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INTRODUCTION AND CLINICAL BACKGROUND

Worldwide, colorectal cancer is the third most commonly diagnosed cancer in males and the second in females 1,2. In 2012 there were an estimated 1.4 million cases and 693,900 deaths 2. Rectal cancer accounts for approximately one third of this incidence 3.

Surgical treatment for rectal cancer was revolutionised in the 1980s and 1990s with the recognition of increased local tumour recurrence in the presence of residual tumour cells at the operative circumferential resection margin (CRM) 4–6. This led to the widespread acceptance that optimal surgery should follow the mesorectal fascial (MRF) planes to achieve negative resection margins 4–6. The use of pre-operative imaging was shown to be accurate in predicting patients with, or at high-risk of, tumour-CRM involvement, or other high-risk features 7–10. This pre-operative staging and so the identification of high-risk tumours has enabled the selective use of neo-adjuvant management to improve overall outcomes 11–14.

With the exception of very early stage tumours, where there is a role for endorectal ultrasound, pelvic magnetic resonance imaging (MRI) is firmly established as the optimal method of local staging for rectal cancer 7–10,15,16. This is reflected in the EURECCA (European Registration of Cancer Care), European Society for Medical Oncology (ESMO),

European Society of Gastrointestinal and Abdominal Radiologists (ESGAR) and UK National Institute for Health and Care Excellence (NICE) statements/guidelines which recommend pelvic MRI for local disease staging, with contrast-enhanced CT of the chest, abdomen and pelvis for distant staging and complete colonoscopy (either pre- or postoperatively) for colonic mucosal assessment 11–14.

There are various definitions for locally advanced rectal cancer (LARC), the main factors associated with higher risk tumours are; extension beyond the muscularis propria of the rectal wall tumour threatening or involving the mesorectal fascia (MRF), growth into adjacent organs, lymph node involvement and extra-mural venous invasion (EMVI) 11–14; see Table 1a. UK treatment recommendations include surgery alone for the low risk tumour group; short-course pre-operative radiotherapy (SCRT) followed by surgery for the moderate risk tumour group; and pre-operative chemo-radiotherapy (CRT) followed by consideration for surgery (based on the tumour response on interval MRI) in the high-risk tumour group12. These guidelines differ to those produced by ESMO at a pan-European level; see Table 1b. Irrespective of the guidelines followed, baseline p~~P~~elvic MRI, ~~therefore,~~ has a pivotal role in identifying LARC and is used to select patients for neoadjuvant treatment.

In addition to primary staging, restaging assessment MRI has an increasingly pivotal role in LARC tumours as a method of quantifying the response to neoadjuvant treatment. Descriptions of the tumour response and/or other changes are important for subsequent medical and surgical treatment planning such as whether standard total mesorectal excision (TME) or more extensive primary surgery is appropriate.

This review will concentrate on the importance of the morphological features of LARC using standard MRI techniques and the potential impact of functional MRI techniques. The importance of accurate radiologist reporting with specific reference to TNM8 is also discussed.

MORPHOLOGICAL MRI

MRI FOR PRIMARY STAGING

T-stage and invasion depth beyond the rectal wall

Thin-section high spatial and tissue contrast resolution MRI allows detailed depiction of the relationship between the rectal tumour and mesorectal anatomy including the layers of the rectal wall, MRF and surrounding structures 8,16,17.

Traditional T-staging according to TNM involved subdivision of tumours into four discrete categories; T1-4 18. However, recent advances outside of TNM staging, have further subdivision of these categories, with the creation of 4 subgroups for T3 tumours (T3a-d) and two subgroups for T4 tumours (T4a-b) recognises a more nuanced approach is needed to quantify the depth of tumour penetration beyond the muscularis propria, which influences the risk of locoregional recurrence 19–21. Although debate remains about the depth of extramural growth beyond the muscularis propria that is significant, current evidence supports grouping tumours as having either < 5mm or > 5mm of extramural growth (T3a-b versus T3c-d) 19–22. Appropriately aligned T2-weighted sequences, parallel and perpendicular to the tumour, allow precise sub-staging using measurements of the depth of invasion of tumours through the muscularis propria, figure 1 17. With integration of these

subcategories into treatment pathways accurate baseline MRI staging is pivotal to direct neoadjuvant treatment, Table 1b.

