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A Descriptive Cross-Sectional Study to Assess the Importance of Diffusion Weighted Magnetic Resonance Imaging (DWI) in Pelvis Imaging in Tertiary Care Center in Rural Population of North Maharashtra

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ABSTRACT

Background: Diffusion-weighted imaging (DWI) is one of the advanced MRI methods that gives functional report about tissue cellularity and water diffusion, supporting in the characterization of pelvic lesions. This study aimed to assess the diagnostic importance of DWI in pelvic organ pathologies at a tertiary care center in rural North Maharashtra.
Materials and Methods: This descriptive cross-sectional study included 70 patients referred for pelvic MRI over a period of 12 months. All patients underwent MRI with DWI and ADC mapping. Lesions were evaluated for diffusion characteristics and correlated with histopathological findings wherever available. Statistical analysis included calculation of sensitivity, specificity, and diagnostic accuracy.
Results: The mean age was 53.63 ± 15.96 years with female predominance (84.3%). Malignant lesions constituted 60% of cases. Restricted diffusion was observed in 68.57% of lesions and was strongly associated with malignancy ($p < 0.0001$). Mean ADC values were lowest in solid lesions ($0.82 \pm 0.15 \times 10^{-3}$ mm²/s) and highest in cystic lesions ($1.95 \pm 0.45 \times 10^{-3}$ mm²/s) ($p < 0.001$). DWI showed 100% sensitivity, 78.6% specificity, and overall diagnostic accuracy of 91.4%.
Conclusion: DWI is a highly sensitive and reliable imaging modality for detecting and characterizing pelvic lesions. It significantly improves diagnostic confidence and helps differentiate malignant from benign conditions, making it a valuable adjunct to conventional MRI.
Keywords: Diffusion-weighted imaging, Pelvic MRI, Apparent diffusion coefficient, Pelvic lesions, Diagnostic accuracy

INTRODUCTION

Pelvic disorders account for a significant medical disease seen in practice and are one of the major reasons for morbidity and mortality all around the world. The pelvis is a complex area within the body consisting of many organ systems such as parts of the gastrointestinal, urinary, and reproductive systems, lymphatic channels, and blood vessels. Due to the complex anatomy involved, there are a number of different types of diseases seen in the pelvis, ranging

from inflammation and infections to tumors and trauma.[1]

Some of the common problems that occur in the pelvis are gynecological disorders including ovarian cysts and tumors, uterine fibroid, endometrial cancer, and pelvic inflammatory disease. On the other hand, some problems related to the male organ include prostatic enlargement and prostatic carcinoma.[1,2] Additionally, problems that affect other nearby organs include rectal involvement, urinary bladder problems, lymph nodes disease, and peritonitis. In developing nations such as India, pelvic problems that occur often include pelvic tuberculosis, infections, and advanced stage carcinoma because patients delay treatment and there is lack of availability of treatment centers. The burden of pelvis disease in India is increased by factors like a high population, increased life expectancy rate, changes in lifestyles, and non-communicable diseases.[3]

The symptoms associated with pelvic diseases are not specific. Pain can occur in the abdomen or pelvis and can be acute or chronic. The pain can be localized or diffuse, and hence, there is difficulty in diagnosing such diseases. Consequently, imaging plays a vital role in the diagnosis and treatment of these diseases.[3-5] There have been many advances in imaging methods, including ultrasonography, CT scan, and MRI. Out of these, MRI is considered a more advanced technique in imaging the pelvis because of its excellent soft tissue contrast and multi-planar imaging capacity.[6,7]

There has been increased emphasis on diffusion-weighted imaging (DWI), which is an enhanced version of MRI that has come into focus in recent years owing to its capacity to offer information regarding functional characteristics at the cellular level.[8] Diffusion-weighted imaging relies on Brownian Motion of water molecules in the tissues under consideration, and it is highly sensitive to cellular changes in addition to changes in cellular membrane integrity. It is thus effective in offering an early diagnosis of conditions long before they can be recognized by standard imaging methods.[8,9]

DWI is important in distinguishing between benign and malignant tumors, considering the latter tends to have lower diffusion because of higher cell density. It is also useful for tumor grading and management and helps monitor treatment effectiveness. Another benefit of using DWI is that it can be done without using contrast agents, which reduces the risks involved in administering contrast, particularly among individuals with kidney dysfunction.[8,9]

In the imaging of the pelvis, DWI has been found to be quite useful in diagnosing various disorders associated with the prostate gland, uterus, cervix, ovaries, and other related areas. DWI provides an excellent supplement to traditional MR imaging modalities owing to the added contrast and improved lesion identification that it offers.[10] With improvements being made in imaging and post-processing technologies, DWI will find increasing applications.

