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ORIGINAL ARTICLE

Feasibility of transperineal minimal invasive surgery when performing sacrectomy for advanced primary and recurrent pelvic malignancies

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Abstract

Background This study aimed to clarify the efficacy and safety of minimally invasive transabdominal surgery (MIS) with transperineal minimal invasive surgery (tpMIS) for sacrectomy in advanced primary and recurrent pelvic malignancies.

Methods Using a prospectively collected database, we retrospectively analyzed the clinical, surgical, and pathological outcomes of MIS with tpMIS for sacrectomies. Surgery was performed between February 2019 and May 2023. The median follow-up period was 27 months (5–46 months).

Results Fifteen consecutive patients were included in this analysis. The diagnoses were as follows: recurrent rectal cancer, $n=11$ (73%); primary rectal cancer, $n=3$ (20%); and recurrent ovarian cancer, $n=1$ (7%). Seven patients (47%) underwent pelvic exenteration with sacrectomy, six patients (40%) underwent abdominoperineal resection (APR) with sacrectomy, and two patients (13%) underwent tumor resection with sacrectomy. The median intraoperative blood loss was 235 ml (range 45–1320 ml). The postoperative complications (Clavien–Dindo grade ≥ 3a) were graded as follows: 3a, $n=6$ (40%); 3b, $n=1$ (7%); and ≥ 4, $n=0$ (0%). Pathological examinations demonstrated that R0 was achieved in 13 patients (87%). During the follow-up period, two patients (13%) developed local re-recurrence due to recurrent cancer. The remaining 13 patients (87%) had no local disease. Fourteen patients (93%) survived.

Conclusions Although the patient cohort in this study is heterogeneous, MIS with tpMIS was associated with a very small amount of blood loss, a low incidence of severe postoperative complications, and an acceptable R0 resection rate. Further studies are needed to clarify the long-term oncological feasibility.

Keywords Extended pelvic surgery · Transperineal minimally invasive surgery · Sacrectomy · Pelvic malignancies

Introduction

Sacrectomy is the ultimate surgical technique for pelvic malignancies with posterior pelvic invasion, and acceptable oncologic outcomes are achieved by R0 resection. Nevertheless, sacrectomy is only performed at highly selective centers because the volume of intraoperative blood loss and high incidence of major perioperative complications remain as serious problems [1, 2].

Minimally invasive transabdominal surgery (MIS) has become widespread in pelvic surgeries because it offers improved visualization of the operative field, allowing for precision in dissection and vascular control, and consequently reducing perioperative complications. In addition, the innovative concept of transanal and transperineal minimal invasive surgery (ta and tpMIS), represented by transanal total mesorectal excision (TaTME), was proposed to overcome the poor surgical view from the transabdominal approach in the narrow male pelvis and in patients with obesity by offering direct visualization of deep pelvic structures [3]. ta and tpMIS further enables down-to-up dissection of the pelvic organs without the need for a wide skin incision on the perineal side. Owing to these benefits, TaTME with

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MIS has become one of the standard options for total mesorectal excision (TME) in rectal cancer [4, 5].

These advantages of MIS with ta and tpMIS encourage the widespread use of extended pelvic surgeries, such as total pelvic exenteration (TPE) and posterior pelvic exenteration (PPE), and the clinical benefits of these operations have been reported [6–8]. However, no studies have reported the reliable technique, landmarks, or clinical outcomes of sacrectomy. This study aimed to demonstrate the standardized surgical technique and treatment results of MIS with tpMIS for sacrectomy.

Materials and methods

This single-center retrospective cohort study assessed the efficacy and safety of MIS with tpMIS for sacrectomy for advanced primary and recurrent pelvic malignancies in patients who underwent surgery between February 2019 and May 2023. Initial staging was performed by total colonoscopy; contrast-enhanced computed tomography (CT) of the lungs, chest, abdomen, and pelvis; and rectal magnetic resonance imaging (MRI). Positron emission tomography–computed tomography (PET-CT) was performed in all recurrent cases.

