

MRI Features of Placental Adhesion Disorders and their Diagnostic Significance

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ABSTRACT

Introduction: Placental Adhesion Disorder (PAD) is a critical obstetric condition in which a deficient decidua basalis allows chorionic villi to penetrate the myometrium, ranging from superficial attachment (accreta vera) to deep invasion (increta) or transmural extension into adjacent organs (percreta). While ultrasonography remains the primary diagnostic tool, Magnetic Resonance Imaging (MRI) serves as a vital adjunct for evaluating posterior placentation or inconclusive sonographic findings, offering a reported sensitivity of 75-100% together with precise mapping of extrauterine extension.

Aim: To evaluate the diagnostic accuracy of specific MRI features and to determine their correlation with definitive intraoperative outcomes in patients with suspected PAD.

Materials and Methods: This longitudinal study was conducted in the Department of Radiodiagnosis, Government T D Medical College, Alappuzha, Kerala, India, over a period of one and a half year. A cohort of 20 women above 18 years of age presenting with risk factors such as placenta previa or prior myomectomy, or with sonographic suspicion of PAD, was included. Participants underwent MRI evaluation followed by surgical intervention at the same facility. Data were collected using a semi-structured proforma detailing sociodemographic profile, obstetric history, and specified MRI markers. Findings were correlated with intraoperative results, and analysed using the Chi-square test in Statistical Package for Social Sciences (SPSS) version 26. A p-value <0.05 was considered statistically significant.

Results: The study included 20 patients, predominantly in the 31-40 years age group (65%), with 75% multiparous and 70% having a prior history of Lower-Segment Caesarean Section

(LSCS); obstetric hysterectomy was required in 80% of the cases. MRI demonstrated variable diagnostic performance in predicting hysterectomy. Abnormal uterine bulge and subserosal hypervascularity each demonstrated a sensitivity of 100%, specificity of 50%, Positive Predictive Value (PPV) of 88.9%, Negative Predictive Value (NPV) of 100% and accuracy of 90%, with a statistically significant association (p-value=0.032). Placental bulge, irregular myometrial interface and myometrial thinning each showed 100% sensitivity, 25% specificity, 84.2% PPV, 100% NPV and 85% accuracy (p-value=0.200). Placental heterogeneity demonstrated 81.3% sensitivity, 50% specificity, 86.7% PPV, 40% NPV and 75% accuracy (p-value=0.249); dark placental bands showed 62.5% sensitivity, 50% specificity, 83.3% PPV, 25% NPV and 60% accuracy (p-value=1.000). Placental protrusion had low sensitivity (31.3%) but very high specificity (100%), with 100% PPV, 26.7% NPV and 45% accuracy (p-value=0.530). Abnormal placental vascularity showed 25.0% sensitivity, 75% specificity, 80.0% PPV, 20% NPV and 35% accuracy (p-value=1.000).

Conclusion: The high sensitivity of features such as subserosal hypervascularity, uterine bulge and myometrial thinning ensures that the majority of invasive cases are detected, thereby, facilitating the surgical preparedness required for obstetric hysterectomy. Abnormal uterine bulge and subserosal hypervascularity emerged as the most statistically significant and reliable predictors of surgical outcome, whereas placental protrusion, though infrequent, was highly specific for advanced invasion. A multiparametric MRI approach focused on these key features is recommended for accurate surgical planning; larger prospective studies are needed to refine diagnostic thresholds.

Keywords: Caesarean section, Diagnostic accuracy, Magnetic resonance imaging, Myometrial thinning, Obstetric hysterectomy, Subserosal hypervascularity

INTRODUCTION

Placental Adhesion Disorder (PAD) is a group of disorders resulting from a deficiency in the decidua basalis that causes the chorionic villi to penetrate the myometrium [1]. The depth of trophoblastic invasion into the uterine wall determines the classification of these disorders [2,3]. The least invasive form, placenta accreta vera, is defined by abnormal fixation of the placenta directly on the myometrium. Placenta increta is characterised by partial invasion of the myometrium, whereas placenta percreta is characterised by complete invasion of the myometrium, reaching or extending beyond the uterine serosa and occasionally into surrounding organs [3,4].