It thus becomes imperative to study the significance of the use of Diffusion-Weighted Magnetic Resonance Imaging in the context of diseases of the pelvis in order to fully comprehend its diagnostic implications and to further improve its implementation in clinical practice. This research focuses on assessing the importance of the use of DWI in identifying and characterizing pelvic organ disease at a tertiary care facility located in rural North Maharashtra.

Aim & Objectives

The present study aims to assess the diagnostic importance of Diffusion-Weighted Magnetic Resonance Imaging (DWI) in evaluating pelvic organ–related pathologies at a tertiary care center in rural North Maharashtra. The primary objectives are to determine the role of DWI in the detection and characterization of various pelvic diseases and to estimate the

proportion of different types of pathologies identified on MRI with diffusion-weighted imaging among patients presenting with pelvic conditions & to classify various radiological findings in patients with pelvic organs related pathologies using Diffusion Weighted Magnetic Resonance Imaging.

MATERIAL & METHODS

The present study is a descriptive cross-sectional observational study performed in a tertiary level healthcare facility in rural North Maharashtra for a period of 12 months. The participants of the study were selected from those patients who were referred to the Department of Radio-diagnosis for MRI scan of pelvis. Sample size estimation was done by assuming that prevalence rate will be 70%, acceptable error will be 7% and applying statistical formula. Minimum sample size required was estimated to be 54, but total 70 subjects participated in the study.

All patients with suspicion of or confirmed pelvic abnormalities referred for an MRI scan were considered in the study without restrictions related to age or sex were included in this study. Patients with any contraindication for MRI, like claustrophobia or metal/implants in their body, were excluded from the study.

Written Informed Consent was taken, and the history and demographic data were documented on a pre-prepared case sheet.

The MRI studies were done with a 1.5 Tesla MR Scanner (BRIVO 355 GE Healthcare). Images were taken in the axial, coronal, and sagittal plane for proper localization of the pathology. The use of Diffusion Weighted Imaging (DWI) and Apparent Diffusion Coefficient (ADC) sequences was used in all the patients. The MRI images were stored using the DICOM file format in an external data storage device for further analysis of the results from DWI, which included diffusion restriction patterns and pathology features.

Data was collected and analyzed using descriptive and inferential statistics. Frequency distributions were used in calculating categorical variables.

RESULTS

The sample size for the study consisted of 70 individuals. In the demographic data the mean age of the patients in the study was found to be 53.63±15.96 years, meaning that the majority of the patients were between middle and older ages, with a fairly wide range of ages. A higher prevalence of females was noted in the study, where out of the 70 subjects, 59 were females (84.3%), while only 11 were males (15.7%). **(Refer Table 1)**

Table 1 – Demographic data

Variable	Value
Total participants	70
Mean age (years)	53.63 ± 15.96
Gender (n, %)	
Female	59 (84.3%)
Male	11 (15.7%)

A variety of symptoms were seen among the study subjects, with vaginal bleeding being the most common complaint followed by heavy menses and vaginal discharge. Some other common problems seen were abdominal pain or mass, urinary symptoms, including retention of urine and hematuria, and bowel problems, including rectal bleeding and constipation.

