特別掲載

Role of Early Phase Helical CT Images in the Evaluation of Wall Invasion of Colorectal Cancer: Pathological correlation

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SmarPrep法により至適化されたhelical CT early phase imageの大腸癌の襞深達度診断に対する有用性について検討した．対象は注腸または内視鏡検査にて大腸癌と診断され，CTにて病変の同定が可能であった10症例である．Early phase imageはSmartPrepアプリケーションにより撮像した．これは造影剤注入後のCT値の上昇を連続的にモニターし，至適なscan delay timeを得る手法である．病理組織標本はCTと同一スライス面，スライス厚で作成した．また病変の造影効果についても測定を行った．全ての病変は腫瘍の大きさに関わらずearly phaseにて強い造影効果を呈した(81.4-112HU, mean95.1HU)．病理組織標本との対比では，CTにて強い造影効果を呈する領域はマクロ標本の腫瘍部位に一致していた．CTにて病変部の外側に認められたlow density zoneは非癌部の筋層に一致し，同部位では腫瘍の壁外浸潤は認められなかった．Low density zoneが断裂した部位では，全例で腫瘍の周囲脂肪織への浸潤が認められた．以上より，大腸癌の術前深達度診断においては，積極的にearly phase imageを撮像することが，より正確な局所深達度診断のために有用と考えられた．

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Introduction

In patients with primary colorectal cancer, the accurate preoperative diagnosis of tumor invasion into the colorectal wall is essential. Over the years, barium enema and colonoscopic evaluation of the colorectal wall have been joined by cross-sectional evaluations such as CT and MRI, particularly using endorectal and endoscopic ultrasonography[1)-4)]. Among these techniques, CT can play an important role in detecting the lesion, and metastasis to the liver and distant lesions[5)-7)]. However, CT is unable to demonstrate detailed layers of the colorectal wall, and an accurate diagnosis of local extension is difficult[8)-11)]. In the present prospective study of colorectal cancer, early phase images by helical CT were used to evaluate local invasion. Early phase images were obtained using SmartPrep software, and the results were compared with histopathologic findings.

Materials and methods

From August 1997 to September 1998, 10 consecutive patients with barium enema- and/or colonoscopy-proven colorectal cancer underwent CT for the evaluation of primary tumor and local extension. The study included 6 men and 4 women ranging in age from 45 to 77years (mean, 61.0 years). The histopathologic diagnosis was confirmed in each case from surgical specimens. The primary site of the cancer was the rectum (n = 8) and the sigmoid colon (n = 2). Macroscopic classification based on the Japanese Classification of Colorectal Carcinoma Criteria[12)] divided the study group into 9 type 2 (ulcerated type with clear margin) and 1 type 3 (ulcerated type with infiltration). Histopathological depth of tumor invasion was classified into1 mp (tumor invasion of muscularis propria), 4 a1 or ss (tumor invasion through muscularis propria into non-peritonealized part or tumor invasion to subserosa), 4 a2 (tumor invasion of non-peritonealized, pericolic, or perirectal tissue), and 1 ai (direct tumor invasion of other organs or structures)[12)]. Histologically, there were 6 well-differentiated adenocarcinomas

Table 1 Patients List of Colorectal Cancer

case	age/sex	location	pathology	type	size (cm)	depth
1	45F	rectum	well	2	4×4	a2
2	68M	sigmoid	well	2	8.5×5	ss
3	41F	rectum	well	2	3.5×3.5	a1
4	59F	rectum	well	2	4×4	a2
5	65F	sigmoid	moderate	2	5.5×4.5	ss
6	77M	rectum	moderate	2	3×2	a2
7	69M	rectum	moderate	3	8×7	a2
8	76M	rectum	moderate	2	3.8×2	mp
9	62M	rectum	moderate	2	6×6	ai
10	51M	rectum	moderate	2	3×2	a1

well: well-differentiated adenocarcinoma, moderate: modereate differentiated adenocarcinoma

