Evidence Tables

Citation: Akin O, Nessar G, Agildere AM, Aydog G (2004) Preoperative staging of rectal cancer with endorectal MR imaging: Comparison with histopathologic findings. *Journal of Clinical Imaging* 28;432-438.

Design: Prospective Case Series

Country: Turkey

Aim: to assess the accuracy of endorectal MR imaging in the preoperative local staging of rectal cancers.

Inclusion criteria
None given

Exclusion criteria
One patient was excluded due to the endorectal coil not being placed appropriately.
One patient was excluded because the neoplasm extended beyond the scope of the endorectal coil
One patient was excluded because they refused surgery.

Population
N=20

Interventions
Endorectal MRI

Outcomes
Sensitivity
Specificity

Results

Endorectal MRI agreed with histopathological staging in 17/20 patients. The overall accuracy of endorectal MRI for determining T stage of rectal tumours was 85%.

		Histopathologic Staging				
		T1	**T2**	**T3**	**T4**	**Total**
Endorectal MRI staging	**T1**	2	1	-	-	3
	T2	-	2	1	-	3
	T3	-	1	11	-	12
	T4	-	-	-	2	2
	Total	2	4	12	2	20

Table: Comparison of staging based on endorectal MRI and histopathologic staging

2 tumours were identified as T1 histopathologically and on endorectal MRI
4 tumours were histopathologically identified as being T2, with 2 of these identified on endorectal MRI. In one case invasion of the muscularis propria was not detected on endorectal MRI resulting in the tumour being under-staged to T1 and in the second case the tumour was over-staged to T3 due to inflammatory changes mimicking tumour invasion into the perirectal fat.
12 tumours were histopathologically identified as T3, 11 of these were correctly identified as T3 by endorectal MRI which clearly demonstrated tumoural invasion of the perirectal fat. In one case endorectal MRI under-staged to T2 due to there being no obvious signal intensity change in the perirectal fat.
In 2 patients with bulky T4 tumours endorectal MRI accurately demonstrated invasion of adjacent pelvic organs and structures.

No significant morphological or signal characteristics on endorectal MRI to differentiate metastatic lymph nodes from normal or inflamed ones.

Considering all lymph nodes measuring greater than 0.5cm in short axis to be metastatic the sensitivity and specificity of endorectal MRI were 90.9% and 55.5% respectively and when 1cm was considered the upper limit the sensitivity dropped to 80% though the specificity increase to 70%.

		Sensitivity	**Specificity**
Lymph nodes on endorectal MRI	>0.5cm	90.9	55.5
	>1cm	80	70

Table: Sensitivity and specificity for the detection of metastatic lymph nodes with endorectal MRI

General comments
Patients underwent surgery within a week of the endorectal MRI and an experienced pathologist with no knowledge of the imaging findings examined all the surgical specimens.

Citation: Beets-Tan RGH, Beets GL, Vliegen RFA, Kessels AGH, Van Boven H, De Bruine A, von Meyenfeldt MF, Baeten CGMI, van Engelshoven JMA (2001) Accuracy of magnetic resonance imaging in prediction of tumour-free resection margin in rectal cancer surgery *The Lancet* 357;497-504

Design: Case-series

Country: The Netherlands

Aim: To assess the accuracy of phased-array MRI for preoperative staging of rectal carcinoma and the accuracy for predicting the distance of the tumour to the circumferential resection margin in a TME.

Inclusion criteria
None given

Exclusion criteria
None given

Population
N=76

Interventions
MRI at 1.5T

Outcomes
Sensitivity
Specificity
Positive Predictive Value (PPV)
Negative Predictive Value (NPV)

Results

- Final histopathologic staging showed 7 T1 tumours, 13 T2 tumours, 40 T3 tumours and 16 T4 tumours.
- For observer 1, MRI stage agreed with histopathologic staging in 83% of cases (63/76) and for observer 2, MRI stage agreed with histological stage in 67% cases (51/76).
- The intraobserver agreement of observer 1 on tumour stage was good (κ=0.80 [0.69-0.91]) and moderate for observer 2 (κ=0.49 [0.34-0.65]).
- Interobserver agreement was moderate (κ=0.53 [0.38-0.69])

	Observer 1	Observer 2
	T2	
Sensitivity	38%	46%
Specificity	94%	83%
PPV	56%	35%
NPV	88%	88%
	T3	
Sensitivity	95%	83%
Specificity	75%	61%
PPV	81%	70%
NPV	93%	76%
	T4	
Sensitivity	100%	75%
Specificity	100%	100%
PPV	100%	100%
NPV	100%	94%

Table: Results for Observer 1 and Observer 2

- The mesorectal fascia was visualised in all patients on MRI with measured distances from tumour ranging from 0mm to 33mm (mean 9.5mm). Both reviewers noted gross involvement of surrounding organs with an involved mesorectal fascia in 12 patients.
- In 29 patients the pathologist reported a tumour free distance to the margin of at least 10mm, Observer 1 correctly predicted a distance of at least 10mm in 28 of these patients and observer 2 correctly predicted a distance of at least 10mm in 27 patients.
- For observer 1, a tumour free resection margin of at least 2.0mm can be predicted with 97.5% certainty when the measured distance on MRI is at least 5.7mm for the first reading and 5.1mm for the second reading and a tumour free resection margin of at least 1.0mm can be predicted with confidence when the measured distances are at least 4.8mm and 4.1mm.
- For the first reading of observer 2 these figures are 5.2mm for a resection margin of 2.0mm and 4.2mm for a resection margin of 1.0mm. The second reading resulted in a much wider 95% prediction interval because of a

single interpretation error.

- A tumour free margin of at least 1.0mm can be predicted with a high degree of certainty when the measured distance on MRI is at least 5.0mm and a margin of 2.0mm when the distance at MRI is at least 6.0mm.

General comments
Histological tumour stage and distance to the mesorectal fascia were taken as the gold standard against which the MRI findings were compared.

Citation: Beynon J, Mortensen NJ, Foy DMA, Channer JL, Virjee J, Goddard P (1986) Preoperative assessment of local invasion in rectal cancer: digital examination, endoluminal sonography or omputed tomography *British Journal of Surgery* 73;1015-1017

Design: Prospective Case Series

Country: UK

Aim: to determine whether digital examination (DRE) endorectal sonography (ELU) or CT is the most accurate assessment in the preoperative staging of rectal cancer when compared with postoperative histopathology.

Inclusion criteria
Patients with primary rectal cancer

Exclusion criteria
None given

Population
N=44

Interventions
Digital Rectal Exam (DRE)
Endorectal Sonography (ELU)
CT

Outcomes
Accuracy
Sensitivity
Specificity
Positive Predictive Value (PPV)
Negative Predictive Value (NPV)

Results

- Surgeons were asked to allocate palpable tumours to one of four grades; grade 1 (tumour mobile over the rectal wall), grade 2 (tumour mobile not separable from the rectal wall), grade 3 (slightly fixed) or grade 4 (fixed).
- Digital exam was not possible in 10 patients due to tumour location and DRE was performed in 25 patients as part of an examination under anaesthetic or immediately prior to definitive operation.
- Accuracy of DRE dropped to 52% if non-palpable tumours were included and rose to 73% for prediction of tumours confined to rectal wall or spread beyond.
- There was a high degree of correlation of endoluminal ultrasound with post-operative histology (0.87, p<0.001).

	DRE (n=34)	ELU	CT
Accuracy	68%	91%	82%
Sensitivity	68%	94%	86%
Specificity	83%	87%	62%
Positive Predictive Value	100%	97%	91%
Negative Predictive Value	46%	78%	50%

Table: Results for DRE, ELU and CT

Citation: Bianchi P, Ceriami C, Rottoli M, Torzilli G, Pompili G, Malesci A, Ferraroni M, Montorsi M (2005) Endoscopic Ultrasonography and Magnetic Resonance in Preoperative Staging of Rectal Cancer: Comparison with Histological Findings *Journal of Gastrointestinal Surgery* 9;9:1222-1227.

Design: Case Series

Country: Italy

Aim: To comparatively assess the ability of EUS, body coil MRI (BC-MRI) and phased array MRI (PA-MRI) in the preoperative staging of rectal carcinoma using histological findings on the specimen as gold standard.

Inclusion criteria
Patients with resectable rectal carcinoma

Exclusion criteria
Patients undergoing emergency surgery
Patients who underwent previous chemotherapy or radiotherapy

Population
N=49

Interventions
Endoscopic ultrasonography
Body coil MRI
Phased array MRI

Outcomes
Sensitivity
Specificity
Positive Predictive Value
Negative Predictive Value
95% confidence interval of the accuracy of the estimates of the T and N stages

Results
There was no significant difference in the accuracies of T staging for EUS (70%, 95% CI; 65%-90%), BC-MRI (43%, 95% CI; 39%-75%) and PA-MRI (71%, 95% CI; 52%-91%).
There was no significant difference in the accuracies of N staging for EUS (63%, 95% CI; 50%-80%), BC-MRI (64%, 95% CI; 47%-82%) and PA-MRI (76%, 95% CI; 58%-94%).

	T-Stage		N-Stage	
	Sensitivity	**Specificity**	**Sensitivity**	**Specificity**
EUS	0.8	0.67	0.47	0.8
BC-MRI	0.55	0.63	0.62	0.8
PA-MRI	0.75	0.67	0.63	0.8

Table: Sensitivity and Specificity of each imaging modality

	T-Stage		N-Stage	
	Positive Predictive Value	**Negative Predictive Value**	**Positive Predictive Value**	**Negative Predictive Value**
EUS	0.85	0.64	0.67	0.64
BC-MRI	0.79	0.36	0.73	0.71
PA-MRI	0.79	0.57	0.75	0.77

Table: positive and negative predictive values for each imaging modality

	T-Stage		N-Stage	
	Overstaged	**Understaged**	**Overstaged**	**Understaged**
EUS	0.17	0.12	0.1	0.27
BC-MRI	0.25	0.32	0.14	0.21
PA-MRI	0.14	0.14	0.09	0.14

Table: proportions of cases overstaged and understaged by each imaging modality

General comments
Patients with T1-T3 disease were included in the analysis while patients with T4 disease were excluded as they received neoadjuvant therapy.

The mean time from preoperative staging to surgery was 7.5 days.

Authors Conclusions: EUS and PA-MRI provide similar results in assessing the T-stage of rectal cancer, in addition PA-MRI allows good assessment of tumour penetration, provides good visualization of rectal wall layers, is less operator dependent than EUS and is not influenced by tumour size of location.
MRI techniques have slightly better sensitivity and accuracy compared to EUS when it comes to lymph node evaluation.

Citation: Bipat S, Glas AS, Slors FJM, Zwinderman AH, Bossuyt PMM, Stoker J (2004) Rectal Cancer: Local Staging and Assessment of Lymph Node Involvement with Endoluminal US, CT and MR imaging – A Meta-Analysis *Radiology* 232;773-783.

Design: Systematic review and Meta-analysis

Country: Netherlands

Aim: to perform meta-analysis to compare endoluminal US, CT and MR imaging in the staging of rectal cancer.

Inclusion criteria
Studies were selected for inclusion if they fulfilled the following criteria:

- More than 20 patients with histologically proven rectal carcinoma or adenocarcinoma which was not treated with pre-operative chemotherapy and/or radiation therapy
- Histopathologic findings were used as the reference standard
- Sufficient data were presented to enable the construction of a 2x2 contingency table of the imaging modalities compared with the reference standard for invasion of the submucosa, muscularis propria, perirectal tissue or adjacent organs or lymph node involvement (raw 2x2 data or sensitivity and/or specificity with the absolute numbers of positive and negative findings or standard errors).

Exclusion criteria
Reviews, letters, comments, case reports and articles that did not present raw data.
Studies where the data was reported elsewhere in more detail

Population
357 articles identified
146 articles potentially eligible
31 articles were excluded due to small numbers (n<20)
1 article was excluded due to a lack or reference standard
19 articles were excluded due to incomplete or inconclusive data
5 articles were excluded due to more detailed reporting of data elsewhere

90 fulfilled the criteria for inclusion

Interventions
Endoluminal ultrasound: type of probe and frequency of transducer
CT: type of contrast material (oral, rectal, intravenous), section thickness and use of spiral mode
MRI: magnetic field strength, sequence, intravenous contrast material and coil type

Outcomes
Summary estimates of sensitivity and specificity

Results
General Study Characteristics

Stage	Imaging Modality	No of data sets	No of patients	Prevalence (%)	Years of Publication
T2	EUS	39	2881	73.1	1985-2002
	CT	2	65	96.9	1986, 1994
	MRI	13	630	83.5	1993-2002
T3	EUS	61	3904	52.7	1985-2002
	CT	18	994	61.1	1985-2002
	MRI	17	746	58.2	1993-2002
T4	EUS	37	2686	7.4	1985-2002
	CT	9	397	6.6	1985-2002
	MRI	11	537	8.4	1993-2002
N	EUS	55	3879	39.9	1986-2002
	CT	18	1123	40.8	1985-2002
	MRI	19	1003	32.5	1986-2002

Table: Study and patient characteristics

From 90 articles, 299 data sets were extracted.
64% of data sets suffered from selective patient sampling
77% suffered suboptimal interpretation of results
73% had poorly described reference standards
90% had complete verification of results
66% had sufficient description of patient populations
89% had sufficient description of diagnostic tests

50% of included data were prospectively collected

Bivariate analysis with covariates was performed to determine whether study results were significantly affected by heterogeneity between individual studies. Variables were considered to be explanatory if their regression coefficients were statistically significant (P<0.05).
Backwards stepwise regression analysis revealed a number of variables as significant predictors of the diagnostic performance of endoluminal ultrasound, CT and MRI for the evaluation of invasion of the muscularis propria, perirectal tissue and adjacent organs and lymph node involvement from rectal cancer. For this stage variables were considered statistically significant if P<0.1

Summary ROC Curves
Summary ROC Curves indicated no difference in diagnostic performance of imaging modalities for lymph node involvement; however curves for perirectal tissue invasion indicated differences in diagnostic performance, with EUS appearing to the better of the three modalities.