Regarding the distribution of the pathologies in relation to their anatomical location, it can be noted that the cervix was the most affected region. This region had 18 pathologies (25.71%). Prostate, uterus, and endometrium pathologies came second with 10 pathologies each representing 14.29% of the total number of samples, while the rectum had 7 samples (10.00%). In addition, vaginal samples had 5 pathologies (7.14%), whereas ovarian/adnexal and bladder samples had 4 pathologies and 2 pathologies, respectively. Other pelvic samples were represented by 7 pathologies (10.00%). **(Refer Fig. 1)**

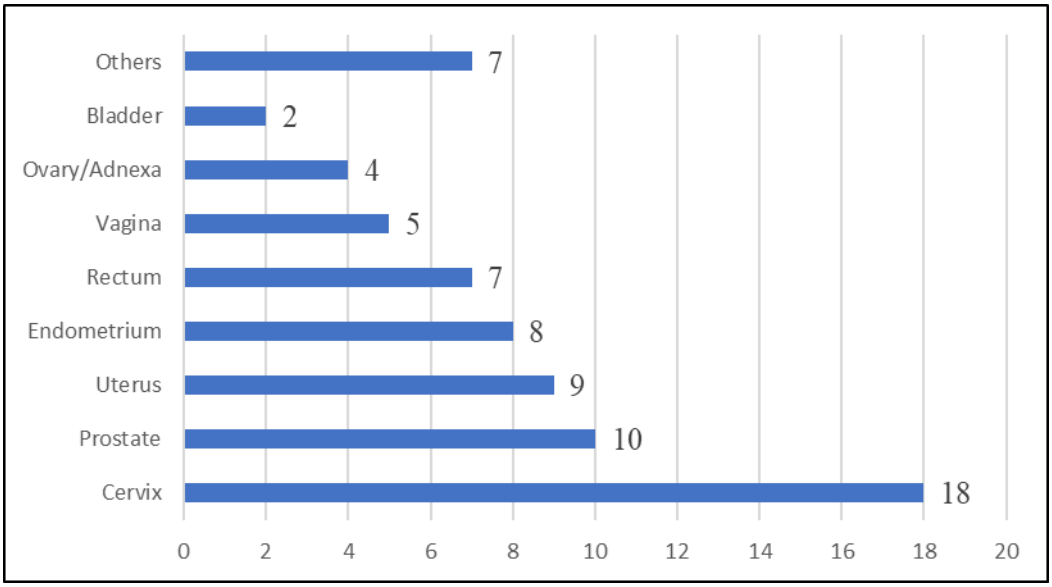

Figure 1 - Pathology Distribution in study participants

In the present study it is observed that majority of lesions demonstrated restricted diffusion on DWI (68.57%), while 31.43 % showed no restriction. Most lesions had low ADC values (<1.0 $\times 10^{-3}$ mm²/s) (68.6%), indicating higher cellularity. In terms of morphology, solid lesions were predominant (65.7%), followed by solid-cystic (21.4%) and cystic lesions (12.9%). Additionally, the vast majority of cases presented as single lesions (95.7%), with only a small proportion being multiple (4.3%). **(Refer Table 2)**

Table 2 Distribution of DWI Findings

Parameter	Category	Frequency (n)	Percentage (%)
DWI Interpretation	Restricted diffusion	48	68.57 %
	No restriction	22	31.43 %
ADC Value ($\times 10^{-3}$ mm²/s)	< 1.0	48	68.60 %
	≥ 1.0	22	31.40 %
Lesion Characteristics	Solid	46	65.70 %
	Solid-cystic	15	21.40 %
	Cystic	9	12.90 %
Number of Lesions	Single	67	95.70 %
	Multiple	3	4.30 %

In the study were malignant, accounting for 42 cases (60.0%). Benign lesions comprised 22 cases (31.4%), while a smaller proportion of cases (6 cases, 8.6%) were categorized as others, including inflammatory, infective, or miscellaneous conditions. **(Refer Fig.2)**

