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MRI Staging of Anorectal Malignancy—A Reporting Dilemma: Is It Adenocarcinoma or Squamous Cell Carcinoma?

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Abstract

Aim Magnetic resonance imaging (MRI) of anorectal malignancy is often reported assuming low rectal adenocarcinoma (LRC). The biopsy may, however, reveal squamous cell carcinoma (SCC). Thus, the aim was to compare the imaging findings of SCC and LRC.

Methods This was a retrospective study of patients who underwent staging MRI for anorectal malignancy (<5 cm from the anal verge) for adenocarcinoma or squamous cell carcinoma between 2016 and 2021. Two radiologists blinded to biopsy reviewed MRI. Imaging findings and apparent diffusion coefficient (ADC) values were compared between SCC and LRC.

Results We studied 137 patients ($n = 60$ SCC, $n = 77$ LRC) with a mean age of 50.4 (standard deviation: 12.4) years and tumor length of 5.6 ± 1.9 cm. SCC patients were older, and their distal tumor margin was closer to the anal verge (5.3 vs. 22 mm for LRC; $p < 0.001$). T2 intermediate signal and diffusion restriction was seen in 97 and 98.2% of SCC and 75.3 and 77% of LRC, respectively. SCC had lower ADC values (0.910×10^{-3} mm^2/s) than LRC (1.126×10^{-3} mm^2/s; $p < 0.001$). But there was no difference in the ADC values when T2 hyperintense tumors were excluded ($p = 0.132$). Extramural vascular invasion (EMVI) was more frequent in LRC (35.1 vs. 16.7%; $p = 0.013$). A combination of distance from the anal verge of less than 11 mm, absent EMVI, and the presence of internal iliac and inguinal nodes had an area under the curve (95% confidence interval) of 0.810 (0.737–0.884).

Conclusion ADC values are unhelpful in differentiating SCC and LRC. Tumors closer to anal verge, absence of EMVI, and the presence of inguinal and internal-iliac nodes may point towards SCC.

Keywords
- squamous cell carcinoma
- low rectal cancer
- adenocarcinoma
- anorectal malignancy
- anal cancer
- MRI

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Clinical Impact

Rectal adenocarcinoma and squamous cell carcinoma (SCC) of the anal canal are two different types of cancers involving the same anatomical region. These cancers have distinct staging systems and magnetic resonance imaging (MRI) is the modality of choice. The biopsy, which is the gold standard for diagnosing the type of cancer, is often not available to the radiologist reporting the MRI. Thus, being able to differentiate these cancers based on imaging features is very relevant. We compared the morphological and functional imaging features of these two types of anorectal cancer and identified imaging findings that can help in differentiating these cancers. Our study findings have implications for the optimal delivery of the very purpose of MRI in these cancers and in the larger picture will indirectly influence the cancer referral pathways.

Introduction

MRI is the standard of care for local staging of both rectal cancer and anal canal cancer.[1] But there is a large difference in the incidence of both these types of cancers. While anal canal cancers are uncommon with an age-adjusted incidence of 1 to 2 per 100,000 per year, the age-adjusted world incidence of colorectal cancer is 19.7 per 100,000 per year.[2,3] In other words, the vast majority (95%) of rectal cancers are adenocarcinoma and the majority (70–80%) of anal canal cancer are SCC. Thus, anal cancer synonymously refers to the SCC of the anal canal. Verrucous and basaloid carcinomas are variants of SCC of the anal canal and behave similarly to anal SCC. The rare anal mucous gland adenocarcinoma, on the other hand, behaves like rectal adenocarcinoma.[4]

The role of MRI in the staging, treatment planning, and reassessment following chemoradiotherapy for both rectal cancer and anal canal cancer is well established.[1,5–13] Often biopsy reports are not available during the MRI reporting sessions. Because of the differences in the incidence of rectal and anal canal cancers, MRI is reported assuming rectal adenocarcinoma. But the treatment, prognosis, and follow-up guidelines of these two types of anorectal cancers are very different. This practice translates into an MRI report with incomplete or inaccurate staging information and the need for report addendum once the biopsy is available.

Literature available on the MRI features of anal cancer is from small series.[7,9–11,14] There has only been one prior study comparing MRI features of rectal adenocarcinoma and SCC of the anal canal, which has shown that tumor signal, tumor location 2 cm above the anal verge, and absence of anal sphincter invasion predicted adenocarcinoma over SCC.[15] Few diffusion-weighted imaging (DWI) studies have shown that the majority of SCC show diffusion-restriction.[6,12] However, there is no literature on the cutoff apparent diffusion coefficient (ADC) values, which can differentiate anorectal SCC from rectal adenocarcinoma. Thus, we aimed to compare the morphological and functional imaging features between anorectal SCC and low rectal adenocarcinoma (LRC).

Methods

Setting and Patients

This was an institutional review board approved (IRB Min No. 14621) retrospective cross-sectional study. Patients were identified using PACS (GE Health system, Barrington, Illinois, United States) database using word search by MRI modality within a specified time frame. Consecutive adult patients who underwent staging MRI for anorectal malignancy and received a biopsy diagnosis of adenocarcinoma or SCC in our center between January 2016 and December 2021 were included. Among the patients with adenocarcinomas, only patients with low rectal cancers defined as distal margin at or below 5 cm from the anal verge on MRI were included. After removing duplicates, we further excluded patients with high and mid rectal cancers, tumors smaller than 1 cm, and those who were partially treated elsewhere.