Due to the homogeneity of either the sensitivity or specificity values, no intercepts or slopes could be defined for data for invasion in the muscularis propria and adjacent organs.

Summary Estimates of Sensitivity and Specificity

Muscularis propria invasion
No analysis could be performed for CT due the small number of data sets available
No significant variables were identified for MRI
Publication year and sample size (>50 patients) were included as co-variates for endoluminal ultrasound

Perirectal tissue invasion
Covariates in the final model included consecutive patient selection for endoluminal ultrasound, publication year for CT and prospective data collection for MRI.

Adjacent organ invasion
The final model included year of publication and sample size (>50) patients as covariates for endoluminal ultrasound, and publication year for MRI. No significant covariates were identified for CT.

Lymph node involvement
Year of publication and prospective data collection for endoluminal ultrasound, complete verification for CT and year of publication and blind interpretation of results for MRI were included in the final model.

Stage	Imaging Modality	Sensitivity (95% CI)	Specificity (95% CI)
Muscularis propria invasion	EUS	94% (90, 97)	86% (80, 90)
	CT	NA	NA
	MRI	90% (89, 97)	69% (52, 82)
Perirectal tissue invasion	EUS	90% (88, 92)	75% (69, 81)
	CT	79% (74, 84)	78% (73, 83)
	MRI	82% (74, 87)	76% (65, 84)
Adjacent organ invasion	EUS	70% (62, 77)	97% (96,98)
	CT	72% (64, 79)	96% (95, 97)
	MRI	74% (63, 83)	96% (95, 97)
Lymph node involvement	EUS	67% (60, 73)	78% (71, 84)
	CT	55% (43, 67)	74% (67, 80)
	MRI	66% (54, 76)	76% (59, 87)

Table: Summary estimates of sensitivity and specificity in the staging of rectal cancer

- Endoluminal ultrasound specificity was significantly higher than that of MRI for muscularis propria invasion (p =0.02).
- For perirectal tissue invasion the sensitivity estimate for endoluminal ultrasound was significantly higher than for CT (p<0.001) and MRI (p=0.003). The specificity estimates did not differ significantly for any of the modalities.
- Sensitivity and specificity estimates did not differ significantly for any modality for adjacent organ invasion.
- There was no significant difference in sensitivity or specificity in relation to lymph node involvement.

Imaging Modality and Technique	Sensitivity (95% CI)	Specificity (95% CI)
MRI with body coil	83 (70, 91)	75 (54,88)
MRI with body coil and additional coil	79 (68, 87)	73 (57, 84)
MRI without contrast material	80 (61, 91)	76 (52, 90)
MRI with contrast material	81 (72, 87)	71 (59, 81)

MRI at <1.5T	86 (70, 94)	73 (48, 89)
MRI imaging at >= 1.5T	80 (70, 87)	74 (60, 84)
Endoluminal US at <7.5 MHz	91 (85, 94)	79 (76, 82)
Endoluminal US at >=7.5 MHz	89 (85, 92)	79 (71, 85)

Table: Subgroup analysis of MRI and EUS for perirectal tissue invasion

No significant difference was observed between the different techniques for MRI or EUS on subgroup analysis for perirectal tissue invasion.

General comments

The following study design characteristics were scored:

- Patient selection (consecutive, non-consecutive)
- Interpretation of test results (blinded, not blinded)
- Verification (complete or partial, if more than 10% of the study group was not subjected to the reference test the study was scored as applying partial verification)
- Methods of data collection (prospective, retrospective or unknown)
- Reporting of study population (sufficient or insufficient – a description was deemed sufficient if at least age and male to female ratio of participants were included)
- Reporting of diagnostic tests (sufficient or insufficient)
- Reporting of reference tests (sufficient or insufficient)
- Year of publication
- Sample size (number of patients)
- Mean patient age

Citation: Brown G, Davies S, Williams et al (2004) Effectiveness of preoperative staging in rectal cancer: digital rectal examination, endoluminal ultrasound or magnetic resonance imaging? *British Journal of Cancer* 91;23-29

Design: Prospective diagnostic Case Series

Country: UK

Setting:

Aim: to determine to accuracy of MRI, DRE and EUS in the identification of favourable, unfavourable and locally advanced rectal carcinoma compared with pathologic findings.

Inclusion criteria
Patients with biopsy diagnosed rectal cancer

Exclusion criteria
None given

Sample Size
N/A

Randomisation Method
N/A

Population
N=98

Study Duration
No details

Interventions
DRE
MRI
EUS

Outcomes
Preoperative identification of favourable prognosis tumours, unfavourable prognosis tumours and locally advanced tumours.

Results
Favourable Prognosis Tumours
DRE correctly identified 71%(22/31) of patients with favourable prognosis tumours; 4 tumours were not identified due to location (beyond the reach of DRE), in 3 cases apparent tethering indication more extensive extramural spread was not confirmed on histologic examination, in 2 cases bulky tumours deemed fixed on clinical assessment were found to be confined to the rectal wall on subsequent histopathologic examination.

EUS identified 45% (14/31) of patients with favourable prognosis tumours; in 15 patients, failure to reach the tumour using the EUS probe was the reason for failure.

MRI correctly identified all patients with favourable prognosis tumours, however in 9 patients there was overlap between MRI and histology assessment.

Unfavourable Prognosis Tumours
Clinical assessment (DRE) correctly identified 36% (14/39) of patients with tumour extension into perirectal fat and/or node positive status.
In 22/39 patients clinical assessment judged tomours as mobile and 9/22 showed tumour spread >5mm into perirectal fat that were not clinically tethered. In 3/39 patients, clinical assessment suggested tumour fixation.

EUS assessment correctly identified 82% (32/39) and MRI correctly identified 85% (33/39) of patients with unfavourable prognosis tumours.

Locally advanced tumours
3/28 of patients with features indicative of locally advanced disease were identified by DRE with the remainder classified as unfavourable (n=18) or favourable (n=7).

EUS identified 1 locally advanced case with tumour unassessable in 12 patients and in the remaining 15 patients, tumour deposits involving the mesorectal fascia resulting in positive CRM had not been identified.

MRI correctly identified 22/28 locally advanced tumours. In 4 cases, nodes close to the mesorectal fascia had not been detected and in 2 cases tumour was thought to have breached the wall anteriorly by <1mm though histopathologic examination showed stage pT4 peritoneal infiltration by tumour.

There was a high degree of agreement between MRI and histological assessment of tumour favourability (94%, κ=0.81, SE=0.05, weighted κ=0.83)
There was poor agreement between DRE and histological assessment (65%, κ=0.08, SE=0.068, weighted κ=0.16).
There was poor agreement between EUS and histological assessment (69%, κ=0.17, SE=0.065, κ=0.17).

Treatments
Based on the results of DRE, 51 patients would have had surgery alone, 39 patients would have had short course radiotherapy and 8 patients would have had long-course radiotherapy versus 22, 14 and 3 patients in each treatment group when basing the results on histopathologic assessment. The remainder of the patients would have been over or under treated.
On EUS staging 48% of patients would have been correctly selected while on MRI staging 88% of patients would have been correctly selected.

Citation: Brown G, Richards C, Bourne A, Newcombe R, Radcliffe A, Dallimore N, Williams G (2003) Morphological predictors of lymph node status in rectal cancer with the use of high-spatial resolution MR imaging with histopathological comparison *Radiology* 227;371-377

Design: Case Series

Country: UK

Aim: To evaluate signal intensity and border characteristics of lymph nodes at high-spatial resolution magnetic resonance imaging in patients with rectal cancer and to compare the findings with size in prediction of nodal status.

Inclusion criteria
Patients who underwent total mesorectal excision of the rectum with a biopsy to determine whether they had rectal carcinoma.

Exclusion criteria
None given

Population
N=42

Interventions
MRI at 1.5T with a four element pelvic phased array wrap around surface coil

Outcomes
Sensitivity
Specificity

Results
437 lymph nodes were harvested from 42 patients, of these 102; all with diameters less than 3mm were not identified on MRI. An additional 51 (7 containing metastasis) lymph nodes were above the area imaged by MRI leaving a total of 284 lymph nodes available for evaluation.

Nodal Size Criteria
The size of lymph nodes containing metastases varied greatly at MRI; 58% (35/60) of positive lymph nodes had a diameter of less than 5mm.
MRI measurement of nodal diameter ranged from 2-10mm in 119 benign nodes from 20 patients with node-negative status and from 3-15mm in 60 cancerous nodes from 22 patients with node-positive status.
In 71% of patients with lymph node metastases, the size of normal or reactive nodes was similar to or greater than the smallest positive node in the same specimen.

	Sensitivity	Specificity
	≤5mm	
Nodal Status	81%	68%
Nodal Detection	42%	87%
	>10mm	
Nodal Status	3%	100%
Nodal Detection	78%	59%

Table: Sensitivity and Specificity

The overall predictive value of MR size is poor due to substantial overlap in size between nodes that are benign and malignant.

Signal Intensity and Border Characteristics
- The signal intensity and border characteristics could not be evaluated further due to image degradation caused by motion artefact in 3/284 nodes depicted by MRI.
- 75 of the remaining 281 nodes were hyper-intense on MRI and of these 3 (4%) were malignant.
- 91 nodes were iso-intense on MRI with 7 (8%) malignant.
- 83 nodes were hypo-intense on MRI, with 11 (13%) malignant.
- 32 nodes showed mixed signal intensity on MRI, with 29 (91%) malignant.
- Using mixed signal intensity alone as a marker for nodal involvement gave a sensitivity of 48% and specificity of 99%.
- 15/232 nodes with smooth borders contained metastases compared with 45/49 nodes with irregular borders thus giving a sensitivity of 75% and a specificity of 98%.
- Defining a positive node as one with either irregular border or mixed signal intensity gave a sensitivity of 85%

(95% CI: 74%, 92%) and specificity of 98% (95% CI: 95%, 99%).

- Using lymph node contour and MR signal intensity to identify patients with nodal metastases resulted in a sensitivity of 77% (95% CI: 57%, 90%) and a specificity of 95% (95% CI: 76%, 99%)
- A comparison of nodal sensitivity and specificity between the assessment of morphology (irregular border or mixed signal intensity) and node size (cut-off of >5mm) showed a significant difference in both sensitivity (43%; 95% CI: 28%, 56%) and specificity (11%; 95% CI: 6%, 16%) in favour of morphology.

General comments

MR images of the nodes were characterized according to nodal size and border contour and signal intensity.
Nodal size criteria – maximum diameter of the lymph node was measured in millimeters
Border Contour and Signal Intensity – borders of each node were classified as smooth and well-defined or as irregular and ill-defined.

Citation: Brown G, Richard C, Newcombe R et al (1999) Rectal Carcinoma: Thin Section MR Imaging for staging in 28 patients *Radiology* 211;215-222

Design: Prospective Case Series

Country: UK

Setting:

Aim: To evaluate the accuracy of thin-section MRI in the preoperative assessment of extramural tumour infiltration.

Inclusion criteria
Patients with rectal carcinoma proven by means of endoluminal biopsy using snare forceps at the time of initial clinical presentation

Exclusion criteria
None given

Sample Size
N/A

Randomisation Method
N/A

Population
N=28 (8 females and 20 males)

Study Duration
No details given

Interventions
MRI with a 1.5T whole body system using a four element flexible wrapping around surface coil performed 7 days before surgery and within 4 weeks of initial assessment and biopsy.

Outcomes
Diagnostic Accuracy of MRI using a four element surface coil, in determining the extent of tumour infiltration compared with histopathology

Results
All patients received preoperative short course radiotherapy followed by total mesorectal excision or abdominoperineal excision.

Each MR image was interpreted by two experienced readers independently and without the knowledge of clinical and histopathologic data.

MRI allowed visualisation and delineation of the layers of the rectal wall and mesorectal fascia in all patients and tumour was identified as having higher signal intensity than the circular and longitudinal muscle layers but a lower intensity than the submucosa.

The primary criterion for the differentiation between T1 and T2 lesions was the lack of extension of the tumour into the circular muscular layer.
The primary criterion for the differentiation between T2 and T3 tumours was infiltration of perirectal fat, further defined as extension beyond the contour of the interface between muscle and fat with a rounded or nodular advancing margin.

Tumour Staging of Rectal Carcinoma
Histopathologic examination showed 5 T", 18 T3 and 2 T4 tumours
3 patients had tumour present at the circumferential excision margins of a portion of the specimen, indicating incomplete excision but no positive histologic evidence of adjacent organ invasion and so these patients were not included in the tumour staging analysis.

There was complete agreement between both readers and MRI correctly predicted the overall histopathologic stage of every completely excised tumour.

11 patients were found to have discrete extraluminal deposits not in continuity with the main tumour; none could be proved to be within lymph nodes though 7/11 had unequivocal involvement of other lymph nodes.

5/17 patients without extramural deposits on MRI were found to have lymph node metastases.

Extramural deposits were found in every patient with involved resection margins.

Measurement of the Depth of Extramural tumour Penetration
23 patients had extramural tumour spread and there appeared to be good agreement between the measured depth visible on preoperative MRI and the corresponding histopathologic slices.

Preoperative MR assessment of extramural penetration in incompletely excised specimens
5/11 patients with extraluminal deposits did not have complete excision at the circumferential margin.
2 patients had involvement of the posterior mesorectal margin and the same two patients represented the greatest measured depth of extramural invasion visible on preoperative MRI (45mm and 30mm compared with a median of 6mm and range of 1-19mm in patients with posterior extramural spread in whom local excision was complete).
The remaining 3 patients had low rectal tumours with anterior margin involvement; 2 were men with seminal vesicle invasion resulting in a histopathologic classification of stage T4. The measured extramural tumour penetration visible on preoperative MRS was 4mm and 5mm compared with <1mm in 2 men with completely excised low anterior tumours.
The remaining female patient had extramural penetration measured at 14mm, no other women had low anterior rectal tumours.

