Multiparametric MRI in Primary Rectal Cancer Staging: Diagnostic Pitfalls, Controversies, and Problem-Solving Strategies

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Abstract

Background: High-resolution magnetic resonance imaging is the principal imaging modality for local staging and preoperative risk stratification of rectal cancer. Its value extends beyond conventional tumor–node–metastasis classification by identifying prognostically important features that influence neoadjuvant treatment selection, surgical planning, and the feasibility of sphincter-preserving approaches. These features include tumor relationship to the mesorectal fascia, depth of extramural invasion, extramural venous invasion, nodal and tumor-deposit involvement, peritoneal reflection invasion, and extension into the anal sphincter complex or adjacent pelvic organs. Nevertheless, rectal MRI remains technically demanding and vulnerable to substantial interpretive variability. Inadequate patient preparation, incorrect sequence orientation, motion and susceptibility artifacts, and failure to integrate morphological and functional imaging findings may result in inaccurate staging. Diagnostic difficulties are particularly encountered in early T-stage tumors, low rectal cancers, mucinous tumors, bulky polypoid lesions, tumors at the peritoneal reflection, and cases with equivocal lymph nodes or threatened resection margins.

Aim: This review examines the major diagnostic pitfalls and unresolved controversies in primary rectal cancer staging using multiparametric MRI. It emphasizes a structured, problem-solving approach that combines high-resolution T2-weighted imaging with diffusion-weighted imaging, apparent diffusion coefficient assessment, and, when clinically justified, dynamic contrast-enhanced imaging. Particular attention is given to distinguishing T2 from early T3 disease, differentiating desmoplastic reaction from true extramural tumor spread, assessing circumferential resection margin risk, evaluating extramural venous invasion, and characterizing mesorectal, lateral pelvic, and extramesorectal lymph nodes. The review also addresses controversial areas, including the incremental value of contrast enhancement, limitations of size-based nodal criteria, interpretation of tumor deposits, and the role of MRI in increasingly individualized treatment pathways.

Conclusion: Accurate primary rectal cancer staging requires more than identification of the primary tumor and assignment of a conventional stage. Optimal interpretation depends on technically adequate imaging, anatomically oriented sequence acquisition, systematic assessment of all prognostic compartments, and careful correlation of morphological and functional findings. Multiparametric MRI can improve diagnostic confidence in difficult cases, but its components should be used selectively and interpreted within the clinical and anatomical context. A structured reporting strategy that explicitly communicates tumor height, T category, mesorectal fascia status, extramural venous invasion, nodal distribution, sphincter involvement, and adjacent organ invasion can reduce avoidable errors, improve multidisciplinary decision-making, and support personalized management of patients with newly diagnosed rectal cancer.

Keywords: Rectal cancer; multiparametric MRI; primary staging; diagnostic pitfalls

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Introduction

Rectal cancer management has evolved from uniform stage-based treatment toward individualized pathways determined by tumor anatomy, biological risk, anticipated surgical margins, and the possibility of organ preservation. Within this framework, pelvic magnetic resonance imaging has become central to baseline locoregional assessment because it depicts the rectal wall, mesorectal compartment, mesorectal fascia, peritoneal reflection, pelvic sidewalls, sphincter complex, and adjacent organs with high soft-tissue contrast. Contemporary MRI staging is therefore expected to provide more than a conventional tumor–node–metastasis category; it must identify imaging features that influence multidisciplinary decisions, including the depth of extramural spread, mesorectal fascia involvement, extramural venous invasion, nodal distribution, tumor deposits, peritoneal invasion, and extension into the anal canal or neighboring structures. Recent European consensus recommendations reinforce this risk-oriented and structured approach to primary rectal cancer staging. [1]

High-resolution T2-weighted MRI remains the anatomical foundation of local staging. Its clinical importance was established by prospective multicenter evidence demonstrating that preoperative MRI could accurately assess the relationship between rectal tumor and the mesorectal fascia and predict whether the surgical circumferential resection margin was likely to be clear. This capability changed the role of imaging from simple tumor detection to prospective assessment of resectability and local recurrence risk. However, the apparent precision of MRI measurements should not obscure the complexity of image interpretation. Tumor-related fibrosis, desmoplastic reaction, inflammation, edema, compressed vessels, and partial-volume effects can resemble true extramural extension. Errors are particularly consequential when differentiating T2 from early T3 tumors or when measuring a small clearance between tumor and mesorectal fascia, because modest over- or understaging may alter recommendations for neoadjuvant therapy and the intended surgical approach. [2]

