



# Assessment of extent and completeness of mesorectal excision for rectal cancer by histopathology and MRI

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**Introduction:** High quality of total mesorectal excision (TME) surgical technique and critical feedback regarding its completeness by pathologist and a radiologist has been shown to influence the quality of surgery in patients with rectal cancer. In this study, we tried to audit the quality of TME by 2 independent observers, a consultant pathologist and radiologist. TME was performed for all patients with rectal tumors located <12 cm from the anal verge.

**Main Outcome Measures:** TME specimens were examined for completeness by experienced single consultant pathologist to avoid interobserver bias. Postoperatively magnetic resonance imaging was done that was interpreted by a single consultant radiologist to avoid interobserver bias in the study.

**Discussion:** Of total 103 patients, TME assessment was done in 53 patients. TME was complete in 35 cases (66%), near complete in 14 cases (26%), and incomplete in 4 cases (8%) ( $P < 0.05$ ). Twenty-eight cases were subjected to radiologic assessment of TME. Complete TME was found in 19 (67%) and residual mesorectum was found in 9 (32%). The radiologic findings co-related with pathology findings in these 28 cases as 17 cases were confirmed TME complete by both magnetic resonance imaging and histopathology, 4 cases were confirmed incomplete by both and out of 7 near complete TME by pathology, 2 were labeled as complete on radiology while 5 were labeled as incomplete ( $P < 0.05$ ). Seven (13.2%) cases had positive circumferential resection margin. Distal resection margin was > 2 cm in about 81.1%, <2 cm in 15% and involved in 3.7% of cases. The lymph node yield was of 4–21 with an average of 11.5 nodes; with 54.7% having adequate nodal harvest (> 12 lymph nodes).

**Conclusions:** Pathologist's and radiologist's constructive criticism will always help a surgeon to improve his quality of TME.

**Keywords:** TME (Total mesorectal excision), LAR (low anterior resection), APR

Total mesorectal excision (TME) refers to complete excision of the mesorectum down to the pelvic floor and is indicated for carcinoma of the middle and lower third of the rectum and has become the contemporary standard of care for patients with rectal cancer. Pathologists play a key role in the evaluation of these specimens, including the quality assurance of surgical performance, as well as evaluation of the circumferential radial margin (CRM). While the latter is the most significant predictor of local recurrence, the quality of the excised mesorectum is another important factor in assessing the risk of local recurrence in patients with a negative CRM. As proper pathologic

assessment of the TME specimen provides important prognostic information, as well as critical feedback to surgeons regarding technical performance. The high quality surgical techniques for mesorectal excision has been shown to influence locoregional control for carcinoma of the rectum. Pelvic recurrence following conventional rectal resection for cancer is common with a worldwide incidence of ~30% that have penetrated rectal wall (pT3) irrespective of nodal status<sup>[1,2]</sup>. There is opinion that local recurrence is because of incomplete excision of mesorectum or breach of mesorectum during rectal dissection. In total mesorectal excision, by sharp and meticulous dissection in the holy plane, Heald et al<sup>[3]</sup> and Enker et al<sup>[4]</sup> have reported low recurrence rate in patients with rectal cancer. Very low rates of tumor recurrence (4%) are also reported by Macfarlane et al<sup>[5]</sup>. However, high chances of increased morbidity and anastomotic site leakage<sup>[6]</sup> and impaired bowel function<sup>[7]</sup> are associated with routine TME. Pathologic involvement of CRM and/or an incomplete mesorectum are predictors of local recurrence<sup>[8,9]</sup>. In a Swedish series half of patients with local recurrence had visible mesorectal tissue in pelvis on postoperative magnetic resonance imaging (MRI) and computed tomography, suggesting that suboptimal surgery had been performed<sup>[10,11]</sup>.

The concept of TME has now also been applied for transanal approaches. A preliminary study by Kang et al<sup>[12]</sup> demonstrated that transanal total mesorectal excision in rectal cancer is safe and feasible. A radiologist can also predict residual mesorectum on postoperative T2-weighted MRI of the pelvis performed on patients following mesorectal excision. MRI is performed after an interval of 6 weeks after surgery to avoid confusions in

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This manuscript has been peer reviewed.

Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

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International Journal of Surgery Oncology (2018) 3:e53

Received 3 October 2017; Accepted 31 October 2017

Published online 7 February 2018

<http://dx.doi.org/10.1097/IJ9.000000000000053>

postoperative changes and mesorectal assessment. This study was conducted to audit the quality of mesorectal excision in our set-up by 2 independent observers, a senior consultant radiologist and senior pathologist. The study was conducted by blinding the surgeon and the independent assessors to each other to strengthen the quality of audit for TME in our set-up.

## Patients and methods

Patients with rectal cancer located within 4–12 cm from anal verge were evaluated as per preset protocol. During this period all rectal cancer operations were performed exclusively by 3 fully trained colorectal consultant surgeons. Therefore, a standard surgical technique was used at the study institution. TME was performed for all tumors located <12 cm from the anal verge. A preoperative MRI was done in these patients then they underwent TME and evaluated postoperatively by MRI that was interpreted by a single consultant radiologist to avoid interobserver bias in the study. Pathologic specimens from such patients were also being examined for completeness of TME by experienced single consultant pathologist to avoid interobserver bias. MRI and pathologic findings were evaluated and compared in extent and completeness of mesorectal excision by experienced faculty as described in a blinded manner in order to ensure a quality audit of surgery (TME) being performed in our department. On the basis of macroscopic assessment pathologist graded specimen as complete, near complete, and incomplete, whereas radiologist graded surgeries as complete or incomplete. Further, all the patients are on follow-up for assessment of local recurrence on long term.

Postoperative T2-weighted MRI of the pelvis was performed on 28 patients following mesorectal excision. MRI was performed after time interval of 6 weeks after surgery to avoid confusions in postoperative changes and mesorectal assessment. A consultant radiologist evaluated the images with regard to residual mesorectum and distal margin. Mesorectal fatty tissue with a discernable tissue interface of fibrosis which separates mesorectum from mesocolon, was considered a sign of residual mesorectal tissue. Tissue fibrosis as differentiated from mesorectal fascia as fibrosis typically has a lower signal on T2-weighted images, often seems more continuous, and may appear thicker than mesorectal fascia. Residual mesorectum was defined as any mesorectal tissue left after low anterior resection (LAR) with TME or abdominoperineal resection (APR). The work has been reported in line with the STROCSS criteria<sup>[13]</sup>.

## Statistical analysis

Statistical package for the social sciences software version 16.0 (SPSS 16.0) was used for data assessment and statistical analysis. All the continuous variables were shown in terms of descriptive statistics and categorical variables were expressed in terms of frequency and percentage. Categorical variables were analyzed with the help of  $\chi^2$  test and Fisher exact test.

## Results

During the study period of 2 years (May 2014 to April 2016) a total of 103 patients of carcinoma rectum were reported to the colorectal department of our institution. In the study the patients which were excluded includes 13 patients with distant metastasis

at presentation, 9 patients with gross residual disease, 12 with local excision, 15 cases of carcinoma of the upper rectum treated with partial mesorectal excision, and 5 patients that were lost in early follow-up. Of the remaining 53 cases, all the specimens were examined by a consultant pathologist for assessment of TME as per guidelines and 28 cases were subjected to radiologic assessment of TME in a blinded manner.

Study subjects in our study were in an age group of 18–75 with a mean age of 48 years. Male:female ratio was 26:27 with almost equal distribution among males and females. Of the 53 cases, TME was complete in 35 cases (66%), near complete in 14 cases (26%), and incomplete in 4 cases (8%) ( $P < 0.05$ ). Twenty-eight cases were subjected to radiologist for assessment of TME in a blinded manner. Complete TME was found in 19 of 28 cases (67%) and residual mesorectum was found in 9 of 28 cases (32%). The radiologic findings co-related with pathology findings in these 28 cases as 17 cases were confirmed TME complete by both MRI and histopathology, 4 cases were confirmed incomplete by both and of the 7 near complete TME by pathology, 2 were labeled as complete on radiology while as 5 were labeled as incomplete ( $P < 0.05$ ). There were about 9 cases that were done laparoscopically. Of the 9 cases, 4 (44.4%) were found to have complete mesorectal excision. Seven of the 53 cases had positive CRM. Cases with negative CRM had complete TME as compared with those with CRM positive (73.9% vs 14.2%, respectively) ( $P = 0.007$ ). Distal resection margin was > 2 cm in about 81.1% of cases, <2 cm in about 15% of cases and was involved in about 3.7% of cases. DRM had no relation with completeness of TME. The lymph node yield was in the range of 4–21 with an average of 11.5 nodes per specimen with 54.7% having adequate nodal harvest (> 12 lymph nodes). In our study, mesorectal defects were equally seen with both APR and LAR (50% vs 51%, respectively) ( $P = 0.28$ ). Seven of the 53 cases (13.2%) received neoadjuvant chemoradiotherapy. TME was complete in 71.4% of patients who received neoadjuvant therapy as compared with 65.2% who did not receive neoadjuvant therapy ( $P = 0.38$ ). There was little difference in 2 groups as neoadjuvant chemoradiotherapy helped independently in downstaging and improved local control (Tables 1 and 2).