Citation: Chun HK, Choi D, Kim MJ, Lee J, Yun SH, Kim SH, Lee SJ, Kim CK (2006) Preoperative Staging of rectal Cancer: Comparison of 3-T High Field MRI and Endorectal Sonography *American Journal of Roentgenology* 187;6:1557-1562

Design: Case Series

Country: South Korea

Aim: to compare phased-array 3-T MRI and endorectal sonography in the preoperative staging of rectal cancer

Inclusion criteria

Exclusion criteria

Population
N=24 patients with rectal cancer

Interventions
3-T MRI
Endorectal sonography

Outcomes
Sensitivity
Specificity
Diagnostic Accuracy

Results
For local invasion, sensitivity and specificity of endorectal sonography and MRI were calculated as follows: for muscularis propria invasion, stage T2 or higher versus stage T1, for perirectal tissue invasion, stage T3 or higher versus stage T2 or lower and for invasion of adjacent organs, stage T4 versus stage T3 or lower.

All rectal cancers were identified on both endorectal sonography and MRI
For local invasion, histopathological examinations revealed 6 T1 cancers, 3 T2 cancers and 15 T3 cancers

Local Invasion
Muscularis Propria
Mean sensitivity and specificity of MRI for all observers was 100% and 66.7% respectively and for endorectal sonography the mean sensitivity and specificity for all observers was 100% and 61.1% respectively. There was no significant difference in the mean sensitivities or specificities for either modality.
The positive predictive value of MRI was 90% and for endorectal sonography was 88.5% and the negative predictive values for both modalities were 100%.
The accuracies of MRI and endorectal sonography for all observers were 91.7% and 90.3% respectively.
Results of ROC assessment of pooled data from three observers, the Az value of MRI and endorectal sonography showed no statistically significant difference in diagnostic accuracy.

Perirectal tissue invasion
The mean sensitivity and specificity of MRI for all observers was 91.1% and 92.6% respectively and for endorectal sonography the mean sensitivity and specificity for all observers was 100% and 81.5% respectively. There was no significant difference in the mean sensitivities or specificities for either modality.
The positive predictive value of MRI was 95.3% and for endorectal sonography was 90% and the negative predictive values for both modalities 86.2% for MRI and 100% for endorectal sonography.
The accuracies of MRI and endorectal sonography for all observers were 91.7% and 93.1% respectively.
Results of ROC assessment of pooled data from three observers the Az value of endorectal sonography had higher diagnostic accuracy than that of MRI (p=0.028).

Lymph Node Involvement
From histopathological examination 225 lymph nodes from the rectal cancer specimens of 21 patients that underwent total mesorectal excision were identified. 35/225 (15.6%) were found to be metastatic; 13 had N0 disease, 7 had N1 disease and 4 had N2 disease.
The mean sensitivity and specificity of MRI for lymph node involvement was 63.6% and 92.3% respectively and for endorectal sonography the mean sensitivity and specificity for all observers was 57.6% and 82.1% respectively. There was no significant difference in the mean sensitivities or specificities for either modality.
The positive predictive value of MRI was 87.5% and of endorectal sonography was 73.1% and the negative predictive values for both modalities were 75% for MRI and 69.6% for endorectal sonography.

The accuracies of MRI and endorectal sonography were 79.2% and 70.8% respectively.
There was no significant difference in diagnostic accuracy for the three observers on ROC assessment of pooled data.

Performance Measures by Imaging Technique	Muscularis Propria Invasion	Perirectal Tissue Invasion	Lymph Node Involvement
Sensitivity			
3-T MRI	100% (54/54)	91.1% (41/45)	63.6% (21/33)
Endorectal Sonography	100% (54/54)	100% (45/45)	57.6% (19/33)
Specificity			
3-T MRI	66.7% (12/18)	92.6% (25/27)	92.3% (36/39)
Endorectal Sonography	61.1% (11/18)	81.5% (22/27)	82.1% (32/39)
Diagnostic Accuracy (Az)			
3-T MRI	0.971 +/- 0.018	0.938 +/- 0.028	0.776 +/- 0.056
Endorectal Sonography	0.978 +/- 0.015	0.996+/- 0.007	0.721 +/- 0.061

Table: Mean sensitivity, specificity and diagnostic accuracy of 3-T MRI and Endorectal Sonography in Preoperative staging of Rectal Cancer by three observers.

Interobserver agreement
The kappa values for muscularis propria invasion showed good or excellent agreement for both imaging techniques. For perirectal tissue invasion the kappa values among observers showed excellent agreement for both techniques. In relation to lymph involvement showed moderate agreement for MRI and good or excellent agreement for endorectal sonography.

Imaging Technique	Muscularis Propria Invasion	Perirectal Tissue Invasion	Lymph node Involvement
3-T MRI			
Observer 1 vs. Observer 2	0.7	0.83	0.503
Observer 1 vs. Observer 3	0.7	0.83	0.417
Observer 2 vs. Observer 3	1	0.822	0.417
Endorectal Sonography			
Observer 1 vs. Observer 2	1	0.903	0.798
Observer 1 vs. Observer 3	0.833	0.903	1
Observer 2 vs. Observer 3	0.833	1	0.798

Table: Interobserver agreement in preoperative staging of rectal cancer

Citation: Dighe S, Purkayastha S, Swift I et al (2010) Diagnostic precision of CT in local staging of colon cancers: a meta-analysis *Clinical Radiology* 65;708-719

Design: Systematic Review

Country:

Setting:

Aim: to determine the accuracy and limitations of CT in identifying poor prognostic factors (muscularis propria invasion and detection of malignant lymph nodes) in colon cancers and to determine which CT technique achieved the best results.

Inclusion criteria
CT used to stage colonic tumours preoperatively
Provided information on the tumour invasion beyond the muscularis propria and presence of malignant lymph nodes (N stage)
Histopathologic analysis as the reference standard
Sufficient per patient data was provided in order that the 2x2 tables could be extracted.

Exclusion criteria
No clear exclusion criteria given however studies were excluded for a variety of reasons including:
Studies in which the majority of tumours analysed were rectal lesions
2x2 tables could not be extracted
No English translation
No histology results
No differentiation between T2 and T3 lesions

Sample Size
N/A

Randomisation Method
N/A

Population
N=19 studies from which the requisite data could be extracted

Study Duration
N/A

Interventions
Preoperative CT

Outcomes
Sensitivity and specificity of CT to differentiate between T1/T2 and T3/T4 tumours and lymph node involvement

Results
19 studies with a total of 907 patients were considered for analysis.

Sensitivity and specificity for the detection for muscularis propria invasion could be derived from 17 studies (n=784 patients) and overall sensitivity and specificity for detection of malignant lymph nodes could be derived from 15 studies (n=674 patients).

There was evidence from the funnel plots that smaller studies were associated with a larger diagnostic odds ratio for both tumour invasion and lymph node detection, though this was not statistically significant (p=0.07).

False Positives and False Negatives
A significant number of false negatives for muscularis propria invasion resulted in understaging of T3/T4 tumours in 4 studies however the three of the four studies were older and CT was performed without the benefit of spiral or MDCT and with a section thickness of 10mm which may be a factor in the failure to detect small amount of tumour invasion. In the fourth study, there did not appear to be any reason for the high false negative rate other than the possibility that the study population included many patients with microscopic invasion beyond the muscularis propria.

The false positive rate was low in all included studies suggesting that CT can reliably identify T3/T4 tumours.

For nodal involvement, earlier studies showed poor results for similar reasons.

Distinction between T1/T2 and T3/T4 tumours
Earlier studies did not make the distinction between T3 (tumour extension beyond muscularis propria) and T4 tumours (tumour with perforation, invading adjacent organs, penetrating peritoneal surface).

A summary estimate (derived by bivariate random effects model) for differentiating between T1/T2 and T3/T4 tumours was 86% (95% CI 78-92%) for sensitivity and 78% (95% CI 71-84%) for specificity.

From eight studies, the summary estimate for differentiating between T3 and T4 disease was 92% for sensitivity and 81% for specificity

	Studies (n)	Patients (n)	Sensitivity (95% CI)	Specificity (95% CI)	Diagnostic Odds Ratio (95% CI)	P value for publication bias
All Studies Combined	17	784	0.86 (0.78-0.92)	0.78 (0.71-0.84)	22.4 (11.9-42.4)	0.07
Quadas Score ≥12	9	448	0.92 (0.83-0.97)	0.84 (0.73-0.91)	58.3 (19-179.2)	0.11
Assessment of TNM staging (distinction between T3 and T4)	8	399	0.92 (0.87-0.95)	0.81 (0.7-0.89)	48.6 (22.9-103.1)	0.51
Section thickness ≤5mm	7	272	0.95 (0.88-0.98)	0.84 (0.74-0.91)	95.3 (38-238.6)	0.63
Rectal insufflations with air or water	8	336	0.95 (0.9-0.97)	0.86 (0.76-0.92)	104.5 (44.8-243.9)	0.43
Oral contrast	6	255	0.84 (0.63-0.94)	0.79 (0.66-0.88)	20.1 (5.7-70.5)	0.22
Spiral CT or MDCT	13	590	0.93 (0.86-0.96)	0.81 (0.72-0.87)	53.5 (24-119.7)	0.04
Studies after 2000	10	499	0.92 (0.84-0.96)	0.8 (0.7-0.88)	46.6 (19.4-112.2)	0.11
Studies before 2004	8	406	0.92 (0.81-0.97)	0.81 (0.68-0.89)	44.9 (15.4-130.7)	0.18
Spiral CT	7	384	0.92 (0.82-0.97)	0.74 (0.63-0.82)	32.7 (12.1-88.5)	0.21
MDCT	6	206	0.93 (0.85-0.97)	0.86 (0.75-0.93)	48.6 (22.9-103.1)	0.64

Table: Tumour Invasion

	Studies (n)	Patients (n)	Sensitivity (95% CI)	Specificity (95% CI)	DOR (95%CI)	p-value for publication bias
Overall Analysis	15	674	0.70 (0.59-0.8)	0.78 (0.66-0.86)	8.1 (4.7-14.1)	0.07
Quadas score ≥12	8	354	0.78 (0.69-0.84)	0.79 (0.66-0.88)	113 (5.6-30.2)	0.09
Section thickness ≤5mm	6	220	0.82 (0.68-0.91)	0.75 (0.62-0.84)	13.6 (4.7-39.7)	0.048
Rectal insufflations with air or water	8	366	0.78 (0.69-0.85)	0.78 (0.64-0.87)	12.6 (5-31.9)	0.14
Oral contrast	6	316	0.66 (0.51-0.79)	0.79 (0.53-0.92)	7.1 (3.1-16.7)	0.45
Spiral CT or MDCT	11	480	0.76 (0.68-0.83)	0.75 (0.65-0.84)	9.7 (4.9-19.3)	0.045
Studies after 2000	6	266	0.75 (0.62-0.85)	0.77 (0.64-0.87)	10.4 (4.2-25.5)	0.25
Studies before 2004	5	206	0.79 (0.65-0.88)	0.8 (0.65-0.9)	15.1 (6.7-33.6)	0.97
Spiral CT	7	346	0.69 (0.6-0.77)	0.78 (0.64-0.88)	8 (3.3-19.4)	0.27
MDCT	4	134	0.87 (0.77-0.93)	0.7 (0.55-0.83)	15.3 (6.15-38.19)	0.39

Table: Subgroup Analysis for Nodal Detection

Citation: Dirisamer A, Halpern B, Flory D et al (2010) Performance of integrated FDG-PET/contrast enhanced CT in the staging and restaging of colorectal cancer: Comparison with PET and enhanced CT *European Journal of Radiology* 73;324-328

Design: Retrospective analysis of diagnostic exams

Country: USA

Setting:

Aim: to evaluate the diagnostic role of 18-FDG-PET/CT including a contrast enhanced CT component compared with FDG PET and CECT alone.

Inclusion criteria
Biopsy proven primary colorectal cancer, suspected recurrent CRC or suspected distant disease recurrence on the basis of other imaging tests, tumour markers or clinical symptoms.

Exclusion criteria
Patients who had received chemotherapy or radiotherapy within 4 weeks prior to PET CT scan.
Patients with co-existent non-colorectal disease

Sample Size
N/A

Randomisation Method
N/A

Population
N=73

Study Duration
Patients were examined between July 2004 and May 2007

Interventions
18-FDG PET/CT

Outcomes
Sensitivity
Specificity
Positive Predictive Value
Negative Predictive Value
Accuracy

Results
Patients image data sets were blinded and separated into CT, PET and PET-CT images
PET images were interpreted by an experienced nuclear medicine physician; CT images were interpreted by a radiologist who was blinded to the PET findings.

Lesion by lesion and patient by patient analysis were conducted performed with PPET/CT images reviewed 6 weeks after reading the PET and CT datasets.

The accuracy of the imaging findings was determined by histological verification or patient follow-up which included histopathologic evaluation of lesions found by imaging or clinical follow-up with available clinical data. For bone metastasis, follow-up examinations were scintigraphy and/or CT/MRI.

Mean clinical follow-up was 18 months.

26/73 patients underwent PET/CT for staging and 47/73 for restaging.
A total of 266 lesions were identified based on histopathology or clinical/imaging follow-up demonstrating either disease progression or response.
On a lesion by lesion basis PET/CT identified 28 metastatic lesions not detected on ce-CT alone and 40 lesions not detected on PET alone.
PET/CT correctly identified 266 lesions and was false positive in 2 lesions.

PET detected only 14/41 lung metastases, the majority of which were smaller than 8mm.
CT detected only 48/72 lymph node metastases with the missed lesions smaller than 12mm in the short axis.

PET/CT correctly identified 107 liver lesions while CT alone detected 103 and PET alone detected 99 lesions.

On a patient basis, every 73 patients were correctly diagnosed with PET/CT.

	Number of Lesions	Staging	Restaging	PET/CT	ce-CT	PET
Local Recurrence	34		34	35	34	35
Lymph Nodes	72	24	48	72	48	72
Liver	107	55	52	108	103	99
Lung	41	10	31	41	41	14
Peritoneal Carcinomatosa	9	3	6	9	9	4
Bone	3	3	0	3	3	3

Table: Summary of Malignant lesion and lesion detection of each modality

	PET	ce-CT	PET/CT
Sensitivity	85%	91%	100%
Specificity	70%	100%	81%
PPV	97%	100%	99%
NPV	25%	33%	100%
Accuracy	84%	86%	99%

Table: Diagnostic Value of PET, ce-CT and PET/CT in the staging and restaging of colorectal cancer

Citation: Fillipone A, Ambrosini R, Fushi M, Marinelli T, Genovesi D, Bonomo L (2004) Preoperative T and N staging of colorectal cancer: Accuracy of Contrast-enhanced Multi-Detector Row CT Colonography – Initial Experience. *Radiology* 231; 83-90

Design: Prospective Case Series

Country: Italy

Aim: To evaluate the accuracy of contrast material-enhanced multidetector row computed tomographic (CT) colonography for preoperative staging of colorectal cancer.