MRI Protocol

Staging pelvic MRI was performed according to standardized imaging protocol using 1.5T (Siemens Healthcare, Erlangen, Germany) or 3T (Philips Healthcare, Best, Netherlands) MRI scanner.[1,16] MRI pelvis protocol was similar for both LRC and anal SCC. T2-high resolution MRI of the pelvis was performed with 0.6 to 0.7 mm in plane resolution; small field of view of 18 to 20 cm; section thickness of 3 mm; in sagittal, oblique axial (perpendicular to the anal canal and the low rectum) and oblique coronal (parallel to the anal canal and low rectum) planes. Axial DWI was obtained using respiratory-triggered, single-shot echo-planar imaging with b-values of 0, 400, and 800 s/mm^{-2}.

Image Interpretation

A single abdominal radiologist (with 12 years of abdominal imaging experience) blinded to biopsy diagnosis reread the staging MRI on PACS (GE Health system, Barrington, Illinois, United States). MRI was reviewed for signal intensity, morphology, longest dimension of the tumor; distance of the distal margin of the tumor from anal verge and the anorectal junction; extramural spread, circumferential resection margin (CRM), extramural vascular invasion (EMVI); extent of infiltration of anal sphincter complex in terms of involvement of internal anal sphincter, inter-sphincteric space, external anal sphincter and ischiorectal fossa; infiltration of puborectalis, levator ani and other skeletal muscles of the pelvis; infiltration of adjacent structures like urethra, bladder, prostate, seminal vesicles in males and vagina, uterus and cervix in females. CRM was defined as the least distance between one of the following: leading margin of tumor, significant node, tumor deposit, EMVI and the adjacent structures such as puborectalis, levator ani muscle, prostate or seminal vesicles in males and vagina in females. Distance of less than 1 mm was considered as an involved CRM (9). Lymph nodes were assessed for its location, size, and number. Clinical TNM stages were derived as per 8th edition of American Joint Committee on Cancer (AJCC) or Union for International Cancer Control staging systems[17] for both LRC and SCC of anal canal for all included patients. For rectal cancer staging, lymph node metastases were assessed based on size and morphology criteria recommended by

European Society of Gastrointestinal and Abdominal Radiology (ESGAR) rectal cancer guidelines.[1] For anal cancer staging, size cutoff of 10 mm was used for mesorectal, internal iliac, external iliac and common iliac nodes; and a cutoff of 15 mm was used for inguinal nodes. Smaller nodes were considered significant if they were irregular or showed central necrosis.[5,9] Other relevant images available on PACS were reviewed to document metastases at staging.

Subsequently, two independent radiologists blinded to biopsy diagnosis reviewed DWI and ADC maps of the staging MRI studies. The pattern of diffusion restriction was documented as one of the following: diffusion restriction when tumor was hyperintense on high b-value DWI and low on ADC map, facilitated diffusion when tumor was hyperintense on both high b-value DWI and ADC map, mixed pattern when there were foci of diffusion restriction and facilitated diffusion, and no diffusion restriction when tumor appeared iso- or hypointense on high b-value DWI and iso- or hypointense on ADC map. Each reader documented three ADC values of the tumor from three representative images by marking the outer margin of the tumor as the region of interest (ROI) using free hand drawing tool. ROI excluded the lumen, air, adjacent collections, or fistula. ADC value of the tumor was taken as an average of the six readings for each patient.

Reference Standard

Histopathology from biopsy specimen of the anorectal malignancy by two experienced gastrointestinal pathologists (4 and 15 years of experience) was the reference standard. Biopsy is usually performed by colorectal surgeons at the outpatient department at the same time when blood tests and imaging tests such as MRI pelvis are requested. Histopathology report was usually available in 5 to 8 days.

Statistical Analysis

Descriptive statistics were reported as mean (standard deviation [SD]) and range for continuous variables and frequency with percentage for categorical variables. Imaging features of LRC and SCC such age, tumor dimension, and ADC values were compared using two-sample independent *t*-test. Pearson chi-squared test and Fisher's exact test were used to compare the categorical variables. Logistic regression analysis was performed on variables that were significantly different between the two types of cancers on univariate analysis to identify imaging finding that best differentiated the two types of anorectal malignancies. The diagnostic performance of those set of imaging findings was assessed using receiver operating characteristic curve (ROC) curve. The area under the curve (AUC), sensitivity, specificity, and the corresponding optimal threshold were calculated. All statistical analysis was performed using Statistical Package for Social Sciences (SPSS) software version 22.0 software (IBM Corp, Armonk, New York, United States).

Results

Patient Demographics

►**Fig. 1** shows the flowchart of patients. A total of 137 patients (81 males, 56 females) with a mean (SD) age 50.4 (12.4) years and a range of 22 to 87 years were included for final analysis. Out of them, 60 patients had SCC and 77 patients had LRC. There was significant difference in the mean age of patients with those diagnosed to have SCC being significantly older than LRC ($p = 0.001$). There was no gender difference ($p = 0.386$). ►**Table 1** compares the clinicopathological features and stages of patients included in the study.