A prior caesarean section and placenta previa are the principal risk factors for placenta accreta. Additional risk factors include advanced maternal age [5], a history of conservative myomectomy, uterine artery embolisation, curettage or uterine rupture [1]. The incidence of placenta accreta in the general population is estimated at 0.9%,

but rises to 9% in the presence of concomitant placenta previa and up to 35% in patients with a combined history of placenta previa and prior caesarean section [6]. The probability of invasive placenta has been reported to be as high as 67% in patients with more than three previous caesarean deliveries [5].

The primary diagnostic modality for evaluating an abnormal placenta is ultrasonography combined with colour Doppler. However, MRI is recommended as an additional imaging method in cases of posterior placenta and when sonographic findings are inconclusive or ambiguous [7]. MRI provides an overall sensitivity of 75-100% and a specificity of 65-100% for the diagnosis of PAD, with negative and positive predictive values of 79-92% and 67.0-84.4%, respectively [1].

Against this background, the present study was undertaken to determine the diagnostic accuracy of individual MRI findings and their correlation with intraoperative findings in patients with suspected placental adhesion disorder.

MATERIALS AND METHODS

This longitudinal study was conducted in the Department of Radiodiagnosis, Government T D Medical College, Alappuzha, Kerala, India, over a period of one and a half year starting from January 2025 after taking Institutional Ethics Committee approval (EC/32/2025). Women who had undergone MRI evaluation for suspected placental adhesion disorders and had subsequently undergone surgery at the same institution were included. As this study was a part of postgraduate thesis, a consecutive sampling technique was employed. Every consecutive patient satisfying the inclusion criteria and referred to the Department of Radiodiagnosis, Government T D Medical College, Alappuzha, was enrolled during the study period.

Inclusion criteria:

- Female patients above 18 years of age suspected of having PAD on ultrasonography, and/or with a prior history of myomectomy or placenta previa.
- Patients referred to the Department of Radiodiagnosis for MRI evaluation, who subsequently underwent surgery in the Department of Obstetrics and Gynaecology at the study centre.
- Patients who provided written informed consent for participation.
- Patients with no contraindication to MRI examination.

Exclusion criteria:

- Patients with general contraindications for MRI, including metallic implants in the body, foreign body in the eyes, cardiac pacemaker or claustrophobia.
- Patients who underwent MRI at the study centre but did not undergo surgery at the same institution.

Study Procedure

Major features: Abnormal uterine bulge; placental bulge; placental heterogeneity; placental protrusion; dark bands on T2-weighted images accompanied by placental recess.

Minor features: Dark placental bands on T2-weighted images; irregular placental-myometrial interface; myometrial thinning; abnormal placental vascularity; subserosal hypervascularity.

Data collection: A semi-structured proforma was used to collect information from the study participants referred from the Department of Obstetrics and Gynaecology. The information recorded included

sociodemographic characteristics, age, present obstetric history, past obstetric history, past relevant medical and surgical history, and personal and family history. Intraoperative findings were obtained from the operative case sheets and correlated with the MRI findings.

STATISTICAL ANALYSIS

All collected data were verified for consistency and entered into a Microsoft Excel spreadsheet. Statistical analysis was carried out using SPSS version 26. Categorical data were expressed as frequencies, ratios and percentages, and their association with the surgical outcome was tested using the Chi-square test. Categorical data were expressed as frequency (n) and percentages (%). A p-value <0.05 was considered statistically significant. Results were presented in the form of tables, graphs and charts.

RESULTS

The study included a total of 20 patients. The majority of patients (65%) belonged to the 31-40 years age group, and 75% were multiparous, 70% participants had a prior history of LSCS and obstetric hysterectomy was required in 80% of the cases [Table/Fig-1].

Variables	Category	Frequency (n)	Percentage (%)
Age (years)	≤30	7	35%
	31-40	13	65%
Parity	Primi	5	25%
	Multi	15	75%
Previous LSCS	Yes	14	70%
	No	6	30%
Outcome	Hysterectomy	16	80%
	No hysterectomy	4	20%

[Table/Fig-1]: Demographic and clinical profile of the study population (N=20).