## Follow-up

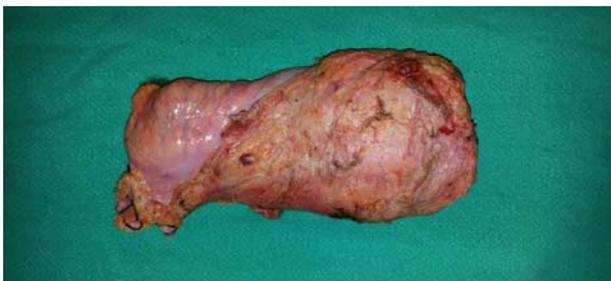
All the patients are in follow-up for assessment of local recurrence as study period was short (2 y). During the study 3 patients were presented with local recurrences. One perianastomotic, 1 nodal, and 1 was on the posterior vaginal wall. All the 3 had negative CRM but incomplete TME on initial surgical procedure.

## Discussion

TME surgery in the treatment of rectal cancer has been shown to result in a reduction in the number of local recurrences in retrospective studies. Macfarlane et al<sup>[5]</sup> studied that mesorectal excision for rectal cancer adds to operative time and complications but has been claimed to eliminate virtually all locally recurrent disease after “curative” surgery. Cecil et al<sup>[14]</sup> observed that TME results in low local recurrence rates in lymph node-positive rectal cancer. Scott et al<sup>[15]</sup> studied that TME appears to be associated with a reduced local recurrence rate following surgery for rectal cancer.

In our study, TME was complete in 35 cases (66%), near complete in 14 cases (26%), and incomplete in 4 cases (8%). Even the near complete category by our pathologist was introduced to be more on critical side rather than favorable side of surgeon which otherwise in many centers would be labeled as complete. We appreciate this because a critical appraisal always helps a surgeon to improve more. The data were statistically significant with a  $P$ -value of  $<0.05$ . Of the 53 cases, 28 cases were assessed by a radiologist for completeness of TME in a blinded manner. Complete TME was found in 19 (67%) and residual mesorectum was found in 9 of the 28 cases (32%). The data were evaluated statistically with the help of  $\chi^2$  test and Fisher exact test. The data were statistically significant with a  $P$ -value of  $<0.05$ . Statistically MRI was better in identifying residual mesorectum than histopathology. There is a possibility that since MRI had only 2 categories and no category of near complete category and probably that was the reason for giving statistical advantage to MRI. In 2013 Bondeven et al<sup>[16]</sup> studied that MRI-detected residual mesorectum was identified in 54 (39.7%) of 136 patients with the pathology findings in 88 patients (64.7%). García-Granero et al<sup>[17]</sup> found that of the 359 specimens, 294 (81.9%) underwent evaluation; 82.3% were “complete.” In our study, mesorectal excision was complete in a good percentage of cases because of a high volume center and all these surgeries were performed by colorectal specialists, and in case we add up near complete specimen to complete ones percentage goes as high as 92% because many studies did not mention about near complete category. The chances of inter-observer variation were greatly reduced in our study by ensuring that only 1 senior professor of radiology reported the MRI in a blinded manner who is considered expert in MRI. Besides, chances of missing a residual mesorectum on MRI got markedly reduced by following this design in our study. Also doing it in a blinded manner further strengthened the audit for quality of TME in our set-up. Proper pathologic assessment of the TME specimen provides important prognostic information, as well as critical feedback to surgeons regarding technical performance (Figs. 1–4).