Primary staging becomes more challenging in tumors with unusual morphology, location, or histological composition. Polypoid and semicircumferential lesions may distort the muscularis propria without truly breaching it, whereas mucinous tumors can demonstrate high T2 signal that obscures the interface between viable tumor, mucin pools, and surrounding tissues. Low rectal tumors require detailed assessment of the internal and external sphincters, intersphincteric plane, levator ani, and puborectalis, while tumors near the anterior peritoneal reflection require careful distinction between peritoneal contact and genuine peritoneal invasion. Nodal staging remains another major source of uncertainty because size alone is insufficient, morphological criteria are imperfect, and the distinction among metastatic nodes, tumor deposits, and discontinuous extramural venous invasion may be difficult. Standardized terminology is consequently essential to reduce ambiguity and communicate these findings consistently. [3]

The term *multiparametric MRI* implies integration of anatomical and functional information rather than dependence on a single sequence. High-resolution T2-weighted images provide the principal structural assessment, while diffusion-weighted imaging and apparent diffusion coefficient maps can improve tumor conspicuity and assist in selected problem-solving situations. Nevertheless, diffusion restriction is not specific for malignancy, and susceptibility artifacts, T2 shine-through, collapsed bowel, luminal contents, and small nodes can produce misleading appearances. Similarly, intravenous contrast may help in selected early or morphologically complex tumors but is not universally required for routine primary staging. The value of each additional sequence therefore depends on the clinical question, technical quality, and anatomical context. Multiparametric interpretation should complement, rather than replace, meticulous evaluation of properly oriented high-resolution T2-weighted images. [4]

Despite increasingly detailed guidelines and structured-reporting templates, important interpretive controversies remain incompletely resolved. These include the imaging boundary between desmoplasia and microscopic T3 invasion, the most clinically meaningful definition of mesorectal fascia involvement, classification of anterior peritoneal reflection invasion, criteria for T4b disease, nodal risk assessment, lateral pelvic nodal thresholds, and differentiation of tumor deposits from nodal metastases or venous invasion. Moreover, existing recommendations frequently address acquisition, staging

terminology, individual prognostic findings, or reporting structure separately, leaving a need for an integrated problem-solving review centered on everyday diagnostic uncertainty. Accordingly, this review aims to critically examine the principal technical and interpretive pitfalls of primary rectal cancer MRI, clarify areas of continuing controversy, and propose a structured multiparametric strategy for resolving equivocal findings and communicating clinically actionable risk features. [5]

MRI Acquisition and Structured Interpretation

A technically adequate examination is the first requirement for reliable staging. Rectal MRI may be performed at 1.5 or 3 T using a pelvic phased-array coil; an endorectal coil is unnecessary. The protocol should include large-field-of-view pelvic images for tumor localization and nodal mapping, followed by small-field-of-view two-dimensional T2-weighted sequences without fat suppression. High-resolution images should use a section thickness of 3 mm or less and submillimeter in-plane resolution. The oblique axial plane must be perpendicular to the tumor axis, because incorrectly angled images exaggerate the apparent length of muscularis propria disruption and may falsely increase extramural invasion. An oblique coronal plane parallel to the tumor is complementary, while coronal imaging parallel to the anal canal is essential in low rectal tumors. [6]

Diffusion-weighted imaging should include a high b value of at least 800 s/mm² and corresponding apparent diffusion coefficient maps. Its principal value at baseline staging is improving tumor conspicuity and supporting anatomical interpretation rather than independently determining T or N category. Restricted diffusion must be confirmed as high signal on high-b-value images with low signal on the ADC map and correlated with a matching structural abnormality on T2-weighted imaging. Rectal gas, susceptibility distortion, collapsed normal bowel, luminal contents, and small benign nodes may mimic restriction, whereas mucinous components may demonstrate relatively high ADC values. Accordingly, DWI should not be used alone to diagnose extramural invasion, mesorectal fascia involvement, or nodal metastasis. [7]

Routine intravenous contrast enhancement is generally unnecessary for primary rectal cancer staging because high-resolution T2-weighted imaging provides the decisive anatomical information. Contrast-enhanced imaging may be reserved for selected problem-solving situations, including equivocal early polypoid lesions, suspected inflammatory complications, or difficult differentiation of tumor from adjacent pelvic structures. Routine rectal distension with gel is also discouraged because it can compress the mesorectal fat, reduce the apparent tumor-to-mesorectal fascia distance, and alter assessment of low tumors. A small rectal micro-enema or an antiperistaltic agent may be used selectively to reduce gas-related susceptibility and motion artifacts, particularly when DWI quality is otherwise likely to be compromised. [8]