Tumor Characteristics on Staging MRI

►**Table 2** provides the comparison of imaging features of SCC and LRC. There was no significant difference in the tumor length and the distance of the distal margin of the tumor from the anorectal junction. There was significant difference in the distance of the distal margin of the tumor from the anal verge with SCC being closer to the anal verge: 5.3 (SD: 8) mm) versus 22 (SD: 15) mm for LRC ($p < 0.001$). While the majority (>80%) of both SCC and LRC were infiltrating in morphology, polypoidal lesions were significantly more common among the LRC and exophytic tumors were significantly more common among the SCC ($p = 0.004$). Nearly all SCC (~97%) and 75% of LRC were intermediate in signal intensity. While 22% of LRC were either hyperintense or mixed in signal intensity, none of the SCC were hyperintense in signal and only one patient with SCC had a mixed signal intensity tumor. Internal iliac (47 vs. 29%), external iliac (20 vs. 4%), and inguinal (37 vs. 5.2%) nodal metastases was significantly more common among patients with SCC. EMVI was significantly more common among patients with LRC (35%) compared to SCC (16.7%; $p = 0.013$). Infiltration of adjacent organs and anal sphincter complex was significantly more common among those with SCC ($p < 0.05$).

Diffusion-Weighted Imaging

Good-quality DWIs were available in 130 patients ($n = 56$ with SCC and $n = 74$ with LRC). There was significant difference in the number of patients who showed diffusion restricting tumors among the two types of cancers ($p = 0.001$). Among patients with SCC, all (98%) except one patient showed diffusion restriction. Among patients with LRC, 77% showed diffusion restriction, 20% showed facilitated diffusion, and 3% showed no restricted diffusion. There was excellent agreement between the ADC values obtained by the two observers with intraclass correlation coefficient and its 95% confidence interval (95% confidence interval [CI]) of 0.942 (0.918–0.959; $p < 0.0001$). ►**Table 3** shows the ADC values of SCC and LRC. The mean ADC value of SCC was $910.42 \pm 126.3 \times 10^{-6}$ mm^2/s and the mean ADC value of LRC was $1105.1 \pm 359.1 \times 10^{-6}$ mm^2/s and this difference was significant ($p < 0.001$). However, when T2 hyperintense and mixed signal intensity tumors were excluded from analysis, there was no difference in the mean ADC values between the two types of cancers. ►**Fig. 2** shows the histograms comparing the ADC values of SCC and LRC.

Multivariate Analysis and ROC Analysis

Among all the findings that were significantly different between SCC and LRC patients on univariate analysis, the following MRI findings were the best predictors of SCC on multivariate analysis: distance from anal verge (odds ratio

