Section: Radiology

Original Research Article

# DIFFUSION-WEIGHTED MAGNETIC RESONANCE IMAGING TO DIFFERENTIATE MALIGNANT FROM BENIGN GALLBLADDER DISORDERS: A HOSPITAL-BASED RETROSPECTIVE STUDY

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## ABSTRACT

**Background:** Distinguishing between malignant and benign gallbladder disorders using standard imaging is often challenging, which can lead to delayed cancer diagnoses or unnecessary surgeries for benign conditions.
**Materials and Methods:** This retrospective, hospital-based study evaluated 132 patients who presented with indeterminate gallbladder lesions at IMS & SUM Hospital, Bhubaneswar, between 2024 and 2025. All patients underwent abdominal Magnetic Resonance Imaging (MRI) that included Diffusion-Weighted Imaging (DWI). To keep the analysis clinically straightforward, we focused exclusively on the Apparent Diffusion Coefficient (ADC) value. These imaging findings were then compared to the final histopathological diagnoses.
**Results:** Of the 132 patients, 42 (31.8%) were diagnosed with malignant lesions and 90 (68.2%) with benign conditions. Malignant lesions showed significantly lower mean ADC values ($1.18 \pm 0.22 \times 10^{-3}$ mm$^2$/s) compared to benign lesions ($2.45 \pm 0.38 \times 10^{-3}$ mm$^2$/s) ($p < 0.001$). By setting an ADC threshold of $1.42 \times 10^{-3}$ mm$^2$/s, the method achieved a sensitivity of 90.4% and a specificity of 88.8%.
**Conclusion:** DWI, specifically through straightforward ADC mapping, is a highly reliable and non-invasive tool for differentiating malignant from benign gallbladder diseases. It offers a practical quantitative metric that can greatly improve pre-surgical planning.
**Keywords:** Diffusion-Weighted Imaging, Apparent Diffusion Coefficient (ADC), Gallbladder Carcinoma, Benign Gallbladder Lesions, Magnetic Resonance Imaging, Diagnostic Accuracy, Biliary Tract Diseases.

## INTRODUCTION

Gallbladder carcinoma (GBC) is an aggressive cancer of the biliary tract. Unfortunately, it is often caught late because its early symptoms closely mimic everyday benign gallbladder issues, such as chronic cholecystitis or gallstone disease. For patients, the difference in diagnosis is life-altering: early-stage cancer requires complex radical surgery, while benign conditions usually just need a simple laparoscopic removal of the gallbladder.

Standard imaging tools like ultrasound and contrast-enhanced CT scans are the usual first steps in evaluating a patient's symptoms. However, they sometimes struggle to tell the difference between a gallbladder wall thickened by chronic inflammation and one thickened by an early tumour.

Recently, Diffusion-Weighted Imaging (DWI) paired with Apparent Diffusion Coefficient (ADC) mapping has become a powerful addition to standard abdominal MRI scans. DWI tracks the random, microscopic movement of water molecules in the body's tissues. Because malignant tumours are densely packed with cells, they trap water molecules, restricting their movement. On a scan, this restricted diffusion shows up clearly and translates into a lower numerical ADC value.

The beauty of the ADC value is its simplicity—it gives radiologists a concrete number to work with, without needing intravenous contrast or complex mathematical modelling. This study aims to evaluate how well simple ADC values can differentiate malignant from benign gallbladder lesions in patients treated at IMS & SUM Hospital, Bhubaneswar, during 2024 and 2025.

## MATERIALS AND METHODS

### .1. Study Design and Patients

This was a retrospective, hospital-based study conducted at IMS & SUM Hospital in Bhubaneswar, Odisha. We reviewed the medical records and imaging data of 132 patients who underwent abdominal MRI for suspicious gallbladder lesions or unexplained wall thickening between January 2024 and December 2025.

### 2.2. Imaging Technique

Scans were performed using the hospital's standard clinical MRI systems. Alongside routine MRI sequences, DWI was captured using simple parameters (b-values of 0 and 800 s/mm$^2$) to minimize motion artifacts and keep the procedure comfortable for the patient.

### 2.3. Measuring the ADC Value

We intentionally avoided complex, multi-layered parameter models to see how the tool performs in a busy, everyday clinical setting. A radiologist manually drew a simple circle (a Region of Interest, or ROI) over the thickest or most solid-looking part of the gallbladder lesion on the ADC map. They were careful to avoid areas filled with fluid or dead tissue. The software then calculated the mean ADC value for that circle.

### 2.4. Statistical Analysis

We compared the average ADC values between the benign and malignant groups using a standard *t*-test. A Receiver Operating Characteristic (ROC) curve helped us pinpoint the exact ADC number (cut-off value) that best separates cancer from benign disease. We considered any result with a *p*-value less than 0.05 to be statistically significant.

## RESULTS

A total of 132 patients were included. As is common with gallbladder disease in India, the majority of our patients were female (65.9%). The clinical profiles of our study group are outlined in Table 1. Patients with malignant tumours were generally older and more frequently presented with alarming symptoms like jaundice and significant weight loss.

**Table 1: Baseline Patient Demographics and Symptoms (N=132)**

| Characteristic | Benign Group (n=90) | Malignant Group (n=42) | p-value |
|---|---|---|---|
| **Average Age (Years)** | 48.2 ± 12.4 | 61.5 ± 10.8 | < 0.001 |
| **Gender (Female/Male)** | 62 / 28 | 25 / 17 | 0.214 |
| **Right Upper Belly Pain** | 78 (86.6%) | 31 (73.8%) | 0.145 |
| **Jaundice** | 12 (13.3%) | 22 (52.3%) | < 0.001 |
| **Unexplained Weight Loss** | 8 (8.8%) | 28 (66.6%) | < 0.001 |

**Description:** This table outlines the basic characteristics and primary complaints of the patients, highlighting the clinical differences between those who ended up having benign versus malignant conditions.