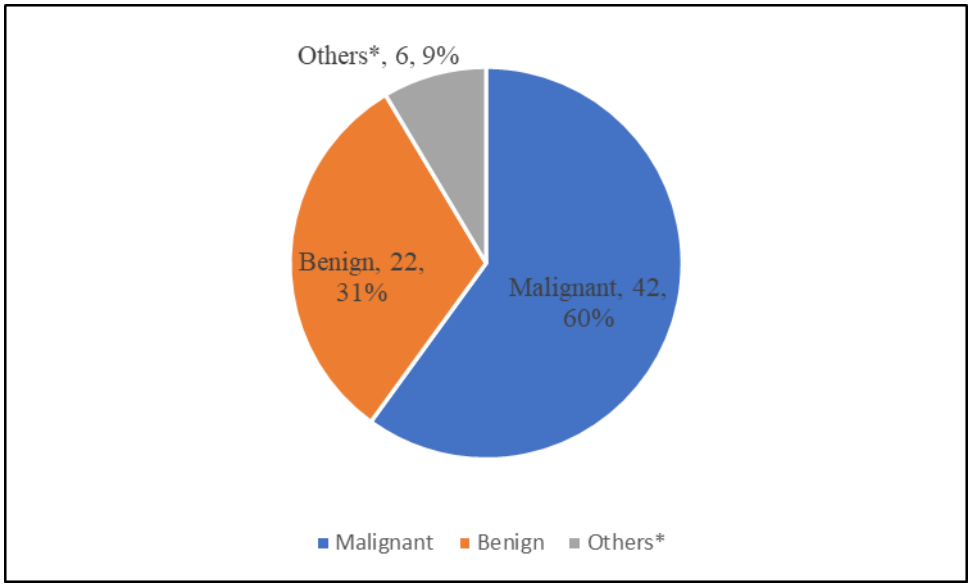

Figure 2 - Distribution of Lesions Based on Nature in study participants

The present study demonstrates a strong association between the nature of the lesion and diffusion characteristics on DWI. All malignant lesions (42 cases, 100%) showed restricted diffusion, whereas the majority of benign lesions (19 out of 22, 86.4%) did not show diffusion restriction, with only a small proportion (3 cases, 13.6%) exhibiting restriction. Among the "other" category, an equal distribution of restricted and non-restricted lesions was observed (3 cases each). This association was found to be highly statistically significant ($p < 0.0001$), indicating that diffusion restriction on DWI is strongly suggestive of malignancy in pelvic lesions. (Refer Table 3)

Table 3 Correlation Between DWI Restriction and Nature of Lesion

Nature of Lesion	Restricted (n)	Not Restricted (n)	Total	P value
Malignant	42	0	42	< 0.0001
Benign	3	19	22	
Others	3	3	6	
Total	48	22	70	

In the correlation between imaging diagnosis and histopathological outcomes in the study population. Among the 70 cases, malignant lesions constituted the majority (42 cases), with histopathology confirming diagnoses such as squamous cell carcinoma, adenocarcinoma, urothelial carcinoma, endometrial carcinoma, and prostatic adenocarcinoma. Benign lesions accounted for 22 cases and included conditions like fibroids, adenomyosis, serous cystadenoma, mature cystic teratoma, endometriotic cysts, benign prostatic hyperplasia, and polyps. A smaller proportion of cases (6 cases) were categorized as others, comprising non-neoplastic conditions such as hematoma, hematocolpos, imperforate hymen, abscess, and inflammatory lesions.

In ADC values across different lesion types. Solid lesions demonstrated the lowest mean ADC value ($0.82 \pm 0.15 \times 10^{-3}$ mm²/s), indicating restricted diffusion, which is commonly associated with higher cellularity as seen in malignant tumors. Solid-cystic lesions showed intermediate ADC values ($1.35 \pm 0.40 \times 10^{-3}$ mm²/s), reflecting a mixed composition of solid and fluid components. In contrast, cystic lesions exhibited the highest mean ADC values ($1.95 \pm 0.45 \times 10^{-3}$ mm²/s), consistent with free diffusion of water content. The difference in ADC values among the lesion types was found to be highly statistically

significant ($p < 0.001$), highlighting the usefulness of ADC in differentiating between various pelvic lesions. (Refer Table 4)

Table 4 Comparison of Mean ADC Values Across Lesion Types

Lesion Type	Mean ADC Value ($\times 10^{-3}$ mm²/s)	Standard Deviation (SD)	p-value
Solid lesions	0.82	± 0.15	**< 0.001**
Solid-cystic lesions	1.35	± 0.40	
Cystic lesions	1.95	± 0.45	

In the present study, there were 42 true positive cases (TP = 42), 6 false positives (FP = 6), 22 true negatives (TN = 22), and no false negatives (FN = 0). The sensitivity was 100%, meaning that all malignant lesions were detected by this technique, with no occurrence of false-negative results. On the other hand, specificity was determined at 78.6%, implying that certain benign or non-malignant lesions exhibited restricted diffusion resulting in false positives. Positive predictive value was estimated at 87.5%, which means that there is a relatively high likelihood that lesions with restricted diffusion were indeed malignant. Negative predictive value stood at 100%, signifying that there was practically no possibility that lesions without restricted diffusion would be malignant. In general, the diagnostic accuracy was found to be 91.4%. (Refer Table 5)

