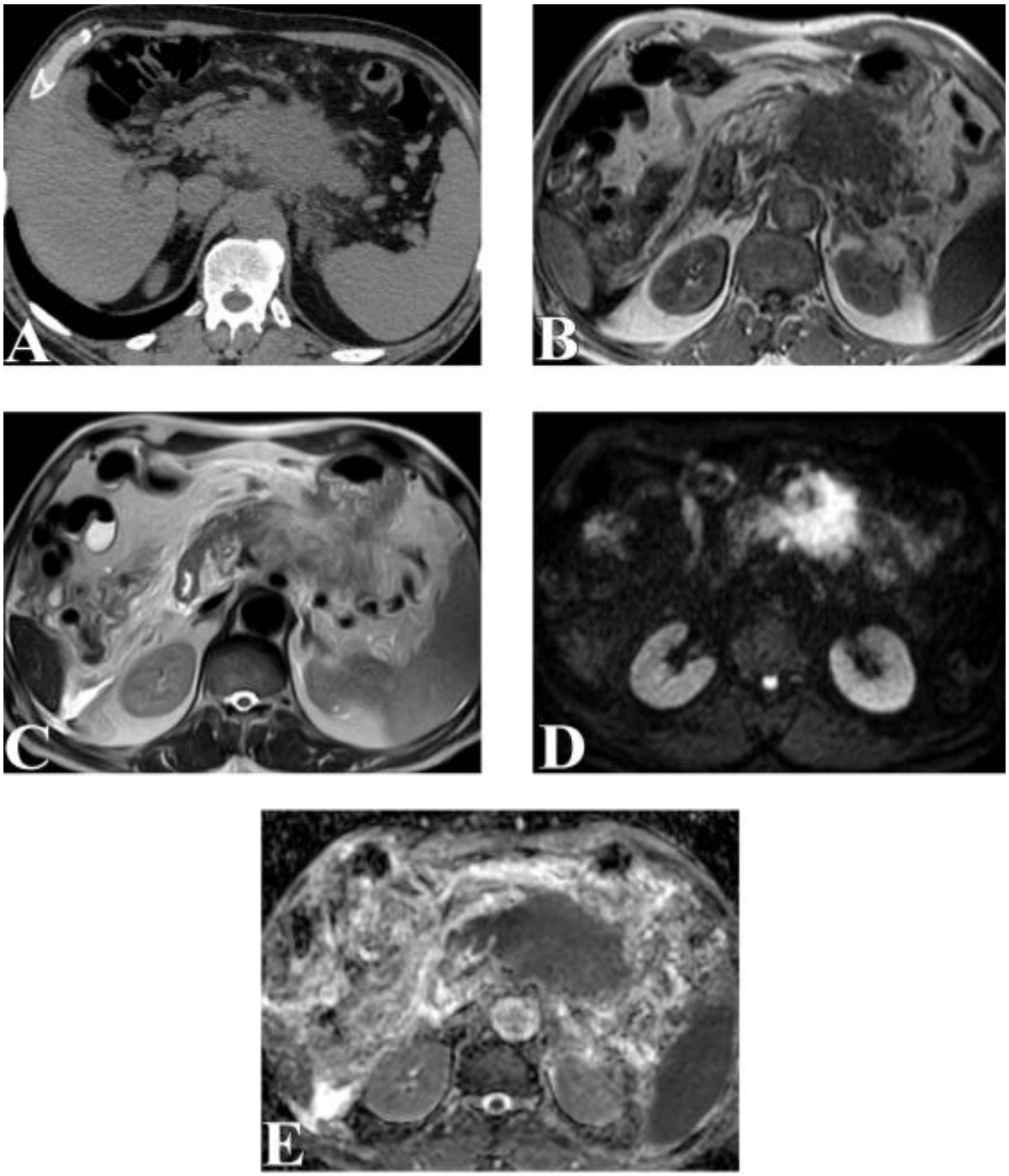


Figure (2): ROC curve of Using ADC to distinguish between malignant and benign tumors.