Sacrectomy is indicated for cases that meet the following criteria: (1) there is no distant recurrence; (2) R0 resection is possible by preoperative imaging; (3) the sacral transection level is below the lower edge of S2; (4) there is no invasion of the common iliac or external iliac artery; (5) patient tolerability has been confirmed by a multidisciplinary conference; and (6) informed consent has been obtained from the patient and family.

MIS with tpMIS is routinely used when performing sacrectomy. However, it is not used in cases in which a good surgical view on the perineal side is achieved by performing a wide perineal skin incision under direct view, or in cases involving patients with an exposed tumor on the perineal side of the skin where the use of pneumoperitoneum in the perineal side would be associated with a risk of dissemination. In such cases, pneumoperitoneum at the perineal side was deemed inappropriate.

tpMIS was indicated when the extent of tumor invasion was limited to the internal obturator muscle and gluteus maximus muscles, which can be dissected under tpMIS. It was not indicated in cases involving lateral invasion of tumor beyond these muscles. MIS with tpMIS was indicated in cases in which dissection of the internal iliac vessels and/or superior gluteal vessels was necessary.

Preoperative therapy was determined by a multidisciplinary team meeting and oxaliplatin-based chemotherapy or 45 Gy chemoradiotherapy (CRT). One patient who was diagnosed with unresectable anal canal cancer had received 60 Gy CRT at the referring hospital.

Flap reconstruction was performed on patients who had a large pelvic dead space due to TPE with sacrectomy or for patients with a large skin defect on the perineal side. A rectus abdominis myocutaneous flap is the first choice for flap reconstruction.

Ethical approval for this study was obtained from Hyogo Medical University (approval number 2798).

Surgical technique of tpMIS for sacrectomy

tpMIS in the Lloyd–Davies position

We previously reported the surgical procedure of tpMIS for sacrectomy [9]. We performed a two-team approach using transabdominal and perineal approaches. In the transperineal approach, the anus is closed and the skin around the anus is incised circumferentially. In patients with recurrent disease after abdominoperineal resection (APR), a 5-cm skin incision is made on the perineal side. The coccyx is identified, and the dorsal aspect of the coccyx is dissected using an open approach. The ischiorectal fat is dissected toward the lateral side to identify the gluteus maximus muscles at the attachment of the coccyx. After achieving poor visual field and insufficient mobility in a narrow surgical field using an open approach, we placed multiple access ports (GelPOINT V-Path®, Applied Medical, Rancho Santa Margarita, CA, USA) at the start of tpMIS using Airseal® (ConMed, Utica, NY, USA) at a pressure of 10–15 mmHg. The gluteus maximus muscles are transected at the attachment of the coccyx, and the ventral side of the gluteus maximus muscles is dissected to the lateral side (Fig. 1a, b). We can identify the sacrotuberous ligament, which is located at the surface of the gluteus maximus muscles and attached between the coccyx, sacrum, and ischial tuberosity (Fig. 1c). Dissection of this ligament opens the lesser sciatic foramen (Fig. 1d). The internal obturator muscle is identified on the lateral side, and dissection along the internal obturator muscle reaches the tendinous arch of the levator ani (Fig. 1e). This point is used as the rendezvous point between the transabdominal and perineal approaches. In addition, in cases requiring combined dissection of the internal obturator muscle, this muscle was resected through a transperineal approach.