Interpretation should follow a fixed anatomical sequence. The radiologist should first confirm that the lesion is rectal using the sigmoid take-off, then document tumor height, craniocaudal length, circumferential location, morphology, and relationship to the anterior peritoneal reflection and anorectal junction. Evaluation should then proceed systematically through T category and extramural depth, the shortest distance to the mesorectal fascia, extramural venous invasion, tumor deposits, mesorectal and lateral pelvic nodes, peritoneal involvement, sphincter complex invasion, and adjacent organ extension. When a finding is equivocal, it should be verified on orthogonal high-resolution T2-weighted planes before consulting DWI and ADC maps. This sequence-based approach prevents a conspicuous but less important finding from distracting from clinically decisive risk features. [9]

Distinguishing T2 From Early T3 Disease and Measuring Extramural Invasion

The distinction between mrT2 and early mrT3 disease is among the most difficult and clinically relevant components of primary rectal MRI staging. An mrT2 tumor remains confined to the muscularis propria, whereas mrT3 disease demonstrates direct extension beyond its outer border into the mesorectal fat. True extramural invasion should appear as intermediate tumor signal extending continuously through a definite muscular defect. Normal vessels penetrating the rectal wall and partial-volume effects on incorrectly angled images may create apparent muscular interruption; therefore, the suspected invasion should be confirmed on tumor-perpendicular high-resolution T2-weighted images. [10]

The principal cause of overstaging is peritumoral desmoplastic reaction. Desmoplasia usually appears as fine, low-signal-intensity linear spicules radiating into the mesorectal fat, while viable extramural tumor more commonly forms a broad, nodular, or irregular intermediate-signal extension continuous with the intramural mass. This distinction is not always possible, particularly in bulky circumferential tumors or when spatial resolution is inadequate. Diffusion restriction or enhancement within adjacent strands should not independently establish T3 disease because both may occur in inflammatory or fibrotic tissue. Orthogonal T2-weighted assessment remains the decisive problem-solving method. [9]

When T3 invasion is present, the maximum extramural depth should be measured in millimeters from the reconstructed outer border of the muscularis propria to the most distant edge of continuous extramural tumor. Desmoplastic strands, separate tumor deposits, metastatic nodes, and extramural venous invasion should not be included in this measurement. Reporting the exact depth is more informative than providing T3 category alone because increasing extramural extension is associated with other adverse pathological features and greater tumor aggressiveness. A depth exceeding 5 mm is commonly regarded as an important adverse threshold, although the exact T3 substaging system should be stated if used. [11]

The practical consequence of minor overstaging should also be recognized. Prospective MERCURY data showed favorable outcomes in MRI-defined good-prognosis tumors characterized by a clear mesorectal fascia and T2 or limited T3 extension of less than 5 mm, supporting selective avoidance of neoadjuvant radiotherapy in appropriately selected patients. When the muscular border remains genuinely indeterminate after multiplanar review, a transparent report such as “mrT2 versus early mrT3, with suspected extramural extension of less than 1 mm” is preferable to an unsupported definitive stage. The report should also emphasize mesorectal fascia status, EMVI, nodal disease, and tumor deposits because treatment should not be determined by the T2–T3 distinction in isolation. [12]