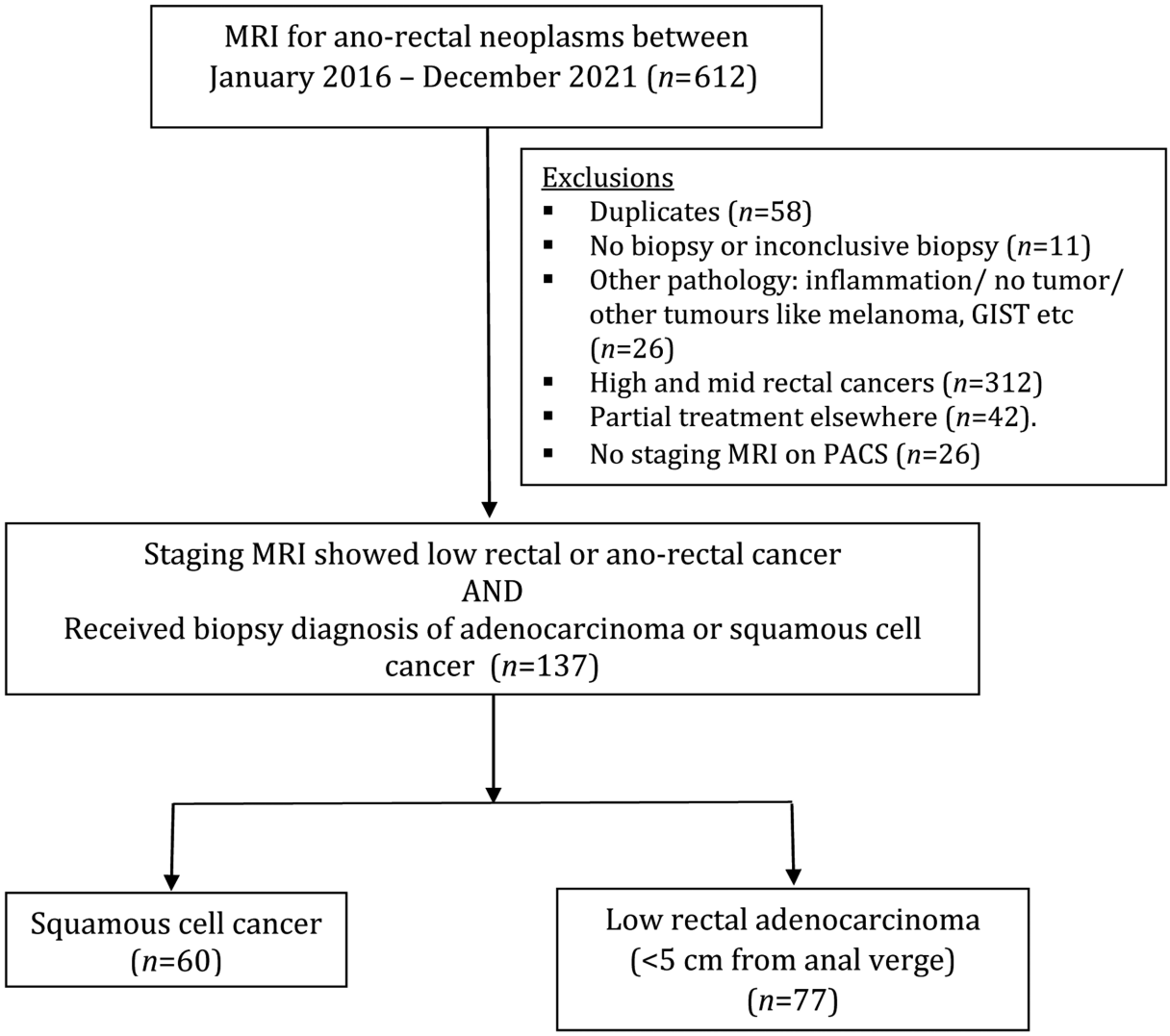

Fig. 1 Flowchart of patients included and excluded from the study. MRI, magnetic resonance imaging.

[OR] =13.6, $p < 0.001$); internal iliac (OR = 3.65, $p = 0.023$) and inguinal nodes (OR = 17.89, $p = 0.020$) and EMVI (OR = 0.242, $p = 0.039$). However, Hosmer and Lemeshow test for goodness of fit for the model created by the above findings had Nagelkerke R^2 value of 0.502, $p = 0.174$. ROC analysis showed an AUC with 95% CI of 0.823 (0.757–0.900) for distance of the distal margin of the tumor to the anal verge ($p < 0.001$). A cutoff distance of 11 mm from the anal verge yielded a sensitivity of 79.5% and specificity of 80%. The AUC (95% CI) for diagnosis of SCC using a combination of distance from anal verge of less than 11 mm, presence of internal iliac and inguinal nodes, and absence of EMVI was 0.810 (0.737–0.884; $p < 0.001$).

Impact of Using Incorrect Staging System

If patients with SCC were staged assuming rectal cancer using rectal cancer staging system, 31.6% of SCC patients will be incorrectly up-staged as T4b instead of cT2 ($n = 9$) and cT3 ($n = 10$) stage SCC and 26.7% ($n = 16$) of patients will be up-staged as M1 disease due to nonregional lymph nodal metastases. This is shown in ►**Fig. 3**.

Discussion

We set out to identify the morphological and functional imaging features that can differentiate the two most common cancers of the anorectum, the LRC with distal margin ($\leq$ 5 cm, $n = 77$ and anal SCC, $n = 60$). In comparison to patients with LRC, we found that the patients with SCC were older; their tumor was closer to the anal verge (5 vs. 22 mm); did not show T2 hyperintense signal or facilitated restriction; and more commonly infiltrated the anal sphincters and the adjacent structures; and were associated with enlarged internal iliac, external iliac, and inguinal nodal metastases and EMVI was less common (16.7 vs. 35%; $p < 0.05$). Of these, tumor closer than 11 mm cutoff distance from anal verge, absence of EMVI and presence of internal iliac and inguinal nodes had an AUC of 0.810 for diagnosis of SCC.

MRI is the investigation of choice for local staging of both rectal adenocarcinoma and anal canal cancers. In clinical practice, MRI, biopsy, and blood investigations are done in parallel to save time and resources. Biopsy report is usually

Table 1 Demographic statistics of patients included in the study

	Squamous cell carcinoma ($n = 60$)	n (%)	Low rectal adenocarcinoma ($n = 77$)	n (%)
Age	54 ± 8.8 (31–73) years		47.5 ± 13.5 (22–87) years	
Gender	Male Female	33 (55) 27 (45)	Male Female	48 (62.3) 29 (37.6)
Histology	Verrucous carcinoma Basaloid Well or moderately differentiated SCC Poorly differentiated	2 (3.3) 3 (5) 43 (71.7) 12 (20)	Well or moderately differentiated Poorly differentiated/ mucinous/ signet	64 (83.1) 13 (16.9)
T-stage	T1/2 T3 T4	20 (33.4) 19 (31.7) 21 (35)	T1/2 T3 T4	15 (19.5) 36 (46.7) 26 (33.8)
N-stage	N0 N1a N1b N1c	14 (23.3) 33 (55) 0 (0) 13 (21.6)	N0 N1 N1c N2	32 (41.6) 14 (18.2) 20 (26) 8 (10.4)
Metastases		5 (8.3)		5 (6.6)
Sites of metastases	Common iliac nodes ($n = 2$) Para-aortic nodes ($n = 2$) Intramuscular ($n = 1$) Liver ($n = 3$) Lungs ($n = 1$) Bone ($n = 1$)		Bones ($n = 1$) Common iliac nodes ($n = 1$) External iliac nodes ($n = 3$) Inguinal ($n = 4$) Liver ($n = 6$) Lungs ($n = 4$)	