Transabdominal approach

Before surgery, the distance between the promontory and the upper edge of the tumor is measured using MRI (sagittal section). During surgery, this length is used as a guide for the dissection border of the posterior side (Fig. 2a). After the dissection reaches the dissection border on the posterior side, the branch of the sciatic nerve at the sacral transection

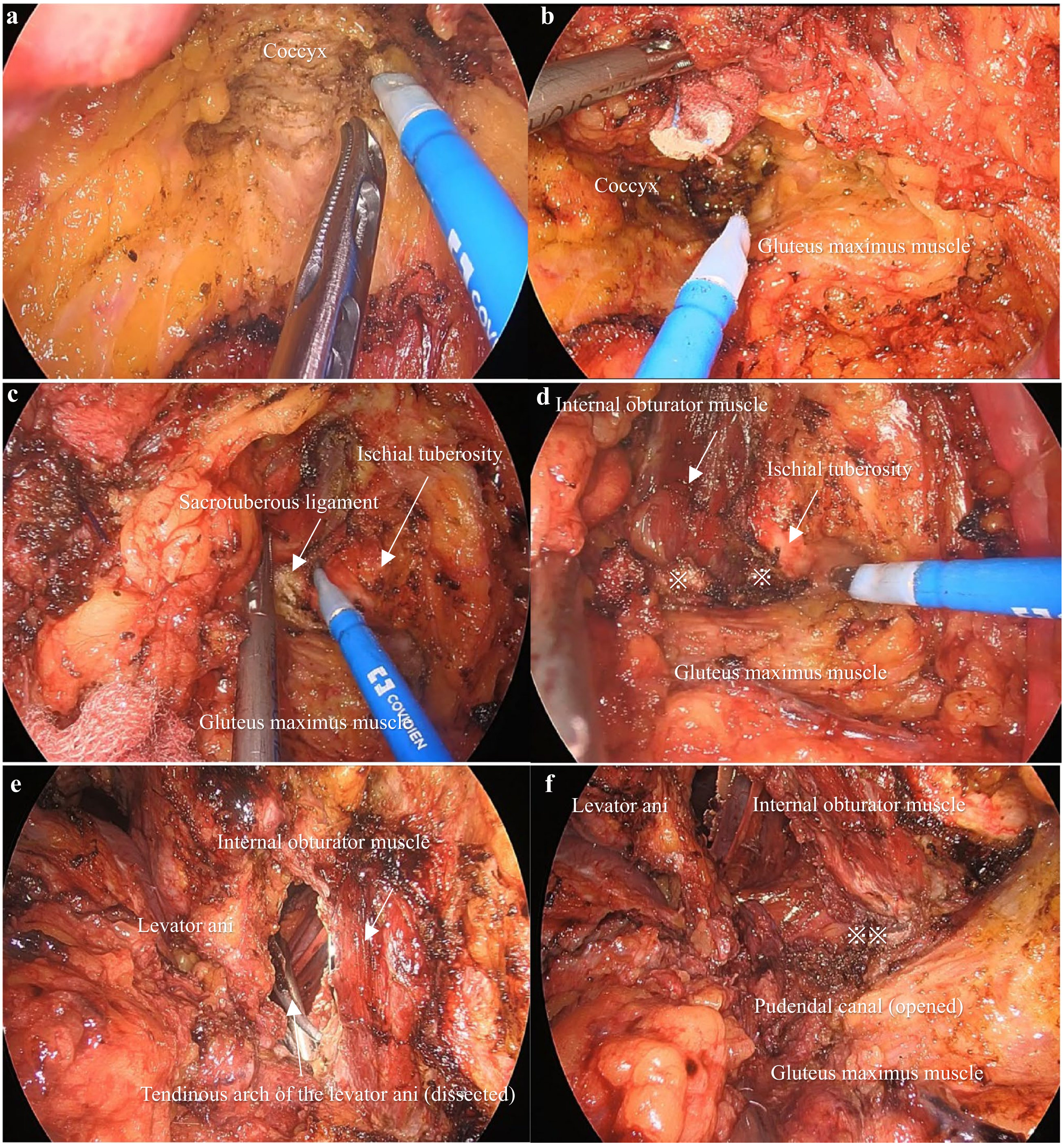

Fig. 1 tpMIS for lithotomy position (left side of patient). *tpMIS* transperineal minimal invasive surgery. **a** The posterior aspect of the coccyx is dissected. **b** The gluteus maximus muscles are transected at the attachment of the coccyx, and the ventral side of the gluteus maximus muscles is dissected laterally. **c** The sacrotuberous ligament can be identified. **d** The dissection of sacrotuberous ligament opens the lesser sciatic foreman. **e** Dissection along the internal obturator muscle reaching the tendinous arch of the levator ani. **f** The pudendal canal is opened by dissecting the coccygeus and sacrospinous ligaments. ※Sacrotuberous ligament (dissected)