Inclusion criteria
Patients with histopathologically proven colorectal cancer

Exclusion criteria
None given

Population
N=41

Interventions
CT Colonography

Outcomes
Sensitivity
Specificity
Accuracy
Positive Predictive Value
Negative Predictive Value

All of the above were calculated for transverse images alone and in combination with MPRs for T and N staging.

Differences in accuracy for T and N staging were calculated.

Results
All 41 colorectal cancers were identified on contrast-enhanced CT colonography as a wall thickening of more than 0.5cm.
Tumours were correctly located in the rectum in 26 patients, the sigmoid colon in 8 patients, the descending colon in 3 and the ascending colon in 4 patients.

T Staging
At histopathological examination, 3/41 neoplasms were staged as pT1, 10/41 as pT2, 25/41 as pT3 and 3/41 as pT4. Overall accuracy of CT colonography was 73% (30/41) when evaluating transverse images alone and improved to 83% (34/41) when evaluating transverse and MPR images in combination.
Over-staging occurred in 22% (9/41) and under-staging occurred in 5% (2/41) patients when using transverse images. When using combined transverse images and MPRs, over-staging occurred in 12% (5/41) patients and under-staging occurred in 5% (2/41) patients.

Stage		Accuracy	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value
≤T2 (n=13)	Transverse Images Alone	90%	82%	93%	82%	93%
	Transverse and MPR images combined	93%	92%	93%	86%	96%
T3 (n=25)	Transverse Images Alone	85%	76%	100%	100%	73%
	Transverse and MPR images combined	90%	88%	94%	96%	83%
T4 (n=3)	Transverse Images Alone	80%	100%	79%	27%	100%
	Transverse and MPR images combined	98%	100%	97%	75%	76%

Table: Results for contrast enhanced CT colonography for each T-stage

N-Staging
At histopathological examination 21/41 neoplasms were staged as pN0, 11/41 as pN1 and 9/41 as pN2. Overall accuracy of N-stage assessment on contrast enhanced multi detector row CT colonography was 59%.
Over-staging occurred in 29% of patients and under-staging occurred in 12% of patients. When using combined transverse images and MPRs, overall accuracy increased to 80% and over-staging occurred in 12% of patients and under-staging occurred in 7% of patients. The difference between transverse images alone and transverse images

in combination with MPRs was statistically significant ($p<0.01$).

Stage		Accuracy	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value
N0 (n=21)	Transverse Images Alone	71%	62%	80%	76%	67%
	Transverse and MPR images combined	85%	81%	90%	89%	82%
N1 (n=11)	Transverse Images Alone	63%	27%	77%	30%	74%
	Transverse and MPR images combined	83%	73%	87%	67%	90%
N2 (n=9)	Transverse Images Alone	83%	89%	81%	57%	96%
	Transverse and MPR images combined	93%	89%	94%	80%	97%

Table: Results for contrast enhanced CT colonography for each N-stage

Nodal metastases were detected in 80% (16/20) of patients using transverse images alone and in 90% (18/20) of patients when using combined images. 59% of patients without nodal metastases were correctly classified using transverse images alone and 77% were correctly classified using transverse images and MPR's in combination.

Interobserver Agreement

Two independent readers were partially blinded to endoscopic results and completely blinded to lesion size, macroscopic features and stage of colorectal cancer. Blinded consensus was used to resolve disagreements between radiologists. For T-stage, overall there was 93% agreement when evaluating transverse images alone and 98% agreement when evaluating transverse images and MPRs in combination. For N-stage, overall agreement was 90% for transverse images alone and 97% for transverse images and MPRs combined.

General comments

CT readers considered three T stages; ≤T2 (to account for known limitations of CT in distinguishing T1 and T2 lesions), T3 (defined as tumours with rounded or nodular advancing margins) and T4.

For N stage, N1 was defined as a cluster of three nodes, independent of size or if fewer than three lymph nodes were present with at least one of them measuring at least 1cm in long axis. N2 was defined as more than three perivisceral lymph nodes regardless of size and N3 was considered to be the presence of enlarged retroperitoneal lymph nodes (≥1cm in long axis).

Citation: Fuchsjager M, Maier A, Schima W, Zebedin E, Herbst F, Mittlbock M, Wrba F, Lechner G (2003) Comparison of transrectal sonography and double-contrast MR imaging when staging rectal cancer *American Journal of Roentgenology* 181;2:421-427.

Design: Prospective Case Series

Country: Austria

Aim: to assess the accuracy of double contrast MR imaging compared with transrectal sonography in the preoperative staging of rectal cancer.

Inclusion criteria
None given

Exclusion criteria
None given

Population
N=39

Interventions
Double contrast MRI
Transrectal sonography

Outcomes
Sensitivity
Specificity

Results
Overall
In 28 patients that underwent both MRI and transrectal sonography, the overall accuracies for MRI were 57% for T-stage and 79% for bowel wall penetration, for transrectal sonography the overall accuracies were 64% for T-stage and 83% for bowel wall penetration. There was no significant difference between MRI and transrectal sonography with regard to T-stage (p=0.6).

Transrectal Sonography
It was not possible to do endosonographic imaging in 28% of patients either due to the tumour being located to high in the rectum or because the tumour was stenotic.
In the remaining patients transrectal sonography had an overall accuracy of 64% for T-stage.
For rectal wall penetration for stages T1 and T2 versus T3 and T4, transrectal sonography showed a sensitivity of 93% (95% CI, 66.1-99.8%), a specificity of 71% (95% CI, 41.9%-91.6%) and an accuracy of 82% (Dukes Classification).
7 patients were over-staged, 6 of whom had undergone preoperative radiation; 3 T1 tumours were over-staged as T2 and 3 T2 tumours were classified as T3.

Accuracy for patients who underwent preoperative radiotherapy (15/28) was 60% for T-staging and 73% for bowel penetration (Dukes Classification). For patients without preoperative radiotherapy the accuracy was 69% for T stage and 92% for bowel wall penetration. There was no statistically significant difference in accuracies between the two groups (p=0.71).

Accuracy of transrectal sonography was 81%, sensitivity was 92% (95% CI, 64-99.8%) and specificity was 71% (95% CI, 41.9-91.6%) for the presence or absence of nodal disease.

Double Contrast MRI
MRI correctly staged 25/39 tumours for an accuracy of 64% for T stage; accuracy for MRI at the 1.0-T MR unit was 67% and for MRI at the 1.5-T MR unit was 62% (p=0.54).
Disease was overstaged in 10 patients, 7 of whom underwent pre-operative radiation and was understaged in 4 patients.
Double contrast MRI showed 100% sensitivity (95% CI, 88.3-100%) and 60% specificity (95% CI, 32.3-83.7%) and an accuracy of 85% (Dukes classification) for rectal wall penetration.

Accuracy for patients who underwent preoperative radiotherapy (19/39) was 53% for T-stage and 68% for bowel wall penetration. For patients that did not undergo preoperative radiotherapy (20/39) the accuracy was 75% for T-stage and 100% for bowel wall penetration. The differences between the two groups were not statistically significant.

Accuracy of MRI was 70%, sensitivity was 81% (95% CI, 54.4-96%) and specificity was 62% (95% CI, 38.4-81.9%) for the presence or absence of nodal disease.

Citation: Halefoglu A, Yildirim S, Avlanmis O, Sakiz D, Baykan A (2008) Endorectal ultrasonography versus phased array magnetic resonance imaging for preoperative staging of rectal cancer *World Journal of Gastroenterology* 14;22:3504-3510

Design: Case Series

Country: Turkey

Aim: to compare diagnostic accuracy of pelvic phased-array magnetic resonance imaging (MRI) and endorectal sonography (ERUS) in the preoperative staging of rectal carcinoma.

Inclusion criteria
Patients with biopsy proven rectal cancer

Exclusion criteria
Patients who previously underwent chemotherapy or radiotherapy

Population
N=34

Interventions
Endorectal Ultrasonography
MRI

Outcomes
Accuracy
Sensitivity
Specificity

Results
Histopathological evaluation of resected tumours revealed adenocarcinoma for all patients; pathological T-stage of tumours was pT1 in 1 patient, pT2 in 9 patients, pT3 in 21 patients and pT4 in 3 patients and pathological N-stage was pN0 in 19 patients pN1 in 9 patients and pN2 in 6 patients.

All tumours could be detected by both ERUS and MRI

T-staging
MRI
The accuracy of T-staging was 89.7%, the sensitivity was 79.41% and the specificity was 93.14%. MRI correctly identified invasion in 23 patients and no invasion in 6 patients for an overall accuracy of 85.29%, sensitivity of 95.8% and specificity of 60% for discriminating between p-T1-pT2 and pT3-pT4 tumours.
The positive and negative predictive values were 85.19% and 85.7% respectively.

ERUS
The accuracy of T-staging was 85.29%, the sensitivity was 70.59% and specificity was 90.20%. ERUS correctly identified invasion in 21 patients and no invasion in 5 patients for an overall accuracy of 76.47%, sensitivity of 76.47% and specificity of 50% for discriminating between p-T1-p-T2 and pT3-pT-4 tumours. The positive and negative predictive values were 80.77% and 62.5% respectively.

N-Staging
The accuracy of phased array MRI for the detection of lymph node metastases was 74.5%, the sensitivity was 61.6% and specificity was 80.88%.
For ERUS, the accuracy for the detection of lymph node metastases was 76.47%, the sensitivity was 52.94% and specificity was 84.31%.

		p-T1	p-T2	p-T3	p-T4
MRI	MR-T1	1	0	0	0
	MR-T2	0	5	1	0
	MR-T3	0	4	18	0
	MR-T4	0	0	2	3
	No. of cases	1	9	21	3
ERUS	ERUS-T1	0	0	0	0
	ERUS-T2	1	4	3	0
	ERUS-T3	0	5	18	1

	ERUS-T4	0	0	0	2
	No. of cases	1	9	21	3

Table: T-staging evaluation by MRI and ERUS

		p-N0	**p-N1**	**p-N2**
MRI	**N0**	8	1	1
	N1	11	8	0
	N2	0	0	5
ERUS	**N0**	7	2	2
	N1	12	7	0
	N2	0	0	4

Table: N-staging evaluation by MRI and ERUS

	T-Stage		**N-Stage**	
	Overstaged	**Understaged**	**Overstaged**	**Understaged**
MRI	6	1	11	2
ERUS	6	4	12	4

Table: Comparison of overstaged and understaged cases by MRI and ERUS

Citation: Kantorova I, Lipska L, Belohlavek O, Visokai V, Trubac M, Schneiderova M (2003) Routine ^{18}F-FDG PET Preoperative staging of colorectal cancer: comparison with conventional staging and its impact on treatment decision making *Journal of Nuclear Medicine* 44;11:1784-1788

Design: Case Series

Country: Czech Republic

Aim: to assess the potential clinical benefit of ^{18}F-FDG PET in the routine staging of colorectal cancer

Inclusion criteria
Patients with histologically proven colorectal cancer

Exclusion criteria

Population
N=38

Interventions
^{18}F-FDG PET
Sonograpy
CT
Chest X-ray

Outcomes
Sensitivity
Specificity
Accuracy

Results
^{18}F-FDG PET correctly detected 95% (35/37) of primary tumours compared to CT which detected 49% and sonography which detected 14%.

Lymph nodes were involved in 7 patients; the sensitivity of ^{18}F-FDG PET was 29% (2/7), specificity was 88% (22/25) and accuracy was 75% (24/32). PET findings were false negative in 5/7 patients and false positive in 3/25 patients. CT and sonography did not detect any lymph node involvement.

Liver metastases were present in 9 patients.

	^{18}F-FDG PET	CT	Sonography
Sensitivity	78%	67%	25%
Specificity	96%	100%	100%
Accuracy	91%	91%	81%

Table: Results for each modality in relation to liver metastases

General comments
There is not a lot of data or information in this paper and the main focus appeared to be how management/treatment decisions were affected by ^{18}F-FDG PET rather than how useful it was for staging.

Citation: Kim CK, Kim SH, Choi D, Kim MJ, Chun HK, Lee SJ, Lee JM (2007) Comparison between 3-T Magnetic Resonance Imaging and Multi-Detector Row Computed Tomography for the Preoperative Evaluation of Rectal Cancer *Journal of Computer Assissted Tomography* 31;853-859

Design: Prospective Case Series

Country: South Korea

Aim: To compare between 3-T magnetic resonance imaging (MRI) and multi-detector row computed tomography (MDCT) for the local staging of rectal cancer.

Inclusion criteria
Patients who underwent both MRI and computed tomographic imaging with histopathologically proven rectal cancer.

Exclusion criteria
Patients that had received preoperative radiation or chemotherapy
Patients that refused surgery
Patients that were inoperable
Patients that underwent MRI only
Patients that had anal fistula
Patients with endometriosis in the rectum

Population
N=31

Interventions
3.0T whole body MRI
Multi-detector row CT

Outcomes
Accuracy
Sensitivity
Specificity
Positive Predictive Value (PPV)
Negative Predictive Value (NPV)

Results

- MR and CT imaging allowed visualisation of tumours in all patients.
- Rectal wall layers seen on MDCT could not be discriminated in all patients with rectal cancer.
- Histopathologic staging revealed 8 patients with T1 tumour, 6 patients with T2 tumour and 17 patients with T3 tumour.
- There was a significant difference between MRI and CT in relation to overall accuracy for ≤T2 staging (p=0.01) and for T3 staging (p=0.001).
- The mean false positive rate and false negative rate for ≤T2 staging for three reviewers using MRI were 12% and 24% respectively compared to 17% and 21% respectively for CT.
- The mean false positive rate and false negative rate for T3 staging for three reviewers using MRI were 7% and 17% respectively compared to 8% and 27% respectively for CT.
- The interobserver agreement for perirectal invasion of rectal cancer on MRI was moderate to substantial, while for CT interobserver agreement was fair.
- 294 lymph nodes were harvested from the rectal cancer resection specimens of 26 patients; 14 were N0, 8 were N1 and 4 were N2 stage.
- There was no statistically significant difference between MRI and CT for the detection of lymph node metastasis.