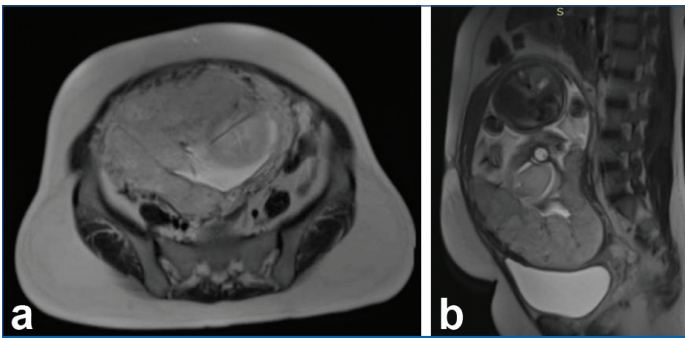
MRI findings for predicting obstetric hysterectomy in PAD showed variable diagnostic accuracy with abnormal uterine bulge and subserosal hypervascularity each demonstrating a sensitivity of 100%, specificity 50%, PPV 88.9%, and NPV of 100% with 90% accuracy with a statistically significant association ($p=0.032$). [Table/Fig-2]. A few cases MRI findings have been shown in [Table/Fig-3-5] showing placental heterogeneity with T2 dark bands, myometrial thinning and abnormal uterine bulge.

MRI parameters	Diagnostic findings	Hysterectomy (+)	Hysterectomy (-)	Sensitivity	Specificity	PPV	NPV	Accuracy	p-value
Abnormal uterine bulge	Finding (+)	16	2	100%	50%	88.9%	100%	90%	0.032*
	Finding (-)	0	2						
Subserosal hypervascularity	Finding (+)	16	2	100%	50%	88.9%	100%	90%	0.032*
	Finding (-)	0	2						
Placental bulge	Finding (+)	16	3	100%	25%	84.2%	100%	85%	0.200
	Finding (-)	0	1						
Irregular myometrial interface	Finding (+)	16	3	100%	25%	84.2%	100%	85%	0.200
	Finding (-)	0	1						
Myometrial thinning	Finding (+)	16	3	100%	25%	84.2%	100%	85%	0.200
	Finding (-)	0	1						
Placental heterogeneity	Finding (+)	13	2	81.3%	50%	86.7%	40%	75%	0.249
	Finding (-)	3	2						
Dark T2 placental bands	Finding (+)	10	2	62.5%	50%	83.3%	25%	60%	1.000
	Finding (-)	6	2						
Placental protrusion	Finding (+)	5	0	31.3%	100%	100%	26.7%	45%	0.530
	Finding (-)	11	4						
Dark T2 bands with recess	Finding (+)	4	1	25.0%	75%	80.0%	20%	35%	1.000
	Finding (-)	12	3						

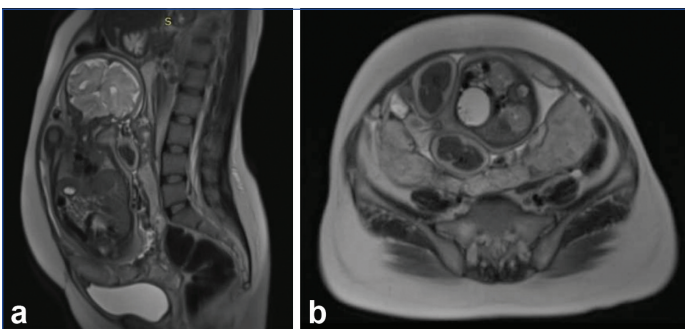
Abnormal placental vascularity	Finding (+)	4	1	25.0%	75%	80.0%	20%	35%	1.000
	Finding (-)	12	3						

[Table/Fig-2]: Diagnostic accuracy of MRI findings for predicting obstetric hysterectomy in placental adhesion disorders.

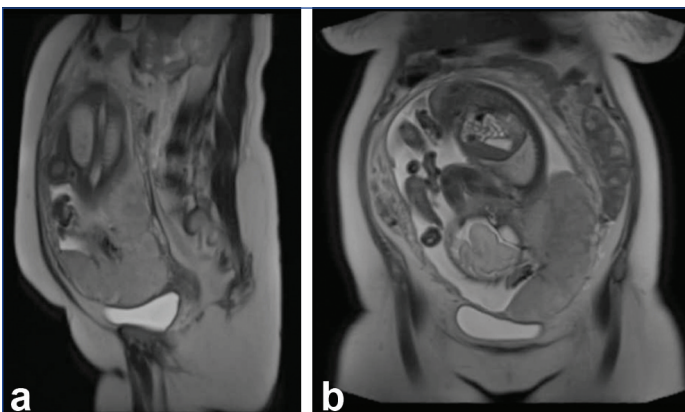
*Statistically significant association (p-value <0.05)



[Table/Fig-3]: a) Case 1: 35-year-old G2P1L1 with a previous history of LSCS; b) MRI showed placental heterogeneity with T2 dark bands, myometrial thinning and placental protrusion into internal cervical os. Placenta is also noted tenting on the bladder wall.