CASE PRESENTATION

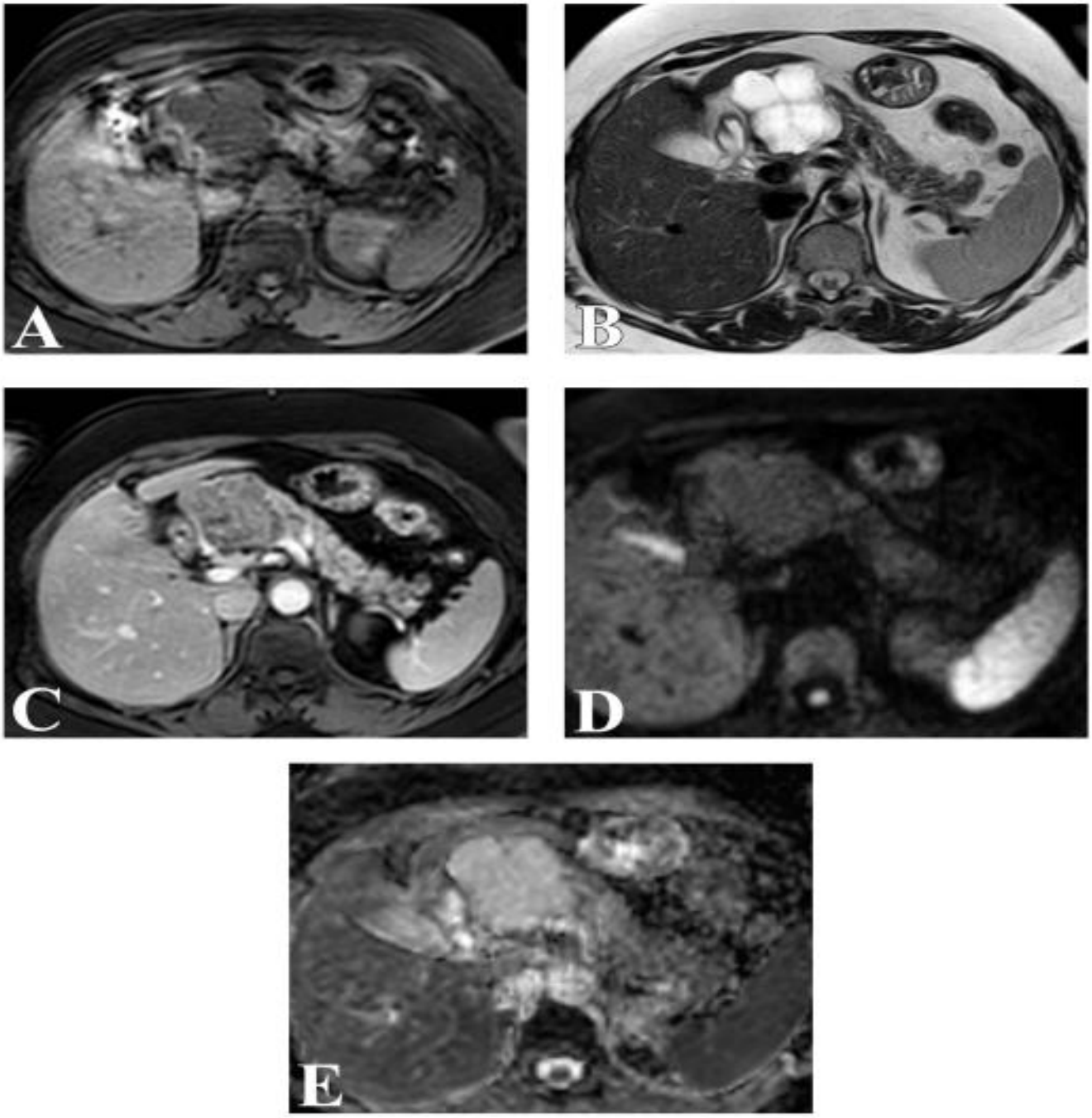
CASE 1

A 66 years old man presented by abdominal pain and weight loss. (A) Non contrast axial CT shows an ill-defined mass involving the body & tail of pancreas. (B) Axial T1 MRI image shows hypointense signal of the mass. (C) Axial T2MRI image shows hyperintense signal of the mass. (D) Axial DW image shows high signal intensity of the mass. (E) ADC map axial image shows low signal intensity reveals diffusion restriction with the calculated ADC value equal to 1.131 x 10^{-3} mm^2/sec.
Pathology: Pancreatic ductal well differentiated adenocarcinoma.