level is taped, making it the landmark of the dissection line on the lateral side (Fig. 2b).

Using the transabdominal approach, we dissected the parietal fascia and clarified the routes of the internal iliac vessels and internal pudendal vessels to prevent injury to those vessels from the transabdominal approach (Fig. 2c). After the rendezvous between the two approaches at the tendinous arch of the levator ani, the levator ani is dissected

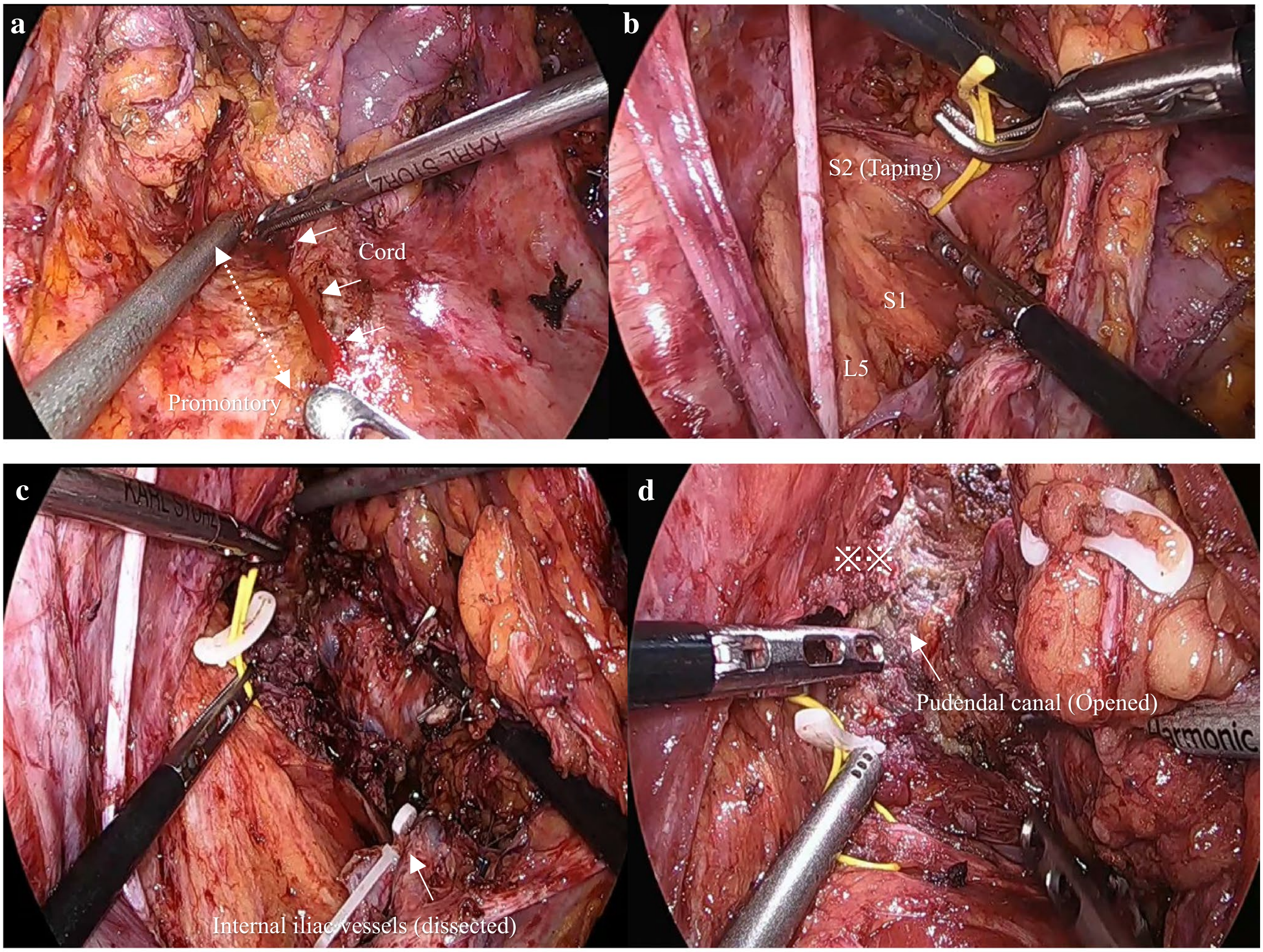

Fig. 2 Transabdominal approach (left side of patient). **a** The distance between the promontory and upper edge of tumor is measured. **b** The branch of the sciatic nerve at the sacral transection level is taped. **c** The parietal fascia is dissected. **d** The coccygeus muscle and sacrospinous ligament are dissected to open the pudendal canal. ※※Coccygeus muscle and sacrospinous ligament

dorsally using a transabdominal and perineal approach. In particular, at the 4 and 8 o'clock positions, the internal pudendal vessels pass through the supralevator space to the infralevator space, which is called the pudendal canal. The route of the internal pudendal vessels is clarified by dissecting the ventral side of the pudendal canal, which consists of the coccygeus muscle and sacrospinous ligament (Figs. 1f, 2d). Internal pudendal vessels are routinely dissected using a transabdominal and peirneal approach; however, in cases in which a dissection margin can be secured, these vessels are preserved. Additionally, the piriformis muscle and presacral tissue are dissected at the sacral transection level.

In the case of the S2 transection, the sacrum is transected at the lower border of the sacroiliac joint, and the superior gluteal vessels pass through this point. Thus, in cases where the S2 sacrum is required to transect the lower border of the sacroiliac joint to maintain the dissection margin, the superior gluteal vessels are dissected. In cases where the sacrum can transect the caudal side of the sacroiliac joint while maintaining the dissection margin, the superior gluteal vessels are preserved.

tpMIS in the prone position

The sacral level is marked on the skin on the radiographs before surgery (Fig. 3a). The sacral transection approach differs according to the level of transection. When S2 and S3 are transected, the patient is repositioned in the prone position, and further dissection of the attachment to the sacrum (gluteus maximus muscles, sacrotuberous ligament, and sacrospinous ligament) is performed using a transperineal approach (Fig. 3b).

After the level of transection is reached, where taping of the sciatic nerve using the transabdominal approach is detected (Fig. 3c), an 8-cm skin incision is made at the sacral transection level on the lower back side. The sacroiliac joint