[Table/Fig-4]: a) Case 2: 35-year-old G2P1L1 with a previous history of LSCS; b) MRI showed placental heterogeneity with myometrial thinning. Multiple T2 hypointense flow voids are noted in subserosal surface likely subserosal hypervascularity.



[Table/Fig-5]: a) Case 3: 33-year-old G2P1L1 with previous history of LSCS; b) MRI showed an abnormal uterine bulge with myometrial thinning.

DISCUSSION

Placental Adhesion Disorder (PAD) represents a spectrum of abnormal placental attachment caused by defective decidualisation, leading to invasion of chorionic villi into the myometrium. Previous cesarean section and placenta previa are the most significant risk factors, with the incidence increasing substantially in women with multiple prior cesarean deliveries, while advanced maternal age and prior uterine interventions also contribute. MRI provides high diagnostic accuracy and is particularly useful for evaluating posterior or lateral placental extension and bladder invasion. Imaging is preferably performed on a 1.5-T scanner without contrast, ideally between 30 and 35 weeks of gestation, as studies performed earlier or later show reduced diagnostic reliability due to physiological placental and myometrial changes. Against this background, the present study aimed to evaluate the diagnostic accuracy of MRI findings and their correlation with intraoperative

observations. The novelty of this study lies in the systematic assessment of individual MRI signs and their direct comparison with operative findings to identify the most reliable predictors of surgical outcomes.

A study by, D'Antonio F et al., [8] reported a higher overall diagnostic performance of MRI for invasive placentation, with sensitivity of 94.4% and specificity of 84.0%, whereas the present study demonstrated very high sensitivity for several individual MRI signs (up to 100%) but comparatively lower specificity values, ranging from 25% to 50%. Srisajakul S et al., [9] reported wide ranges of sensitivity and specificity for MRI features such as dark intraplacental bands (63-100% sensitivity; 65-100% specificity) and placental bulge (10-93% sensitivity; 71-100% specificity), which are broadly comparable to the sensitivities observed in the present cohort but with lower specificity values. Masselli G et al., [10] demonstrated that MRI was significantly superior to ultrasonography in assessing the depth and topography of placental invasion, achieving 100% accuracy in defining topographic extent, whereas the present study results emphasised the association of individual MRI findings with operative outcomes, demonstrating that features with low sensitivity, such as placental protrusion, still showed very high specificity.

Familiari A et al., [11] reported consistently higher specificity for MRI across the spectrum of placental invasion, with specificity values ranging from 96.8% to 98.8% and sensitivities between 86.5% and 100%, whereas the present study demonstrated uniformly high sensitivity for several MRI signs (100% for subserosal hypervascularity, uterine bulge, placental bulge, irregular myometrial interface and myometrial thinning) but lower specificity values (25%-50%), along with intraplacental dark bands as the most sensitive marker across accreta, increta and percreta, while in the present study dark placental bands showed lower sensitivity (62.5%) and specificity (50%).

Agostini TCF et al., [12] reported high specificity for major MRI signs such as placental bulge (90.3%) and abnormal uterine bulge (90.2%), whereas the corresponding specificity values in the present study were markedly lower at 25%. Additionally, while Agostini TCF et al., [12] reported placental protrusion to have both high sensitivity (83.8%) and specificity (82.4%), the present findings showed substantially lower sensitivity (31.3%) but perfect specificity (100%), indicating stronger predictive value when present. Ueno Y et al., [13] emphasised placental protrusion as a novel and reliable sign with good interobserver agreement, which aligns with the observation of its high specificity despite low sensitivity in the present cohort.