Table 5 Diagnostic Accuracy of DWI in Differentiating Malignant and Non-Malignant Lesions

Parameter	Value
Sensitivity	100%
Specificity	78.60%
Positive Predictive Value (PPV)	87.50%
Negative Predictive Value (NPV)	100%
Diagnostic Accuracy	91.40%

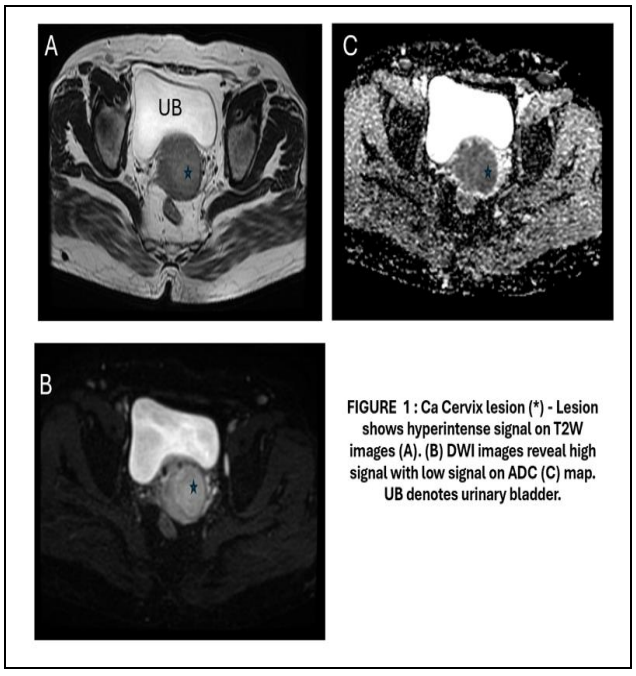

FIGURE 1 : Ca Cervix lesion (*) - Lesion shows hyperintense signal on T2W images (A). (B) DWI images reveal high signal with low signal on ADC (C) map. UB denotes urinary bladder.

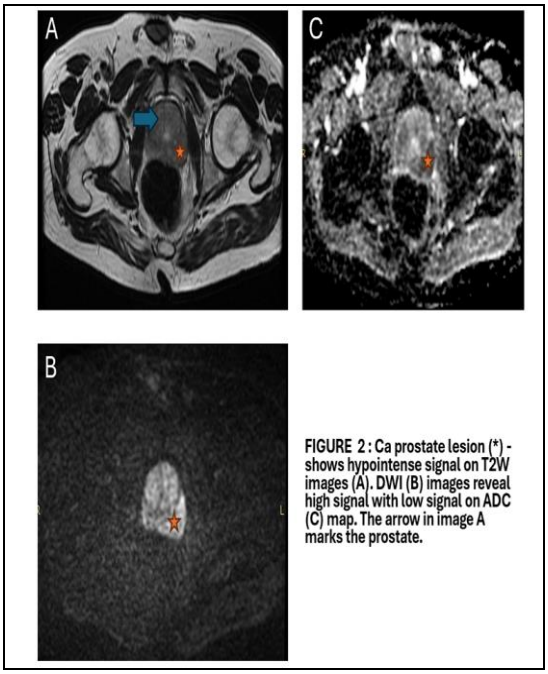

FIGURE 2 : Ca prostate lesion (*) - shows hypointense signal on T2W images (A). DWI (B) images reveal high signal with low signal on ADC (C) map. The arrow in image A marks the prostate.