In our study, both direct tumor extension and the presence of positive lymph nodes within 1 mm of the CRM were considered to be a positive margin. Cases with negative CRM had higher rates of complete TME as compared with those with CRM positive (73.9% vs 14.2%, respectively). The data were statistically significant,  $P = 0.002$  ( $P < 0.05$ ). Our results are consistent with world literature which support that higher rates of complete TME are present in CRM negative cases. Nagtegaal et al<sup>[18–20]</sup> showed that the risk of having a positive CRM is related to the quality of the mesorectum, as patients with a positive CRM



**Figure 1.** Complete total mesorectal excision specimen. Gross external appearances of various total mesorectal excision specimens as evaluated by a senior pathologist.



**Figure 2.** Near complete total mesorectal excision specimen. Gross external appearances of various total mesorectal excision specimens as evaluated by a senior pathologist.

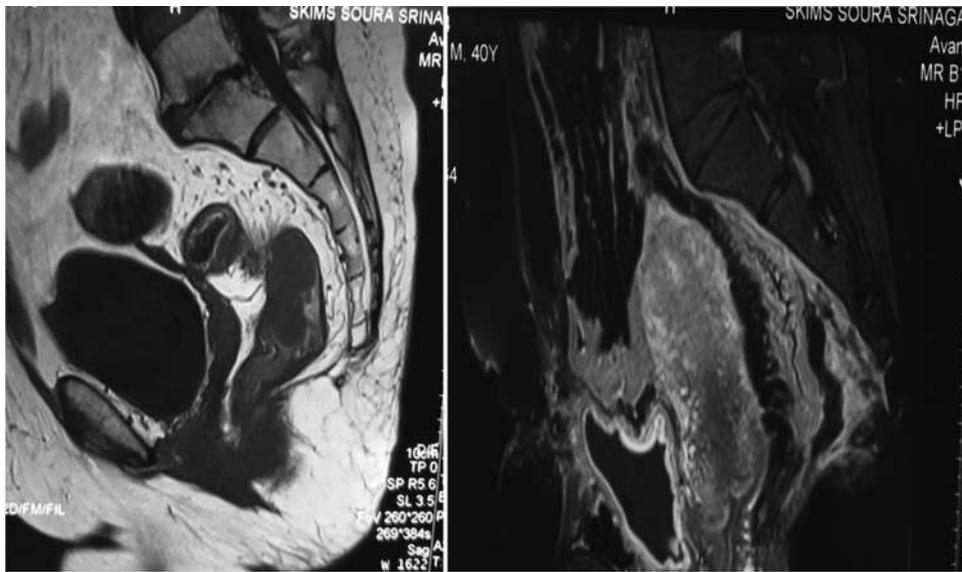
due to tumor extension more frequently had an incomplete mesorectum compared with those with a negative CRM (44% vs 24%,  $P < 0.05$ ). Jeyarajah et al<sup>[21]</sup> found that tumors with a CRM  $> 1$  mm were more likely to have complete or near complete mesorectal excision although García-Granero et al<sup>[17]</sup> did not observe a statistically significant relationship between quality of mesorectal excision and CRM status. Accurate determination of CRM status is essential, because this is the single most important factor for predicting the risk of local recurrence in patients with rectal cancer.

In our study, residual mesorectum were equally seen with both APR and LAR (50% vs 51%, respectively) ( $P = 0.28$ ). Bondeven et al<sup>[15]</sup> showed that residual mesorectum was more frequent in patients treated with partial mesorectal excision (63%) than those who had total mesorectal excision/LAR (36%) or APR (13%). García-Granero and colleagues found that APR was the sole covariate associated with inadequate mesorectal excision. They found that CRM involvement and noncomplete mesorectum, CRM positive, poorly differentiated tumors, nodal involvement, and APR were independent risk factors for overall recurrence<sup>[17]</sup>. However in our study no significant difference was noted on the basis of surgical procedure, as residual mesorectum was equally seen with both APR and LAR (50% vs 51%, respectively). In our study the number of patients subjected to APR is quite low as compared with LAR and that might be the reasons for same percentage of residual mesorectum.

In our study 7 of the 53 cases (13.2%) received neoadjuvant chemoradiotherapy. TME was complete in 71.4% of patients who received neoadjuvant therapy as compared with 65.2% who



**Figure 3.** Incomplete total mesorectal excision specimen. Gross external appearances of various total mesorectal excision specimens as evaluated by a senior pathologist.