Stage		≤T2 (n=14)		T3 (n=17)	
		CT	MRI	CT	MRI
Reviewer 1	Sensitivity	79%	100%	71%	88%
	Specificity	76%	88%	79%	100%
	PPV	73%	88%	80%	100%
	NPV	81%	100%	69%	88%
	Accuracy	77%	94%	74%	94%
Reviewer 2	Sensitivity	71%	93%	71%	94%
	Specificity	76%	88%	79%	93%

	PPV	71%	87%	80%	94%
	NPV	76%	94%	69%	93%
	Accuracy	74%	90%	74%	94%
Reviewer 3	**Sensitivity**	86%	86%	76%	94%
	Specificity	76%	94%	93%	86%
	PPV	75%	92%	93%	88%
	NPV	87%	89%	76%	86%
	Accuracy	81%	90%	83%	90%
Mean	**Sensitivity**	79%	93%	73%	92%
	Specificity	76%	88%	83%	93%
	PPV	73%	89%	84%	94%
	NPV	81%	94%	71%	89%
	Accuracy	77%	91%	78%	92%

Table: Results for ≤T2, T3 and N staging

	N0 (n=14)		**N1 (n=8)**		**N2 (n=4)**	
	MR	**CT**	**MR**	**CT**	**MR**	**CT**
Sensitivity	89%	64%	88%	63%	100%	75%
Specificity	92%	83%	89%	61%	100%	91%
PPV	92%	90%	78%	42%	100%	60%
NPV	85%	69%	94%	79%	100%	95%
Accuracy	88%	77%	88%	62%	100%	88%

Table: Results for N staging

General Comments

Three experienced reviewers, who were blinded to each other and to the histopathologic results, prospectively assessed the MR and MDCT images.

Citation: Kim CK, Kim SH, Chun HK, Lee WY, Yun SH, Song SY, Choi D, Lim HK, Kim MJ, Lee J, Lee SJ (2006) Preoperative staging or rectal cancer: accuracy of 3-Tesla magnetic resonance imaging *European Radiology* 16;5:972-980

Design: Case Series

Country: South Korea

Aim: to evaluate the accuracy of 3-telsa magnetic resonance imaging for the preoperative staging of rectal cancer

Inclusion criteria
Histopathologically proven rectal cancer

Exclusion criteria
Patients receiving preoperative radiation or chemotherapy
Patients refusing surgery
Patients that were inoperable
Anal fistula
Endometriosis in the rectum

Population
N=35

Interventions
MRI with 3T whole body system using six elements phased array coil.

Outcomes
Sensitivity
Specificity
Accuracy

Results
Three experienced observers who were blinded to each other and to the histopathological results examined the MR images prospectively.
All 35 rectal cancers were identified on MRI and in all patients MRI allowed visualisation and delineation of the layers of both the rectal wall and mesorectal fascia.

T-Staging

		Observer 1	Observer 2	Observer 3	Mean
T1 (n=8)	**Sensitivity**	88%	88%	88%	88%
	Specificity	100%	100%	100%	100%
	Accuracy	97%	97%	97%	97%
T2 (n=7)	**Sensitivity**	100%	85%	71%	86%
	Specificity	89%	86%	93%	89%
	Accuracy	91%	86%	89%	89%
T3 (n=20)	**Sensitivity**	90%	85%	95%	90%
	Specificity	100%	93%	87%	96%
	Accuracy	94%	89%	91%	91%
Total (n=35)	**Mean Accuracy**	94%	90%	92%	

Table: Prediction of sensitivity, specificity and accuracy of staging with MRI by three independent observers

Observer performance was investigated by analysing the ROC curve with diagnostic accuracy measured using the area under the curve (Az). The Az values in all three observers were high and there was no significant difference among the Az values in the three observers.

	Observer 1	Observer 2	Observer 3
Az	0.973	0.927	0.920
95% CI	0.853, 0.995	0.786, 0.986	0.77, 0.983
Sensitivity	90%	85%	95%
Specificity	100%	93%	87%

Table: Prediction for performance in depicting perirectal invasion of rectal cancers

N-Staging
The number of lymph nodes in each specimen varied from three to 26 at histopathologic examination, with a total of 310 lymph nodes revealed in 30 patients. Of these, 53 nodes, all less than 3mm in diameter were not identified on MRI.

	Sensitivity	Specificity	PPV	NPV	Accuracy
Observer 1	78% (31/40)	98% (213/217)	89% (31/35)	96% (213/222)	95%
Observer 2	80% (32/40)	98% (212/217)	86v (32/37)	96% (212/220)	95%
Observer 3	83% (33/40)	97% (211/217)	85% (33/39)	97% (211/218)	95%
Mean	80%	98%	86%	96%	95%

Table: Prediction of nodal metastases of rectal cancer between 3 observers

Interobserver Agreement

The interobserver agreement for T-staging was; observer 1 vs. observer 2 κ=0.55; observer 2 vs. observer 3 κ=0.8 and observer 1 vs. observer 3 κ=0.63.
Interobserver agreement for determining the presence of perirectal invasion was moderated to substantial.

The interobserver agreement for N-staging was; observer 1 vs. observer 2 κ=0.63; observer 2 vs. observer 3 κ=0.72 and observer 1 vs. observer 3 κ=0.51.
Interobserver agreement for determining the presence of regional lymph node metastasis was moderate to substantial.

General comments

Tumours were classified as follows:
T1: tumour signal intensity is confined to the submucosal layer and has a relatively low signal compared with the high signal intensity of surrounding submucosa
T2: tumour signal intensity extends to the muscle layer leading to an irregular or thickened muscle layer but without perirectal infiltration.
T3: tumour signal intensity extends through the muscular layer into the perirectal fat or an angiolymphatic tumour invasion in the mesorectum.
T4: tumour signal intensity extends to adjacent organs, mesorectal fascia or bowel.

Most staging failures with MRI occur in the differentiation of T2 stage and borderline T3 stage due to over-staging and therefore observers scored the MR images independently for tumour penetration into the perirectal fat using a confidence level scoring system. The appearance of nodules, interruption of the outer rectal wall, or irregularly thickened speculation were considered to be indicators of perirectal invasion. The following confidence intervals were used for T3 staging; 1 definitely absent, 2 probably absent, 3 possibly present, 4 probably present and 5 definitely present.

Citation: Kulinna C, Scheidler J, Strauss T, Bonel H, Herrmann K, Aust D, Reiser M (2004) Local staging of rectal cancer: assessment with double contrast multislice computed tomography and transrectal ultrasound *Journal of Computer Assisted Tomography*

Design: prospective case series

Country: Germany

Aim: to evaluate the accuracy of multislice computed tomography (MSCT) with double-contrast technique and transrectal ultrasound (TRUS) in staging of rectal carcinoma compared with histopathological confirmation.

Inclusion criteria

Exclusion criteria

Population
N=92

Interventions
MSCT
TRUS

Outcomes
Accuracy
Sensitivity
Specificity

Results

Stage	MSCT (n=92)	Accuracy	TRUS (n=63)	Accuracy	Pathology
T-Stage					
<T2	32/38	84%	15/31	48%	38
T3	44/50	84%	23/32	72%	50
T4	2/4	50%	0		4
All	76/92	83%	38/63	60%	92
N-Stage					
N0	47/59	80%	29/39	74%	59
N+	25/33	76%	12/24	50%	33
All	72/92	78%	41/63	65%	92

Table: Results of MSCT and TRUS compared with pathology

T-Staging
There was a significant difference between MSCT and TRUS in determining T-stage (p=0.0001), with MSCT being more sensitive, specific and accurate than TRUS.

	Sensitivity	Specificity	PPV	NPV	Accuracy
Overall					
MSCT (n=92)	82%	84%	88%	76%	83%
TRUS (n=63)	59%	63%	72%	48%	60%
Comparison of findings for MSCT and TRUS of same patients					
MSCT (n=63)	85%	87%	88%	84%	86%
TRUS (n=63)	59%	63%	72%	48%	60%

Table: Results for MSCT and TRUS for determining T-stage

N-Staging
There was no significant difference between MSCT and TRUS in detecting metastatic nodes.

	Sensitivity	Specificity	PPV	NPV	Accuracy
Overall					
MSCT (n=92)	68%	85%	75%	79%	78%
TRUS (n=63)	55%	71%	50%	74%	65%
Comparison of findings for MSCT and TRUS of same patients					
MSCT (n=63)	75%	85%	75%	85%	81%
TRUS (n=63)	55%	71%	50%	74%	65%

Table: Results for MSCT and TRUS for determining N-stage

UICC-Staging

UICC staging includes T-stage and N-stage and is useful in determining which patients benefit from preoperative radiotherapy. Preoperative radiotherapy is effective for UICC >1 (T3 and/or N1) but not for UICC = 1 (T2N0). In the current study, 80% of patients receiving preoperative radiotherapy were correctly staged with MSCT compared with 69% correctly staged with TRUS. For patients not receiving preoperative radiotherapy, 94% were correctly staged with MSCT compared with 68% with TRUS. The overall accuracy rating was significantly better with MSCT than with TRUS ($p<0.0001$), when looking at only patients that had undergone both MSCT and TRUS (n=63).

	Sensitivity	Specificity	PPV	NPV	Accuracy
MSCT (n=63)	91%	86%	89%	89%	89%
TRUS (n=63)	67%	67%	83%	44%	66%

Table: Results for UICC-staging with MSCT and TRUS in the same patients

Citation: Kulinna C, Eibel R, Matzek W et al (2004) Staging of rectal cancer: diagnostic potential of multi-planar reformatting with multidetector CT *AJR* 183:421-427

Design: Prospective Diagnostic Case Series

Country: Germany

Setting:

Aim: to evaluate whether the addition of coronal and saggital MPRs to axial slices alone could improve UICC staging.

Inclusion criteria
Biopsy proven rectal carcinoma

Exclusion criteria
None given

Sample Size
N/A

Randomisation Method
N/A

Population
N=55

Study Duration
No details

Interventions
MDCT

Outcomes
Sensitivity, specificity, positive predictive value, negative predictive value and accuracy for:

Detectability of tumour
Tumour location
Depth of tumour infiltration
Regional lymph nodes

Results
Results of histopathologic examination showed that 24 patients had pT2 tumours, 30 patients had pT3 tumours and 1 patient had pT4 tumour.
N staging showed 36 patients without lymph node metastasis, 16 patients with pN1 and 3 patients with pN2.

23 patients with UICC stage 1 and 32 patients with UICC stage 2 were identified histologically.

Inter-observer variability was good to excellent; the lowest inter-observer variability was found fro UICC staging in saggital reconstructions (κ=0.881) and the highest inter-observer variability was observed on coronal reconstructions in N staging (κ=0.606).

T-staging
There was a statistically significant difference between acial and coronal reconstructions (p=0.006) and between axial and sagittal reconstructions (p=0.02) but only for reviewer 1.

Type of Image	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Accuracy (95% CI)
Reviewer 1					
Axial	81% (63%-92%0	58% (36%-77%)	71% (53%-85%)	70% (45%-88%)	71% (57%-82%)
Coronal	98% (88%-100%)	75% (53%-90%)*	84% (68%-93%)	97% (81%-100%)	89% (77%-95%)*
Saggital	98% (88%-100%)	83% (62%-95%)*	87% (73%-96%)	97% (83%-100%)	93% (82%-98%)*
Reviewer 2					
Axial	77% (77%-87%)	67% (44%-84%)	75% (56%-88)	70% (47%-86%)	72% (59%-83%)
Coronal	88% (87%-96%)	62% (40%-81%)	75% (57%-87%)	79% (54%-93%)	76% (63%-86%)
Saggital	90% (74%-98%)	79% (57%-92%)	85% (68%-94%)	86% (65%-97%)	85% (73%-93%)

*p<0.05

Table: Overall T stage assessment in rectal cancer (n=55)

N Staging

There were statistically significant differences between axial and coronal reconstructions (p=0.006) and between axial and saggital reconstructions (pp=0.01) but again only with reviewer 1.

Type of Image	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Accuracy (95% CI)
Reviewer 1					
Axial	84% (60%-96%)	67% (49%-81%)	57% (37%-75%)	89% (69%-98%)	73% (59%-83%)
Coronal	98% (82%-100%)	86% (70%-95%)	79% (57%-92%)	98% (88%-100%)	91% (80%-97%)*
Saggital	97% (82%-100%)	94% (81%-99%)	95% (69%-98%)	98% (89%-100%)	96% (87%-99%)*
Reviewer 2					
Axial	80% (54%-93%)	67% (44%-84%)	61% (35%-74%)	86% (67%-96%)	71% (57%-82%)
Coronal	90% (69%-98%)	61% (43%-76%)	55% (36%-72%)	91% (73%-99%)	71% (57%-82%)
Saggital	98% (82%-100%)	70% (Not given)	63% (43%-80%)	95% (67%-100%)	80% (67%-89%)

*p<0.05

Table: assessment of N staging rectal cancer (n=55)

UICC Staging

There were statistically significant differences between axial and coronal reconstructions (reviwer 1 p=0.01; reviewer 2 p=0.04) and between axial and sagittal reconstructions (reviewer 1 p=0.001; reviewer 2 p=0.012) for both reviewers.