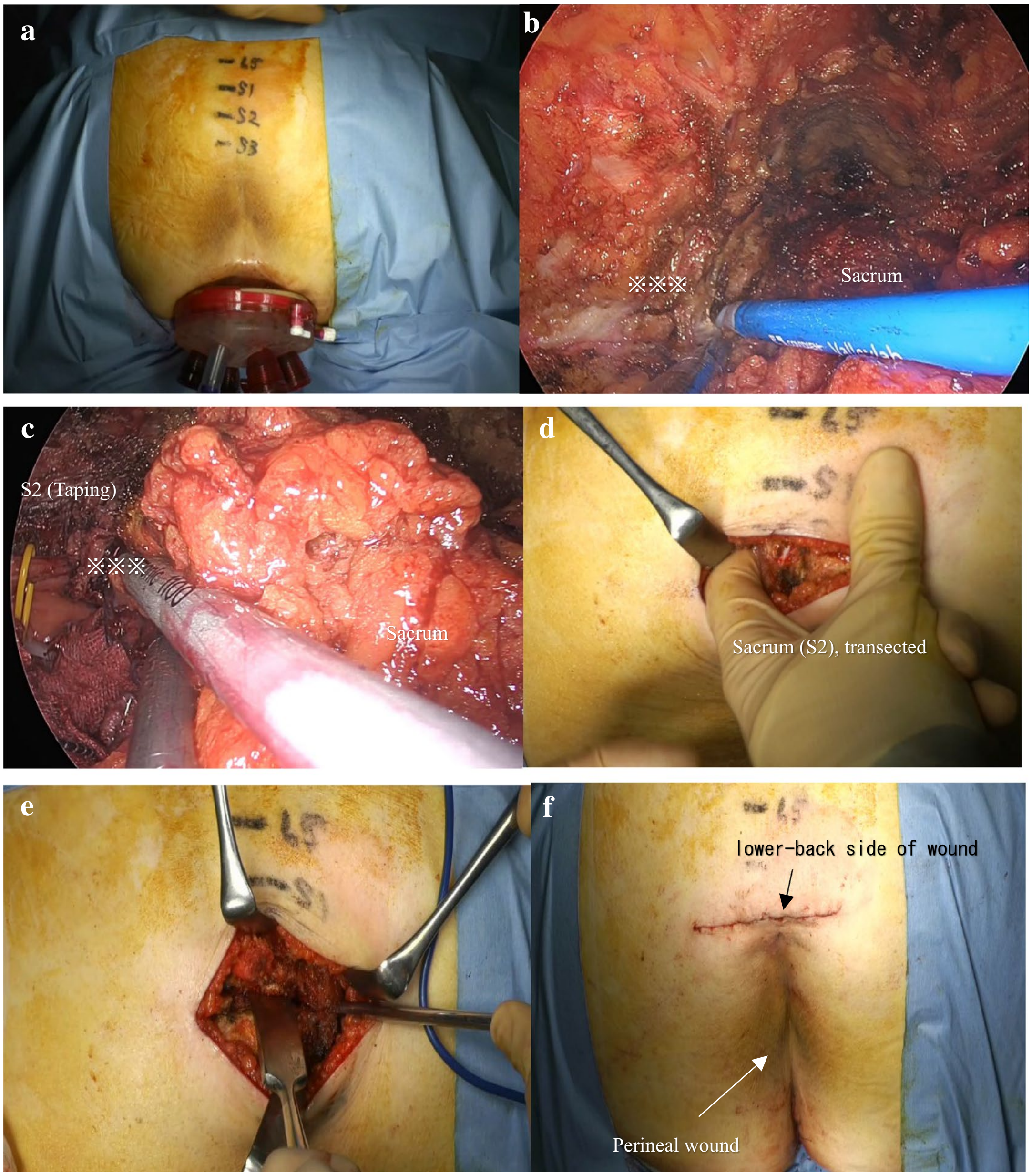

Fig. 3 tpMIS for prone position. *tpMIS* transperineal minimal invasive surgery. **a** The sacral level is marked on the skin. **b** The dissection of the attachment to the sacrum (gluteus maximus muscles, sacrotuberous ligament, and sacrospinous ligament). **c** The transection level can be confirmed by the taping of sciatic nerve. **d** The sacroiliac joint was palpated. **e** The osteotome is used to transect the sacrum. **f** The perineal side and lower back side of incision are closed. ※※※Attachment to the sacrum

is palpated to check the distance between the joint and the sacrum transection level (Fig. 3d). In addition, pulsation of the superior gluteal artery is palpated to prevent vessel injury. An osteotome is then used to transect the sacrum (Fig. 3e), and the perineal and lower back sides of the incision are closed (Fig. 3f).