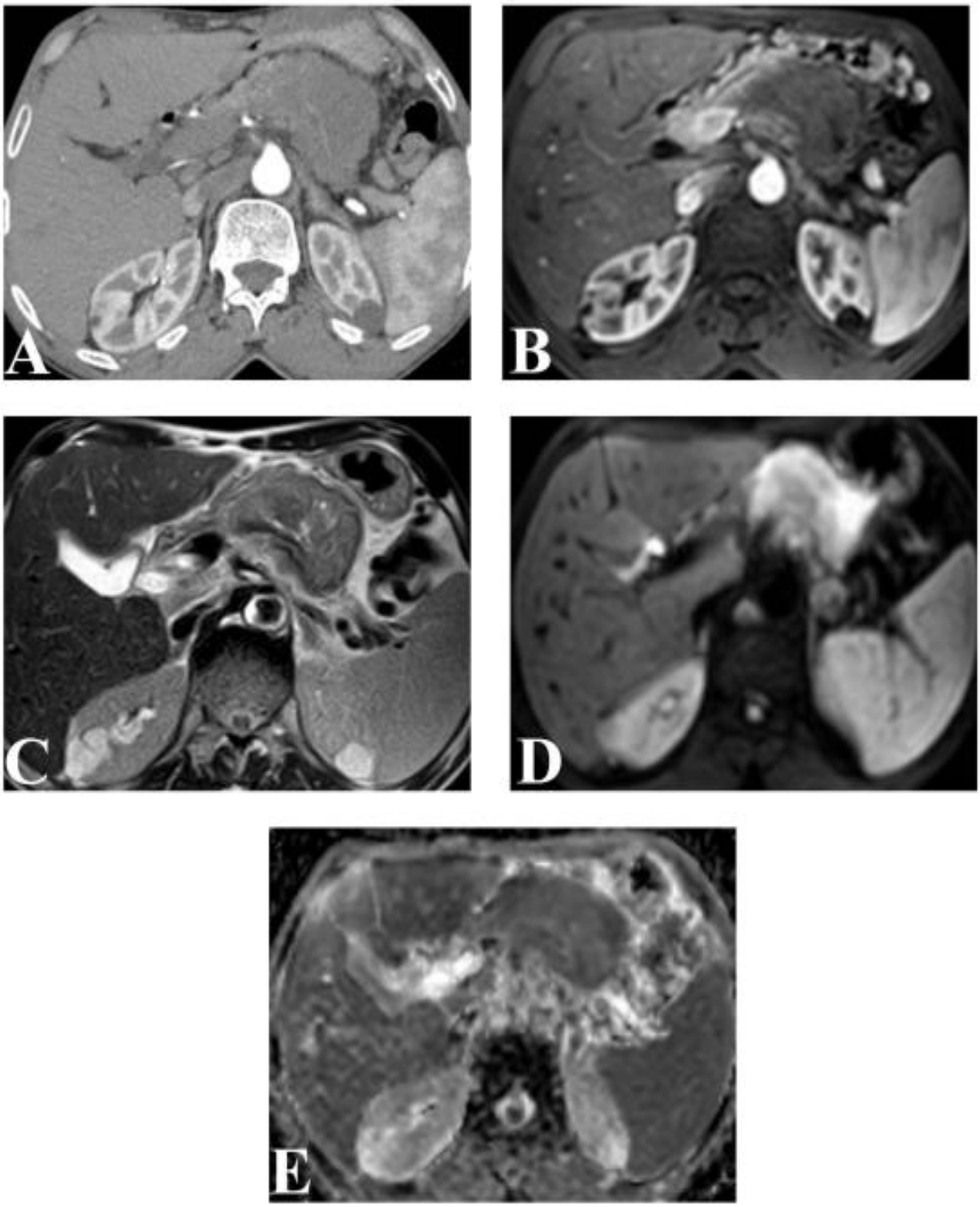
CASE 2

A 54 years old woman was presented by nausea and vomiting. (A & B) Axial T1 &T2 MRI shows well defined multilocular cystic lesion at head of pancreas displaying low SI in T1WI & high SI in T2WI. (C) Axial T1 post contrast MRI shows low signal of the cystic lesion with septal & marginal enhancement. (D) Axial DW image showed low signal intensity of the cystic lesion. (E) Extracted corresponding ADC map image showed facilitated diffusion with the calculated ADC equals to 2.671 x 10^{-3} mm^2/sec.
Pathology: Pancreatic mucinous cystadenoma.



CASE 3

A 56 year old man presented by abdominal pain. (A & B) Axial post contrast CT & axial T1 post contrast MRI shows well defined non-enhancing pancreatic mass involving body and tail. (C) Axial T2 MRI image shows high signal of the mass. (D) Axial DW image shows high signal intensity of the mass. (E) ADC map axial image shows low signal intensity reveals diffusion restriction with the calculated ADC value equal to 1.119 x 10^{-3} mm^2/sec.
Pathology: Pancreatic ductal moderate differentiated adenocarcinoma.