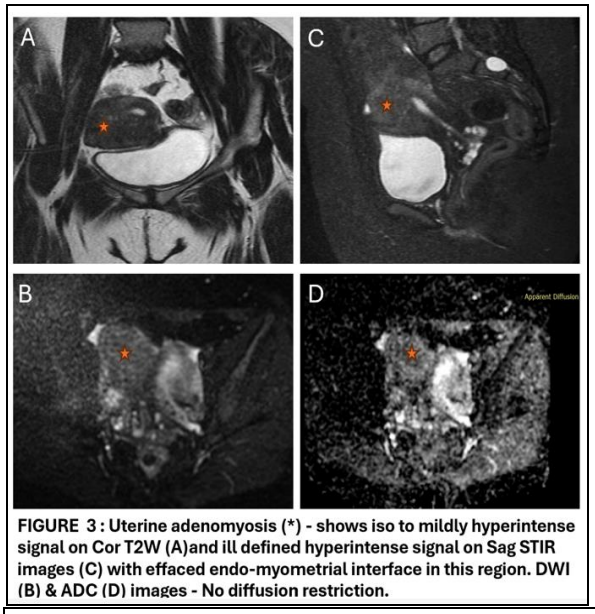

FIGURE 3 : Uterine adenomyosis (*) - shows iso to mildly hyperintense signal on Cor T2W (A)and ill defined hyperintense signal on Sag STIR images (C) with effaced endo-myometrial interface in this region. DWI (B) & ADC (D) images - No diffusion restriction.

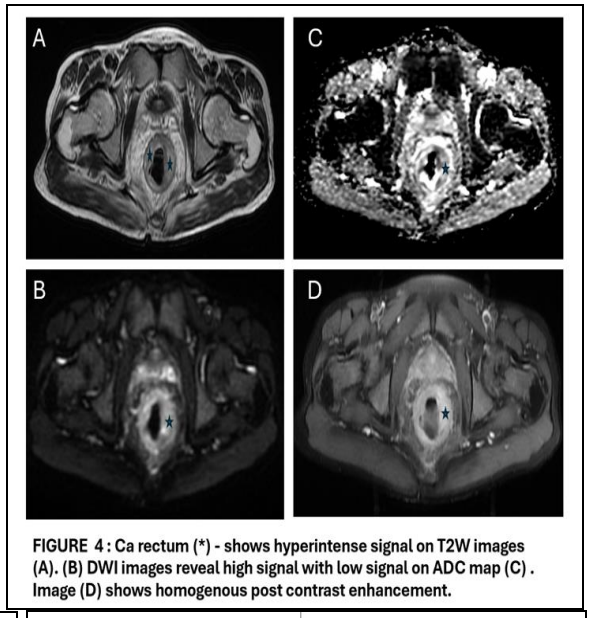

FIGURE 4 : Ca rectum (*) - shows hyperintense signal on T2W images (A). (B) DWI images reveal high signal with low signal on ADC map (C) . Image (D) shows homogenous post contrast enhancement.

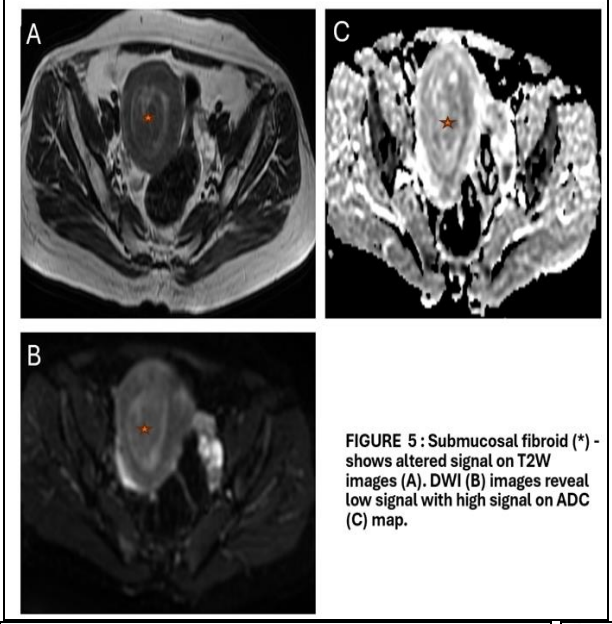

FIGURE 5 : Submucosal fibroid (*) - shows altered signal on T2W images (A). DWI (B) images reveal low signal with high signal on ADC (C) map.