Lu T et al., [14] demonstrated improved diagnostic performance by integrating Diffusion-Weighted Imaging (DWI) parameters with conventional MRI features, achieving Area Under the Curve (AUC) values of 0.903 and 0.858, with sensitivities of 90% and 77% and specificities of 89% and 90.9% for posterior and anterior Placenta Accreta Spectrum (PAS), respectively; this contrasts with the present findings, in which abnormal placental vascularity and dark placental bands showed lower sensitivities (25.0% and 62.5%) and specificities (75% and 50%). Silva KC et al., [15] also reported high sensitivity (87.5%) and specificity (90.9%) of placental bulge for placenta percreta and strong associations of uterine bulge and myometrial thinning with adverse maternal outcomes. The similarities observed across studies are likely attributable to the consistent pathophysiological basis of placental invasion, which produces reproducible MRI features when standardised imaging protocols and established diagnostic criteria are applied.

In the review by Cuthbert F et al., [1], MRI features such as uterine bulge, myometrial thinning, placental heterogeneity, dark T2 bands and subserosal hypervascularity were illustrated as characteristic findings of placental adhesion disorder, but no sensitivity or specificity values were provided, limiting quantitative comparison with the present sensitivities of up to 100% and specificities ranging from 25% to 75%. Similarly, Azour L et al., [6] focused on standardised MRI reporting of abnormal placentation and described uterine bulge, abnormal placental vascularity and placental-myometrial interface disruption as key signs, without reporting numerical sensitivity or specificity, whereas in the present study these features showed high sensitivity (100% for uterine bulge and interface irregularity) but low specificity (25%).

Maurea S et al., [16] demonstrated superior diagnostic performance when multiple MRI signs were combined, reporting an AUC of 0.92 for the presence of two abnormal signs compared with single-sign analysis (AUC 0.764), whereas the present study evaluated individual MRI features and demonstrated accuracies ranging from 35% to 90%, with subserosal hypervascularity and abnormal uterine bulge (both 90%) approaching that performance. Rahaim NS and Whitby EH, [17] reported a broad range of MRI sensitivity (75-100%) and specificity (65-100%) for PAD, which aligns with the wide variability observed in the present study, in which sensitivity and specificity from 25% to 100% across the different MRI markers. Goergen SK et al., [18] identified dark intraplacental T2 bands as both the most sensitive and specific feature, with substantial interobserver agreement ($\kappa=0.7$), whereas in the present cohort dark placental bands demonstrated lower sensitivity (62.5%) and specificity (50%), indicating reduced discriminatory power for operative correlation. Stewart MJ et al., [19] reported overall MRI sensitivity and specificity of 93% and 81% respectively, with high AUC values for myometrial thinning (0.881), placental heterogeneity (0.864) and placental bulge (0.845); Collectively, compared with studies, the present results highlighted the heterogeneous diagnostic accuracy of individual MRI signs when directly correlated with surgical outcomes.

Ahmed HA et al., [20] reported similarly high MRI sensitivity of 100% but a higher specificity of 89.47% and overall accuracy of 92%, whereas in our study specificity for individual MRI signs ranged from 25% to 100% and accuracy from 35% to 90%, reflecting greater variability when individual features were analysed rather than overall MRI diagnosis. Fallatah EM et al., [21] demonstrated an overall MRI sensitivity of 100% and specificity of 93% for placental adhesions, exceeding the specificity observed for most MRI markers in the present study, although sensitivities for several features were comparable. Riteau AS et al., [22] reported lower MRI sensitivity of 76.9% and specificity of 50% for placenta accreta, with uterine bulge showing a PPV of 85% that increased to 90% when combined with dark intraplacental bands. Sathyakumar K et al., [23] reported MRI sensitivity of 100% and specificity of 37.5% for PAD, closely mirroring the low-specificity range observed in the present study; their reported sensitivities and specificities for dark intraplacental bands (100% and 50%) and placental heterogeneity (75% and 75%) were broadly comparable to the corresponding values observed in the present cohort.