**Figure 4.** A, Preoperative magnetic resonance imaging (MRI) of rectal carcinoma. B, Postoperative MRI showing complete total mesorectal excision.

did not receive neoadjuvant therapy ( $P = 0.385$ ). There was little difference in the 2 groups as neoadjuvant chemoradiotherapy helped independently in downstaging and improved local control.

Effect of laparoscopic approaches for carcinoma of the rectum such as laparoscopic LAR had direct impact on quality of mesorectal excision. There were about 9 cases that were done laparoscopically. Of the 9 cases, 4 (44.4%) were found to have complete mesorectal excision. The incompleteness of mesorectal excision in

rest of cases was attributed to learning phase of laparoscopic LAR surgery. There were breaches in mesorectal fascia during gut manipulation due to learning phase of laparoscopic rectal surgeries which were picked up by pathologist as mesorectal defects in the specimen. The quality of mesorectal excision in laparoscopic LAR will improve once surgeons expertise in laparoscopic management of these cases gets negotiated. The laparoscopically operated patients had less postoperative pain, better-preserved pulmonary function, earlier restoration of gastrointestinal function, and an

<b>Table 1</b>						
<b>Incidence of various parameters related to completeness of TME on histopathology report.</b>						
Parameters	No. Patients	Complete TME (%)	Near Complete TME (%)	Incomplete TME (%)	Statistical Significance (P)	
Total cases	53	35 (66)	14 (26)	4 (8)	< 0.05*	
Sex ratio (M:F)	26:27	19:16	5:9	2:2	1.00*	
Distance from AV (cm)					0.36**	
0–5	21	14 (67)	5 (24)	2 (10)		
5.1–10	30	19 (63)	9 (30)	2 (7)		
10.1–12	2	2 (100)	0	0		
Adjuvant therapy					0.34**	
No	46	30 (65)	13 (28)	3 (7)		
Yes	7	5 (71)	1 (14)	1 (14)		
Operation					0.28**	
LAR	44	29 (66)	12 (27)	3 (7)		
APR	9	6 (67)	2 (22)	1 (11)		
CRM					0.007**	
negative	46	34 (74)	9 (20)	3 (6)		
positive	7	1 (14)	5 (71)	1 (14)		
T Stage					0.41**	
T0	4	3 (75)	1 (25)	0		
T1	2	2 (100)	0	0		
T2	22	16 (73)	4 (18)	2 (9)		
T3	20	12 (60)	7 (35)	1 (5)		
T4	5	2 (40)	2 (40)	1 (20)		

APR indicates abdominoperineal resection; AV, anal verge; CRM, circumferential resection margin; F, female; LAR, low anterior resection; M, male; TME, total mesorectal excision.

\*Fisher exact test.

\*\*Pearson  $\chi^2$  test.

**Table 2**  
**Incidence of various parameters related to completeness of TME on magnetic resonance imaging report.**

Parameters	No. Patients	Complete TME (%)	Incomplete TME (%)	Statistical Significance (P)
No. patients	28	19 (68)	9 (32)	0.000*
Sex ratio (M:F)	12:16	6:13	6:3	0.79*
Distance from AV (cm)				0.31**
0–5 cm	12	8 (67)	4 (33)	
5.1–10 cm	15	10 (67)	5 (33)	
10.1–12 cm	1	1 (100)	0	
Adjuvant therapy				0.26**
No	26	17 (65)	9 (35)	
Yes	2	2 (100)	0	
Operation				0.26**
LAR	23	17 (74)	6 (26)	
APR	5	2 (40)	3 (60)	
CRM				0.002**
Negative	24	19 (79)	5 (21)	
Positive	4	0	4 (100)	
T Stage				0.31**
T0	2	2 (100)	0	
T1	1	1 (100)	0	
T2	10	8 (80)	2 (20)	
T3	11	6 (55)	5 (45)	
T4	4	2 (50)	2 (50)	
Pathologic correlation of TME				<0.05***
Complete	17	17 (100)	0	
Near complete	7	2 (29)	5 (71)	
Incomplete	4	0	4 (100)	

APR indicates abdominoperineal resection; AV, anal verge; CRM, circumferential resection margin; F, female; M, male; TME, total mesorectal excision.