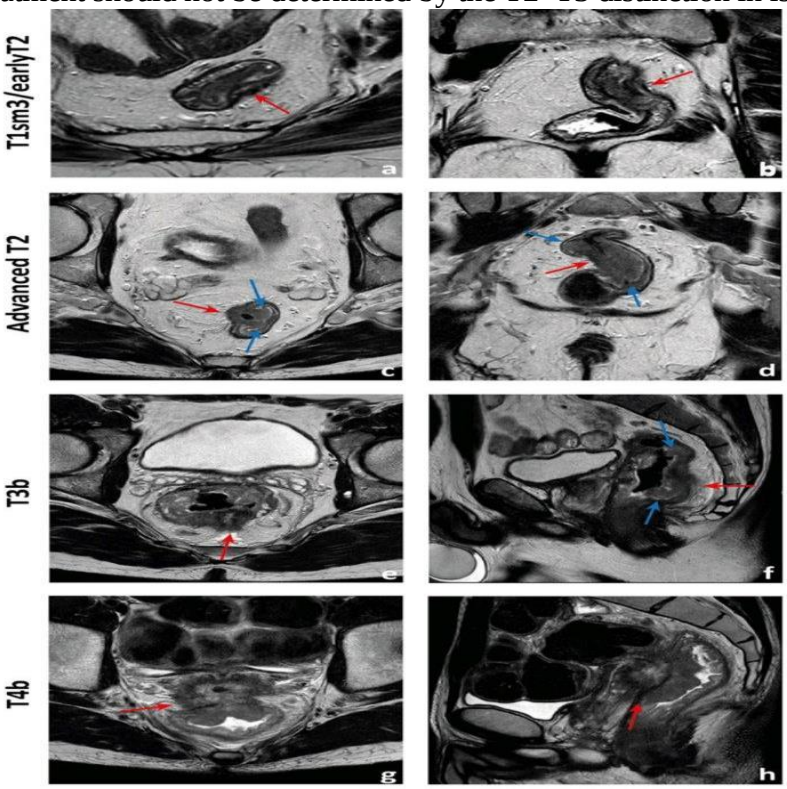

Figure 1: Examples of differently T-staged tumours. a, b Arrows point to an early polypoid tumour occupying the full depth of the submucosa centrally and therefore staged clinically as mrT1sm3/early T2. Total mesorectal excision was performed, and at pathology, it corresponded to a T1sm3. c, d This ulcerated tumour extends in depth through the full thickness of the muscularis propria and was therefore staged as an MR advanced T2 (red arrows), which was confirmed at pathology. Notice how the periphery of the tumour overhangs the rectal wall both in the axial and coronal planes (blue arrows) **(**e, f This mid-high, sub-circumferential rectal cancer extends 4 mm into the mesorectal fat at its most central area (red arrows) and was therefore staged as T3b. Notice the overhanging edges on the sagittal plane (blue arrows in f).. g, h An anterior midhigh rectal cancer crosses the Denonvillier fascia and the peritoneal reflection to invade the seminal vesicles in this male patient, corresponding to an mrT4b.

The patient underwent chemoradiation and is currently under palliative treatment due to distant metastatic disease[12]

Mesorectal Fascia and Circumferential Resection Margin

The mesorectal fascia (MRF) is the thin low-signal boundary surrounding the mesorectal compartment and represents the expected surgical plane during total mesorectal excision. Strictly, MRI assesses the tumor's relationship to the MRF, whereas the circumferential resection margin is a postoperative pathological measurement influenced by the actual surgical plane. Current ESGAR recommendations define MRF involvement when tumor-bearing tissue lies **1 mm or less** from the fascia. The shortest distance should be reported in millimeters together with its clock-face location. A distance greater than 1 mm is considered clear, although many centers additionally describe a narrow but clear margin as "threatened" to facilitate multidisciplinary planning. [1]

MRF assessment should include all potentially malignant structures, not only the primary tumor. Direct extramural tumor extension, irregular metastatic nodes, tumor deposits, and extramural venous invasion within 1 mm of the fascia may each create an involved margin. In contrast, a smooth benign-appearing node close to the MRF should not automatically classify the margin as involved. Measurement must be made on a high-resolution plane perpendicular to the relevant tumor-bearing structure; oblique measurement, volume averaging, rectal overdistension, and failure to distinguish the fascia from adjacent pelvic vessels or peritoneum may produce false-positive results. The prospective MERCURY analysis established 1 mm as the most appropriate MRI threshold for predicting pathological margin involvement and local recurrence. [13]

The MRF is thinnest anteriorly and tapers distally as the mesorectum narrows, making anterior and low rectal tumors particularly difficult. Below the termination of the mesorectal envelope, margin assessment should shift from a simple tumor-to-MRF distance to the tumor's relationship with the muscularis propria, intersphincteric plane, external sphincter, puborectalis, levator ani, prostate, vagina, and pelvic sidewall. A statement such as "MRF clear" is therefore insufficient for a very low tumor. The report should identify the threatened anatomical plane and indicate whether the proposed sphincter-preserving or extralevator surgical plane could achieve clearance. Multiplanar small-field-of-view imaging is essential because an apparently involved anterior margin on one plane may represent oblique contact rather than invasion.

MRF involvement is a major adverse prognostic and treatment-planning feature. Five-year MERCURY follow-up demonstrated that MRI-predicted margin involvement was associated with poorer disease-free survival and increased local recurrence, supporting its use for preoperative risk stratification. [14] Recent evidence further indicates that MRF involvement caused by tumor deposits or extramural vascular invasion carries important prognostic information and should not be overlooked when the primary mass itself remains distant from the fascia. [15] In equivocal cases, the most useful report provides the exact distance, responsible structure, anatomical location, and degree of diagnostic confidence rather than relying only on a binary "positive" or "negative" designation.

