Preoperative Assessment of Mesorectal Fascial Involvement in Patients with Rectal Cancer: The Diagnostic Value of MDCT for Measuring the Mesorectal Fascial Thickness

Min-Jeong Seo, M.D., Jung-Hee Yoon, M.D., Eun-Joo Lee, M.D., Seong-Sook Cha, M.D., Sang-Suk Han, M.D.

**Purpose:** To assess the diagnostic value of the use of multi-detector row computed tomography (MDCT) in evaluating mesorectal fascial (MRF) involvement in patients with T3 stage rectal cancer.

**Materials and Methods:** From September 2005 to June 2006, we enrolled 21 patients with T3 stage rectal cancer. In addition, 21 healthy patients were enrolled in a control group. Two radiologists measured the mean MRF thickness independently. We considered positive MRF involvement when the MRF thickness exceeded 4 mm, and then we measured the MRF thickness of patients with T3 rectal cancer. We analyzed interobserver agreement for the measured MRF thickness of the control group and assessed the diagnostic value of 4 mm, 5 mm and 6 mm as references in predicting MRF involvement.

**Results:** The mean MRF thickness of the control group was 3.24±0.50 mm (radiologist 1) and 3.04±0.51 mm (radiologist 2). Using 4 mm, 5 mm and 6 mm as a reference thickness in predicting MRF involvement, sensitivity was 100%, 100% and 28.57%, specificity was 71.43%, 85.71% and 92.86%, the false negative rate (FNR) was 0%, 0% and 71.43%, the false positive rate (FPR) was 28.57%, 14.29% and 7.14%, the negative predictive value (NPV) was 100%, 100% and 72.2%, the positive predictive value (PPV) was 63.64%, 77.78% and 66.7%, and the accuracy was 80.95%, 90.48% and 71.43%.

**Conclusion:** Preoperative assessment of the MRF thickness on MDCT is beneficial in predicting MRF involvement in patients with advanced rectal cancer and a value of 5 mm as a reference MRF thickness was established.

**Index words:** Fascia, mesorectum
Rectal neoplasms
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Rectum

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Rectal cancer is a common disease with a high mortality rate in Western countries and is on the increase in Korea (1). The standard surgical procedure for rectal cancer is en bloc resection of the tumor and total mesorectal excision (TME). The local tumor recurrence is strictly dependent upon the circumferential resection margin (CRM) and the mesorectal fascia represents the CRM when TME is used as the surgical approach (Fig. 1) (2, 3). A local tumor recurrence after resection of a rectal cancer occurs in 3-32% of patients. Complete TME results in reduced local tumor recurrence rates below 10% without additional radiotherapy. Preoperative neoadjuvant radio- or chemotherapy is needed for prevention of the local tumor recurrence in patients with a close or involved resection margin (4-8).

To achieve the treatment plan for reducing local tumor recurrence, the anticipated plan of the TME must be evaluated. Magnetic resonance (MR) imaging has been reported to be highly accurate in the prediction of a wide or involved CRM by measuring the shortest distance between the tumor and mesorectal fascia (5, 9, 10).

In clinical practice, many centers in Korea perform computed tomography (CT) for the initial staging of rectal cancer. However, there are few studies on the role of CT in assessing mesorectal fascial involvement with advanced rectal cancer (7).

We have experienced that there is difficulty in measuring the shortest distance between the tumor/or metastatic lymph node and mesorectal fascia using multi-detector row computed tomography (MDCT), as there is a limitation of the low spatial resolution and a problem of differentiation between a benign reactive lymph node and a metastatic lymph node. According to one study, the mesorectal fascia is better seen with MDCT than with MR, particularly in patients with gross obesity (4).

In this study, we attempted to assess the diagnostic value of the mesorectal fascial thickness on MDCT in evaluating mesorectal fascial involvement in patients with histopathologically proven T3 stage rectal cancer.

Materials and Methods

Patients

From September 2005 to June 2006, we selected 40 patients with histopathologically proven T3 stage rectal cancers that underwent preoperative MDCT. Of these patients, 19 patients were excluded because they underwent preoperative radio- or chemotherapy; thus the study population comprised 21 patients (9 males and 12 females; median age, 59.5 years; age range, 33-83 years).

For a control group, we enrolled 21 patients without any rectal and perirectal pathology (control group; 12 males and 9 females; median age, 58 years; age range, 34-80 years).