Mesorectal fascia involvement

T2-weighted sequences enable accurate depiction of tumours to within 1mm of the MRF, a cut-off that has been validated in large series 23, despite smaller studies suggesting alternative values, such as 0.4 mm or 2.0 mm 16,24. Pre-operative identification of tumour relationship to the MRF is recommended because it identifies tumours at a higher risk of local recurrence and pathological involvement of the circumferential resection margin (CRM) without neoadjuvant treatment, figure 2.

Despite the acknowledged influence of tumour involvement of the MRF on prognosis, the relevance of which mechanism of tumour spread threatens or involves the MRF has not been well established. A single relatively small study demonstrated lymph node-MRF involvement had no impact on local recurrence rates, unlike other tumour components that are significant (i.e. 'direct' from primary tumour, or 'indirect' from EMVI or lymphatic vessel invasion)19. However, the US National Comprehensive Cancer Network (NCCN) and TNM v8 definition of MRF involvement do not discriminate between 'direct' and 'indirect' MRF involvement18,25.

Low rectal tumours have higher rates of positive CRM involvement than higher rectal tumours following surgical excision 26,27. This is partly due to the closer anatomical relationships of structures in the lower rectal canal; the anal sphincter muscles and the lack of surrounding adipose tissue, Figure 3. However, because of its high contrast resolution

MRI has been specifically validated in low rectal cancers to adequately provide detailed pre-operative descriptions of the relationships between the tumour and nearby structures 28,29. These descriptions therefore guide the resection required to reduce the risk of tumour involvement at the CRM. For example, MRI should be able to demonstrate tumours involving the external sphincter and levator muscles that are more suitable for a more extensive extralevator abdominoperineal excision (ELAPE) resection than a conventional abdominoperineal (APR) resection 26,29,30.

Lymph node involvement

Despite advances in MRI, rectal cancer lymph node metastases are difficult to determine with reported sensitivity ranging between 42% and 89%43–47. It has been reported that this can result in around 25% of lymph nodes being over-staged, with a resultant increase in potentially unnecessary preoperative treatment and morbidity 48. Given the difficulties in radiological assessment of lymph node metastatic involvement, various solutions have been suggested including lymph node size, morphological criteria or completely discounting radiological assessment of lymph nodes 11,15.

Recent European and North American guidelines aim to provide a practical solution to lymph node staging with the use of combined morphological and size criteria 11,43,50. The three morphological criteria include a round shape, irregular lymph node contour and mixed MRI signal with none, two and three required for lymph nodes measuring >9mm, 5-8mm and <5mm respectively 11. The widespread adoption of these criteria has been poorly studied, but they provide a consensus position for practicing radiologists, with the inaccuracies of this compromise clearly acknowledged by the authors of the guidelines 11.

When metastatic lymph node involvement is suspected, in theory the lymph node capsule provides a distinct physical boundary to surrounding structures. Extra-capsular lymph node extension describes the situation whereby tumour has breached the lymph node capsule and so directly spreads into the extra-nodal tissues. It has been investigated for its effect on prognosis with meta-analyses demonstrating it is associated with increased rates of ~~to~~ recurrence and all cause-mortality51–53; however, it is not included in current staging criteria.