and 4 moderately differentiated adenocarcinomas (Table1). CT was performed on a GE High-Speed Advantage SP/SG (General Electric Medical System, Milwaukee, WI). A precontrast scan covered the entire area of the lesion based on a barium enema. Patients received100ml of non-ionic iodinated contrast material (300mgI/ml, Omnipaque, Daiichi Pharmaceutical, Japan) from a dorsal vein of the hand at a rate of 3ml/sec. Early phase images were obtained using SmartPrep software. Placing the ROI in the abdominal aorta at the level of L2/3, the CT number of the ROI was monitored continuously (Fig. 1). The lesion was scanned immediately at the time the density curve started to increase. Scanning parameters included 5mm beam width, 5mm/sec table speed, and 5mm reconstruction thickness. Delayed images were obtained 150 sec after the initiation of contrast injection. The evaluation was made from the images on cancer enhancement by measuring the CT number of the lesion, adjacent normal colorectal wall and gluteal muscle. The CT number of the cancer averaged 3 points within the lesion.

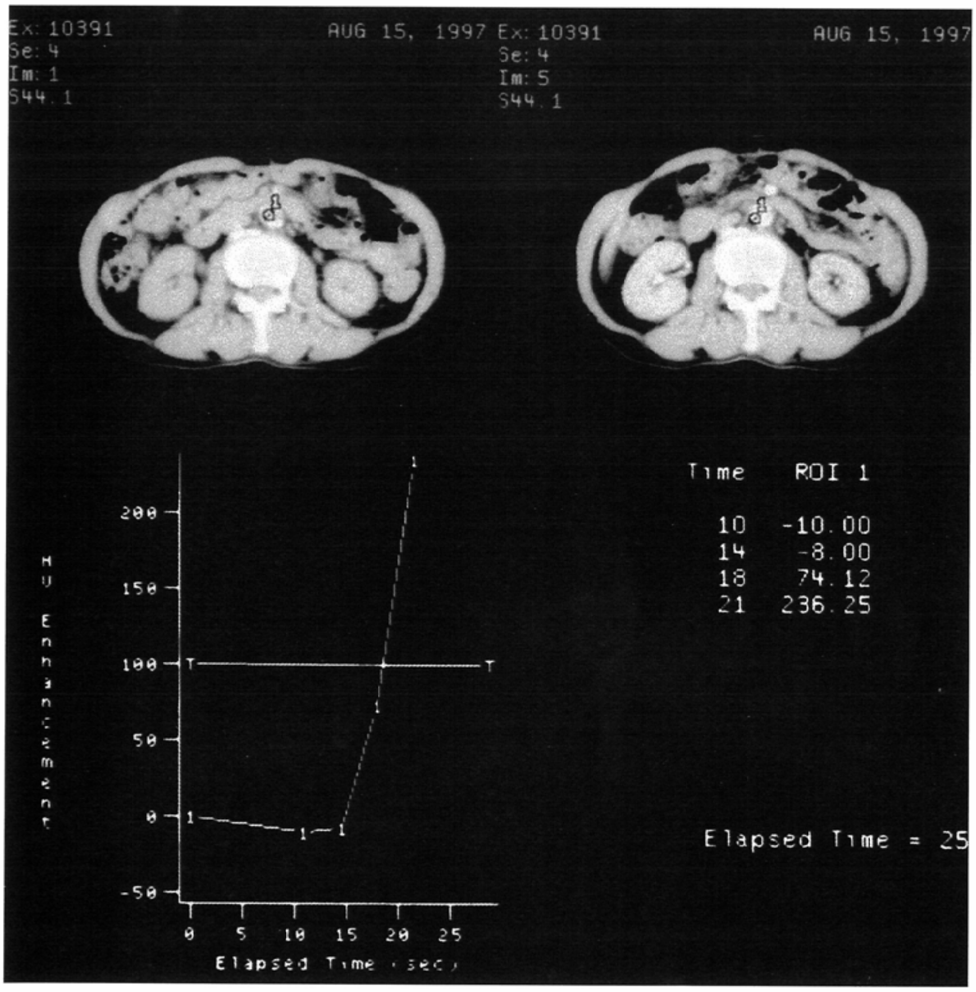
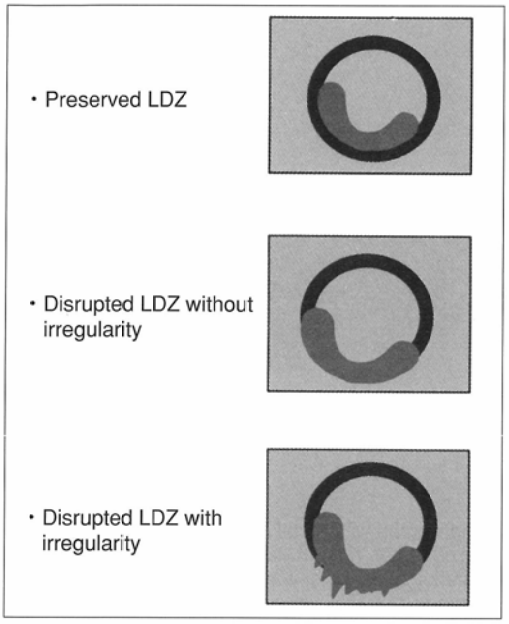