Abbreviation: SCC, squamous cell carcinoma.

not available to radiologists reporting MRI. Tumor marker such as serum carcinoembryonic antigen levels is unreliable to predict the type of cancer since its sensitivity ranges between 50 and 80% and specificity is just above 80%.[18] In this situation, the radiologists often report the MRI assuming rectal adenocarcinoma because over 95% of primary rectal cancers are adenocarcinomas.[19] While this strategy might work in the majority, in a subset of patient's biopsy might reveal SCC. SCC is a great imaging mimic of rectal adenocarcinoma and have very different staging systems. Thus, incorrect staging information in the MRI report defeats the very purpose of MRI in these cancers. Discrepancies between the radiology staging and pathology results lead to stage change at the multi-disciplinary team level and negates the time and effort put by a primary radiologist who reported the MRI. In the larger picture, these practices can negatively affect the cancer referral pathways.

Previous study by Cattapan et al showed that T2 hyperintense or mixed signal intensity, distance of the distal margin of tumor from the anal verge of 2.2 cm, and absence of infiltration of anal sphincter predicted LRC 15. Of these, we found only the distance from anal verge to be a significant predictor of the type of anorectal cancer (AUC = 0.823). In our cohort, LRC was further away from the anal verge (22 ± 15 mm) compared to SCC (5.3 ± 8.1 mm), and a cutoff distance of 11 mm from anal verge yielded the best diagnostic performance (sensitivity and specificity of 79.5 and 80%, respectively) compared to 21 mm cutoff distance in the previous study (with both sensitivity and specificity of 90%).[15] AJCC recommends distance of the tumor from the dentate line for differentiating rectal and anal canal cancers, and defines LRC as tumors with an epicenter of 2 cm proximal to or above the dentate line and anal canal cancers as those distal to or below the dentate line.[20] Dentate line that corresponds to the anorectal ring or the origin of puborectalis muscle is not visible on MRI. It is presumed to be at the junction of distal two-third and proximal one-third of the length of anal canal. LRC has been defined as tumors located 5 to 6 cm from the anal verge.[21,22] Results of our study and those of the previous showed much lower distance cutoffs from anal verge than what is recommended by AJCC, European Society for Medical Oncology, and MERCURY II.[5,20–22] The anatomical origin and the direct spread of cancer from rectum to the anal canal and vice versa could be the explanation for this finding. Unlike previous study,[15] our study showed that anal sphincter infiltration was common in both LRC and SCC. We found internal and external anal sphincter infiltration in 40.3 and 20.8% of LRC and 75% and 43.3 of SCC, respectively. This could be due to the large size and the advanced stage of the tumors we see in our practice.

Most of the LRC (88.3%) and SCC (83.3%) were infiltrating type of tumors and thus, morphology was less useful in identifying the type of cancer. Eight patients (13%) with SCC had exophytic cauliflower like growths and were from malignant transformation of anal condylomas. Similar morphology was not seen in LRC. While 22% of LRC in our cohort had T2 mixed or hyperintense signal suggestive of mucin producing adenocarcinoma, none of the SCC were T2 hyperintense in signal. The pattern of diffusion restriction followed the T2 signal. The association between T2 signal and mucinous adenocarcinoma is well known. The diagnostic dilemma during MRI reporting sessions is usually with the

Table 2 Comparison of imaging findings of patients with squamous cell carcinoma and low rectal adenocarcinoma

	Squamous cell carcinoma ($n = 60$)	Low rectal adenocarcinoma ($n = 77$)	*p*-Value
Tumor length	57.1 ± 21.6 mm	55.4 ± 16.8 mm	0.606
Distance of distal tumor margin from the anal verge	5.3 ±8.1 mm	22 ± 15.7 mm	<0.0001
Distance from ARJ	2.4± 7.6 mm	4.2 ± 8.5 mm	0.202
Morphology:			
Infiltrating	50 (83.3%)	68 (88.3%)	0.004
Polypoidal	2 (3.3%)	9 (11.7%)	
Exophytic	8 (13.3%)	0 (0.0)	
T2 signal intensity:			
Intermediate	58 (96.7%)	58 (75.3%)	0.005
Hyperintense	0 (0.0)	10 (13)	
Mixed	1 (1.7)	7 (9)	
Hypointense	1 (1.7)	2 (2.6)	
Lymph nodes metastases:			
Mesorectal	33 (55)	43 (55.8)	0.539
Presacral	3 (5)	5 (6.5)	0.505
Internal iliac	28 (46.7)	22 (28.6)	0.023
External iliac	12 (20)	3 (3.9)	0.003
Common iliac	3 (5)	1 (1.3)	0.222
Inguinal	22 (36.7)	4 (5.2)	0.000
EMVI	10 (16.7)	27 (35.1)	0.013
Tumor deposits	15 (25)	23 (29.9)	0.331
Anal sphincter complex:			
Internal sphincter	45 (75)	31 (40.3)	0.000
External sphincter	26 (43.3)	16 (20.8)	0.004
Ischiorectal fossa	4 (6.7)	7 (9.1)	0.425
Puborectalis	21 (35)	22 (28.6)	0.268
Levator ani	8 (13.3)	5 (6.5)	0.144
Infiltration of adjacent organs (prostate/ vagina/ urethra)	22 (36.7)	10 (13)	0.001

Abbreviations: ARJ, anorectal junction; EMVI, extramural vascular invasion.

intermediate signal diffusion restricting anorectal cancers. While we found significantly higher ADC values among patients with LRC (1.126×10^{-3} mm^2/s) compared to SCC (0.910×10^{-3} mm^2/s; $p < 0.001$), a subgroup analysis after excluding T2 hyperintense/ mixed signal tumors showed no significant difference ($p = 0.134$) between the two types of cancers (►**Fig. 2**). Thus, our results show that in T2 intermediate signal anorectal cancers, ADC values are not useful in differentiating the two types of cancer.