Extramural Venous Invasion and Tumor Deposits

Extramural venous invasion (EMVI) represents tumor extension into veins beyond the muscularis propria and should be evaluated systematically on high-resolution T2-weighted MRI. The most reliable feature is intermediate tumor signal expanding or replacing a recognizable extramural vein, producing an irregular or nodular vessel contour and continuity with the primary tumor. Serpiginous tumor signal following the course of mesorectal vessels increases diagnostic confidence. In contrast, simple vessel displacement, narrowing, or contact without intraluminal tumor signal should not be classified as EMVI. MRI has relatively high specificity but more limited sensitivity, particularly for invasion of small-caliber vessels. [16]

The established five-point mrEMVI score ranges from definitely absent to definitely present according to vessel caliber, contour, and replacement by tumor signal. Scores of 3 or 4 are generally considered positive, whereas scores of 0 to 2 indicate absent or equivocal disease. Assessment should primarily use T2-weighted imaging in at least two planes. Diffusion-weighted imaging may improve conspicuity when restricted tumor signal follows a vessel, but susceptibility distortion and adjacent lymph nodes can

generate false-positive appearances. Positive mrEMVI should be reported independently of T and N categories because it is strongly associated with distant metastatic recurrence and poorer survival. [17]

Tumor deposits are discontinuous malignant nodules within the mesorectal or perirectal fat that lack identifiable residual lymph-node tissue and are not clearly contained within a vascular or neural structure. On MRI, they commonly appear as irregular, spiculated, or infiltrative nodules separated from the primary tumor. Their distinction from metastatic lymph nodes and discontinuous EMVI is controversial because MRI cannot demonstrate the microscopic tissue of origin. A rounded lesion with a smooth contour favors a lymph node, while a serpiginous lesion connected to a vessel favors EMVI; however, these signs are imperfect, particularly when lesions are 5 mm or smaller. The report should therefore describe morphology, location, vascular continuity, and relationship to the mesorectal fascia rather than forcing uncertain lesions into a single category. [18]

Both mrEMVI and MRI-detected tumor deposits are markers of aggressive tumor biology and may provide greater prognostic information than conventional nodal staging alone. They can threaten the mesorectal fascia even when the primary tumor remains separated from it and should therefore be included in margin assessment. A practical report should state whether EMVI and tumor deposits are absent, present, or equivocal; identify the largest involved vessel or deposit; document extension toward the mesorectal fascia or pelvic sidewall; and avoid incorporating tumor deposits into the extramural-depth measurement. Recognizing these findings separately improves risk stratification and prevents irregular extramural tumor nodules from being inaccurately reported simply as metastatic lymph nodes. [18]

Nodal Staging: Mesorectal and Lateral Pelvic Nodes

Nodal staging is a major limitation of primary rectal MRI because metastatic involvement cannot be determined reliably by size alone. Many malignant nodes are small, while reactive nodes may be enlarged. Suspicious mesorectal nodes are better identified by combining short-axis diameter with morphological features, particularly an irregular or spiculated border, heterogeneous signal intensity, and a rounded configuration. High-resolution T2-weighted imaging is essential, whereas diffusion restriction is nonspecific and should not independently determine nodal status. [19]

Even combined size and morphological criteria have only moderate diagnostic performance. A recent histopathologically matched study showed that short-axis diameter of at least 5 mm and heterogeneous signal were associated with malignancy, but the established ESGAR criteria demonstrated limited sensitivity. Moreover, structures interpreted as nodes on MRI may pathologically represent tumor deposits or EMVI. Radiologists should therefore avoid excessive confidence in individual small nodules and assess the overall nodal burden together with T stage, EMVI, tumor deposits, and other high-risk features. [20]

The report should document the number, morphology, short-axis diameter, anatomical compartment, and relationship of suspicious nodes to the mesorectal fascia. Mesorectal and superior rectal nodes should be distinguished from lateral pelvic and distant nodal disease because their surgical and oncological implications differ. The updated ESGAR recommendations favor a patient-level estimation of nodal risk rather than rigid node-by-node classification, while irregular nodes situated within 1 mm of the mesorectal fascia should also be considered potential causes of margin involvement. [1]

Lateral pelvic nodes require separate assessment, particularly in low rectal tumors. Internal iliac and obturator nodes should be measured in the short axis and reported by side and compartment. A pretreatment short-axis diameter of **7 mm or greater** is an important high-risk threshold. Multicenter evidence demonstrated that such nodes remained associated with substantial lateral local recurrence after neoadjuvant chemoradiotherapy and total mesorectal excision alone, whereas the addition of lateral node dissection reduced recurrence in selected patients. Morphology, compartment, and proximity to pelvic vessels or sidewall structures should accompany the measurement because treatment strategies remain multidisciplinary and vary internationally. [21]