Fig. 1 Concept of SmartPrep application. Helical CT scanning is performed during continuous monitoring of the ROI placed in the abdominal aorta. Time-density curve is obtained after the injection of contrast material.



LDZ; low density zone

Fig. 2 Schematic relationship between tumor and colonic wall.

Table 2 CT Values in Early Phase Image

case	pathology	CT number (HU) tumor	wall	muscle
1	well	81.4	29.3	46.7
2	well	83.0	31.4	47.7
3	well	84.1	39.4	45.3
4	well	85.8	40.1	32.6
5	moderate	97.3	42.1	39.3
6	moderate	98.1	43.4	51.6
7	moderate	101.7	44.0	55.3
8	moderate	102.6	45.7	46.9
9	moderate	105.1	47.3	37.6
10	moderate	112.0	47.5	38.4
	mean	95.11	41.02	44.14
	SD	10.75	6.26	7.00

well: well-differentiated adenocarcinoma
moderate: moderate differentiated adenocarcinoma

The CT numbers of the adjacent normal colorectal wall and gluteal muscle were measured with same method. Standard deviation of CT numbers were calculated from averaged CT number of each ROIs. Attention was paid to a low density zone adjacent or posterior to the cancer. If this zone was obliterated or disrupted, further attention was paid to the irregularity of the cancer edge (Fig. 2). For the evaluation of the low density zone and cancer edge, relatively narrow window setting was used to obtain good contrast between the tumor and low density zone. A histopathological analysis was made using specimens, which were sectioned close to the same plane and at the same slice thickness as the CT images, to determine the cancer location and depth of invasion. The findings by CT images and histopathological analysis were compared with regard to primary tumor location and depth of invasion of the cancer.