We used to stage the entire cohort with both LRC and SCC staging systems to examine the effects of using incorrect staging system. By using rectal cancer staging system on the SCC patients, we might end up over-staging a quarter to a third of patients with SCC. This is mainly because of the differences in the definitions of adjacent organ infiltration and nodal metastases. The T-staging of rectal cancer is based on the depth of infiltration. But T-staging of anal cancer is based on the longest dimension of the tumor and the adjacent organ infiltration. While infiltration of puborectalis muscle and levator ani constitutes T4b disease in rectal cancer, this finding is not interpreted as adjacent organ infiltration in SCC. However, the prognostic implications of these differences are not clear in the literature. Secondly, in rectal cancer, the nodal staging is based on the number of regional (meso-rectal and internal iliac) nodes. But in SCC, nodal staging is based on the distance from the tumor. While inguinal nodes are regional nodes in anal SCC, they are regional nodes for LRC with distal margin extending below the dentate line and metastatic nodes for those distal margins above the dentate line.[17] Such nuances in the staging

Table 3 Comparison of DWI findings of patients with squamous cell carcinoma and low rectal adenocarcinoma

All patients ($n = 130$)	Squamous cell carcinoma ($n = 56$)	Low rectal adenocarcinoma ($n = 74$)	*p*-Value
DWI pattern			
Restricted	55 (98.2%)	57 (77%)	
Facilitated	0 (0.0)	15 (20.3%)	0.001
No diffusion restriction	1 (1.8%)	2 (2.7%)	
Mean ADC value[a]	Obs1: 910.5 ± 123	Obs1:1126 ± 381	<0.001
	Obs2: 910.3 ± 121	Obs2:1084.1 ± 324.7	<0.001
Mean of six ADC values[a]	910.42 ± 126.3	1105.1 ± 359.1	<0.001
Subgroup analysis after removing T2 hyperintense tumors ($n = 112$)	Squamous cell carcinoma ($n = 55$)	Low rectal adenocarcinoma ($n = 57$)	*p*-Value
Mean ADC value[a]	Obs1: 909.5 ± 124	Obs1: 952.5 ± 166.1	0.132
	Obs2: 909.6 ± 121	Obs2: 947.4 ± 148	0.145
Mean of six ADC values[a]	910.6 ± 127.3	949.9 ± 165.7	0.137

Abbreviations: ADC, apparent diffusion coefficient; DWI, diffusion-weighted imaging; Obs1, observer 1; Obs2, observer 2.
[a]Mean ADC values are displayed in (10^{-6} mm^2/s).

systems of LRC and SCC also contribute to the degree of overstaging when anal SCC is reported with an assumption of rectal adenocarcinoma (►**Figs. 4** and **5**).

We found that internal iliac and inguinal nodal metastases were useful predictors of SCC. Having said that the criteria for nodal metastases are well described for rectal cancer, it is less clear for anal canal cancer.[1,9] We also studied the incidence of prognostic quality MRI findings such as EMVI and extra nodal tumor deposits in both types of cancer.

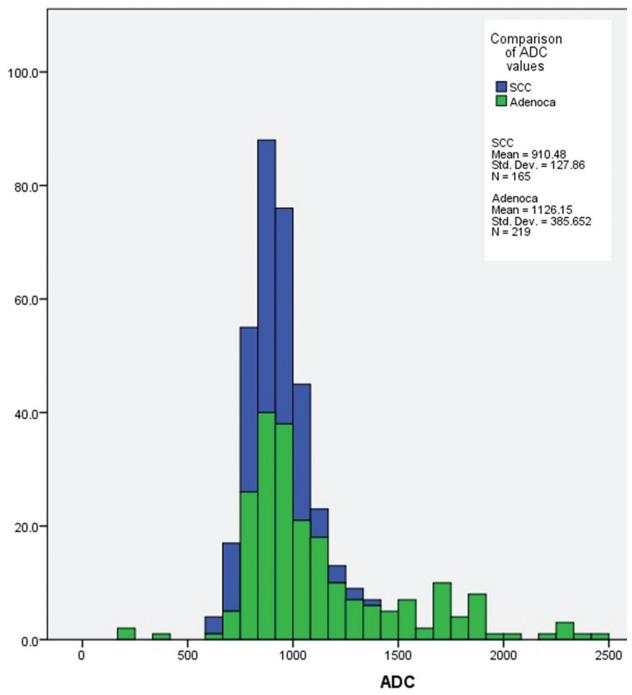

Fig. 2 Histogram of apparent diffusion coefficient (ADC) values of low rectal adenocarcinoma and squamous cell carcinoma (SCC) demonstrating the degree of overlap in the ADC values between the two anorectal cancers.