Another contentious patient management issue is metastatic involvement of lateral pelvic side wall lymph nodes (LPLN), figure 4. Metastatic spread to LPLN is more likely to be associated with low rectal tumours, extending below the anterior peritoneal reflection, compared to high rectal tumours; involvement is reported in up to 20% of low rectal tumours compared to 8% of high rectal tumours 56,57. Subsequently, there has been interest in LPLN dissection to resect these malignant lymph nodes, or even as a prophylactic measure 58,59. Although LPLN dissection is not routine practice in the West for low rectal tumours, it is in Japan, where it ~~is~~ has been shown to reduce the risk of intra-pelvic tumour recurrence by 50%, and improve the 5-year survival rate by 8–9% 58,60. As a result LPLN dissection is recommended in Japan for T3 and T4 low rectal tumours 60. A recent comparison of the surgical techniques, demonstrated traditional TME with LPLN dissection had lower recurrence rates than TME alone 61. Although disputed by its proponents, TME with LPLN dissection has been associated with increased morbidity, specifically longer operation time, greater blood loss, impotence and urinary bladder dysfunction 62,63. By comparison, in the West, neoadjuvant treatment is more widely used than LPLN dissection,

having been shown within Western populations to reduce the risk of local recurrence and offer control for metastatic spread to LPLN 64–66. However, this is also not without its own controversies with increased rates of faecal incontinence and other acute or chronic radiation-induced toxicities such as a skin ulceration and urinary bladder dysfunction 65,67. Recent data also suggest radiotherapy may offer inadequate treatment when LPLN involvement is suspected (in lymph nodes measuring larger than 10 mm), with localised pelvic sidewall recurrence occurring in 33.3% (4-year rate) compared to 10.1% ~~w~~ in patients with smaller nodes despite patients being irradiated in the lateral compartment 68.

Irrespective of the proposed treatment, radiologists should be aware of which tumours are at an increased risk of associated metastatic LPLNs, identify these and appropriately describe the predicted sites of involvement for clinicians.

Extra-Mural Sites of Disease beyond lymph nodes

Histopathological studies identified the prognostic significance in rectal cancer of the invasion of peri-rectal veins beyond the muscularis propria~~,~~ by the primary tumour in the 1980s 69. Subsequent studies have confirmed that micro- or macro-scopic EMVI is associated with local recurrence, reduced disease-free and overall survival 69–73. The high spatial- and contrast-resolution achieved with MRI has been shown to provide high specificity and sensitivity for the detection of EMVI on baseline pre-operative MRI (mrEMVI) 74–77, figure 5, which allows tumours with mrEMVI to be identified and considered for neoadjuvant treatment 29,71,78. Whether they are treated as moderate- or high-risk tumours remains contentious with differences between UK and European treatment guidelines 12,13.

Additionally, tumours with mrEMVI have been shown to be more resistant to neoadjuvant treatment 75. However, where mrEMVI decreases on restaging MRI after neoadjuvant treatment it has been shown to be associated with improved disease free-survival 78, indicating that accurate quantification of mrEMVI on reassessment MRI is important when considering benefits of intensive treatment for these patients 78.

Similarly the importance of extra-nodal tumour deposits (ENTDs) not within a lymph node, vessel or nerve, is highly topical but poorly understood, despite being included in TNM v8 as N1c18. Their presence appears to have a more pivotal role in local recurrence and overall survival than larger lymph node metastases 18,54,55. A recent meta-analysis demonstrating ENTDs shows they have a greater association with EMVI than nodal involvement 55. ENTDs are likely, therefore, be completely separate entities to lymph node metastases. The influence of number and size of ENTDs is poorly studied but both have been suggested as important prognostic factors 54. Currently, however, the presence or absence of ENTDs is all that should be incorporated within baseline rectal cancer staging, as per TNM v8 18.