CT scans

All patients underwent contrast-enhanced ab-
dominopelvic MDCT. All preoperative MDCT scans were obtained within a 6-week period before surgery (mean interval, 38 days). All CT studies were performed with a four-detector row scanner (Siemens Medical Solutions, Erlangen, Germany) or a sixty-four detector row scanner (Toshiba, Nasu Shiobara, Japan). The scanning parameters for the four-detector row CT were 5-mm section thickness, pitch of 6, tube current of 120 kVp, 120 mAs. The scanning parameters for the sixty-four detector row CT were 5-mm section thickness, pitch of 0.5, tube current of 120 kVp, and 350-400 mAs. An nonionic contrast material (100 ml, Iopromide, Ultravist® 370; Schering, Berlin, Germany) was injected intravenously at a rate of 3-4 mL/sec by using a power injector. Oral contrast media, rectal contrast media and air insufflation were not used.

Scans were acquired in a craniocaudal direction from the level of the diaphragm to the anus during one breath-hold. The delay between the beginning of contrast material injection and image acquisition was 45 seconds for patients with a primary rectal cancer and 120 seconds or 180 seconds for the control group patients.

**Image Analysis**

We retrospectively reviewed imaging findings by using the cine mode on the picture archiving and communication system viewer (Marotech, Seoul, Korea). Independently, two radiologists (J.H. Yoon, M.J. Seo) measured the greatest thickness of the mesorectal fascia of the control group patients. The two radiologists using a consensus approach measured the mesorectal fascial thickness. Based on the mean mesorectal fascial thickness of the control group patients, we considered as positive mesorectal fascial involvement when the mesorectal fascial thickness was more than 4 mm. Radiological mesorectal fascial involvement was then compared with histopathological mesorectal fascial involvement. All histopathologica|c assessment was performed after surgical excision with TME.

**Statistical analysis**

In measuring the mean mesorectal fascial thickness of the control group patients, interobserver agreement was analyzed using the Pearson coefficient and paired t-test. A p value of less than 0.05 was considered statistically significant. We analyzed the sensitivity, specificity, false negative rate (FNR), false positive rate (FPR), positive predictive value (PPV), negative predictive value (NPV) and accuracy of three different reference points (4 mm, 5 mm and 6 mm) in the predicting the involved mesorectal fascia.

**Results**

The mean mesorectal fascial thickness of the control group patients was 3.24±0.50 mm (as determined by radiologist 1) and 3.04±0.51 mm (as determined by radiologist 2) (Fig. 2). In measuring the mean mesorectal fascial thickness of the control group patients, the Pearson coefficient was 0.847 and the p-value was less than 0.001, indicating an excellent correlation between the two radiologists.

Under the consensus approach, the mesorectal fascial thickness was 3.70±1.22 mm (total of 14 cases; range, 2.7-6.3 mm) in the negative CRM group of patients and
5.59±0.53 mm (total of 7 cases; range, 5.1-6.3 mm) in the positive CRM group of patients. The distributions are shown on graph 1.

When we used 4 mm as a reference mesorectal fascial thickness on axial MDCT scans, 11 cases were interpreted as having an involved mesorectal fascia but on histopathology, 7 cases had an involved mesorectal fascia. There were four false positive cases. The sensitivity was 100%, specificity was 71.43%, the FNR was 0%, the FPR was 28.57%, PPV (Fig. 3) was 63.64%, NPV (Fig. 4) was 100% and accuracy was 80.95%.

When we used 5 mm as a reference mesorectal fascial thickness on axial MDCT scans, 9 cases were interpreted as having an involved mesorectal fascia. There were two false positive cases. The sensitivity was 100%, specificity was 85.71%, the FNR was 0%, the FPR was 14.29%, PPV was 77.78%, NPV was 100% and accuracy was 90.48%.

When we used 6 mm as a reference mesorectal fascial thickness on axial MDCT scans, 3 cases were interpreted as having an involved mesorectal fascia. There was one false positive case and five false negative cases. The sensitivity was 28.57%, specificity was 92.86%, the FNR was 71.43%, the FPR was 7.14%, PPV was 66.7%, NPV was 72.2% and accuracy was 71.43% (Table 1).