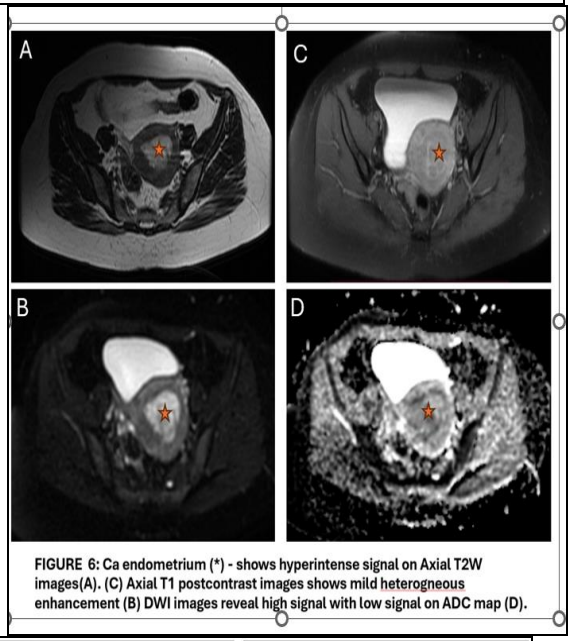

FIGURE 6: Ca endometrium (*) - shows hyperintense signal on Axial T2W images(A). (C) Axial T1 postcontrast images shows mild heterogneous enhancement (B) DWI images reveal high signal with low signal on ADC map (D).

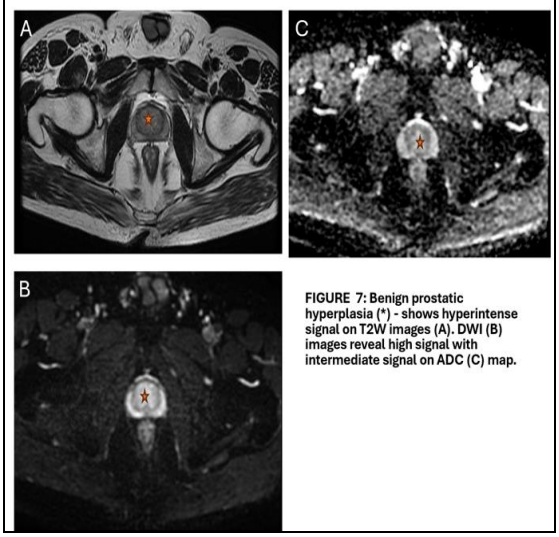

FIGURE 7: Benign prostatic hyperplasia (*) - shows hyperintense signal on T2W images (A). DWI (B) images reveal high signal with intermediate signal on ADC (C) map.

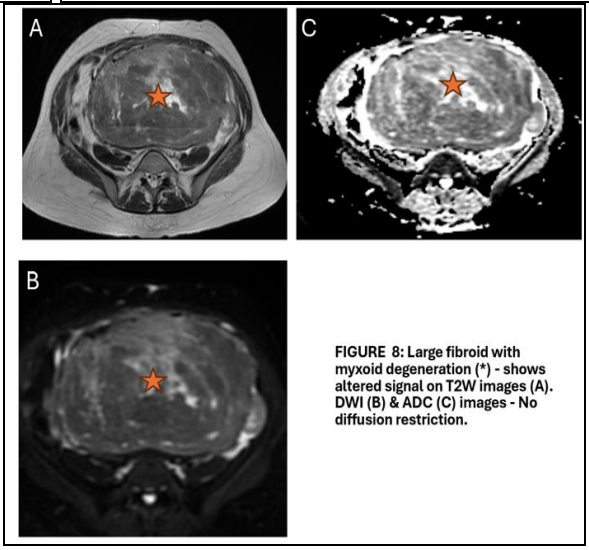

FIGURE 8: Large fibroid with myxoid degeneration (*) - shows altered signal on T2W images (A). DWI (B) & ADC (C) images - No diffusion restriction.

DISCUSSION

Pelvic pathologies are quite broad in their scope, spanning various organ systems and commonly presenting with symptoms which are not very specific. Imaging is extremely important in their assessment, with MRI being considered the best option owing to its excellent soft tissue differentiation capabilities and the ability to image the organs in several planes. In recent times, DWI has emerged as an extremely significant technique in the field of MRI because of its functional nature and dependence on the diffusion of water in different structures. The ability to use it in helping differentiate lesions with no administration of contrast makes it an invaluable addition to the imaging of pelvis.