Type of Image	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Accuracy (95% CI)
Reviewer 1					
Axial	78% (60%-90%)	39% (19%-46%)	64% (47%-78%)	56% (29%-80%)	62% (47%-74%)
Coronal	98% (89%-100%)*	74% (61%-89%)*	84% (68%-94%)	97% (80%-100%)	89% (77%-95%)*
Saggital	98% (89%-100%)*	87% (66%-97%)*	91% (76%-98%)	96% (83%-100%)	95% (84%-98%)*
Reviewer 2					
Axial	78% (60%-97%)	52% (30%-73%)	69% (51%-83%)	63% (38%-83%)	67% (53%-79%)
Coronal	87% (71%-96%)*	52% (30%-73%)	72% (55%-85%)	75% (47%-92%)	73% (59%-83%)*
Saggital	97% (83%-99%)*	78% (56%-92%)	86% (70%-95%)	95% (74%-99%)	89% (77%-95%)*

*p<0.05)

Table: Assessment for UICC staging in rectal cancer (n=55)

General comments

Tumours on MDCT were classified by a modified TNM stage:
Tumours confined to the bowel wall were classified as T1 or T2
An indistinct or speculated border between the outer rectal wall and the surrounding fat at the level of the tumour was considered to be evidence of perirectal invasion (T3).
Tumour infiltration into adjacent organs was considered to be T4

Lymph nodes were considered to be positive for metastases if at least one perirectal lymph node with a short-axis diameter of more than 3mm was found.

Citation: Kwok H, Bisset IP, Hill GL (2000) Preoperative Staging of Rectal Cancer *International Journal of Colorectal Disease* 15;1:9-20

Design: Systematic Review

Country: New Zealand

Aim: to evaluate computed tomography (CT), endorectal sonography (ES) and magnetic resonance imaging (MRI) as preoperative staging methods in rectal cancer.

Inclusion criteria
Studies presenting (1) pathological staging of rectal cancer as a gold standard; (2) a minimum of 20 patients in the whole study; (3) sufficient raw data to allow data extraction and (4) original data.
If only a subset of patients within the study met the inclusion criteria, only this subset were included.

Exclusion criteria
Reviews, comments and editorials which presented no new data
Papers with internal inconsistency

Population
N=4879 patients from 83 studies

Interventions
CT
ES
MRI

Outcomes
Bowel penetration and nodal status
Accuracy
Sensitivity
Specificity
Positive Predictive Value
Negative Predictive Value
Positive likelihood ratio
Negative likelihood ratio

T stage
Accuracy
Percentage under-staged
Percentage over-staged

Results
Studies included
275 studies identified from Medline and citation lists
86 excluded as irrelevant
40 excluded due to small patient numbers (<20)
15 excluded due to insufficient data
20 excluded because data was included in subsequent papers
36 excluded because they presented no new data

83 studies reporting data on 4879 patients were included in the review, the overall numbers of patients receiving pre-operative staging by CT, ES and MRI were 1429, 3640 and 665 respectively.

Wall Penetration
23 studies (22 papers) used CT in the pre-operative assessment of local tumour penetration and a total of 1116 patients met the inclusion criteria. The pooled sensitivity, specificity and accuracy were 78%, 63% and 73% respectively.
Four studies with a total of 135 patients classified wall penetration according to TNM notation, of these 80% were correctly staged, 13% were over-staged and 7% were under-staged.

53 studies (48 papers) with a total of 2915 eligible patients, assessed wall penetration with ES. The pooled sensitivity, specificity and accuracy were 93%, 78% and 87% respectively.
31 studies, representing a total of 1852 patients reported wall penetration according to TNM notation, of these 84% were correctly staged, 11% over-staged and 5% were understaged.

18 studies (15 papers) with a total of 521 patients and 546 MRI scans (some patients were evaluated by more than one type of MRI) assessed wall penetration with MRI. The pooled sensitivity, specificity and accuracy were 86%, 77% and 82% respectively.
8 studies, representing 246 patients reported results using TNM notation, of these 74% were correctly staged, 13% were overstaged and 13% were under-staged.
Subgroup analysis on patients using endorectal surface coil (6 studies; 169 patients) resulted in a pooled sensitivity, specificity and accuracy of 89%, 79% and 84% respectively.
4 studies (124 patients) reported the results according to TNM notation, of these 81% were correctly staged, 12% were overstaged and 6% were understaged.

Nodal Involvement
18 studies (17 papers) with a total of 945 patients assessed nodal status by CT. The pooled sensitivity, specificity and accuracy were 52%, 78% and 66% respectively.

38 studies (36 papers) with a total of 2032 patients assessed nodal involvement by ES. The pooled sensitivity, specificity and accuracy were 71%, 76% and 74% respectively.

15 studies (14 patients) with a total of 436 MRI scans assessed local nodal involvement by MRI. The pooled sensitivity, specificity and accuracy were 65%, 80% and 74% respectively.
181 patients (6 studies) received MRI with endorectal surface coil; the pooled sensitivity, specificity and accuracy for this subgroup were 82%, 83% and 82% respectively.

	Sensitivity	Specificity	Accuracy	Positive Predictive Value (PPV)	Negative Predictive Value (NPV)	Positive likelihood ratio (PLR)	Negative likelihood ratio (NLR)
Wall Penetration							
CT	78%	63%	73%	82%	58%	2.11	0.35
ES	93%	78%	87%	87%	87%	4.31	0.09
MRI (all)	86%	77%	82%	83%	81v	3.7	0.19
MRI (endorectal coil)	89%	79%	84%	82%	86%	4.22	0.14
Nodal Involvement							
CT	52%	78%	66%	68%	64%	2.38	0.61
ES	71%	76%	74%	69%	78%	2.99	0.38
MRI (all)	65%	80%	74%	72%	75%	3.27	0.43
MRI (endorectal coil)	82%	83%	82%	76%	87%	4.7	0.22

Table: Pooled sensitivity, specificity, accuracy, PPV, NPV, PLR and NLR for all modalities

Comparing CT, ES and MRI
- Overall ES had the highest sensitivity, specificity and accuracy of the three modalities.
- MRI assessment of wall penetration had lower sensitivity, specificity and accuracy than ES although subgroup analysis of those patients undergoing MRI with endorectal coil had a sensitivity, specificity and accuracy close to that of ES.
- In assessing nodal involvement, MRI performed with an endorectal coil has the highest sensitivity, specificity and accuracy, ES had similar results to MRI overall.
- CT showed the lowest sensitivity, specificity and accuracy for both wall penetration and nodal involvement.

Radiotherapy
All studies in which patients received radiotherapy were combined irrespective of the regimen. In patients receiving radiotherapy preoperative staging using CT and ES had the lowest sensitivity and specificity and MRI seemed less affected by radiotherapy when compared with those with no radiotherapy.

General Comments
Medline was searched for papers published between January 1980 and November 1998 and the resulting list was supplemented by searching the citations for any further papers. No information on any other databases searched was provided.

Data extracted from each of the studies included; the study type, year of publication and investigation, patient demographics, details of examination technique, examiner blinding, tumour factors and use of radiotherapy.

Wall penetration was defined as 'through wall' (invading the muscularis propria) or 'not through wall' and where possible according to the T component of the TNM staging system. Patients staged by other systems were reclassified according to the conversion matrix established by the 1990 World Congress of Gastroenterology Working Party on Clinicopathological Staging.

Nodal involvement was defined as either 'positive' or 'negative'

Citation: Llamas-Elvira JM, Rodriguez-Fernandez A, Gutierrez Sainz J, Gomez-Rio M, Bellon-Guardia M, Ramos Font C, Rebollo Aguirre AC, Cabello Garcia D, Ferron Orihuela A (2007) Fluorine-18 fluorodeoxyglucose PET in the preoperative staging of colorectal cancer. *European Journal of Nuclear Medicine and Molecular Imaging* 34;6:859-867

Design: Case Series

Country: Spain

Aim: to evaluate the utility of FDG-PET in the initial staging of patients with colorectal cancer in comparison with conventional staging methods and to determine it's impact on therapeutic decisions.

Inclusion criteria

Exclusion criteria

Population
N=104

Interventions
CT
FDG-PET

Outcomes
Sensitivity
Specificity
Positive Predictive Value
Negative Predictive Value
Accuracy

Results
Both FDG-PET and CT showed changes at the level of the primary lesion that were compatible with tumour status; most primary tumours showed FDG uptake, with only 1 small, well-differentiated mucinous adenocarcinoma showing no significant uptake.

Lymphatic spread was studied in 90 patients to evaluate the presence or absence of involved lymph nodes. CT correctly detected the presence/absence of lymph node involvement in 54 patients with 36 false negative and 2 false positive results. FDG-PET correctly detected presence/absence of lymph node involvement in 50 patients, with 38 false negatives and 2 false positive results.

	FDG-PET	**CT**	**FDG-PET**	**CT + Chest X Ray**
	N0/N+		**M0/M+**	
Sensitivity	21% (11-35%)	25% (14-40%)	89% (64-98%)	44% (22-69%)
Specificity	95% (83-99%)	100% (83-99%)	93% (85-97%)	95% (88-98%)
Overall Accuracy	56% (45-66%)	60% (49-70%)	92% (85-96%)	87% (78-92%)
PPV	83% (51-97%)	100% (70-99%)	73% (50-88%)	67% (35-89%)
NPV	51% (40-63%)	54% (42-65%)	98% (91-100%)	89% (80-94%)

Table: Diagnostic Accuracy in N0/N+ and M0/M+ staging

General comments
Diagnostic validity of CT and FDG-PET in N and M staging was analysed by comparing the information in the reposts of each examination with the reference criteria, solely considering N0-N+ and M0-M+ categories.

Citation: Low RN, McCue M, Barone R, Saleh F, Song (2003) MR staging of primary colorectal carcinoma: comparison with surgical and histopathological findings *Abdominal Imaging* 28;6:784-793

Design: Retrospective Case Series

Country: USA

Aim: to evaluate the accuracy of magnetic resonance imaging in staging colorectal cancer and assessing local tumour extent, nodal involvement and distant abdominal and pelvic metastases.

Inclusion criteria

Exclusion criteria

Population
N=48 patients (21 patients with rectal cancer and 27 patients with colon cancer)

Interventions
Presurgical abdominal and pelvic MRI

Outcomes
Sensitivity
Specificity

Results
Abdominal and pelvic imaging was performed with body in 27 patients and with combination body coil for abdomen and phased array surface coil for pelvis in 19 patients. (Note: There appear to be 2 patients unaccounted for here.)

Overall Staging
MRI agreed with surgical and pathologic stagin in 85% (41/48) patients. Over-staging occurred in 1 patient and under-staging occurred in 6 patients with the largest category of staging error occurring in stage 3 tumours.

	Surgical/Histopathologic TNM stage					
MRI	**Overall**	**0**	**1**	**2**	**3**	**4**
	0	0				
	1		12			
	2			8	5	1
	3		1		8	
	4					13

Table: Comparison of MRI and surgical/pathological staging

Depth of Tumour Penetration (T-staging)
Depth of tumour penetration into the bowel wall could not be evaluated in 4 patients. In 86% (38/44) of patients depth of tumour penetration on MRI agreed with surgical and pathologic findings. In 95% of patients, MRI correctly distinguished tumour confined to the bowel wall.

	Surgical/Histopathologic TNM stage					
MRI	**T-Stage**	**0**	**1**	**2**	**3**	**4**
	0	1				
	1		1			
	2		2	9	1	
	3			1	22	2
	4					5

Table: Comparison of MRI and surgical/pathologic staging for T-stage

Nodal Metastases (N-staging)
MRI showed a sensitivity of 68%, specificity of 96% and accuracy of 83% for the identification of local and regional nodal metastases.

Distant Metastases (M-staging)
Surgical exploration confirmed colorectal cancer with distant metastases in 14/48 patients with MRI correctly depicting metastatic tumour in 13/14 patients.

Rectal Cancer
MRI staging agreed with surgical/pathologic staging in 20/21 patients with rectal cancer. Depth of tumour penetration

was correctly estimated on MRI in 16/19 patients and nodal metastasis was correctly depicted in 8/9 patients. *Colon Cancer* MRI staging agreed with surgical/pathologic staging in 21/27 patients. Depth of tumour penetration was correctly estimated in 22/25 patients and nodal metastasis was correctly depicted in 7/13 patients.
General comments Surgical staging occurred in all patients within 5 weeks of MRI Staging of colon carcinoma was based on TNM classification

Citation: Mainenti PP, Cirillo LC< Camera L, Perscio F, Cantalupo T, Pace L, De Palma GD, Persico G, Alvatore M (2006) Accuracy of single phase contrast enhanced multidetector CT colonography in the preoperative staging of colorectal cancer *European Journal of Radiology* 60;453-459

Design: Case Series

Country: Italy

Aim: to assess the value of single portal venous phase contrast enhanced multidetector CT colonography (CE CTC) in the preoperative staging of colorectal cancer

Inclusion criteria
Histologically proven colorectal adenocarcinoma
Highly suspected colorectal cancer on conventional colonoscopy

Exclusion criteria
None given

Population
N=52 (20 with histologically proven colorectal adenocarcinoma, 32 with highly suspected diagnosis of colorectal cancer on conventional colonoscopy)

Interventions
CT colonography

Outcomes
Accuracy
Sensitivity
Specificity
Positive Predictive Value
Negative Predictive Value

Results
All 52 colorectal cancers were identified on CE-CTC with a total of 56 adenocarcinomas present and correctly located with CE-CTC.

Site	Number
Rectum	11
Rectal-sigmoid colon junction	5
Sigmoid colon	24
Splenic flexure	1
Transverse Colon	4
Hepatic flexure	3
Ascending colon	2
Cecum	4
Anastomosis in patients with previous colic resection	2

Table: site and number of tumours detected on CE-CTC

	Stage ≤T2 (n=10)	Stage T3 (n=41)	Stage T4 (n=5)	N+ (n=29)
Accuracy (95% CI)	93 (86, 100%)	93 (86, 100%)	100 (99.9, 100%)	71 (59, 83%)
Sensitivity (95% CI)	70 (40, 100%)	97 (92, 100%)	100 (99.9, 100%)	86 (73, 99%)
Specificity (95% CI)	98 (94, 100%)	80 (59, 100%)	100 (99.9, 100%)	55 (36, 74%)
Positive Predictive Value (95% CI)	87 (62, 100%)	93 (85, 100%)	100 (99.9, 100%)	68 (53, 83%)
Negative Predictive Value (95% CI)	94 (87 (100%)	92 (77, 100%)	100 (99.9, 100%)	79 (60, 98%)

Table: Results for CT Colonography for T and N stage

General comments
Pathological findings served as the reference standard for depth of tumour invasion and nodal involvement.
The radiologists reading the results were blinded to the surgical and pathological findings.