The position is changed to the Lloyd–Davies position, and the resected specimen is removed. Reconstruction is subsequently performed. Omental flap transposition is routinely performed. Urinary diversion is performed by creating an ileal conduit, and the perineal incision and dead space are covered by the rectus abdominis myocutaneous flap, if necessary.

When the transection level is S4 or lower, sacral transection is performed in the Lloyd–Davies position (without prone position) using a Gigli wire saw. After the Gigli wire saw is positioned at the sacral transection level, it is used to transect the sacrum. This procedure has been described previously [10].

We have provided a video of the tpMIS technique of tpMIS for sacrectomy (Supplementary Data).

Definitions

Postoperative complications were classified using the Clavien–Dindo (CD) classification. Surgical site infection (SSI) was classified into one of three categories: superficial incisional SSI, deep incisional SSI, and organ/space SSI, as defined by the Center for Disease Control and Prevention/National Healthcare Safety Network [11]. Cases with negative bacterial cultures were diagnosed with pelvic fluid collection. In the pathological examination of the resected specimens, we followed the Japanese Clinical and Pathological Guidelines 2019 for the Colon, Rectum and Anus [12].

Results

Patient characteristics

During the study period, 16 patients underwent sacrectomy via MIS at our institution. After excluding one patient who did not undergo tpMIS since a wide perineal skin incision had to be performed due to tumor invasion, 15 patients were included in this study (Table 1). The median age was 64 years (48–82 years), and nine (60%) of the patients were female. Recurrent rectal cancer was observed in 11 (73%) patients. Preoperative treatment was performed in 13 (87%) patients. The reasons for not receiving preoperative therapy were patient refusal ($n = 1$) and recurrent ovarian cancer ($n = 1$).

Table 1 Patient characteristics

Age, years, median [range]	64	[48, 82]
Sex, *n* (%)		
Male	6	(40)
Female	9	(60)
BMI, kg/m^2, median [range]	22	[18, 26]
ASA score, *n* (%)		
I	10	(67)
II	5	(33)
III	0	(0)
Diagnosis, *n* (%)		
Recurrent rectal cancer	11	(73)
Primary rectal cancer	3	(20)
Recurrent ovarian cancer	1	(7)
Perioperative therapy, *n* (%)		
Chemotherapy	9	(60)
CRT	4	(27)
None	2	(13)

Numerical data are indicated as medians. Values in parentheses are the percentages

BMI body mass index, *ASA* American Society of Anesthesiology, *CRT* chemoradiotherapy

Surgical outcomes

The type of surgery, level of disease involvement, and sacral transection level are shown in Table 2. In 14 of the 15 patients, the sacrum was transected at one vertebral body above the level of disease involvement. In 12 patients, the sacral transection level was set at S2 or S3 and transection was performed by osteotome with the patient in the prone position. In three patients, the sacral transection level was set at S4 or S5 and transection was performed using a Gigli wire saw with the patient in the Lloyd–Davies position.

To secure the lateral margin, the internal iliac vessels were dissected unilaterally in seven patients and bilaterally in six patients. On the other hand, the internal iliac vessels were preserved in two cases without invasion to the lateral side.

Five patients underwent a rectus abdominis myocutaneous flap procedure, including four patients who received total pelvic exenteration (TPE) with sacrectomy, and one patient with anal canal cancer who received 60 Gy CRT.

None of the patients required conversion to a laparotomy. The median operative time was 936 min (range 606–1319 min) and the median intraoperative blood loss was 235 ml (45–1320 ml).

Postoperative outcomes

The postoperative outcomes are summarized in Table 3. The CD classifications of the postoperative complications were as follows: grade 0–2, $n = 10$ (67%); 3a, $n = 6$ (40%); 3b, $n = 1$ (7%); and ≥ 4, $n = 0$ (0%), with some overlap. All six patients with CD3a received percutaneous drainage, and three were culture-positive, while three were culture-negative at the time of discharge. A patient with grade 3b bleeding had postoperative bleeding from the branch of the internal iliac vessels 15 days after surgery, and bleeding was successfully stopped by interventional radiography (IVR).