**Discussion**

The rectum is surrounded by fatty tissue that forms a structure known as the mesorectum. The mesorectum contains lymph nodes, vessels, and several fibrous septa and is surrounded by the mesorectal fascia. The mesorectal fascia has been defined as the fine linear structure enveloping the mesorectum, which represents

**Table 1.** Statistical Parameters and Results of Mesorectal Fascial Involvement According to the Thickness of the Mesorectal Fascia Determined on Axial MDCT

<table>
<thead>
<tr>
<th></th>
<th>4 mm (%)</th>
<th>5 mm (%)</th>
<th>6 mm (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>100</td>
<td>100</td>
<td>28.57</td>
</tr>
<tr>
<td>Specificity</td>
<td>71.43</td>
<td>85.71</td>
<td>92.86</td>
</tr>
<tr>
<td>False negative rate</td>
<td>0</td>
<td>0</td>
<td>71.43</td>
</tr>
<tr>
<td>False positive rate</td>
<td>28.57</td>
<td>14.29</td>
<td>7.14</td>
</tr>
<tr>
<td>Accuracy</td>
<td>80.95</td>
<td>90.48</td>
<td>71.43</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>63.64</td>
<td>77.78</td>
<td>66.7</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>100</td>
<td>100</td>
<td>72.2</td>
</tr>
</tbody>
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**Graph 1.** Distribution chart of mesorectal fascial thickness in the rectal cancer group; the mean mesorectal fascial thickness was 3.70±1.22 mm (total of 14 cases; range, 2.7-6.3 mm) in the negative CRM group and 5.59±0.53 mm (total of 7 cases; range, 5.1-6.3 mm) in the positive CRM group.

**Fig. 3.** A positive CRM in a 33-year-old man.

A. On an axial contrast enhanced MDCT image, the mesorectal fascia in the right posterolateral aspect is thickened to 6.3 mm (arrow).

B. On histopathology, tumor cell infiltrations are identified in the stained mesorectal fascia (arrowheads).
the CRM when TME is used as the surgical approach (3-5, 9). The use of TME is an accepted procedure for the surgical treatment of rectal cancer as part of either anterior resection or abdominoperineal excision (4). The use of TME implies the complete excision of all of the mesorectum enclosed within the mesorectal fascia. This dissection is performed in a circumferential manner down to the levator muscles to produce a globular, bilobed tissue block (2).

The most important factor, particularly in terms of local tumor recurrence, is CRM involvement. Although a complete TME results in reduced local tumor recurrence rates, in the U.S.A., postoperative chemotherapy combined with radiotherapy has been used for the treatment of patients with T3/N1 tumors. In Europe, preoperative radiotherapy is also used for treatment of rectal cancers for patients with fixed tumors. For patients with a close or involved resection margin, preoperative neoadjuvant radio- or chemotherapy are needed for prevention of the local recurrence (4-8).

This study shows the normal mesorectal fascial thickness on MDCT and the diagnostic value of the mesorectal fascial thickness in predicting mesorectal fascial involvement in patients with advanced rectal cancer.

There was a previous report about the effect of rectal distension and implications for preoperative prediction of tumor-free circumferential resection margin on MR (10). For exclusion of the possibility that rectal insufflation influenced the mesorectal fascial thickness, we did not use rectal contrast media or air insufflation during the performance of the MDCT scans.

In this study, there was a different scan interval used for the primary rectal cancer group of patients and the control group of subjects. It was not that we intended to assess the enhancement pattern, but that we intended to measure the thickness. We believed that the different scan intervals would not influence the thickness itself.

The mesorectal fascia limited mesorectum showed hypodensity, and the mesorectal fascia itself was seen as a thin, curvilinear structure of similar density of the muscle adjacent to the rectum (3). Usually, the mesorectal fascia is best visualized at the level of the middle portion of the acetabulum. As there is an abundant fatty component, the mesorectal fascia can be more clearly visualized.

It is believed that CT has a low tissue contrast resolution as compared to MR. Taking the circumstances into consideration, we used 1 mm-intervaled three different standpoints as references in the predicting the mesorectal fascial involvement. However, we believe that the spatial resolution of MDCT can well delineate the mesorectal fascia itself in spite of the inherent lower contrast resolution than that of MR and all the mesorectal fascias were well visualized in our study.

In our study, the mean mesorectal fascial thickness of the positive CRM group of patients as determined by histopathology was significantly thicker than that of the other groups.

The specificity was elevated and the false positive rate was reduced as the reference mesorectal fascial thickness was thicker. Using 6 mm as a reference mesorectal fascial thickness showed the lowest sensitivity, lowest

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Fig. 4. An negative CRM in a 57-year-old man.
A. On an axial contrast enhanced MDCT image, the distance between the tumor and mesorectal fascia is very close, but there is no evidence of mesorectal fascial thickening (arrow).
B. On histopathology, there is no evidence of tumor cell infiltration in the mesorectal fascia.
NPV, lowest accuracy and highest FNR. We consider that 5 mm as a reference mesorectal fascial thickness is the most valuable cut-off value in the predicting the mesorectal fascial involvement in patients with advanced rectal cancer.