T4 Disease: Peritoneal, Sphincter, and Adjacent-Organ Involvement

An mrT4a tumor invades the visceral peritoneum, most commonly at or above the anterior peritoneal reflection. Simple tumor contact with the peritoneal surface is insufficient; convincing findings include nodular or irregular thickening of the peritoneal line, broad-based tumor extension into it, or tumor signal

extending beyond the peritoneal surface. Sagittal imaging localizes the reflection, while tumor-perpendicular axial images confirm invasion. In a prospective pathological-correlation study, MRI achieved 90.6% accuracy for locating tumors relative to the peritoneal reflection but only 80.5% accuracy for diagnosing its involvement, illustrating the persistent risk of both over- and understaging. [22]

MrT4b disease requires direct invasion of an adjacent organ or anatomical structure. Loss of an intervening fat plane, broad contact, or surrounding inflammatory stranding alone should not be considered definitive. Greater confidence is obtained when intermediate tumor signal extends continuously into an adjacent organ, disrupts its muscular wall, or produces intramural nodularity. The report should specify the involved structure—such as the prostate, seminal vesicles, vagina, uterus, bladder, ureter, sacrum, pelvic sidewall, or pelvic-floor musculature—because operability and surgical planning depend on the precise site and extent of invasion. Multiplanar T2-weighted imaging remains more reliable than diffusion or enhancement alone. [23]

Low rectal tumors require a separate anatomical assessment because the mesorectum narrows distally and conventional MRF measurement becomes less informative. Coronal images parallel to the anal canal should define the tumor's relationship to the anorectal junction, internal sphincter, intersphincteric plane, external sphincter, puborectalis, and levator ani. Extension confined to the internal sphincter does not itself establish T4 disease because the internal sphincter represents continuation of the rectal muscularis propria. Tumor entering the intersphincteric plane is generally categorized as T3, whereas invasion of the external sphincter or levator/pelvic-floor musculature constitutes T4b disease and may preclude conventional sphincter-preserving surgery. [24]

The major pitfalls are confusing close contact with invasion, mistaking the peritoneal reflection for the anterior MRF, and imaging the sphincter complex in an incorrect plane. International multireader data demonstrated substantial variability in classifying T4a disease and determining the depth of sphincter involvement. In equivocal cases, the report should state the suspected structure, describe whether contact or definite invasion is present, and provide the level of diagnostic confidence. Clear anatomical description is more clinically useful than assigning an unsupported T4 category, particularly when the distinction could alter neoadjuvant therapy or the extent of pelvic surgery. [25]

Functional MRI: Added Value and Limitations

Diffusion-weighted imaging (DWI) improves detection and delineation of rectal tumors by demonstrating high signal at high b values with corresponding low signal on the apparent diffusion coefficient (ADC) map. It is particularly helpful when the primary lesion is small, obscured by luminal contents, or difficult to separate from adjacent normal rectal wall. However, its spatial resolution and anatomical detail remain inferior to high-resolution T2-weighted imaging. Although individual studies have reported comparable overall T-staging performance, DWI cannot reliably demonstrate microscopic penetration of the muscularis propria or distinguish viable extramural tumor from desmoplastic reaction. It should therefore be used to localize suspicious tissue before confirming its anatomical extent on correctly oriented T2-weighted images. [26]

Several artifacts limit DWI interpretation. Rectal gas can produce susceptibility-related distortion, while luminal contents, collapsed bowel, inflammation, and normal lymphoid tissue may show high signal at high b values. T2 shine-through should be excluded by reviewing the ADC map, but low ADC values are not specific for malignancy. Mucin-rich tumors may demonstrate relatively high ADC values because of their abundant extracellular water, creating false reassurance. Similarly, DWI can increase the number of visible lymph nodes but cannot reliably distinguish benign from metastatic nodes; one histologically validated study found that visual DWI signal and nodal ADC measurements had poor discriminatory performance. [27]

Dynamic contrast-enhanced MRI provides information regarding tumor perfusion, vascular permeability, and enhancement kinetics, but its routine value in untreated rectal cancer remains uncertain. Enhancement does not reliably differentiate tumor from inflammation, desmoplasia, or normal vascular structures, and quantitative parameters vary with acquisition technique, temporal resolution, pharmacokinetic model, and region-of-interest placement. A systematic review found heterogeneous and sometimes conflicting

associations between DCE parameters, tumor aggressiveness, and staging; the strongest evidence concerned prediction and evaluation of response after chemoradiotherapy rather than baseline local staging. Consequently, gadolinium-enhanced imaging should not replace high-resolution T2-weighted assessment or be routinely required in every primary staging examination. [28]