Following surgery or biopsy, we confirmed the exact nature of every lesion under a microscope. Table 2 breaks down these final diagnoses.

Figure 1: Final Histopathological Diagnoses

Description: This figure provides a detailed breakdown of the exact diseases found under the microscope, confirming 90 benign cases and 42 malignant cases.

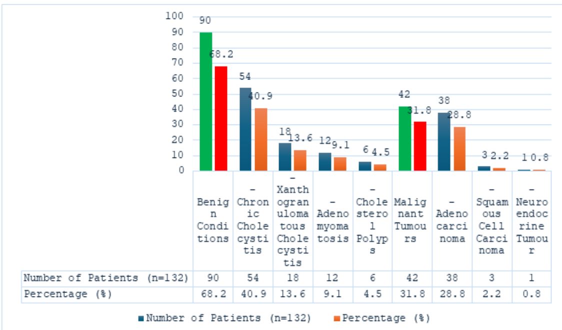


**Figure 1: Final Histopathological Diagnoses**

When we looked at the ADC values, the difference was stark and highly significant. Because malignant tumours restrict the movement of water, their ADC values were much lower than those of benign, inflammatory tissues, as shown in Table 2.

**Table 2: Comparison of Mean ADC Values**

| Lesion Type | Mean ADC Value (×10−3 mm2/s) | Range (×10−3 mm2/s) | p-value |
|---|---|---|---|
| **Benign Lesions** | $2.45 \pm 0.38$ | 1.80 – 3.10 | — |
| **Malignant Lesions** | $1.18 \pm 0.22$ | 0.85 – 1.55 | $< 0.001$ |

**Description:** This table highlights the core finding of the study—the dramatic and statistically significant drop in ADC values in cancerous lesions compared to benign ones.

Using these numbers, we found that setting an ADC cut-off of $1.42 \times 10^{-3}\ \mathrm{mm}^2/\mathrm{s}$ provided the best balance for diagnosing cancer. Any value below this number strongly suggested malignancy. [**Table 3]**

**Table 3: How Well the ADC Cut-off Works ($< 1.42 \times 10^{-3}\ \mathrm{mm}^2/\mathrm{s}$)**

| Diagnostic Metric | Value (%) | What it means in practice |
|---|---|---|
| **Sensitivity** | 90.4% | It correctly identifies 9 out of 10 true cancers. |
| **Specificity** | 88.8% | It correctly rules out cancer in nearly 9 out of 10 healthy/benign cases. |
| **Positive Predictive Value** | 79.1% | If the test says "cancer," it is correct 79% of the time. |
| **Negative Predictive Value** | 95.2% | If the test says "benign," you can be 95% sure there is no cancer. |
| **Overall Accuracy** | 89.3% | The test is correct in roughly 89% of all patients scanned. |

**Description:** This table measures the real-world reliability of using our ADC cut-off to diagnose cancer, showing excellent accuracy and negative predictive value.

While the numbers are powerful, simply looking at the shape of the thickening on the MRI also provided strong clues. Focal, irregular lumps were usually cancer, while even, smooth thickening was almost always benign. [**Table 4]**

**Table 4: Gallbladder Wall Thickening Patterns**

| Wall Thickening Shape | Benign Cases (n=90) | Malignant Cases (n=42) | p-value |
|---|---|---|---|
| **Focal / Irregular (Lumpy)** | 14 (15.5%) | 35 (83.3%) | $< 0.001$ |
| **Diffuse / Symmetric (Even)** | 76 (84.4%) | 7 (16.6%) | $< 0.001$ |

**Description:** This table pairs the quantitative ADC data with what the radiologist actually sees, proving that irregular wall shapes are highly suspicious for cancer.

## DISCUSSION

Figuring out whether a gallbladder problem is cancerous or benign before taking the patient into the operating room is one of the most critical steps in their care journey. If a surgeon goes in expecting simple inflammation but finds cancer, the surgery may be inadequate. Conversely, putting a patient with a benign condition through major cancer surgery causes unnecessary physical and emotional trauma.

Our data clearly shows that using the ADC value is an incredibly effective and simple way to solve this problem. The malignant tumours in our study had an average ADC of $1.18 \times 10^{-3}\ \mathrm{mm}^2/\mathrm{s}$, which was drastically lower than the $2.45 \times 10^{-3}\ \mathrm{mm}^2/\mathrm{s}$ seen in benign lesions. This happens because rapidly multiplying cancer cells pack tightly together, physically blocking water from moving freely.

Our findings line up perfectly with global research. For example, our optimal cut-off value of $1.42 \times 10^{-3}\ \mathrm{mm}^2/\mathrm{s}$ successfully caught over 90% of the cancers in our cohort. What makes this tool so appealing for daily hospital use is that it doesn't require complex math or highly specialized software. A radiologist simply circles the lesion on the screen, reads the number, and instantly gains high-confidence insight into the biology of the tumour.

Furthermore, this method is safe. Because DWI doesn’t require the injection of contrast dye, it is a perfect option for older patients or those with kidney problems who might not safely tolerate traditional contrast scans.

## CONCLUSION

Diffusion-Weighted MRI, specifically utilizing straightforward ADC values, is a highly accurate, non-invasive way to tell malignant gallbladder tumours apart from benign diseases. By incorporating a simple ADC cut-off into routine MRI reports, doctors can confidently plan the right surgical approach—sparing benign patients from radical operations and ensuring cancer patients get the comprehensive care they need from day one.

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