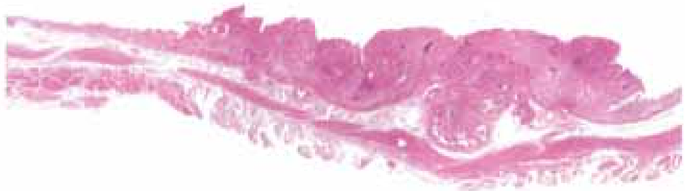
Results

All 10 cancers showed strong enhancement on early phase images regardless of their size. The CT number of the cancer ranged from 81.4 to112 HU (average 95.1 ± 10.8 HU), which was significantly greater than that of adjacent normal colorectal wall (from 29.3 to 47.5 HU, average 41.0 ± 6.3HU) ($p < 0.05$). The CT numbers for the different histological classifications were also significantly different: that for well-differentiated adenocarcinoma was 83.6 ± 1.9HU, while that for moderately differentiated adenocarcinoma was102.8 ± 5.4 HU ($p < 0.05$) (Table 2). A strongly enhanced area was correlated to the primary cancer, regardless of size and histologic differentiation. Fifteen histopathologic specimens from10 cases were available for correlation. In 6 of these15 specimens, a low-density zone was present adjacent or posterior to the strongly enhanced primary cancer. This zone correlated to the preserved colorectal wall on histopathology. No extraluminal invasion of the cancer was observed in these cases (Fig. 3, 4). In the remaining 9 specimens, the low density zone was partially or totally obliterated at the primary cancer, which was the area of extraluminal invasion. All of these 9 specimens showed pericolorectal fat infiltration, while 5 showed irregularity at the edge of the primary cancer (Fig. 5) and 4 did not (Fig. 6, 7) (Table 3).

Discussion

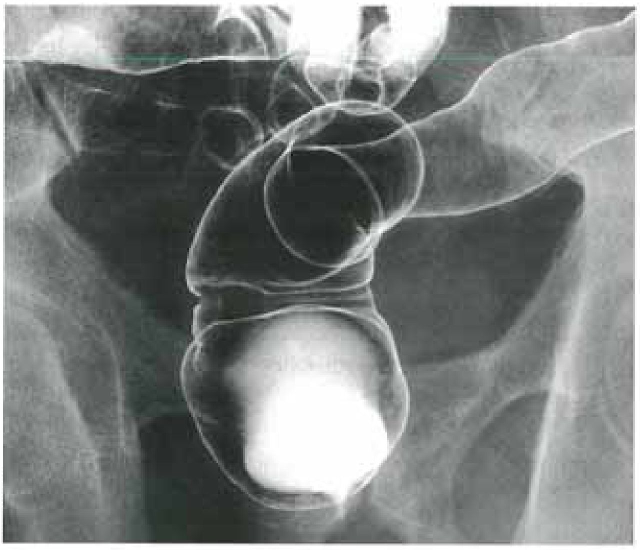
Previous reports have stressed the value of delayed phase images in the diagnosis of extraluminal invasion. Their findings were irregularity at the edge of the tumor and linear strands extending into the pericolorectal fat tissue[8)-10)]. Using these findings, the sensitivity for detecting wall invasion ranged from 55 to 77% [8)-10),13)]. This low sensitivity was probably due to the difficulty of separating tumor invasion from inflammatory and scar changes and congested vessels[7)]. It is essential to clearly separate the primary tumor and the normal colorectal walls on CT images. Helical CT enabled us to scan wider areas with a short scan duration. This has already been applied to the diagnosis of gastric cancer and its wall invasion[13)-14)]. However, there has been no previous report regarding the diagnosis of colorectal cancer wall invasion with early phase images. The current study revealed that the strongly enhanced lesion accurately correlated with the histopathologic findings of the primary tumor. A preserved colorectal wall was demonstrated as a low density zone. As long as a low density zone was

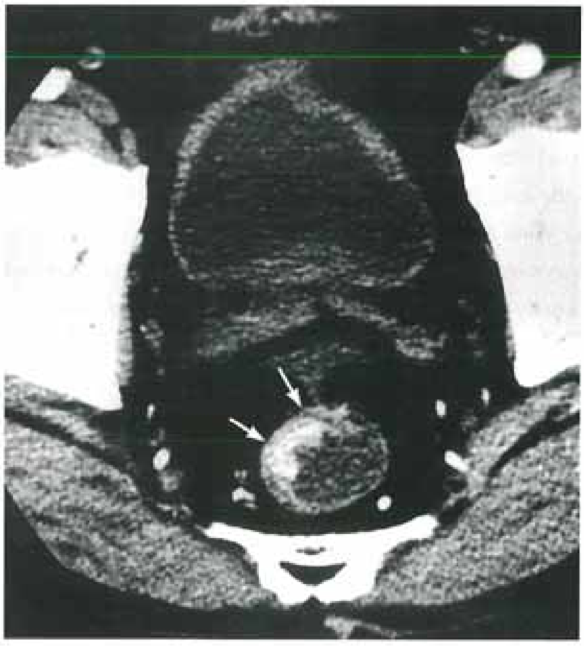
(A)