Among LRC patients, EMVI and tumor deposits were seen in 35 and 30%, respectively. These results are concordant with the previous studies and meta-analysis, which showed a pooled prevalence of 26% (range between 9 and 61%).[23–25] Among those with SCC, EMVI and tumor deposit were seen in 16.7 and 25%, respectively. While these prognostic quality variables and their prevalence have been studied extensively for rectal adenocarcinoma, their prevalence and prognostic implications are unknown in anal SCC. But studying this aspect is beyond the scope of the current work.

Our study had few other limitations apart from the those posed by a single center and a retrospective nature of the study. Though we found imaging features that can be used for predicting the type of anorectal cancer, we could not create a model with a satisfactory goodness of fit for confident use in clinical practice. This would mean that we might need to look for alternative solutions to the problem. These include providing the staging information for both LRC and SCC in the MRI report when histopathology is not known; altering the workflow to ensure pathology report is available to the radiologists and exploring the use of radiomics and machine learning for predicting the type of anorectal cancer. We did not see the known female gender predilection for anal canal SCC. On the other hand, we found significant association between age of patients and the type of anorectal cancer. These results could have been due to referral bias and influenced in part by our population structure and their health seeking behavior. Though this could affect the generalizability, our results would still be applicable to all tertiary care centers treating advanced stage anorectal cancers.

In conclusion, tumor morphology and ADC values were unhelpful in differentiating SCC from T2 intermediate signal LRC. Tumors replacing most of the anal canal with its distal margin close to the anal verge (at or below 11 mm from anal verge), absence of EMVI and presence of inguinal and internal-iliac nodes may point towards SCC (AUC = 0.810).

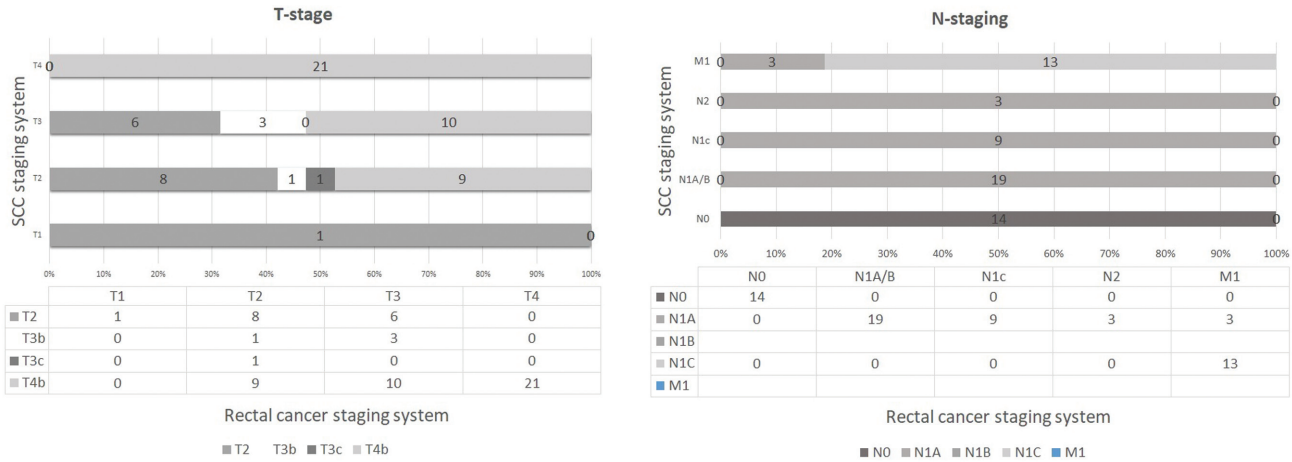

Fig. 3 Bar graphs with inbuilt tables showing the effect of using a rectal adenocarcinoma staging system on T-staging and N-staging in patients with biopsy-proven squamous cell carcinoma. This shows that 19 patients with cT2 and cT3 stage squamous cell carcinoma (SCC) were over-staged as cT4b stage by using rectal cancer staging and 16 patients with N1a and N1c stage SCC were over-staged as M1 using rectal cancer staging.

