RESEARCH ARTICLE

Diagnostic accuracy of MRI in diagnosing morbidly adherent placenta, taking intraoperative findings as the gold standard

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Abstract

Objective: To evaluate the diagnostic accuracy of magnetic resonance imaging in detecting morbidly adherent placenta in pregnant women with inconclusive ultrasound findings, using intraoperative findings as the gold standard.

Method: The cross-sectional study was conducted at the Radiology Department of the Armed Forces Institute of Radiology, Rawalpindi, Pakistan, from January to June 2023, and comprised pregnant females aged 18-40 years having uncertain ultrasound findings and suspicion of morbidly adherent placenta. Magnetic resonance imaging scan of the pelvis was performed with a 1.5 Tesla scanning system on all patients, and findings were noted to compare with operative findings. Sensitivity, specificity, positive and negative predictive values and diagnostic accuracy were calculated for magnetic resonance imaging. Data was analysed using SPSS 23.

Results: Among the 14 subjects with a mean gestational age of 32.93±3.36 weeks, both ultrasound and magnetic resonance imaging scan indicated placenta previa in 11(78.6%). Dark intraplacental T2 band was consistently observed in all 14(100%) patients, and complications involving placental separation were noted in 6(42.9%) cases. Magnetic resonance imaging had an accuracy of 85.71% in diagnosing morbidly adherent placenta with 90.9% sensitivity and 66.7% specificity.

Conclusion: Magnetic resonance imaging was found to be a valuable diagnostic tool for detecting morbidly adherent placenta, especially in cases with inconclusive ultrasound results.

Key Words: Magnetic resonance imaging, Morbidly adherent placenta, Placenta accreta, Placenta previa.

(JPMA 75: 1527; 2025) **DOI: https://doi.org/10.47391/JPMA.20433**

Introduction

Placental implantation disorders can be categorised into two main types: abnormal localisation known as placenta previa (PP), and abnormal attachment referred to as placenta accreta spectrum (PA) or morbidly adherent placenta (MAP).[1,2] PP is seen in approximately 4 out of every 1,000 pregnancies,[3] whereas PA is a rare disorder, occurring in about 4.8 out of every 10,000 pregnancies.[4] The placenta is ideally situated at a distance of at least 2cm from the internal cervical opening or orifice of the cervix (OS) in most cases, while in PP, the placenta is wholly or partially implanted in the lower segment of the uterus. It is responsible for approximately one-third of all cases of antepartum bleeding.[5] PA is a serious and potentially life-threatening obstetric condition characterised by the absence of the decidua basalis, which normally separates the anchoring placental villi from the myometrium. Depending on the extent of myometrial invasion, PA spectrum disorder is categorised into three subtypes: placenta accreta, increta and percreta.[6] Failure to accurately diagnose PA can lead to severe complications, including life-threatening antepartum haemorrhage,[7] emergency hysterectomy [8] and, in some cases, maternal mortality.[9]Although ultrasonography (USG) is the primary tool for diagnosing MAP, its accuracy can be limited by operator dependence and difficulty in visualising certain regions, like the posterior placenta.[10] When USG results are inconclusive, magnetic resonance imaging (MRI) serves as a valuable adjunct due to its superior soft-tissue resolution, and the ability to assess the depth of invasion.[11] However, evidence on MRI's diagnostic accuracy varies widely,[12] which highlights the need for standardised MRI diagnostic criteria and enhanced specificity.

Notably, most studies have examined MRI features in broad populations,[6,8,11] with limited focus on its role in cases of inconclusive USG results. Additionally, research from low-resource settings, where advanced imaging and multidisciplinary care are often unavailable, remains scarce.

The current study was planned to fill the gap in literature by evaluating MRI's diagnostic accuracy for MAP in cases

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Submission complete: 01-09-2024 **First Revision received:** 06-12-2024

Acceptance: 09-07-2025 **Last Revision received:** 08-07-2025

with uncertain USG findings, using intraoperative outcomes as the reference standard.