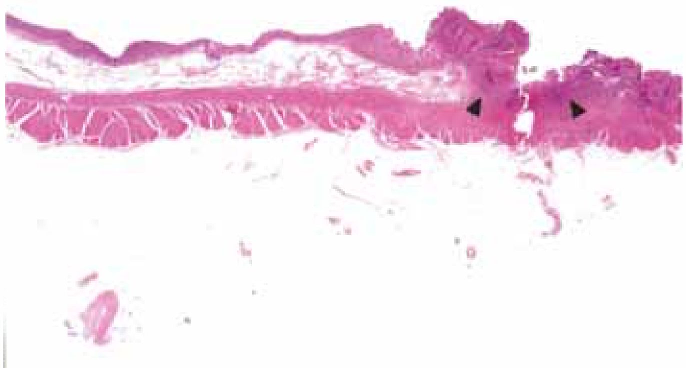


(B)

Fig. 3 A 59-year-old woman with rectal cancer, type 2. (A) CT image shows a well-enhanced tumor in the rt. lateral wall of the rectum. The low-density zone posterior to the tumor is clearly preserved (arrows). (B) Histopathologic specimen (hematoxylin-eosin stain; original magnification, × 1) shows tumor invasion limited to the submucosal layer.







A	B
C	

Fig. 4 A 76-year-old man with rectal cancer, type 2. (A) Barium-enema shows an elevated mass in the rt. lateral wall of the rectum. (B) CT shows a markedly enhanced tumor with a preserved low-density zone posterior to the tumor (arrows). (C) Histopathologic specimen (hematoxylin-eosin stain; original magnification, × 1) demonstrates the tumor invading to the muscularis propria (arrowheads). No tumor extension into the perirectal fat is observed.