In the present study, the total number of subjects used was 70 with the average age of 53.63 ± 15.96 years, having a significant female prevalence rate of 84.3%. In addition, the most common organ affected was the cervix at 25.71%, and then came the prostate, uterus, and endometrium, implying that the main cause of diseases affecting the pelvis is mainly due to gynecological causes. The study done by Nguyen TL et al., used subjects with similar average ages, which was 55.6 ± 19.7 years.[5] The main focus of their study was abscesses, cysts, and tumors of different origins.

Maccioni F et al. and Oommen J et al. has mentioned in their study that magnetic resonance imaging is gradually becoming the technique of choice for the assessment of diseases in the pelvis involving the gastrointestinal tract and gynecology, such as abscesses and tumors. Nevertheless, it can sometimes be difficult to characterize complicated pelvic masses. While contrast enhancement in MR imaging has been conventionally used to facilitate mass characterization, there could be no added benefit in some situations.[11,12] Diffusion-weighted imaging (DWI) has emerged as a valuable adjunct to conventional MRI sequences, enhancing diagnostic accuracy by providing functional information, especially in differentiating inflammatory, benign, and malignant pelvic lesions.[13,14]

The majority of lesions in the study demonstrated restricted diffusion on DWI (68.57%), with a corresponding proportion showing low ADC values (<1.0 $\times 10^{-3}$ mm²/s), suggesting high cellularity. Most lesions were solid in nature (65.7%) and predominantly single (95.7%). In terms of pathology, malignant lesions constituted the largest group (60%), followed by benign (31.4%) and other non-neoplastic conditions (8.6%), indicating a higher prevalence of malignancy among the studied pelvic lesions.

In the present study, a strong association was observed between diffusion characteristics and the nature of lesions. Diffusion restriction was evident in all malignant lesions (100%), while most of the benign lesions were not restricted in terms of diffusion, and the relationship was very high statistically ($p < 0.0001$). Moreover, a very high difference was also seen in the mean ADC values of lesions, with solid lesions having lower ADC values (0.82 ± 0.15 $\times 10^{-3}$ mm²/s), followed by solid-cystic lesions, which had moderate ADC values (1.35 ± 0.40 $\times 10^{-3}$ mm²/s), and cystic lesions, which had higher ADC values (1.95 ± 0.45 $\times 10^{-3}$ mm²/s). This was also statistically significant ($p < 0.001$). The results obtained in this study are similar to those obtained by other researchers in the field, such as by Nguyen et al. and Katano K et al., who showed a strong relationship between diffusion restrictions and malignancy and that the mean ADC values are low in solid/malignant lesions as compared to cystic/benign lesions.[5,15]

According to the present study, diffusion-weighted imaging (DWI) was characterized by high sensitivity of 100% and negative predictive value of 100%, implying that all malignancies were diagnosed without errors. Specificity was at 78.6%, while overall diagnostic accuracy was at 91.4%, thus indicating that some benign and non-malignant lesions also had diffusion

restriction causing false-positive results. Comparing the current research with Nguyen et al.'s study, was at 92%, while specificity was at 100%.[5] Similar in study by Goel R. et al.'s (2021) research where high sensitivity of 96.4% and specificity of 100% were reported.[16], The findings across studies consistently highlight the strong diagnostic value of DWI in differentiating malignant from benign pelvic lesions.

CONCLUSION

The present study determines that "diffusion-weighted magnetic resonance imaging" (DWI) is a highly valuable, non-invasive tool in the assessment of pelvic organ pathologies. DWI showed exceptional sensitivity and high diagnostic accuracy in detection and describing lesions, with a strong correlation among diffusion restriction and malignancy. Lower ADC values were constantly allied with solid and malignant lesions, while higher ADC values were monitored in cystic and benign conditions, aiding in effective lesion differentiation. The outcomes also feature that most lesions were solid and single in nature, with a predominance of malignant cases in the study population. Overall, DWI significantly increases the diagnostic capability of conventional MRI and can be reliably used for early detection, characterization, and clinical decision-making in pelvic diseases, particularly in resource-limited rural settings.

The present study is limited by its relatively small sample size and single-center design, which may affect the generalizability of the findings.

Declaration by Authors

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