MRI FOR RESTAGING AFTER NEOADJUVANT TREATMENT

Timing of reassessment scans

Debate remains for the optimal timing of post-CRT surgical excision of tumour. By inference there is also uncertainty about the best time to perform reassessment MRI (yMRI) 79–86. This is due the consolidation effects of neoadjuvant CRT for several weeks after treatment; the suggested range of optimal surgery is between 4 and 16 weeks after completion of neoadjuvant treatment 79–86. Whilst one study demonstrated the rate of pathological

complete responders (pCR) increased from 10% to 18%, comparing an interval of <13 weeks to 15–16 weeks from the start of CRT to surgery 80, demonstrated no benefit in pCR rate, but worse morbidity in cohorts who delayed surgery to 11 weeks compared to 7 weeks 86. Thus, a 6 to 8 week interval remains most commonly recommended in UK clinical practice, with up to date imaging before surgery 11,50. Greater standardisation of the timing of scans and the interval to surgery is imperative to improve our understanding of the radiological appearances and their pathological correlation. This is particularly relevant in imaging reassessment of patients being considered for organ preservation ('watch and wait') treatment programmes 86–88.

Tumour regression grading (TRG)

Grading systems have been developed to provide a more objective assessment of the tumour to neoadjuvant treatment 89–93. These have been developed using pathological rather than radiological datasets 89–96. They predominantly rely on semi-subjective scales to quantify the replacement of tumour with fibrosis 94–96. Changes in the size of a tumour are incorporated into yMRI-based modified tumour regression grade (ymrTRG), however, reports of their reproducibility are mixed 97–99. Consequently, ymrTRG is not yet consistent enough for routine clinical use 93,98,100. Current reporting guidelines suggest re-staging tumours based on a three-point scale describing the residual mass without a more complex ymrTRG scale; no mass with a normalised rectal wall, no mass but fibrotic wall thickening or a residual mass/ focal high signal on diffusion weighted imaging (DWI; plus yT stage (post-neoadjuvant treatment T stage)). These roughly correlate into pCR (pathological complete response), partial response and little to no response TRG categories 11,50, figure 6.

Further collaborative studies and on-going feedback with education are required to improve concordance between radiologists ymrTRG vs. histopathologists ypTRG (post-neoadjuvant treatment, pre-operative MRI TRG versus post-operative pathological TRG).

Volumetry

Volumetric assessment of tumour burden has been used for primary staging, response assessment to neoadjuvant treatment and for radiotherapy planning 90,91,101–104. A recent review indicated that unlike tumour volumes, standard bi/tri-dimensional (2D/3D) length measurements offered no value in reassessing tumour response 105. Standard bi-dimensional quantification is more affected by movement, visceral tortuosity and tumour irregularity than gross tumour volumes 106. Additionally, tumours volumes calculated using diffusion weighted image sequences (DWI; using high b-values) offer a more reliable method of delineating volume than standard T2w sequences; despite the higher image resolution of T2w 90,91,101–104,107.

The practical difficulties of implementing tumour volume assessment, however, has prevented its inclusion into clinical practice and recent ESGAR guidelines 11. Advances in semi-automated tumour segmentation are promising and offer significant time-saving benefits compared to manual delineation, potentially making it a clinically useful tool 108,109.

Identification of complete responders

After CRT about 15–25% of patients undergo a pCR hence the growing interest in identifying these patients for recruitment into ‘watch and wait’ treatment programmes to avoid the