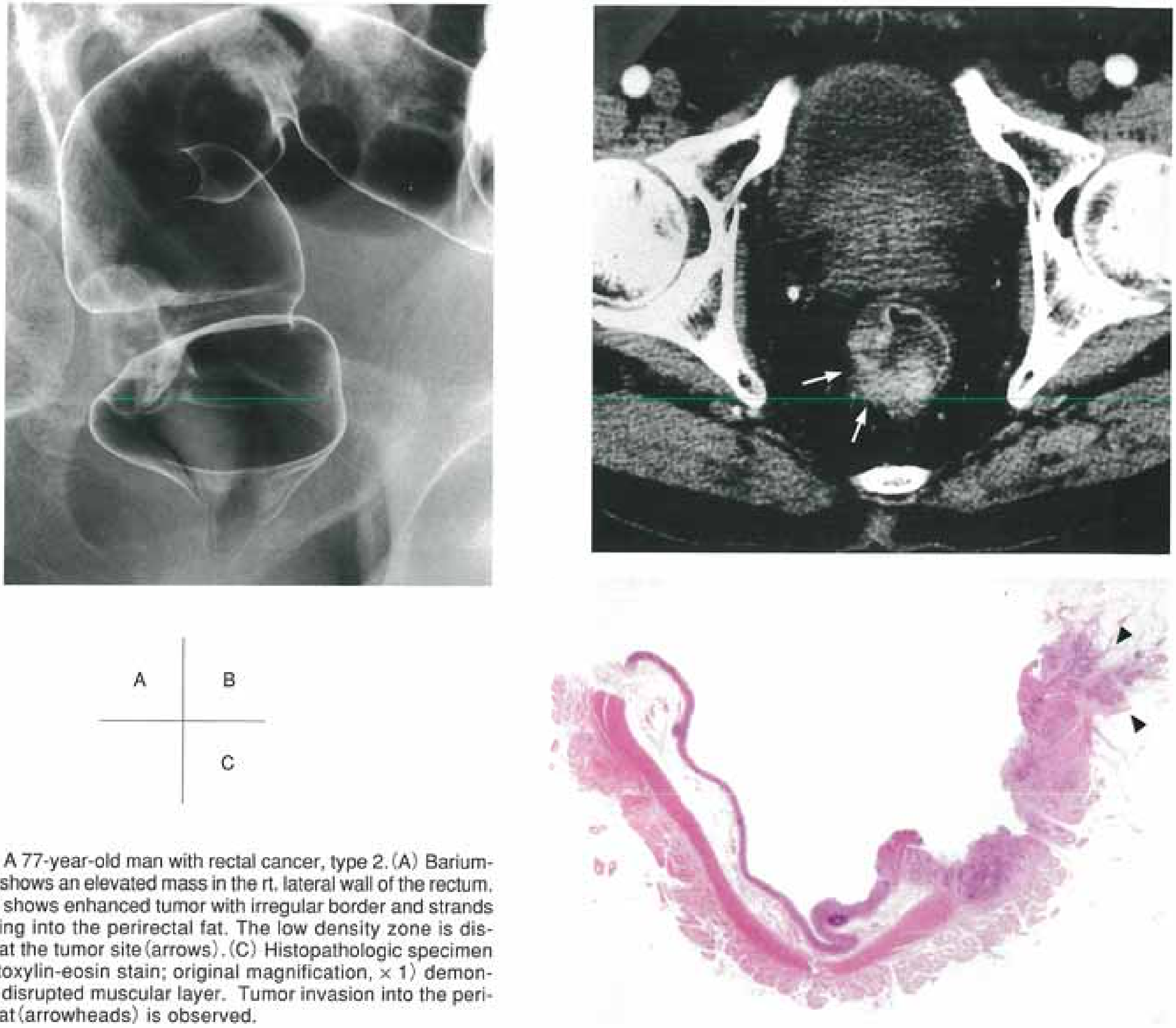


Fig. 5 A 77-year-old man with rectal cancer, type 2. (A) Barium-enema shows an elevated mass in the rt. lateral wall of the rectum. (B) CT shows enhanced tumor with irregular border and strands extending into the perirectal fat. The low density zone is disrupted at the tumor site (arrows). (C) Histopathologic specimen (hematoxylin-eosin stain; original magnification, × 1) demonstrates disrupted muscular layer. Tumor invasion into the perirectal fat (arrowheads) is observed.

preserved adjacent to the primary tumor, no extraluminal invasion was present. In all of the specimens, obliteration or disruption of a low density zone corresponded to extraluminal invasion and pericolorectal fat infiltration. We concluded that the irregularity of the edge of the cancer and linear strands extending into the pericolorectal fat tissue were not accurate signs of extraluminal invasion of the cancer. Angelellia reported that the diagnosis of wall invasion by colon cancer could be improved by filling the colon with a large amount of water[11]. We did not use any premedication nor bowel preparation. These preparation may increase CT room occupying time and may create patient's discomfort. Our results indicated that local extension of the colorectal cancer could be evaluated without expansion nor filling of the colon. With regard to the enhancement pattern and histologic differentiation, Furukawa stated that well-differentiated adenocarcinoma was enhanced homogeneously, while half of moderately differentiated adenocarcinoma was enhanced heterogeneously[17]. We were unable to explain these different enhancement patterns based on the results of histopathology. SmartPrep was essential for the current study to obtain optimal early phase images using a personalized time-density curve[18].