The most effective multiparametric strategy is therefore hierarchical rather than additive. High-resolution T2-weighted imaging should determine the tumor category, extramural depth, MRF relationship, EMVI, nodal morphology, sphincter involvement, and adjacent-organ invasion. DWI should support tumor localization and resolve selected equivocal abnormalities only when geometrically matched with the anatomical images. Contrast enhancement may be reserved for uncommon problem-solving situations, such as a small polypoid lesion, suspected inflammatory complication, or uncertain separation from an adjacent organ. No functional sequence should override a convincing anatomical finding, and discordant results should be reported transparently rather than converted into false staging certainty. Current ESGAR guidance similarly emphasizes only limited use of DWI during primary staging. [1]

Conclusion

Multiparametric MRI is indispensable for primary rectal cancer staging, but its accuracy depends on technically optimized acquisition, correct anatomical orientation, and structured interpretation. High-resolution T2-weighted imaging should remain the foundation, while diffusion-weighted and contrast-enhanced sequences should be used selectively for problem-solving rather than as independent staging tools. Particular attention to extramural invasion, mesorectal fascia status, EMVI, tumor deposits, nodal compartments, peritoneal reflection, sphincter complex, and adjacent-organ involvement can reduce common interpretive errors. Clear reporting of equivocal findings, anatomical relationships, and confidence levels improves multidisciplinary decision-making and supports more individualized treatment planning.

References

1. ESGAR Rectal Imaging Guideline Group. MRI to guide clinical management of rectal cancer: updated consensus recommendations from the European Society of Gastrointestinal and Abdominal Radiology (ESGAR)—part I: primary staging. *Eur Radiol.* 2026;36(6):4592-4607. doi:10.1007/s00330-025-12274-w
2. MERCURY Study Group. Diagnostic accuracy of preoperative magnetic resonance imaging in predicting curative resection of rectal cancer: prospective observational study. *BMJ.* 2006;333(7572):779. doi:10.1136/bmj.38937.646400.55
3. Lee S, Kassam Z, Baheti AD, et al. Rectal cancer lexicon 2023 revised and updated consensus statement from the Society of Abdominal Radiology Colorectal and Anal Cancer Disease-Focused Panel. *Abdom Radiol (NY).* 2023;48(9):2792-2806. doi:10.1007/s00261-023-03893-2
4. Beets-Tan RGH, Lambregts DMJ, Maas M, et al. Magnetic resonance imaging for clinical management of rectal cancer: updated recommendations from the 2016 European Society of Gastrointestinal and Abdominal Radiology consensus meeting. *Eur Radiol.* 2018;28(4):1465-1475. doi:10.1007/s00330-017-5026-2
5. Granata V, Caruso D, Grassi R, et al. Structured reporting of rectal cancer staging and restaging: a consensus proposal. *Cancers (Basel).* 2021;13(9):2135. doi:10.3390/cancers13092135
6. Fraum TJ, Ma J, Jhaveri K, et al. The optimized rectal cancer MRI protocol: choosing the right sequences, sequence parameters, and preparatory strategies. *Abdom Radiol (NY).* 2023;48(9):2771-2791. doi:10.1007/s00261-023-03850-z
7. Gormly KL. High-resolution T2-weighted MRI to evaluate rectal cancer: why variations matter. *Korean J Radiol.* 2021;22(9):1475-1480. doi:10.3348/kjr.2021.0560
8. Moreno CC, Sullivan PS, Mittal PK. MRI evaluation of rectal cancer: staging and restaging. *Curr Probl Diagn Radiol.* 2017;46(3):234-241. doi:10.1067/j.cpradiol.2016.11.011
9. Horvat N, Rocha CCT, Oliveira BC, Petkovska I, Gollub MJ. MRI of rectal cancer: tumor staging, imaging techniques, and management. *Radiographics.* 2019;39(2):367-387. doi:10.1148/rg.2019180114
10. Brown G, Richards CJ, Newcombe RG, et al. Rectal carcinoma: thin-section MR imaging for staging in 28

patients. *Radiology.* 1999;211(1):215-222. doi:10.1148/radiology.211.1.r99ap35215