\*Fisher exact test value 21.9 and *P*-value <0.05.

\*\*Pearson  $\chi^2$  at 1 *df*=9.85 with *P*=0.002.

\*\*\*Pearson  $\chi^2$  test at 2 *df*=21.45 with *P*<0.05.

earlier discharge from the hospital. The postoperative stress response is lower after laparoscopic colectomy. The incidence of port site metastases is <1%. Survival after laparoscopic resection of colon cancer appears to be at least equal to survival after open resection. The operative but overall costs when compared with hospital stay are more for open as proven in our other study. However, there are some under-reported problems in laparoscopic surgery of rectum like application of Endo GI staplers especially with 60 mm cartridge always poses lot of difficulty and it is always better to use 45 mm cartridge in third world patients as their pelvis is narrow. Another significant difficulty encountered is to be sure about the distal margin with smaller lesions where hand sensation is missing, but a limited Pfannenstiel conversion helps to feel the lower margin. Laparoscopic resection of colon cancer is a safe and feasible procedure that improves short-term outcome. Results regarding the long-term survival of patients enrolled in large multicenter trials will determine its role in general surgery.

Distal resection margin was >2 cm in about 81.1% of cases, <2 cm in about 15% of cases, and was involved in about 3.7% of cases (*P*<0.05). In involved distal margins, there is a definite chance of recurrence. DRM had no relation with completeness of TME. Involvement of distal resection margin was slightly higher in our cases. Probably the reason for more involvement of DRM is because of a high volume center we are more in favor of ultra low resection rather than APR even in very low growth. Over a period

of time because of experience we have seen that even patients with DRM involvement doing well with adjuvant therapy. The distal margin, although less important than the CRM in terms of frequency of involvement and impact on recurrence, is still important to assess. Results from the Dutch TME trial showed that while in nearly 40% of cases the distance between the tumor and the distal margin was <2 cm, there was no statistical difference in recurrence between patients with a distal margin <2 cm compared with those with a distal margin >5 cm<sup>[22]</sup>.

## Conclusions

For rectal cancer TME should be the standard surgical treatment. Careful macroscopic as well as microscopic assessment of distance of tumor to CRM, is the most significant predictor of local recurrence. Moreover, implementation of TME has resulted in progressive changes in preoperative imaging, histopathologic staging, and neoadjuvant treatment, highlighting the importance of the multidisciplinary team in patient management. Differences in outcomes between surgeons specifically trained in TME have been observed in multicenter trials. Local recurrence represents the ultimate outcome marker of this variability, and it is directly related to the quality of mesorectal excision. Currently, there are 2 important morphologic observations related to surgical quality: the involvement CRM and the macroscopic assessment of mesorectal excision. The prognostic importance of the CRM involvement is beyond question. However, macroscopic assessment of mesorectal excision is a more recently described quality marker with less influence in current guidelines. Assessment of surgical quality, that is, quantifying the proportion of specimens graded as complete by the pathologist, may add some relevant information to other prognostic parameters. Besides a post-operative MRI at 6 weeks interval has proved another excellent method of audit to assess the completeness of TME. This study made us to believe and realize that there is always a scope of improvement to upgrade your surgical skills.

## Ethical approval

The study was done after receiving due ethical clearance from IEC committee S.K.I.M.S soura.

## Sources of funding

Funding for MRI was done by fee exemptions by the department of radiodiagnosis and hospital administration.

## Authors' contribution

T.H.: conducted the research work. F.Q.P.: supervise, guide, supports practical and surgical cases. N.A.C.: provide inter-department corroboration, expert advice, did TME surgeries, and helped in difficult cases. Z.R.: interpreted rectal cancer specimens. F.A.S.: interpreted MRI regarding TME. R.A.W.: helped in interpreting and analyzing data besides patient providing.

## Conflict of interest disclosures

The authors declare that they have no financial conflict of interest with regard to the content of this report.

## Research registration unique identifying number (UIN)

Registered under CTRI India under reference no 2015/10/009886.

## Guarantor

Tajamul Hassan.