DISCUSSION

Magnetic resonance imaging is becoming a crucial diagnostic tool for identifying pancreatic lesions [5].

Diffusion-weighted MRI and ADC maps, in which restriction of diffusion represents greater tumor cellularity and decreasing extracellular space, can be used to provide additional information [6].

ADC measurements have been found in numerous studies to be useful in identifying benign from malignant pancreatic tumors [7].

In our study, most of the detected lesions were malignant in nature (81.4%), and the remaining 18.6% of cases had benign lesions.

Similar to our findings, **Abdallah *et al.*** [8] reported that malignant lesions formed 73.3% of the studied patients with pancreatic masses.

In contrast to the previous findings, other authors reported that of the 36 analyzed patients, 24 had benign lesions, while 12 had malignant lesions. The prevalence of malignant masses was 33.3% [9]. Difference in sample size and the epidemiology of pancreatic cancer could explain the previous heterogeneity.

In our study, restricted diffusion was detected in 50 (84.7%) patients, while the remaining (15.3%) patients had non-restricted diffusion. Malignant tumors are thought to be associated with restricted water diffusion due to its increased cellularity [10].

In a previous similar study that evaluated DWI in pancreatic masses cases, 34/50 (68%) lesions showed restricted diffusion, while 16/50 (32%) lesions had non-restricted diffusion [11].

Our findings showed that ADC had significantly lower values in patients with malignant disease with mean 1.14 $X10^{-3}$ mm^2/sec vs. 2.38 X 10^{-3} mm^2/sec in benign cases.

This finding is consistent with the results of **Kartalis *et al.*** [9] study, which also reported the significantly lower ADC value of malignant pancreatic lesions 1.40 X 10^{-3} mm^2/sec compared with that of benign pancreatic lesions 2.57 X 10^{-3} mm^2/sec.

Moreover, **Barral *et al.*** [12] reported that ADC had mean values of 1.15 X 10^{-3} mm^2/sec and 2.49 X 10^{-3} mm^2/sec in the malignant and benign pancreatic neoplasm groups respectively, which was significant on statistical analysis ($p < 0.005$)

Furthermore, **Seif *et al.*** [13] confirmed the previous findings as ADC had mean values of 1.27 X 10^{-3} mm^2/sec and 2.05 X 10^{-3} mm^2/sec in patients with malignant and benign pancreatic masses respectively ($p < 0.001$)

A clear separation of ADC measurements between malignant and benign lesions has been observed.

In our study, when a cut-off value of 1.36 x 10^{-3} mm2/sec was used, ADC had sensitivity and specificity of 95.8% and 90.9%, respectively, and an accuracy of 94.9 percent in discriminating between benign and malignant cases.

Barakat *et al.* [14] who reported sensitivity, specificity, and diagnostic accuracy of 92.31%, 88.89%, and 90.32%, respectively, to distinguish between benign and malignant lesions using an ADC cut-off of 1.47 x 10^{-3} mm^2/sec.

Abdallah *et al.* [8] reported 95.5% sensitivity, and 75% specificity to differentiate between benign and malignant cases. In addition, a lower sensitivity (87.2 %) and specificity (69.2%) for mean ADC has been reported by **Lee *et al.*** [15] using a near cut-off value of about 1.33 x 10^{-3} mm^2/sec.

Diffusion MRI was used in the current study demonstrated 100% sensitivity, 81.8 % specificity, and 96.6 % accuracy in distinguishing between benign and malignant patients.

Kartalis *et al.* [9] reported that for detecting pancreatic cancer, DWI has 92% sensitivity, 97% specificity, and 96% accuracy. **Ichikawa *et al.*** [16] also reported 96.2% sensitivity and 98.6% specificity for detecting malignant pancreatic neoplasms.

The previous studies agree with us regarding the efficacy of DWI MRI in evaluating patients with pancreatic neoplasms.

Our study has some limitations; it included a sample size that was collected from a single medical center Moreover, a small number of non-malignant patients were included in the study.

In conclusion, differentiating between benign and malignant pancreatic masses can be aided by combined qualitative and quantitative analysis of DWI and ADC results. It has been discovered that using DWI in conjunction with conventional imaging is an easy and non-invasive approach that helps in the evaluation of pancreatic neoplasms. DWI can be utilized as an alternate approach to contrast-enhanced imaging in situations when the administration of contrast is contraindicated.