11. Tong T, Yao Z, Xu L, et al. Extramural depth of tumor invasion at thin-section MR in rectal cancer: associating with prognostic factors and ADC value. *J Magn Reson Imaging.* 2014;40(3):738-744. doi:10.1002/jmri.24398
12. Santiago I, Figueiredo N, Parés O, Matos C. MRI of rectal cancer-relevant anatomy and staging key points. Insights Imaging. 2020 Sep 3;11(1):100. doi: 10.1186/s13244-020-00890-7. PMID: 32880782; PMCID: PMC7471246
13. Taylor FGM, Quirke P, Heald RJ, et al; MERCURY Study Group. One millimetre is the safe cut-off for magnetic resonance imaging prediction of surgical margin status in rectal cancer. *Br J Surg.* 2011;98(6):872-879. doi:10.1002/bjs.7458
14. Taylor FGM, Quirke P, Heald RJ, et al; MERCURY Study Group. Preoperative magnetic resonance imaging assessment of circumferential resection margin predicts disease-free survival and local recurrence: 5-year follow-up results of the MERCURY study. *J Clin Oncol.* 2014;32(1):34-43. doi:10.1200/JCO.2012.45.3258
15. Feng Y, Hu T, Gu W, et al. Mesorectal fascia involvement by tumor deposits or extramural vascular invasion at MRI predicts prognosis in rectal cancer. *Radiology.* 2025;317(1). doi:10.1148/radiol.243627
16. Smith NJ, Barbachano Y, Norman AR, Swift RI, Abulafi AM, Brown G. Prognostic significance of magnetic resonance imaging-detected extramural vascular invasion in rectal cancer. *Br J Surg.* 2008;95(2):229-236. doi:10.1002/bjs.5917
17. Tan JJ, Carten RV, Babiker A, Abulafi M, Lord AC, Brown G. Prognostic importance of MRI-detected extramural venous invasion in rectal cancer: a literature review and systematic meta-analysis. *Int J Radiat Oncol Biol Phys.* 2021;111(2):385-394. doi:10.1016/j.ijrobp.2021.05.136
18. Lord AC, D'Souza N, Shaw A, et al. MRI-diagnosed tumor deposits and EMVI status have superior prognostic accuracy to current clinical TNM staging in rectal cancer. *Ann Surg.* 2022;276(2):334-344. doi:10.1097/SLA.0000000000004499
19. Brown G, Richards CJ, Bourne MW, et al. Morphologic predictors of lymph node status in rectal cancer with use of high-spatial-resolution MR imaging with histopathologic comparison. *Radiology.* 2003;227(2):371-377. doi:10.1148/radiol.2272011747
20. Rutegård MK, Båtsman M, Blomqvist L, et al. Evaluation of MRI characterisation of histopathologically matched lymph nodes and other mesorectal nodal structures in rectal cancer. *Eur Radiol.* 2025;35(7):4080-4090. doi:10.1007/s00330-025-11361-2
21. Ogura A, Konishi T, Cunningham C, et al; Lateral Node Study Consortium. Neoadjuvant (chemo)radiotherapy with total mesorectal excision only is not sufficient to prevent lateral local recurrence in enlarged nodes: results of the multicenter lateral node study of patients with low cT3/4 rectal cancer. *J Clin Oncol.* 2019;37(1):33-43. doi:10.1200/JCO.18.00032
22. Álvarez Sarrado E, Giner Segura F, Batista Domenech A, et al. Rectal cancer at the peritoneal reflection: preoperative MRI accuracy and histophatologic correlation—a prospective study. *Cir Esp (Engl Ed).* 2022;100(8):488-495. doi:10.1016/j.cireng.2022.05.019
23. Khasawneh H, Khatri G, Sheedy SP, et al. MRI for rectal cancer: updates and controversies—AJR Expert Panel narrative review. *AJR Am J Roentgenol.* 2025;224(6). doi:10.2214/AJR.24.31523
24. Lee MH, Kim DH. Low rectal cancers at initial staging MRI. *Radiographics.* 2023;43(11). doi:10.1148/rg.230080
25. El Khababi N, Beets-Tan RGH, Curvo-Semedo L, et al; Rectal MRI Study Group. Pearls and pitfalls of structured staging and reporting of rectal cancer on MRI: an international multireader study. *Br J Radiol.* 2023;96(1150):20230091. doi:10.1259/bjr.20230091
26. Feng Q, Yan YQ, Zhu J, Xu JR. T staging of rectal cancer: accuracy of diffusion-weighted imaging compared with T2-weighted imaging on 3.0-T MRI. *J Dig Dis.* 2014;15(4):188-194. doi:10.1111/1751-2980.12124
27. Heijnen LA, Lambregts DMJ, Mondal D, et al. Diffusion-weighted MR imaging in primary rectal cancer staging demonstrates but does not characterise lymph nodes. *Eur Radiol.* 2013;23(12):3354-3360. doi:10.1007/s00330-013-2952-5
28. Dijkhoff RAP, Beets-Tan RGH, Lambregts DMJ, Beets GL, Maas M. Value of DCE-MRI for staging and response evaluation in rectal cancer: a systematic review. *Eur J Radiol.* 2017;95:155-168. doi:10.1016/j.ejrad.2017.08.009