Thiravit S et al., [24] reported MRI sensitivity of 91.7% and specificity of 44% for detecting placenta percreta, comparable to the low-to-moderate specificity range observed in the present study (25-75%); their observation of 100% specificity for extrauterine invasion parallels the perfect specificity (100%) seen for placental protrusion in the present cohort, despite its low sensitivity. Ari SA et al., [25] demonstrated overall MRI sensitivity of 81%, specificity of 85% and accuracy of 84%, exceeding the specificity values of most individual MRI signs in the present study. Lopes ES et al., [26] reported MRI sensitivity of 92.9% with PPV of 76.5% and NPV of 75.0%; subgroup analysis showed anterior

placenta accreta with 100% sensitivity and 33.3% specificity, which closely mirrors the pattern of very high sensitivity with reduced specificity for several MRI features in the present cohort; posterior placenta accreta in their study showed high specificity (100%), comparable to the specificity observed for placental protrusion in the present cohort. Maher MA et al., [27] reported MRI sensitivity of 85.7% and specificity of 76.9%, values higher than the specificity of most individual MRI markers in the present study but lower than the sensitivity demonstrated by subserosal hypervascularity and uterine-related features. In total, when compared with these studies, the present results demonstrated consistently high sensitivity across multiple MRI features. The high sensitivity of MRI in our study likely stems from its superior soft-tissue contrast and multiplanar imaging capabilities, which allow for the precise visualisation of the uteroplacental interface and the detection of subtle myometrial invasion that might be obscured on ultrasound.

Abdel Aziz S et al., [28] reported balanced overall MRI performance with sensitivity and specificity of 86.7% and 86.0% respectively, higher than the specificity observed for most individual MRI signs in the present study. Additionally, their reported sensitivities for individual signs such as dark intraplacental bands (76.6%), heterogeneous placenta (69.1%), myometrial thinning (82.8%), and placental bulge (51.8%) were lower than the 100% sensitivity observed for corresponding uterine-related features in the present cohort. Ayati S et al., [29] reported lower MRI sensitivity (76%) but higher specificity (83%) compared with the generally higher sensitivity but lower specificity pattern seen in the present results. Hashem LB et al., [30] observed MRI sensitivity of 80% and specificity of 85.7%, exceeding the specificity of most MRI features in the present study, while remaining lower than the sensitivity demonstrated by several MRI markers reported here.

Although many commonalities exist across these studies, some reveal slight variations in the final outcome. The differences observed in the parameters assessed in the present study may be attributed to the comparatively small sample size, differences in study design, geographic and socioeconomic variations, differences in MRI assessment scales, imaging techniques, interobserver bias and variable technical expertise. The higher sensitivity in the present cohort may be explained by the inclusion of multiple MRI features that act as early and subtle markers of placental invasion, thereby increasing the likelihood of detecting true cases. The lower specificity, conversely, may reflect overlap of MRI features with physiological placental and myometrial changes occurring in late gestation, leading to a higher rate of false-positive interpretations when correlated with operative findings.

Collectively, MRI demonstrated high sensitivity for detecting placental adhesion disorders, with several imaging features showing strong correlation with operative findings, particularly for identifying cases requiring hysterectomy. However, the specificity of individual MRI signs varied widely, reflecting overlap with physiological placental and myometrial changes in advanced gestation. MRI thus, remains a valuable diagnostic tool, whose greatest clinical utility lies in the combined interpretation of multiple imaging features alongside surgical correlation to guide management planning.

Limitation(s)

The main limitations of the present study include the relatively small sample size ($n=20$), single-centre design and the potential for interobserver variability in MRI interpretation. The high proportion of severe cases (80% required hysterectomy) may also have influenced specificity calculations, given the limited number of MRI-positive but hysterectomy-negative cases. These findings should therefore, be interpreted with caution and validated in larger, multicentre prospective studies.

CONCLUSION(S)

The present study demonstrated that MRI is a highly sensitive modality for evaluating placental adhesion disorders and for identifying patients who are likely to require hysterectomy, thereby supporting its role in preoperative planning. Several MRI features showed excellent sensitivity, indicating their strong ability to correctly identify true cases of severe placental invasion. Among all evaluated MRI markers, abnormal uterine bulge and subserosal hypervascularity demonstrated the strongest overall diagnostic performance, with a balanced combination of high sensitivity, acceptable specificity and strong predictive reliability, and showed a significant correlation with operative findings. Placental protrusion, though infrequent, demonstrated very high specificity and PPV, suggesting that its presence strongly indicates severe disease. It is therefore recommended that MRI be routinely considered when ultrasound findings are equivocal or when posterior placenta is suspected, with emphasis on interpreting multiple MRI features collectively rather than in isolation. Future studies with larger cohorts should focus on the development of standardised MRI-based scoring systems to improve specificity and predictive accuracy.

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- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

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