Subjects and Methods

The prospective, cross-sectional study was conducted from January to June 2023 at the Armed Forces Institute of Radiology, Rawalpindi, Pakistan. After approval from the institutional ethics review board, the sample size was calculated using the formula $n = Z^2 \times P(1-P)/d^2$ with the help of the World Health Organisation (WHO) sample size calculator,[13] with expected MAP prevalence (P) 1%,[14] confidence level 95%, margin of error (d) 5% and Z 1.96. The sample was raised using purposive sampling technique. Those included were pregnant women aged 18-40 years having gestational age 24-40 weeks with uncertain USG results for MAP, like posterior placenta, poorly seen anterior placenta, Caesarean section (CS) scar and advanced maternal age with a low-lying anterior placenta. Patients were referred from antenatal clinics or emergency department (ED) with suspected abnormal placentation, often presenting with painless bleeding, low-lying placenta, or prior CS with inconclusive USG. All the patients were managed as inpatients before MRI and delivery. Patients who were ineligible for MRI due to contraindications, such as an MRI-incompatible cardiac pacemaker, prosthetic devices or claustrophobia, were excluded. Patients with significant motion artefacts on MRI were also excluded, as image distortion could impair accurate assessment of placental invasion and compromise diagnostic validity.

After taking written informed consent from the subjects, baseline data was collected. A 1.5 Tesla MRI scanning machine (Siemens 3T- Skyra, Germany) was used to image the pelvis. The MRI images were evaluated by a senior radiologist having 5 years of experience. The MRI findings were noted. Subsequently, all the patients underwent CS, and the surgical findings were documented. The critical surgical observations encompassed the ease of placenta separation, any complications related to bleeding, or the need for a hysterectomy during placental separation, and the extent of placental invasion into uterine tissue or nearby organs. MAP diagnosis was based on intraoperative findings, such as difficult separation and excessive bleeding, not necessarily gross invasion. The MRI findings were compared with operative findings to assess the diagnostic accuracy, encompassing sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of MRI.

Data was analysed using SPSS 23. Data was expressed as frequencies and percentages, or as mean ± standard deviation (SD). A 2×2 contingency table was employed to evaluate MRI's sensitivity, specificity, PPV, NPV and diagnostic accuracy of MRI in detecting MAP.

Results

Of the 40 patients screened, 14(35%) comprised the final sample (Figure 1). The mean gestational age was 32.93±3.36 weeks, mean parity was 2.0±1.24 and mean gravida was 3.21±1.25. Most of the patients had multiple pregnancies, with 7(50%) having 4 pregnancies, while 2(14.3%) were nullipara and 3(21.4%) were primipara (Figure 2).

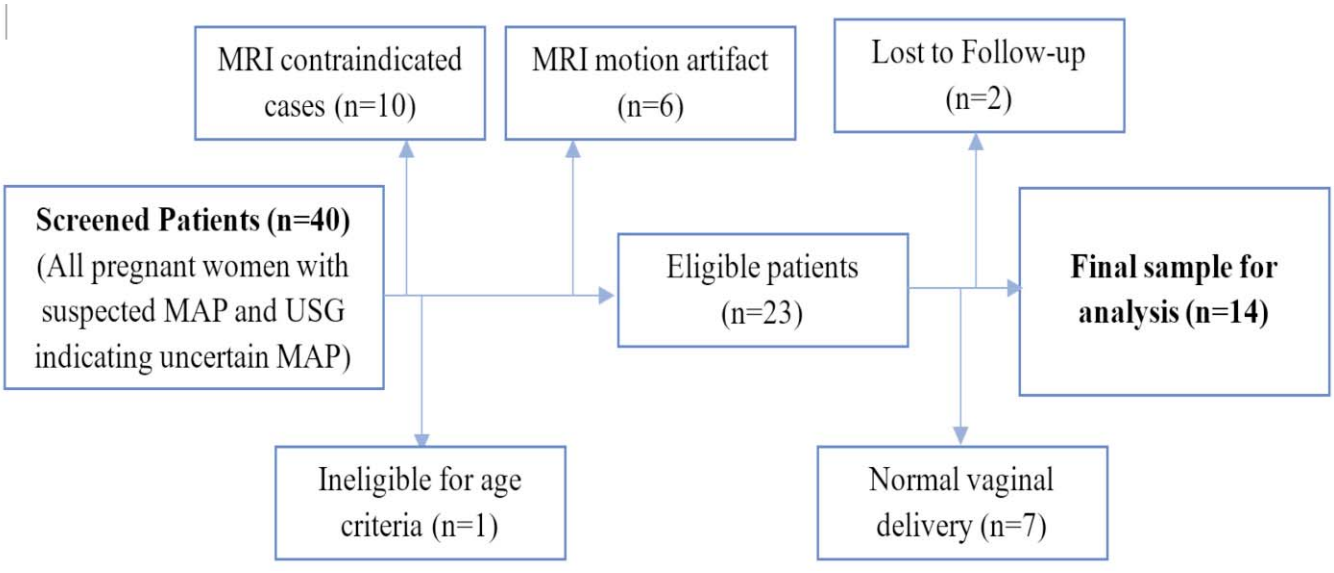

Figure-1: The patient selection process.