240 associated morbidity of surgery 88,110. ymrTRG system has a reported sensitivity and
241 specificity for identifying complete responders of 74% and 63% respectively 98,111. The
242 addition of functional (diffusion-weighted) imaging can improve the sensitivity compared to
243 T2-weighted imaging alone, with a pooled meta-analysis demonstrating an improvement
244 from 50 to 84% in the identification of a pCR112. Even the combination of these sequences
245 is not fully sensitive, as it does not appreciate small volumes of residual viable tumour cells.
246 The efficacy of 18-Fluorine-Fluorodeoxyglucose Positron Emission Tomography/Computed
247 Tomography (FDG-PET/CT) has been investigated to identify patients with a pCR, however
248 results are also mixed with no conclusive evidence to support its use 113,114. At present,
249 the most accurate non-operative recognition of an complete response relies on MRI volume
250 reduction, fibrotic transformation of the tumour and changes in diffusion 115 (see later
251 section for a more detailed discussion of appearances on diffusion imaging).
252
253 **MRI assessment after surgery**
254 **Tumour recurrence and assessment following anastomotic leak**
255 Local recurrence is more common when there has been an anastomotic leak, independent
256 of tumour stage 116. Although subsequent studies have cast doubt on this, a recent meta-
257 analysis has shown the adverse impact of an anastomotic leak in local disease control
258 117118. The reasons for this are unclear, but the correlation between an anastomotic leak
259 and the technical difficulty of the surgical resection and the subsequent inflammatory
260 microenvironment have both been implicated in promoting the implantation of tumour cells
261 119. Radiologists should be aware of this risk and extra vigilant to assess for sites of
262 recurrence when reviewing follow-up imaging in cases where there has been an
263 anastomotic leak, particularly since the imaging is inherently more complex because of the

distortion of tissues and fibrosis which forms in response to the leak. Important signs of recurrence include ill-defined or spiculated borders to a soft tissue mass and identifying asymmetric oedema at a tumour margins, as this may indicate tumour spread rather than reactive change 41, figure 7.

FUNCTIONAL MRI

Diffusion-weighted imaging

DWI is a measure of the random movement of water molecules within the extra-cellular space, which is hindered by densely packed cell membranes commonly seen in tumours. Apparent diffusion coefficient (ADC) is a more objective measure of the diffusion restriction also accounting for the background level water content.

DWI for baseline staging

There is limited evidence that DWI has a role in baseline staging of advanced tumours compared to T2w sequences; particularly with reference to the T-staging, MRF and EMVI evaluation. The value of DWI for the detection of metastatic lymph node involvement is more contentious; some studies show improved lymph node staging by using DWI and ADC alongside conventional T2w sequences 120–124. However, both benign and malignant lymph nodes can display high DWI signal, so DWI is insufficient alone to discriminate these 120. Hence, although DWI is often included by radiologists in primary staging assessment MRI, it does not feature in staging criteria. It can, however, subsequently be used for retrospective comparisons to assess tumour response at the time of yMRI 11.

DWI for restaging

Restaging DWI and ADC imaging have a greater role in comparing neoadjuvant treatment response in the primary tumour, MRF involvement and lymph nodes containing metastatic disease, when compared to pre-CRT diffusion appearances 102,120,124–128. However, the utility of DWI / ADC is improved in combination with standard morphological T2w imaging112. Combining morphological and functional imaging improves the accuracy of an ymrCR representing a true pCR 11,92,102,112,128, figure 8. Furthermore, an automated version of predicting pCR can be achieved using a combination of T2w derived volumetry with DWI, but this remains a pre-clinical tool 92. DWI, however, is not a panacea as it will tend to over-diagnose pCR. Just as with morphological imaging, small numbers of viable tumour cells will not be seen, and, there is limited evidence for reassessment of nodal involvement 124,129–131.

Given the reduced spatial resolution inherent to DWI it is important that radiologists appreciate its specific technical limitations, which include; misinterpretation of low signal fibrosis on ADC map, susceptibility effects, T2w shine-through of fluid in the rectal lumen, suboptimal sequence angulation and collapsed rectal wall 128.

Dynamic contrast enhancement (DCE)/perfusion

MRI dynamic contrast enhancement/perfusion (DCE) is a technically challenging MRI technique that combines anatomical detail with semi-quantification of vascular parameters as an indirect measure of angiogenesis. More angiogenic tumours are associated with a worse prognosis, because of their disorganised vasculature and associated increased vascular permeability, which should be quantifiable using a contrast agent 132. However, despite some results supporting the utility of MRI DCE, others have been more equivocal

regarding its added value 132–138. In spite of the lower contrast resolution, CT perfusion imaging is also being assessed in colorectal cancer, since the technical practicalities of CT perfusion are easier to overcome than MRI DCE, with studies suggesting poor perfusion is associated with worse clinical outcomes139–141.