Citation: Mercury Study Group (2006) Diagnostic accuracy of preoperative magnetic resonance imaging in predicting curative resection of rectal cancer: prospective observational study

Design: Prospective Case Series

Country: Europe (four countries)

Aim: To assess the accuracy of preoperative staging of rectal cancer with MRI to predict surgical circumferential resection margins.

Inclusion criteria

Exclusion criteria
Pregnant patients
History of pelvic malignancy
Pelvic radiotherapy or pelvic floor surgery for faecal incontinence or rectal prolapse.
Patients that were unable to undergo MRI because of metal fragments of implanted metal devices with the body

Population
N=408

Interventions
Clinical Assessment including digital rectal exam and rigid sigmoidoscopy
Radiological Assessment including MRI with a body coil and a high resolution protocol

Outcomes
Accuracy of MRI in predicting a curative resection based on histological yardstick of presence or absence of tumour at the margins of the specimen.

Results
<u>MRI prediction of circumferential resection margin</u>
MRI predicted clear margins in 349 patients that underwent surgery, of these 327 had clear margins (94%, 95% CI; 91% to 96%).
Accuracy for predicting the status of circumferential resection margin by initial imaging or imaging after pre-operative treatment in 408 patients was 88% (95% CI; 85% to 91%).

311/408 patients underwent primary surgery and the accuracy for prediction of a clear margin was 91% (95% CI; 88% to 94%) with a negative predictive value of 93% (95% CI; 90%-96%) compared to an accuracy of 77% (95% CI; 69% to 86%) and negative predictive value of 98% in 97 patients that underwent preoperative chemoradiotherapy or long course radiotherapy.

<u>Patients with a curative resection on histopathology</u>
354 patients had clear margins on histopathology, 327 of which were correctly predicted on MRI resulting in a specificity of 92% (89% to 95%).
27 patients were incorrectly diagnosed as having involved margins on MRI; 21 patients received chemoradiotherapy or long course radiotherapy and the appearance of tumour at the margins on their scans after treatment correspond to changes related to treatment.

<u>Patients with non-curative resection on histopathology</u>
54/508 patients showed affected margin on histopathology, 32 of which were correctly predicted on MRI.
22/54 patients were not predicted to have involved margins on MRI due to perforation of tumour during surgery which could not have been predicted by MRI; in 7 patients the affected margin was not due to direct spread of tumour but to the presence of nodes containing tumour that had not been detected by the scan; in 1 patient, changes on the scan were interpreted as post-radiotherapy fibrosis at the margin and in 3 patients, although the local extent of tumour had been correctly documented compared with pathology, the distance to the mesorectal fascia had been over-estimated by the radiologist.

<u>Accuracy of digital rectal examination versus MRI</u>
MRI resulted in more accurate information than did digital rectal examination (DRE). The accuracy for circumferential resection margin status in patients who underwent primary surgery was 70% for DRE and 92% for MRI ($p<0.001$).
When DRE showed fixed or tethered tumour this corresponded to an involved circumferential margin in only 15% of patients.

	MRI
Accuracy (95% CI)	88% (85% to 91%)
Sensitivity (95% CI)	59% (46% to 72%)
Specificity (95% CI)	92% (90% to 95%)
Positive Predictive Value (95% CI)	54% (42% to 67%)
Negative Predictive Value (95% CI)	94% (91% to 96%)

Table: Results for MRI by margin status

	MRI	
	Primary Surgery/short course radiotherapy	**After Chemotherapy**
Accuracy (95% CI)	91%	77%
Sensitivity (95% CI)	42%	94%
Specificity (95% CI)	98%	73%
Positive Predictive Value (95% CI)	71%	45%
Negative Predictive Value (95% CI)	93%	98%

Table: Result for MRI by treatment

	MRI	DRE
Accuracy	92%	70%
Sensitivity	42%	38%
Specificity	98%	74%
Positive Predictive Value	73%	15%
Negative Predictive Value	93%	91%

Table: Results for MRI versus DRE prediction at circumferential resection margin

Citation: Mercury Study Group (2007) Extramural Depth of tumour invasion at thin section MR in Patients with rectal cancer: Results of the Mercury Study *Radiology* 243;1:132-139

Design: Prospective Diagnostic Study

Country: UK

Setting:

Aim: to evaluate the accuracy of MRI in depicting the extramural depth of invasion in patients with rectal cancer

Inclusion criteria
≥18 years
Able to provide written consent
Recently diagnosed adenocarcinoma of the rectum (the distal 15cm region of the large bowel)
Patients scheduled to undergo preoperative short-course radiotherapy only

Exclusion criteria
Pregnancy
Previous history of pelvic malignancy, pelvic radiation therapy or pelvic floor surgery for faecal incontinence or rectal prolapsed
Patients unable to undergo MRI due to claustrophobia or metal fragments or implanted metal devices in the body.
Patients referred for palliative care only
Patients who received treatment at locations other than the study centres
Patients who had or were scheduled to undergo local excision of primary tumour
Patients scheduled to undergo chemoradiotherapy or long course radiotherapy

Sample Size
277 patients were required ($\beta=0.025$, $\alpha=2\beta=0.05$)

Randomisation Method
N/A

Population
N=679

Study Duration
Patient Recruitment: February 2002 – November 2003

Interventions
MRI

Outcomes
Equivalence between MRI measurement of extramural depth of tumour invasion and histopathologic measurement after primary surgery.

Results
428 histopahtologic specimens were available
Values of tumour height (defined as measured distance of the tumour from the anal verge) were 0-5cm in 137 cases, 5.1-10cm in 152 cases and >10.1cm in 105 cases. Measurements were missing in 34 cases.

311 patients (183 men and 128 women, median age 67 years, range 33-92 years) underwent primary surgery and 97 underwent surgery following treatment with either chemoradiotherapy or long-course radiotherapy.

Anterior resection was performed in 302/428 cases and the hartmann procedure in 25 cases.

Overall, 266 mesorectal specimens were graded as complete, 81 were graded as moderate and 23 were graded as incomplete. The specimen grade was not available in 58 cases.

The median number of nodes found per specimen was 13 (range 1-50).

Overall, 311 patients were eligible for primary end-point assessment of extra mural depth of tumour spread.

MRI versus Histopathological Measurement of Extramural Depth of Tumour Invasion
Measurement of extramural depth of invasion was available for both histopathology and MRI in 295/311 patients (95%) who underwent primary surgery.

Mean extramural depths of invasion at MRI was 2.80mm (SD±4.6mm) and for histopathologic analysis was 2.81mm (SD±4.28mm).
The mean difference between MRI and histopathologic assessments of extramural depth of invasion was -0.05mm±3.85 (95% CI -0.49mm-0.4mm) resulting in more than 95% certainty that the mean difference was within the predefined 0.5mm boundary and thus that the assessments were equivalent.

In 92.5% of patients, depth of tumour spread depicted on the thin-section MRI was with 5mm of the histopathologic measurements.
In 7.5% of patients, MRI resulted in apparent over-estimation of extramural depth of invasion by more than 5mm which would have resulted in patients being assigned to an incorrect prognostic group.

In 4 of the 22 patients, the presence of transacted tumour at the circumferetial margin likely represented pathologic under-estimation.

Review of the images showed that in 7 of the remaining 18 patients there were image interpretation errors and 11 overestimations due to incorrect angulation of the imaging plane in tumours in the very low region of the rectum and tumours above the peritoneal reflection.

MRI led to underestimation of tumour depth in 4.4% (13/295) of patients; at review of these patients imaged it was noted that there were 5 impterpretation errors due to movement artefact.

General comments
MRI and histopathologic results were considered to be equivalent when the 95% CI of the difference between them was within ±0.5mm, giving a less than 5% probability that of a false claim of equivalence if the true mean difference between MRI and histopathologic results exceeded ±0.5mm.

Citation: Nicholls R, York Mason A, Morson B et al (1982) The clinical staging of rectal cancer *British Journal of Surgery* 69;404-409

Design: Case Series Study

Country: UK

Setting:

Aim: to investigate the ability of digital rectal examination to recognise significant stages of local extent and lymph node involvement in adenocarcinoma of the lower two thirds of the rectum

Inclusion criteria
None Given

Exclusion criteria
None Given

Sample Size
N/A

Randomisation Method
N/A

Population
N=70

Study Duration
No details provided

Interventions
DRE
CT
Pathology (Reference)

Outcomes
Not clear from the study

Results

Level of tumour
Digital estimations of the level of tumour from the anal verge in patients having total rectal excisions were within 2cm of the pathologist's measurements on the lower border to the dentate line in 70% of cases examined by clinician 1, 82% of cases examined by clinician 2 and 82% of cases examined by clinician 3.

Quadrants
The number of involved quadrants was correctly assessed in 77%, 69% and 71% of cases examined by clinician 1, 2 and 3 respectively.
Tumours occupying three or more quadrants were correctly identified in 96%, 80% and 67% of cases examined by clinician 1, 2 and 3 respectively.
A relationship was observed between the number of quadrants judged to be involved by the clinician and extent of local spread.

Morphology
All 3 non-ulcerated carcinomas were correctly identified by all clinicians.

Extent of Local Spread

	Clinical assessment by Clinicians 1, 2 and 3											
	Nil			**Slight**			**Moderate**			**Extensive**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Patients Examined	5	11	18	23	23	14	12	10	21	20	19	11
Pathological Assessment												
Nil	4	8	8	5	3	4	0	0	1	0	0	0
Slight	1	2	8	13	14	5	5	2	5	3	2	1
Moderate	0	0	2	4	4	3	4	4	8	8	8	6
Extensive	0	1	0	1	2	2	3	4	6	8	7	4
No specimen (deemed inoperable)	0	0	0	0	0	0	0	0	1	1	1	0
Concordance of clinical with pathological	**80**	**73**	**44**	**56**	**61**	**36**	**33**	**40**	**38**	**45**	**42**	**36**

assessments (%)												

Table: Digital Assessment of Local Spread in 70 Patients

	Clinical assessment by clinicians 1, 2 and 3					
	Nil and Slight			Moderate and Extensive		
	1	**2**	**3**	**1**	**2**	**3**
Patients examined	28	34	32	32	29	32
Pathological assessment						
Nil and Slight	23	27	25	8	4	7
Moderate and extensive	5	7	7	24	24	25
Concordance of clinical and pathological assessments (%)	82	79	78	75	83	78

Table: Digital Assessment of Local Spread in 70 Patients (grouped by nil/slight and moderate/extensive)

Lymph Node Involvement
Full pathological examination of lymph nodes was available for 64 tumours

	Clinical Assessment by clinicians 1, 2 and 3					
	Involved			Not Involved		
	1	**2**	**3**	**1**	**2**	**3**
Patients examined	36	34	53	18	23	3
Pathological assessment						
Not Involved	24	22	30	6	8	1
Involved	12	12	23	12	15	2
Concordance of clinical and pathological assessments (%)	67	65	57	67	65	67

Table: Digital Assessment of Pararectal Lymph Nodes in 64 patients

Tumours underassessed as confined
Clinician 1 wrongly assessed 1 patient, clinician 2 wrongly assessed 2 patients and clinician 3 wrongly assessed 10 patients.
1 patient was wrongly assessed as confined by all 3 clinicians.

Computed Tomography
Extrarectal spread was seen on CT in 2/18 tumours with nil or slight spread and in 13/18 tumours with moderate or extensive spread.
CT showed higher sensitivity than clinical examination in identifying extensive local spread; 89% of tumours deemed extensive (8/9) were found to have extrarectal spread greater than 1.5cm compared with sensitivities of 71%, 56% and 33% obtained by clinicians 1, 2 and 3 respectively.
CT was not more reliable than clinical examination for growths with moderate spread with extrarectal spread seen on in 55% (5/9) of cases.
Nodes were seen on CT in 28% of Dukes C tumours compared with 27%, 58% and 8% respectively for clinicians 1, 2 and 3.

Choice of Treatment
31/69 resectable tumours were treated by total rectal excision and 38/69 were treated by sphincter preserving operation.
A relationship was observed between choice of operation and level of tumour and also selection by surgeon in charge based on local extent.
Patients with tumours between 5-8cm from the anal verge appeared more likely to be treated with a sphincter preserving operation if local spread was assessed to be nil or slight and by total rectal excision when local spread was considered moderate or extensive.

Citation: Rafaelsen S, Kronborg O and Fenger C (1994) Digital rectal examination and transrectal ultrasonography in staging of rectal cancer *Acta Radiology* 35;3:300-304

Design: A prospective, blind study

Country: Denmark

Setting:

Aim: Not clearly stated in the paper, it appears that the aim was to stage rectal cancer pre-operatively by digital rectal exam and transrectal linear ultra sonography (TRUS) and to compare the results with pathology.

Inclusion criteria
Patients with rectal carcinoma

Exclusion criteria
None given

Sample Size
N/A

Randomisation Method
N/A

Population
N=107 (50 males and 57 females)

Study Duration
1989-1992

Interventions
Clinical Examination (Digital rectal evaluation of mobility, consistency, number of quadrants involved, depth of rectal wall penetration and palpable perirectal lymph nodes)
Rigid Sigmoidoscopy
TRUS

Outcomes

Results
TRUS was performed immediately following clinical examination and the ultrasonographer was informed that the patient had a tumour. Comment: The study was apparently blinded, though if the ultrasonographer was aware that a tumour was present prior to carrying out TRUS then they are not blinded.

31/107 patients were treated by local excision, 58/107 were treated by low anterior resection and 18/107 were treated by abdominoperineal excision

Primary Tumour

	TRUS	
Pathological Specimen		
	Penetration	**No Penetration**
Penetration	65	3
No Penetration	9	30
Total	74	33

Table: Penetration of the rectal wall in 107 patients as evaluated by TRUS and pathology

Pathological Specimen	**TRUS**		**Digital Rectal Exam**	
	Penetration	**No Penetration**	**Penetration**	**No Penetration**
	N=66	**N=28**	**N=76**	**N=18**
Penetration (n=61)	59	2	56	5
No Penetration (n=33)	7	26	20	13

Table: Penetration of rectal wall in 94 patients as evaluated by TRUS, digital examination and pathology

In 13 patients, tumour was beyond the reach of the finger; digital examination underestimated penetration in 5/18 patients versus 2/28 by TRUS (p=0.09).
Overestimation of penetration occurred in 20/76 patients on DRE versus 7/66 patients on TRUS (p=0.02).