In conclusion, on early phase images by helical CT, colorectal cancer showed strong enhancement, regardless of size or histologic differentiation. The preserved colorectal wall adjacent to the cancer appeared as a low density zone. In cases where this zone was obliterated or disrupted, the cancer invaded beyond the colorectal wall into the pericolorectal fat tissue. The clinical use of early phase images in the diagnosis of local extension of colorectal cancer appears to be justified.

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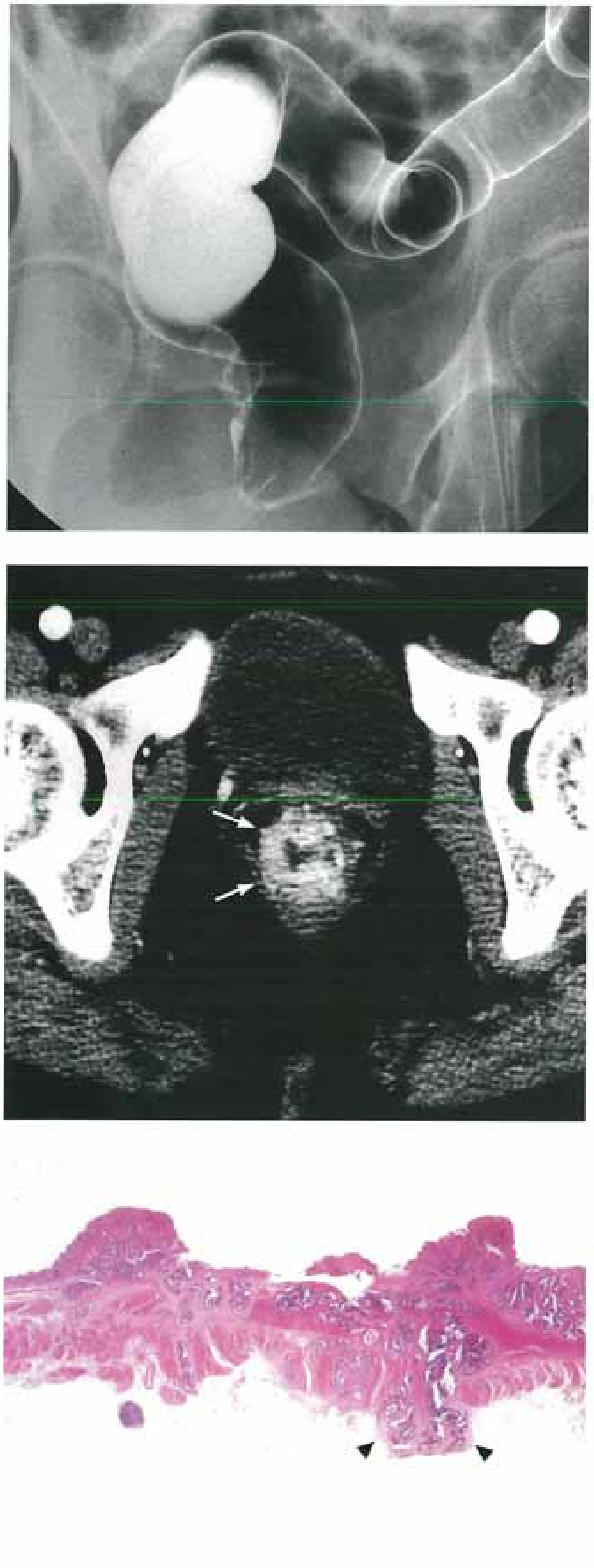
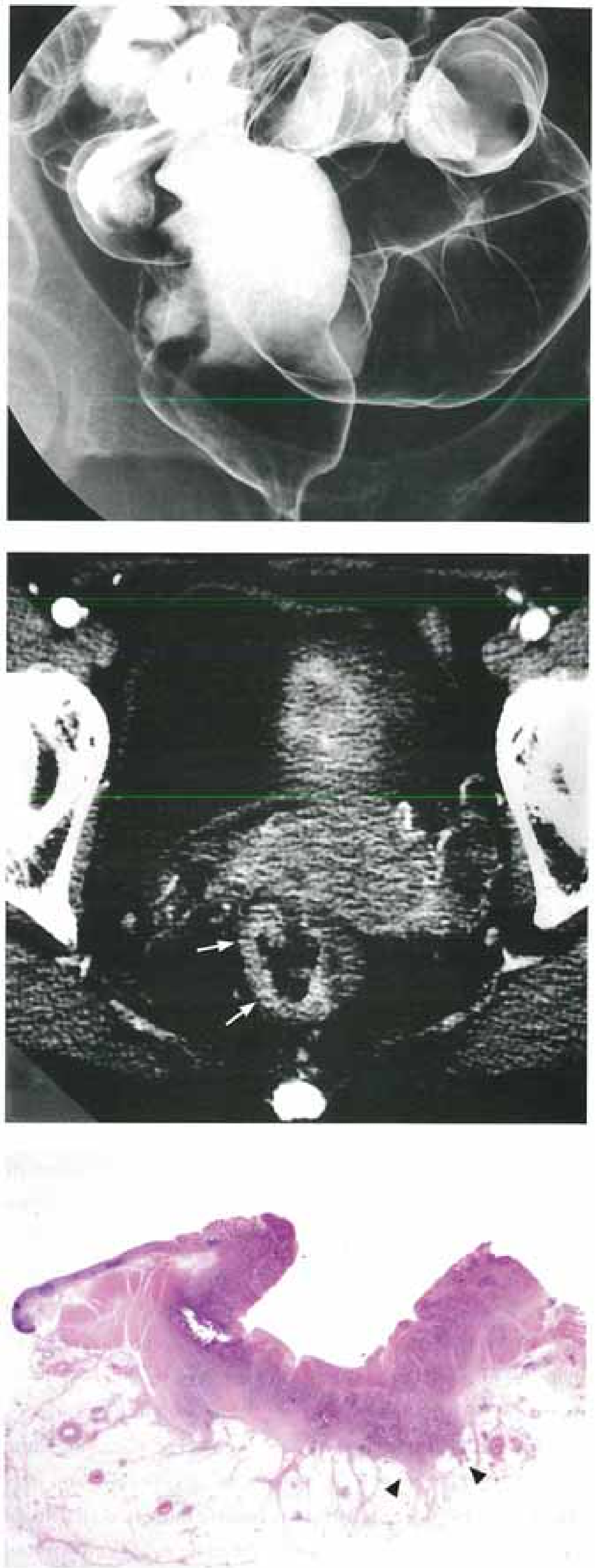


(A)
(B)
(C)

Fig. 6 A 59-year-old woman with rectal cancer, type 2. (A) Barium-enema shows an elevated mass in the rt. lateral wall of the rectum. (B) CT shows a markedly enhanced tumor without marginal irregularity. Low density zone is disrupted at the tumor site (arrows). (C) Histopathologic specimen (hematoxylin-eosin stain; original magnification, × 1) demonstrates a disrupted muscular layer and deeply extended tumor (arrowheads).



(A)
(B)
(C)

Fig. 7 A 41-year-old woman with rectal cancer, type 2. (A) Barium-enema shows an elevated mass in the rt. lateral wall of the rectum. (B) CT shows enhanced tumor without marginal irregularity. The low density zone is disrupted at the tumor site (arrows). (C) Histopathologic specimen (hematoxylin-eosin stain; original magnification, × 1) demonstrates disrupted muscular layer and minimal tumor extension beyond the muscular layer (arrowheads).

Table 3　Correlation between CT Findings and Histopathological Results

	pathological results		
extraluminal extension	LDZ (+)	LDZ (−), irregularity (+)	LDZ (−), irregularity (−)
positive	0	5	4
negative	6	0	0
total	6	5	4

LDZ; low density zone

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