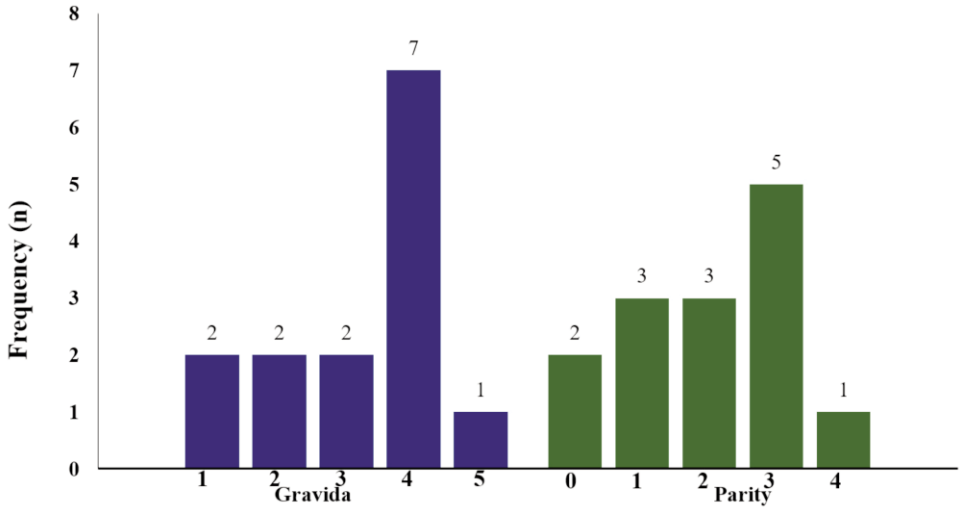

Figure-2: The parity and gravida status of the participants.

Table-1: Baseline and clinical characteristics (n=14).

Variables	Frequency n Total=14	Percentages %
Gestational Age in weeks (Mean±SD)	32.93	3.36
Mean Gravida (Mean±SD)	3.21	1.25
Mean Parity (Mean±SD)	2.00	1.24
Risk factors		
Previous Placenta Previa	1	7.1
Previous C-section	11	78.6
Other Uterine Surgery	0	0.0
Ultrasound Findings		
Placenta Previa	11	78.6
Placenta Lacunae	4	28.6
Loss of retroplacental clear space	10	71.4
Reduced Myometrial thickness	6	42.9
Gap in the retroplacental blood flow	2	14.3
MRI Findings		
Placenta Previa	11	78.6
Heterogeneous signal intensity within the placenta	12	85.7
Dark Intraplacental T2 band	14	100.0
Uterine Bulging	5	35.7
Focal Interruption in Myometrial Wall	10	71.4
Tenting of the bladder	2	14.3
Direct invasion of pelvic structures by placental tissue	1	7.1
Operative Findings		
Easily separated placenta	8	57.1
Difficulty in separation followed by bleeding and Hysterectomy	6	42.9
Placental invasion by uterine serosa/adjacent organ	0	0.0

C: Caesarean, SD: Standard deviation.

Of the total, 11(78.6%) patients had a CS history. USG findings showed 11(78.6%) patients with PP and 10(71.4%) with loss of retroplacental clear space. MRI findings also revealed 11(78.6%) cases with PP. Dark intraplacental T2 band was noted in all 14(100%) patients. Separation of the placenta from the uterus was complicated in 6(42.9%) patients with heavy bleeding (Table 1), and, consequently, their uterus was removed.