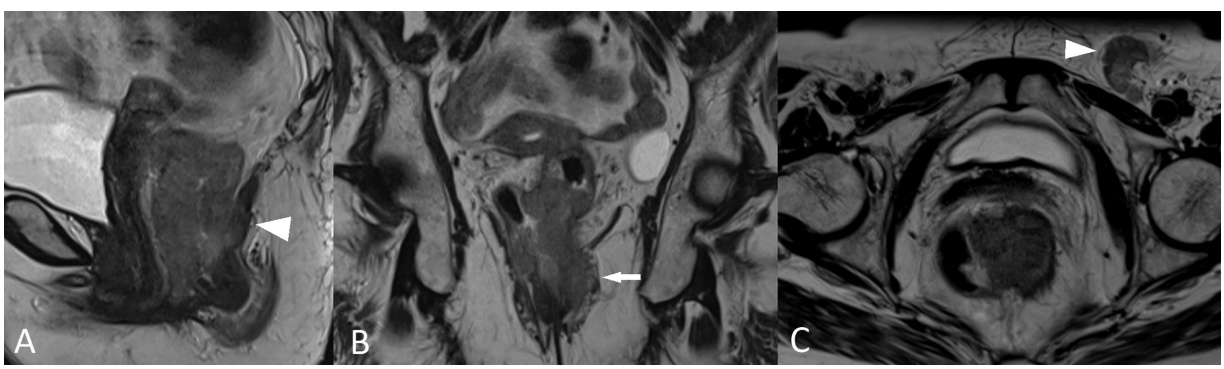

Fig. 4 **(A–C)** Staging magnetic resonance imaging T2-weighted high-resolution images of a biopsy-proven squamous cell carcinoma showing intermediate signal 5.8 cm long tumor infiltrating puborectalis (arrowhead in A) and left side of the anal sphincter below the dentate line (arrow in B), and left inguinal node metastases (arrowhead in C). This tumor was staged as T4b, N2, M0 using a rectal cancer staging system and as T3, N1a, M0 using an anal cancer staging system.

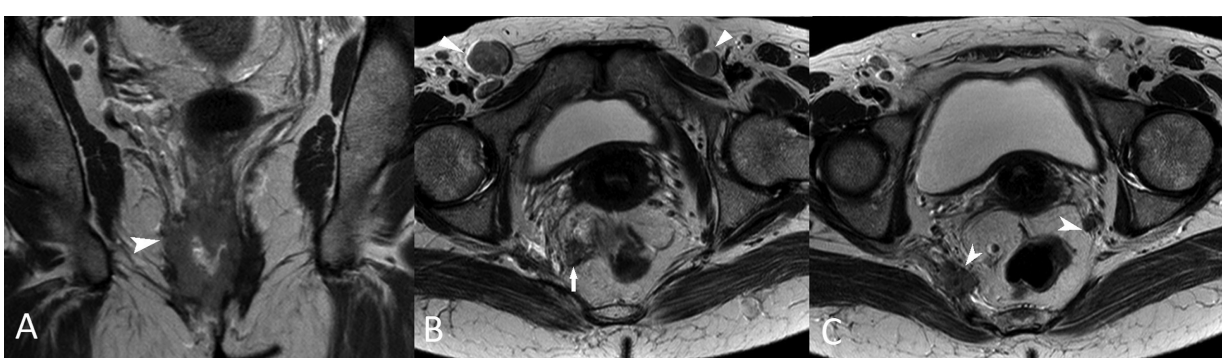

Fig. 5 (A–C) Staging magnetic resonance imaging T2-weighted high-resolution images of another patient with biopsy-proven squamous cell carcinoma showing an intermediate signal 4 cm long anorectal tumor extending below the dentate line, infiltrating right puborectalis (arrowhead in A), has extramural vascular invasion, tumor deposit (arrow in B), and bilateral inguinal (arrowheads in B) and internal iliac nodes (arrowheads in C). Using rectal cancer staging, the tumor was staged as T4b, N2, M0 and as T2, N1a, M0 using the SCC staging system.

However, for the time being we do not have robust model, which can help us predict the type of anorectal cancer with high degree of certainty and confidence. Thus, we might still have to seek alternative solutions to circumvent problems associated with reporting staging MRI of anorectal cancers without biopsy diagnosis. Our study also calls attention to having a closer look at our structured reporting formats, the pitfalls and gray areas in the MRI staging of anorectal cancers.

Highlights

- Reporting SCC assuming adenocarcinoma can cause overstaging in a quarter to a third of patients.
- ADC values are unhelpful in differentiating anal SCC and low rectal adenocarcinoma
- Tumors closer to anal verge, absence of EMVI, and presence of inguinal and internal-iliac nodes may point towards SCC.

Abbreviation

LRC – low rectal cancer
SCC – squamous cell carcinoma
CRT – chemoradiotherapy
APE - abdominoperineal excision
ELAPE - extra-levator APE
TME – total mesorectal excision
p-CRM - pathological CRM
MMC - mitomycin C (MMC) and
5-FU - 5-fluorouracil

Ethical Approval and Consent to Participate

Institutional Review Board approval was obtained. IRB Min No. 14621, 27.04.2022. Written informed consent was waived by the Institutional Review Board.

Availability of Data and Materials

The datasets generated and/or analyzed during the current study are not publicly available due to institutional data protection policies but are available from the corresponding author on reasonable request.

Authors' Contributions

Anuradha Chandramohan conceptualized and designed the study. Anuradha Chandramohan, Kirthi Sathyakumar, and Antony Augustine contributed to literature research and manuscript preparation. Anuradha Chandramohan, Kirthi Sathyakumar, Antony Augustine, Mark Rajan Jesudason, Rohin Mittal, Jeba Karunya, Thomas S. Ram, and Ashish Singh helped in clinical studies. Reka K was involved experimental studies/data analysis and statistical analysis. Anuradha Chandramohan, Kirthi Sathyakumar, Antony Augustine, Reetu John, Betty Simon, Rijo Issac, Dipti Masih, Jeba Karunya, Thomas S Ram, Ashish Singh, Mark R Jesudason, and Rohin Mittal edited the manuscript. Anuradha Chandramohan and Rohin Mittal are guarantor of integrity of the entire study.

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Conflict of Interest

None declared.

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