## References

- [1] Rich T, Gunderson LL, Lew R, *et al.* Patterns of recurrence of rectal cancer after potentially curative surgery. *Cancer* 1983;52:1317–29.
- [2] Pilpshen SJ, Heilwell M, Quan SHQ, *et al.* Patterns of pelvic recurrence following definitive resections of rectal cancer. *Cancer* 1984;53:1354–62.
- [3] Heald RJ, Moran BJ, Ryall RD, *et al.* Rectal cancer; the basic stokes experience of total mesorectal excision 1978-1997. *Arch Surg* 1998;133:894–9.
- [4] Enker WE, Thaler HT, Cranor ML. Total mesorectal excision in operative treatment of cancer of rectum. *J Am Coll surg* 1995;181:335–46.
- [5] Macfarlane JK, Ryall RDH, Heald RJ. Mesorectal excision for rectal cancer. *Lancet* 1993;341:457–60.
- [6] Karanja ND, Corder AP, Bearn P. Leakage from stapled low anastomosis after total mesorectal excision for carcinoma of rectum. *J Am Coll surg* 1994;181:335–46.
- [7] Karanja ND, Schache DJ, Heald RJ. Function of distal rectum after low anterior resection. *Br J surg* 1992;79:114–6.
- [8] Garlipp B, Ptok H, Schmidt U, *et al.* Factors affecting quality of mesorectal excision. *Br J Surg* 2012;99:714–20.
- [9] Quirke P, Steele R, Monson J, *et al.* Effect of plane of surgery achieved on local recurrence in patients with operable rectal cancer; a prospective study using data from MRC CR07 and NCIC-CTG CO16 randomised clinical trial. *Lancet* 2009;373:821–8.
- [10] Syk E, Torkzad MR, Blomqwist L, *et al.* Radiologic findings do not support lateral residual tumour as a major cause of local recurrence of rectal cancer. *Br J Surg* 2006;93:113–9.
- [11] Syk E, Torkzad MR, Blomqwist L, *et al.* Local recurrence in rectal cancer: anatomic localization and effect of radiation target. *Int J Radiat Onco* 2008;72:658–4.
- [12] Kang L, Chen WH, Luo SL, *et al.* Transanal total mesorectal excision for rectal cancer: a preliminary report. *Surg Endosc* 2016;30:2552–62.
- [13] Agha RA, Borrelli MR, Vella-Baldacchino M, *et al.* STROCCS Group. The STROCCS Statement: strengthening the reporting of cohort studies in surgery. *Int J Surg* 2017;46:198–202.
- [14] Cecil TD, Sexton R, Moran BJ, *et al.* TME results in low recurrence rates in lymph node positive rectal cancer. *Dis Colon Rectum* 2004;47:1145–50.
- [15] Scott N, Jackson P, Al-Jaberi T, *et al.* Total mesorectal excision and local recurrence: a study of tumour spread in the mesorectum distal to rectal cancer. *Br J Surg* 1995;82:1031–3.
- [16] Bondeven P, Hageman-Madesson RH, Laurberg S, *et al.* Extent and completeness of mesorectal excision as evaluated by postoperative MRI. *Br J Surg* 2013;100:1357–67.
- [17] García-Granero E, Faiz O, Muñoz E, *et al.* Macroscopic assessment of mesorectal excision in rectal cancer. *Cancer* 2009;115:3400–11.
- [18] Nagtegaal ID, Marijnen CAM, Klein Kranenbarg E, *et al.* Circumferential margin involvement is still an important predictor of local recurrence in rectal carcinoma: not one millimeter but two millimeters is the limit. *Am J Surg Pathol* 2002;26:350–7.
- [19] Nagtegaal ID, van Krieken JHJM. The role of pathologists in the quality control of diagnosis and treatment of rectal cancer—an overview. *Eur J Cancer* 2002;38:964–72.
- [20] Nagtegaal ID, van de Velde CJH, van der Worp E, *et al.* Macroscopic evaluation of rectal cancer resection specimen: clinical significance of the pathologist in quality control. *J Clin Oncol* 2002;20:1729–34.
- [21] Jeyarajah S, Sutton CD, Miller AS, *et al.* Leicester Colorectal Specialist Group. Factors that influence the adequacy of total mesorectal excision for rectal cancer. *Colorectal Dis* 2007;9:808–15.
- [22] Wiggers T, Van de Velde CJH. The circumferential margin in rectal cancer: recommendations based on the Dutch total mesorectal excision study. *Eur J Cancer* 2002;38:973–6.