MRI findings were true positive (TP) for 10(71.4%) cases, false positive (FP) for 1(7.1%) case, true negative (TN) for 2(14.3%) cases and false negative (FN) for 1(7.1%) case. The accuracy of the MRI in diagnosing MAP

Table-2: Diagnostic accuracy of magnetic resonance imaging (MRI) scan in the evaluation of morbidly adherent placenta (MAP), taking surgical findings as the gold standard

MRI Findings	Operative Findings		Total
	MAP (Positive)	MAP (Negative)	
MAP (Positive)	TP10 (71.42%)	FP 1 (7.14%)	TP+FP 11(78.56%)
MAP (Negative)	FN 1(7.14%)	TN 2(14.28%)	FN+TN 3(21.42%)
Total	TP+FN 11(78.56%)	FP+TN 3(21.42%)	14 (100%)

TP: True positive, FP: False positive, FN: False negative, TN: True negative.
Accuracy: (TP + TN)/ (TP+TN+FP+FN) x 100 = 85.71% (95% confidence interval [CI]: 57.2-98.2%)
Sensitivity: TP / (TP + FN) x 100 = 90.90% (95% CI: 58.7-99.8%)
Specificity: TN / (TN+FP) x 100 = 66.7% (95% CI: 9.4-99.2%)
Positive predictive value (PPV): TP / (TP + FP) x 100 = 90.90% (95% CI: 58.7-99.8%)
Negative predictive value (NPV): TN / (TN + FN) x 100 = 66.7% (95% CI: 9.4%–99.2%)

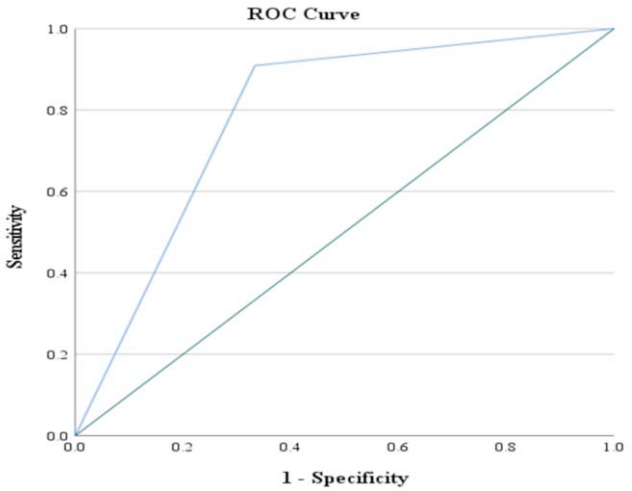

Figure-3: Receiver operating characteristic (ROC) curve for magnetic resonance imagng (MRI) in detecting morbidly adherent placenta (MAP)
*Area under the curve (AUC) 0.788.

was 85.71% (95% confidence interval [CI]: 57.2-98.2%. MRI was 90.9% (95% CI: 58.7-99.8%) sensitive and 66.7% (95% CI: 9.4-99.2%) specific. The PPV was 90.9% (95% CI: 58.7-99.8%), and the NPV was 66.7% (95% CI: 9.4-99.2%) (Table 2). MRI demonstrated good diagnostic accuracy in identifying MAP when compared with intraoperative findings, having area under the curve (AUC) of 0.788 (Figure 3).

Discussion

The placenta plays a vital role during pregnancy, facilitating the foetus's nutritive, respiratory and excretory functions. However, MAP significantly elevates maternal and foetal morbidity and mortality risks. This condition is often associated with severe postpartum haemorrhage, which can lead to multi-organ failure.[7,9] Moreover, MAP accounts for approximately one-third to one-half of all emergency hysterectomies performed.[15] Timely diagnosis and a collaborative, multidisciplinary approach significantly increase the chances of reducing complications for both the maternal and the foetal aspects in MAP cases.[16] According to a meta-analysis, using established diagnostic criteria, third-trimester MRI demonstrated a sensitivity of 86.7% and a specificity of 86.0%. Among the various criteria, myometrial thinning exhibited the highest sensitivity (82.8%), but the lowest specificity 59.3%, while bladder wall interruption showed the highest specificity 98.5%, but the lowest sensitivity 38.4%.[17]

Additionally, in the realm of antenatal care, USG plays a pivotal role due to its accessibility, non-invasive nature, and its ability to provide sensitive and specific results. It stands as the primary choice for initial imaging when diagnosing MAP.[10] Nonetheless, USG precision is mainly dependent on the skill and experience of the person operating the equipment. Furthermore, it can be challenging to thoroughly assess the entire placenta, particularly its posterior and distal portions. In such complex cases, MRI serves as a valuable problem-solving tool. MRI is adept at identifying specific diagnostic signs that might remain elusive through USG.[18]

The current results demonstrate a comprehensive diagnostic precision of 85.7% for MRI in detecting MAP, with sensitivity and specificity rates of 90.9% and 66.7%, respectively. These outcomes are in line with those reported in comparable studies.[17,19,20] In a study, only eight confirmed cases of MAP on MRI were reported during five years, and it found MRI to have a sensitivity and specificity of 100% and 21.1%, respectively, in diagnosing MAP.[21]