There were several false positive cases. One was pseudo-thickening due to a partial volume averaging effect between the mesorectal fascia and presacral fascia (Fig. 5). The mesorectal fascia has a close and delicate anatomic relation with its boundaries. It is attached posteriorly to the presacral fascia by the Waldeyer fascia. The rectovaginal fascia is present anteriorly and attaches to the perineal body inferiorly, the uterosacral ligaments superiorly, and the arcus tendineus fascia pelvis laterally (11). The partial volume between the mesorectal fascia and these structures can lead to misinterpretation. In another negative CRM case, the mesorectal fascial thickness was 4.2 mm. On histopathology, it showed a close CRM in which the shortest distance between tumor infiltration and the mesorectal fascia was 2 mm (Fig. 6). Most histopathologists define the surgical margin as involved if the tumor extends to within 1 or 2 mm of the CRM and clinically, close and involved CRM are similarly treated and need preoperative neoadjuvant therapy. The mesorectal fascial thickness was thicker than 5 mm in two cases. One case showed a thickness of 5.6 mm and the other case showed a thickness of 6.3 mm. These levels resulted from benign mesorectal fas-

**Fig. 5.** An false positive CRM due to partial volume averaging in a 70-year-old man.
**A.** On an axial contrast enhanced MDCT image, the mesorectal fascia in the left posterolateral aspect is thickened to 4.6 mm (arrow), suggesting a positive CRM.
**B.** At 5 mm below the level in A, the mesorectal fascial thickness is normal (arrowhead). On histopathology (data not shown), there is no evidence of tumor cell infiltration in the mesorectal fascia.

**Fig. 6.** An false positive CRM in a 61-year-old man.
**A.** On an axial contrast enhanced MDCT image, the mesorectal fascial thickness is 4.2mm (arrow), so it was considered as a positive CRM.
**B.** On histopathology, there is no evidence of mesorectal fascial involvement. However, the shortest distance between the mesorectal fascia and tumor cell infiltration is 2 mm (arrow).
cial thickening from inflammatory cell infiltration or desmoplastic reactions. It is very difficult to differentiate between a desmoplastic reaction caused by fibrosis and true tumor cell infiltration because of the radiological similar findings.

We selected pathologically proven T3 stage rectal cancers as prognostically T3 tumors are the most important tumors to be accurately assessed as current trends advocate the use of neoadjuvant therapies. Preoperative staging using CT scans in rectal cancer patients was first reported in the early 1980s. Early reports with conventional CT mainly focused on locally advanced rectal cancer and the accuracies for the T3 stage were 79- 94% ([12-14]). Most early studies were performed using nonhelical CT units that were limited by a lack of the high resolution, thin collimation images achievable by the current MDCT instruments. According to Mathur et al. ([8]), CT was significantly understaging T3 tumors compared to MR and majority of patients were staged as T2 by CT. Recently MDCT has been used to stage rectal cancer with a reported accuracy of over 90%. MDCT allows the use of thinner collimation with improved multiplanar reconstruction [MPR] images. Non-axial images have been used in MR imaging for the staging of rectal cancer, but on MDCT, MPR images are possible within a single breath-hold. MPR images are particularly useful as they can be aligned parallel or perpendicular to the axis of the tumor, similar to the MR image, and can provide more accurate staging ([15, 16]).

This study has several limitations. First, most studies about mesorectal fascial assessment in rectal cancer is evaluated using the shortest distance between the tumor and mesorectal fascia. However, we ignored this evaluation in the assessment of the CRM. To overcome the false positive rate, a further study will be needed in combination with determination of the mesorectal fascial thickness and shortest distance between the tumor and mesorectal fascia. Second, we did not use MPR images of the MDCT that can give coronal and sagittal images. By using these images, more accurate information characterizing the anatomical relationship for the mesorectal fascia and the adjacent structures, including the anal sphincter, may be obtained. Third, CT has a low tissue contrast resolution as compared with MR. This can influence the identification of the mesorectal fascia and the measurement of the mesorectal fascial thickness on CT scans, but all the mesorectal fascias were well visualized in our study. Finally, the use of 5 mm as a reference mesorectal fascial thickness was the most valuable in predicting the mesorectal fascial involvement in advanced rectal cancer in our study. However, the number of samples is too small for generalization. Further evaluation with a large population will be needed.

We conclude that preoperative assessment of the mesorectal fascial thickness on axial MDCT scan is beneficial in predicting the mesorectal fascial involvement in patients with advanced rectal cancer and the use of 5 mm as a reference mesorectal fascial thickness is valuable in predicting mesorectal fascial involvement in advanced rectal cancer.

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