In addition to risk-stratifying primary tumours, MRI DCE has been used to aid the prediction of tumour response to neoadjuvant treatment (from pre- and post- neoadjuvant treatment scans), often using semi-quantification of changes in perfusion but results are inconsistent132,133,136,142,143. DCE remains limited to clinical trials with no recommendation for routine clinical use.

Other MR techniques

Lymph node–specific contrast agents, such as ultra-small super paramagnetic particles of iron oxide (uSPIO) and gadofosveset trisodium, have shown potential for identifying metastatic lymph node involvement but none are clinically available and so they have no routine clinical role 144–147.

There have been a limited number of small studies assessing susceptibility-weight imaging (SWI) and dynamic-susceptibility contrast (DSC) MRI in rectal cancer. Although these, show the feasibility of SWI the relationship to prognosis is less clear148,149.

REPORTING FOR ADVANCED RECTAL CANCER

Pros and cons of pro-forma reports

Structured reporting in radiology and pathology has been shown to improve communication of imaging findings and consistency of reports for both clarity and content 160–163. This is particularly true in rectal cancer, given the number of tumour descriptors that are of prognostic significance163. Recent consensus statements published by ESGAR and SAR both recommend using structured report templates for primary staging and restaging of rectal cancer 11,50. These provide a minimum dataset of key tumour descriptors that should be documented for every case, to allow retrospective audit of standards. In LARC or low rectal tumours further key tumour descriptors are recommended, however to date there is no agreed template to satisfy these requirements. Template reporting also allows greater opportunity for radiological-pathological correlation and consequently individual and departmental/hospital feedback for service standardisation and quality improvement.

TNM8 overview

TNM v8 has recently been implemented for colorectal cancer staging 18. This has several minor modifications from earlier versions, see Table 2 for the latest version. Although developed from pathological datasets it is routinely adapted to baseline MRI staging. Important changes in TNM8 include~~,~~:

- Primary tumour staging:
    - T1 tumours invade beyond the submucosa; T2 tumours invade into the muscularis propria; T3 tumours invade beyond muscularis propria; and T4 tumours invade directly into other organs or structures and/or perforate the visceral peritoneum.

- Although not part of TNM 8 the T3 subdivisions measure the depth of tumour invasion through the muscularis propria and <5mm/>5mm has shown to be of prognostic significance:~~,~~ T3a <1mm, T3b 1-5mm, T3c 5-15mm and T3d >15mm.
- The definitions of T4a and T4b have switched from TNM v5; now a pT4a tumour cells have breached the peritoneal surface and pT4b tumour invades adjacent organs.

- Nodal staging: subdivision of pN1 (N1a; 1 involved node, N1b; 2-3 involved lymph nodes) and pN2 (≥4 involved lymph nodes) and a new category of extra-nodal tumour deposits (ENTDs, without regional lymph node metastases) has been created, pN1c. There are no minimum size criteria and tiny subserosal deposits will not be seen radiologically. Isolated tumour cells in nodes are no longer counted as pathologically involved, although these could never be seen radiologically, which should increase the correlation with pathology for N status.
- Metastatic staging: further subdivisions into pM1a-c and abolition of pM0/pMx.
- Venous, perineural and lymphatic channel invasion are included and are subclassified into intramural or extramural at their deepest extent, whereas radiological assessment may only detect extramural spread in large veins.

Conclusion

MRI remains our best in vivo method for rectal cancer staging and response assessment but, in spite of recent imaging advances including DWI, contrast enhanced MRI and FDG-PET/CT, accurate categorisation of key tumour variables remains challenging for radiologists.