Additionally, literature indicates a sensitivity range of 57.7-90.8% and specificity of 50.4-98.0% for detecting heterogeneous placental signals, often linked to intra-parenchymal haemorrhage and lacunae.[22] However, it should be noted that such signal heterogeneity may be observed in both regular placentas and those afflicted by morbid adherence, and, hence, it is essential to consider marked heterogeneity as an indicator of invasion.[23]

Othman et al. reported MRI sensitivity and specificity rates of 100% and 85.7%, respectively, in diagnosing MAP.[24] Meanwhile, a local study found MRI to have a sensitivity, specificity and overall accuracy of 71.4%, 72.2% and 72%, respectively, in diagnosing MAP.[25] Similarly, Einerson et al. reported a sensitivity of 77.3% and a specificity of 75.0%.[19] Compared to the current findings, the relatively high sensitivity underscores the reliability of MRI in identifying MAP cases, particularly in high-risk populations. However, the moderate specificity highlights potential challenges in distinguishing MAP from other placental abnormalities, which could lead to over-diagnosis and unnecessary interventions. Variations in sensitivity and specificity across studies may stem from differences in MRI protocols, operator experience, timing of imaging during gestation, and patient selection criteria, including placental location and prior uterine surgeries. Clinically, these findings emphasise the need for a multidisciplinary approach when interpreting MRI results, combining radiological and clinical assessments to optimise patient outcomes. Furthermore, the current results highlight the importance of refining MRI criteria to improve specificity, particularly in resource-limited settings where overuse of surgical interventions can exacerbate maternal morbidity. MRI can aid surgical planning in high-risk pregnancies with inconclusive USG findings. However, due to limited availability and higher cost, selective use based on clinical risk may be a more feasible and cost-effective strategy in resource-constrained settings.

By enhancing diagnostic accuracy, MRI can play a pivotal role in preoperative planning and risk stratification, ultimately improving maternal and foetal outcomes.[24] Although colour flow Doppler is widely used as the initial diagnostic tool for placenta accreta, MRI offers distinct advantages by providing superior detail on the degree and depth of placental invasion. Its capability to accurately differentiate between placenta accreta, increta and percreta makes it an indispensable modality, particularly in complex cases where precise surgical planning is critical for optimising patient care.[11]

The current study has several limitations. It has a small sample size due to the rarity of MAP, and its strict inclusion criteria limited the statistical power to detect smaller effect sizes or subgroup differences. Patients with

contraindications to MRI were excluded, which may have limited the generalisability of the findings. Among the 14 cases, there was 2 FP and FN results were recorded which could have been owing to limitations in spatial resolution and interpretive variability. Further, the study was sone at a single centre, and the MRI interpretation by a single radiologist may have introduced observer bias. Also, the loss of 2 patients to follow-up may have impacted the diagnostic accuracy calculations. Finally, the study did not assess long-term outcomes or the cost-effectiveness of MRI in diagnosing MAP.

All these limitations underscore the need for more extensive, multicentre studies with diverse populations and standardised imaging protocols to validate the current findings. Although an ROC curve was generated in the current study, the limited use of visual aids may affect data clarity. Future studies should consider adding more graphical presentations for better interpretation. Discrepancies between MRI and intraoperative findings in the current study could have stemmed from limitations in visualising subtle placental invasions, particularly in anterior or posterior placentation, or due to observer-dependent interpretation. These variations highlight the need for standardised MRI protocols and structured reporting criteria.

Conclusion

MRI was found to be a valuable diagnostic tool for detecting MAP, particularly in cases with inconclusive USG results. With a high diagnostic accuracy and sensitivity as well as the consistent identification of key MRI features, such as the dark intraplacental T2 band, MRI proved to be a reliable imaging modality to support surgical planning and reduce maternal and foetal risks.

Acknowledgement: We are grateful to the Radiology Department staff and the supervisor for facilitating the research.

Disclaimer: None.

Conflict of Interest: None.

Source of Funding: None.

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AUTHOR'S CONTRIBUTION:

QUAM & NA: Concept, design, data acquisition, analysis, interpretation, drafting, revision and final approval.

MZA: Drafting, revision, final approval and agreement to be accountable for all aspects of the work.

SA: Concept, design, data acquisition, analysis, interpretation, final approval and agreement to be accountable for all aspects of the work.