The clinician expressed doubt about 8/76 patients considered to have penetration on DRE and further investigation found no penetration in 6/8 of these patients, 5 of which were correctly identified on TRUS. Excluding the 8 patients resulted in overestimation of penetration by DRE of 14/68 versus 6/65 by TRUS (p=0.09).

Overestimation of penetration appeared to occur more often in small tumours compared with larger tumours (p=0.07).
There was a significant difference in overestimation when comparing tumours located in a single quadrant and those located in more than one quadrant (p=0.01).
Underestimation of penetration was significantly higher with DRE in larger tumours versus smaller tumours (<2cm diameter) (p=0.006).
Hard tumours were significantly more likely to be underestimated than soft tumours (p=0.006).

The majority of specimens with tumour penetration were correctly identified by DRE and also by TRUS although not in more than 13 of the same 33 patients examined by DRE (p=0.001). The difference remained significant when patients with uncertain results were excluded (p=0.02).

Overestimation of tumours with a diameter ≥4cm occurred in 5/41 patients on TRUS versus 8/49 patients on DRE (p=0.64).
27 tumours involved 4 quadrants and none were confined to the rectal wall by pathological exam and neither were they overestimated by TRUS or DRE.

Perirectal Lymph Node Status

	N	DRE			TRUS		
Pathology							
Dukes Stage		**A**	**B**	**C**	**A**	**B**	**C**
A	9	1	8	0	7	1	1
B	25	1	23	1	1	17	7
C	19	1	18	0	0	8	11

Table: Characteristics of 53 patients having complete clinical and pathological examination and complete TRUS

Complete clinical and pathological staging could be obtained from 53 patients and palpable lymph nodes were found in one patient on DRE but no metastases were found in the resected specimen.
TRUS correctly identified 11/19 patients with lymph node metastases.

TRUS correctly staged 35/53 patients versus 24/53 correctly staged by DRE (p=0.05)

Citation: Rao SX, Zeng MS, Xu JM, Q XU, Chen CZ, Li RC, Hou YY (2007) Assessment of T-staging and mesorectal fascia status using high-resolution MRI in rectal cancer with rectal distention *World Journal of Gastroenterology* 13;30:4141-4146.

Design: Case Series

Country: China

Aim: to assess the accuracy of MRI for pre-operative T staging of rectal cancer and the distance to the mesorectal fascia with rectal distention.

Inclusion criteria
Patients with histopathologically proven rectal cancer by means of endoluminal biopsy

Exclusion criteria

Population
N=67

Interventions
MRI using 1.5T whole body systems and a phased array multi-coil.

Outcomes
Accuracy
Sensitivity
Specificity
Positive predictive value
Negative predictive value

Results
T1 and T2 tumours were combined to represent on T stage ≤T2 due to the limitations of MRI in distinguishing between T1 and T2 tumours.
At histopathological examination 20 of 67 neoplasms were staged ≤pT2, 42/67 were classified as pT3 and 5/67 were classified as pT4.
The overall accuracy of MRI was 85.1%; over-staging occurred in 9/67 patients and under-staging occurred in 1/67 patients. Accuracy for each T-stage was 89.6% for ≤T2, 85.1% for T3 and 95.5% for T4.

	≤pT2 (n=20)	pT3 (n=42)	pT4 (n=5
Accuracy	89.6% (60/67)	85.1% (57/67)	95.5% (64/67)
Sensitivity	70% (14/20)	90.5% (38/42)	100% (5/5)
Specificity	97.9% (46/47)	76% (19/25)	95.2% (59/62)
PPV	93.3% (14/15)	86.4% (38/44)	62.5% (5/8)
NPV	88.5 % (46/52)	82.6% (19/23)	100% (59/59)

Table: Results for MRI

Mesorectal fascia was visualised on MRI in all patients and found to be involved in 15 patients by pathologists using a cut-off distance of 2mm between a tumour and the mesorectal fascia. Overall accuracy of predicting mesorectal fascia involvement on MRI was 88%. The sensitivity was 80%, specificity was 90.4%, PPV was 70.6% and NPV was 94%.

Citation: Salerno G, Daniels I, Moran B et al (2009) Magnetic Resonance Imaging Prediction of an Involved Surgical Resection Margin in Low Rectal Cancer *Diseases of the Colon and Rectum* 52;4:632-639

Design: Diagnostic Case Series

Country: UK

Setting:

Aim: to assess positive resection margin prediction by using MRI staging

Inclusion criteria
A subgroup of patients with low rectal cancer already part of the MERCURY study comprised the population for this study.
Patients forming the subgroup were those with:
Full pathology and MRI data available
Tumours ≤5cm from the anal verge
MRI scans available for review

Exclusion criteria
Patients with tumours >5cm above the anal verge

Sample Size
N/A

Randomisation Method
N/A

Population
N=101

Study Duration
No details

Interventions
High resolution, body coil, phased array MRI.

Outcomes

MRI Stage 1	Tumour on MRI appears confined to the bowel wall but not through full thickness
MRI Stage 2	Tumour on MRI replaces the muscle coat but does not extend into the intersphinteric plane
MRI Stage 3	Tumour on MRI invading into the intersphinteric plane or laying within 1mm or levator muscle
MRI Stage 4	Tumour invading into the external anal sphincter and infiltrating or extending beyond the levators with or without invasion of adjacent organs

Outcomes of the study are not clearly stated, it appears to be the ability of MRI to assign one of the above stages to tumour.

Results
A single experienced MRI radiologist who was blinded to the pathologic and surgical outcomes reviewed images of 101 patients

45/70 patients undergoing abdominoperineal excision received preoperative chemoradiotherapy; 29 of these patients had pre and post treatment MRI scans available for analysis of tumour regression grade (TRG).
10/31 patients undergoing low anterior resection received either preoperative chemoradiotherapy or short-course radiotherapy. Only 1 patient had pre-treatment and post-treatment MRI scans available for analysis of tumour regression grade.

Median age of patients eligible for analysis was 68 years (range 29-88); 70 patients underwent APE and 31 underwent LAR. 27% (27/101) had pathologically involved margins.

Significantly more patients with MRI stage 3 to 4 had positive resection margins (24/47, 36.7%) compared with patients with MRI stage 1 to 2 (3/54, 5.6%) ($p<0.001$).

Patients with anterior tumours had a higher risk of positive margins versus patients with a posterior tumour (36.7% versus 17.3%, $p=0.026$).

Patients with a tumour regression grade of 1 to 2 had a significantly higher risk of positive margins compared with

patients with tumour regression grade of 3 to 5 (73.3% versus 13.3%, p=0.001).

There was no significant difference between operation type or between patients that did and did not have any preoperative therapy.

On multivariate analysis, MRI stage remained a significant predictor of positive margins (OR for stages 3-4, 15.2, p=0.002) but tumour location (anterior versus posterior) was no longer significant (p=0.095).

Results of multivariate logistic regression analysis suggested that thumour regression grade and quadrant were predictive of positive margins however the authors deemed the results unreliable and chose not to present them in this study.

Citation: Tatli S, Mortele K, Breen E, Bleday R, Silverman S (2006) Local staging of rectal cancer using combined pelvic phased array and endorectal coil MRI *Journal of Magnetic Resonance Imaging* 23;4:534-540

Design: Case Series

Country: USA

Aim: to assess the accuracy of MRI using a pelvic phased array coil and an endorectal coil for preoperative local staging of rectal cancer.

Inclusion criteria
Patients with biopsy proven adenocarcinoma of the rectum

Exclusion criteria
Patients in whom endorectal coil could not be used

Population
N=51

Interventions
MRI with phased array coil and endorectal coil

Outcomes
Accuracy
Sensitivity
Specificity
Positive Predictive values
Negative Predictive values

Results
At pathological examination, 25% of patients had T1, 29% had T2 and 29% had T3. In 16% of patients no residual tumour was identified on pathological examination.
Overall MRI-based T-staging was identical to pathology based T-staging in 45/51 (88%) patients according to retrospective reading of images.
MRI correctly identified 31/36 (86%) of T0-T2 tumours and 14/15 (93%) of T3 tumours.
Blinded retrospective MRI reading correctly identified lymph node involvement in 29/39 patients.

	Total	Chemoradiotherapy	No chemoradiotherapy
Accuracy	88%	81%	96%
Sensitivity	93%	100%	80%
Specificity	86%	69%	100%
PPV	74%	67%	100%
NPV	97%	100%	95%

Table: Blinded retrospective reader interpretation of MRI for T-staging of rectal cancer

	Total	Chemoradiotherapy	No chemoradiotherapy
Accuracy	74%	81%	69%
Sensitivity	85%	100%	33%
Specificity	69%	69%	80%
PPV	58%	67%	33%
NPV	90%	100%	80%

Table: Blinded retrospective reader interpretation of MRI for N-staging of rectal cancer

Interobserver agreement between blinded retrospective reading (single reader) and prospective readings (seven radiologists) from radiological experts were excellent (κ=0.85) for prediction of T3 tumour and good (κ=0.80) for prediction of nodal metastasis.

General comments
An experienced radiologist without knowledge of the results of the pathological examination and surgical stage of the tumours evaluated all MRI images retrospectively.

Tumours were classified as:
T1 = confined to the mucosa and submucosa
T2 = muscularis propria invasion
T3 = mesorectal fat extension
T4 = adjacent organ invasion

N0 = no nodal involvement

N1 = one to three regional nodes positive for tumour
N2 = four or more regional nodes positive for tumour
Where a lymph node ≥5mm was deemed positive.

Citation: Tateishi U, Maeda T, Morimoto T, Miyake M, Arai Y, Kim, E (2007) Non-enhanced CT versus contrast enhanced CT in integrated PET/CT studies for nodal staging of rectal cancer *European Journal of Nuclear Medicine and Molecular Imaging* 34;10:1627-1634

Design: Retrospective Case Series

Country: Japan

Aim: to determine the diagnostic accuracy of non-enhanced CT and contrast enhanced CT in integrated PET/CT studies for preoperative nodal staging of rectal cancer.

Inclusion criteria
Patients with histologically proven rectal cancer
Performances Status (PS) PS0: fully active, able to carry on all pre-disease performance without restriction or PS1: restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature.

Exclusion criteria
Evidence of distant metastasis
Diabetes
Pregnancy or lactation in women

Population
N=53

Interventions
PET/CT with non-enhanced CT
PET/CT with enhanced CT

Outcomes
Accuracy
Sensitivity
Specificity
Positive Predictive Value
Negative Predictive Value

Results
Nodal status of regional lymph nodes was examined in all patients and a total of 106 lymph nodes were pathologically metastatic nodes. On the CT portion of non-enhanced PET/CT, nodal status was correctly determined in 17 (32%) patients versus 27 patients (51%) on CT of the contrast-enhanced PET/CT.
Nodal stage was correctly diagnosed in 37 (70%) of patients on non-enhanced PET/CT and in 42 patients (79%) in contrast-enhanced PET/CT.
There was no significant difference in accuracy of contrast enhanced PET/CT and non-enhanced PET/CT for nodal staging (p=0.063).

	Contrast Enhanced PET/CT	Non-enhanced PET/CT
Sensitivity	85%	85%
Specificity	68%	42%
Positive Predictive Value	83%	73%
Negative Predictive Value	72%	62%
Accuracy	79%	70%

Table: Results of nodal staging for contrast enhanced PET/CT and non-enhanced PET/CT

Contrast enhanced PET/CT determined the pararectal nodal status, internal iliac nodal involvement and obturaror nodal status more accurately than did non-enhanced PET/CT
Contrast enhanced PET/CT was significantly more accurate that non-enhanced PET/CT in the staging of regional lymph node metastasis.

Lymph Nodes	Non-enhanced PET/CT	Contrast enhanced PET/CT	P value
Pararectal Nodes			
Correct	35 (66%)	45 (85%)	0.002
Overstaged	10 (19%)	5 (9%)	
Understaged	8 (15%)	3 (6%)	
Internal Iliac Nodes			
Correct	35 (66%)	44 (83%)	0.004
Overstaged	7 (14%)	5 (9%)	
Understaged	11 (21%)	4 (8%)	
Obturator Nodes			

Correct	33 (62%)	47 (89%)	<0.0001
Overstaged	16 (30%)	2 (4%)	
Understaged	4 (8%)	4 (8%)	

Table: Staging performance for non-enhanced PET/CT and contrast enhanced PET/CT in respect of regional lymph nodes

	Contrast Enhanced PET/CT			**Non-enhanced PET/CT**		
	Pararectal Nodes	**Internal Iliac Nodes**	**Obturator Nodes**	**Pararectal Nodes**	**Internal Iliac Nodes**	**Obturator Nodes**
Sensitivity	73% (22/30)	60% (9/15)	50% (5/10)	90% (27/30)	73% (11/15)	80% (8/10)
Specificity	57% (13/23)	82% (31/38)	84% (36/43)	78% (18/23)	87% (33/38)	91% (39/43)
PPV	69% (22/32)	56% (9/16)	42% (5/12)	84% (27/32)	69% (11/16)	67% (8/12)
NPV	62% (13/21)	84% (31/37)	87% (31/37)	86% (18/21)	89% (33/37)	95% (39/41)
Accuracy	66% (35/53)	75% (40/53)	77% (41/53)	85% (45/53)	83% (44/53)	89% (47/53)

Table: Diagnostic accuracy of contrast enhanced and non-enhanced PET/CT with respect of regional lymph node status.

General comments
Total mesorectal resection and lymphadenectomy were performed in all patients and histopathologic results used as the reference standards.

Authors Conclusion: Contrast enhanced PET/CT shows a trend towards more accurate N-staging of rectal cancer compared with non-enhanced PET/CT.