Template reporting can improve completeness of data collection. Further technical developments and education are required to maximise the potential for patient risk stratification and personalised therapies based on baseline and re-assessment imaging. Future prospective work is required to improve the accuracy of rectal cancer staging in routine clinical practice, including better discrimination of malignant lymph nodes. Additionally, studies should assess using the tumour phenotype as a prognostic marker and a predictor of response to neoadjuvant therapies, which might include texture analysis when obstacles around MRI texture analysis have been overcome.

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Figure and Table Legends

Figure 1: Sagittal (a and c) and axial (b and d) T2 weighted MRI image demonstrating low (a and b) and high (c and d) rectal tumours (red line) and their axis (red arrow). The white lines

demonstrate the planes required on MRI, orthogonal to the axis of the tumour to optimise the scan and ensure appropriate axial images of the tumour and surrounding structures are obtained (c and d).

Figure 2: Axial T2 weighted MRI image. The white arrowheads show where the mesorectal fascia is not involved or threatened by the rectal tumour. By comparison the white arrows show where there is tumour invasion through the muscularis propria and involving the mesorectal fascia.

Figure 3: Coronal and sagittal (A) and axial (B) T2 weighted MRI images of a lower rectal tumour demonstrating the close relationship between the levator ani muscles and the lower rectal canal at positions 1, 2, 3 and 4 descending inferiorly. The axial image 4 is the anorectal junction at where the puborectalis muscle passes around the anorectal canal. These images demonstrate the close relationships between the lower rectal canal and the mesorectal fascia and so the increased likelihood of residual tumour involvement at the margin of these tumours following surgical resection because of there increased technical difficulty.

Figure 4: Axial T2 weighted MRI image of a low rectal tumour with metastatic involvement of adjacent lymph nodes. The white arrow demonstrates an intra-mesorectal lymph node at the 3 o'clock position and the arrowhead demonstrates an extra-mesorectal lymph node on the right lateral pelvic sidewall at an 8 o'clock position. These images also demonstrate

extramural venous invasion within the mesorectal fascia between the 9 and 11 o'clock positions.

Figure 5: Sagittal T2 weighted MRI image of a mid-rectal tumour with macroscopic extra-mural venous invasion (white arrows) extending along the mesorectal fascia.

Figure 6: Coronal T2 weighted MR images of a mid-rectal tumour pre (a) and post (b) neoadjuvant treatment demonstrating progressive disease. Axial T2 weighted MR images of a low rectal tumour pre (c) and post (d) neoadjuvant treatment demonstrating partial tumour response. Coronal T2 weighted MR images of a mid rectal tumour with extra-luminal disease, pre (e) and post (f) neoadjuvant treatment demonstrating complete tumour response and residual fibrotic tissue.

Figure 7: Tumour recurrence in the pre-sacral space following a leak from the colorectal anastomosis. Sagittal CT (a) and subsequent T2 weighted sagittal MRI obtained 12 months later. The CT demonstrates a pre-sacral fluid collection that has formed as a consequence of an anastomotic leak. The MRI demonstrates tumour recurrence at this same site.

Figure 8: Axial T2 weighted (a), diffusion-weighed image (b, accquried with a b value of 750) and apparent diffusion co-efficient image (c). These demonstrate a large mid-rectal tumour with minor and heterogenous diffusion restriction.

Table 1: Comparison of definitions (Table 1a) for locally advanced rectal cancer and their associated treatments (Table 1b) generated by the UK National Institute for Health and Care Excellence (NICE) and the European Society for Medical Oncology (ESMO).

Table 2: Table outlining the current AJCC TNM8 criteria used for staging of colorectal cancers with additional criteria of prognostic significance included. * The term intramucosal carcinoma is not used in the UK, instead these lesions are termed high grade dysplasia in UK practice. ** not in TNM8 staging criteria but of prognostic significance. ***Current guidelines suggest the addition of morphological criteria in addition to nodal size to determine metastatic lymph node involvement; these are not included in TNM8 but are in ESGAR and SAR reporting guidelines and include: [1] round shape, [2] irregular border, [3] heterogeneous signal.