Conflict of interest: The authors declare no conflict of interest.

Sources of funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author contribution: Authors contributed equally in the study.

REFERENCE

1. **Thind K, Simons-Linares C, Chahal P (2021):** Endoscopic Ultrasound-Guided Drainage of Pancreatic Fluid Collections. In: Facciorusso A, Muscatiello N (eds) Endoscopic Ultrasound Management of Pancreatic Lesions. Springer, Cham. pp. 95-113. https://doi.org/10.1007/978-3-030-71937-1_7
2. **Singhal S, Prabhu N, Sethi P *et al.* (2017):** Role of multi detector computed tomography (MDCT) in

preoperative staging of pancreatic carcinoma. Journal of Clinical and Diagnostic Research, 11(5):1-6.

3. **Trajkovic-Arsic M, Heid I, Steiger K *et al.* (2017):** Apparent diffusion coefficient (ADC) predicts therapy response in pancreatic ductal adenocarcinoma. Scientific Reports, 7(1):1-9.
4. **De Robertis R, Martini P, Demozzi E *et al.* (2015):** Diffusion-weighted imaging of pancreatic cancer. World Journal of Radiology, 7(10):319-324.
5. **Serrao E, Kessler D, Carmo B *et al.* (2020):** Magnetic resonance fingerprinting of the pancreas at 1.5 T and 3.0 T. Scientific Reports, 10(1):1-11.
6. **Kulali F, Semiz-Oysu A, Demir M *et al.* (2018):** Role of diffusion-weighted MR imaging in predicting the grade of nonfunctional pancreatic neuroendocrine tumors. Diagnostic and Interventional Imaging, 99(5):301-309.
7. **Ding X, Xu H, Zhou J *et al.* (2019):** Reproducibility of normalized apparent diffusion coefficient measurements on 3.0-T diffusion-weighted imaging of normal pancreas in a healthy population. Medicine, 98(14):e15104. doi: 10.1097/MD.0000000000015104.
8. **Abdallah E, Ali M, Awadallah M *et al.* (2016):** Role of diffusion weighted imaging in characterization of pancreatic pathology. The Egyptian Journal of Radiology and Nuclear Medicine, 47(3):723-727.
9. **Kartalis N, Lindholm T, Aspelin P *et al.* (2009):** Diffusion-weighted magnetic resonance imaging of pancreas tumours. European Radiology, 19(8):1981-1990.
10. **Motoshima S, Irie H, Nakazono T *et al.* (2011):** Diffusion-weighted MR imaging in gynecologic cancers. Journal of Gynecologic Oncology, 22(4):275-287.
11. **Okasha A, Abd-Elrazek G, Negm M *et al.* (2022):** Role Of Contrast-Enhanced Magnetic Resonance Imaging and Diffusion-Weighted Magnetic Resonance Imaging In evaluation of the pancreatic Lesions. SVU-International Journal of Medical Sciences, 5(1):305-314.
12. **Barral M, Sebbag-Sfez D, Hoeffel C *et al.* (2013):** Characterization of focal pancreatic lesions using normalized apparent diffusion coefficient at 1.5-Tesla: preliminary experience. Diagnostic and Interventional Imaging, 94(6):619-627.
13. **Seif E, Elsayed F, Elbialy A (2022):** The Value of Diffusion Weighted MRI in Evaluation of Pancreatic Lesions. International Journal of Health Sciences, 6(3):5719-5728.
14. **Barakat M, Abdurrahman L, Anany D *et al.* (2021):** The Diagnostic Role of Normalized and Mean Apparent Diffusion Coefficient in Differentiation between Pancreatic Lesions. The Egyptian Journal of Hospital Medicine, 85(2):3927-3935.
15. **Lee S, Byun J, Park B *et al.* (2008):** Quantitative analysis of diffusion- weighted magnetic resonance imaging of the pancreas: usefulness in characterizing solid pancreatic masses. Journal of Magnetic Resonance Imaging: An Official Journal of the International Society for Magnetic Resonance in Medicine, 28(4):928-936.
16. **Ichikawa T, Erturk S, Motosugi U *et al.* (2007):** High-b value diffusion-weighted MRI for detecting pancreatic adenocarcinoma: preliminary results. AJR Am J Roentgenol., 188(2):409-414.