Pathological and oncological outcomes

The pathological outcomes are summarized in Table 4. Two patients (13%) were diagnosed with R1; therefore, the R0 rate was 87%. The R1 location was the sacral transection edge and the lateral side of the dissection margin.

During the median follow-up period of 27 months (5–46 months), local re-recurrence (re-LR) developed in two patients (13%) (intrapelvic dissemination, $n = 1$; skip metastasis between the coccygeus and gluteus maximus muscles in the right gluteal region, $n = 1$) for recurrent rectal cancer.

Table 2 Surgical outcomes

Type of surgery, *n* (%)		
APR with sacrectomy	6	(40)
TPE with sacrectomy	4	(27)
PPE with sacrectomy	3	(20)
Tumor resection with sacrectomy	2	(13)
Level of disease involvement/sacral transection level, *n* (%)		
S3/S2	3	(20)
S4/S3	8	(53)
S4/S4	1	(7)
S5/S4	2	(13)
Coccyx/S5	1	(7)
Sacral dissection approach, *n* (%)		
Osteotome at prone position	12	(80)
Gigli wire saw at Lloyd–Davies position	3	(20)
Dissection of internal obturator muscle※, *n* (%)	6	(40)
Dissection of superior gluteal vessels※※, *n* (%)	1	(7)
Dissection of internal iliac vessels, *n* (%)		
One side	7	(47)
Both side	6	(40)
None	2	(13)
Rectus muscle flap reconstruction, *n* (%)	5	(33)
Conversion to laparotomy, *n* (%)	0	(0)
Operative time (min), median [range]	936	[606, 1319]
Intraoperative blood loss (ml), median [range]	235	[45, 1320]
Intraoperative transfusion, *n* (%)	2	(13)

Numerical data are presented as medians. Values in parentheses are percentages and values in brackets are ranges

APR abdominoperineal resection, *TPE* total pelvic exenteration, *PPE* posterior pelvic exenteration

※Cases in which muscles on at least one side were dissected

※※Cases in which at least one artery or vein was dissected

Among the two patients with re-LR, the former died as a result of their current illness and the latter was treated for a re-LR lesion with focal carbon ion radiotherapy. Six patients (40%) developed distant metastases. The locations of distant metastasis were as follows: lung, $n = 2$ (13%); peritoneum, $n = 2$ (13%); inguinal lymph nodes, liver and inner side of gluteus maximus muscles, $n = 1$ (7%) (with some overlap). Fourteen patients remained alive at the end of the follow-up period.

Discussion

This study demonstrates the surgical technique and treatment results of tpMIS for sacrectomy, along with the outcomes of 15 patients who were successfully treated using this approach and who were followed for a median period of 27 months. CD ≥ 3b complications were observed in one patient (7%). No patients required reoperation, and no patients required conversion to laparotomy. The median blood loss was 235 ml, and the maximum blood loss was 1320 ml. The median operating time was 15.5 h, and the R0 rate was 87%. On the other hand, the largest single-center retrospective study of conventional sacrectomy was summarized by Milne et al. [13], which included 100 patients. The outcomes demonstrated that major complications requiring reintervention or causing long-term disability occurred in 43% of cases. Reoperation was performed in 23% of cases. The median blood loss was 4500 ml and the maximum blood loss was 14,500 ml. The median operating time was 12 h and the R0 rate was 72%. A direct comparison is not appropriate. However, these outcomes indicate that MIS with tpMIS for sacrectomy is associated with low blood loss, reduced complications, and an acceptable R0 rate. To the best of our knowledge, this is the first observational study to assess the feasibility of MIS combined with tpMIS for sacrectomy.

Sacrectomy for MIS with tpMIS is a highly difficult and complex surgical procedure. The key points of this surgical technique are as follows: (1) The rendezvous point between the transabdominal and perieanl approaches is set as the tendinous arch of the levator ani. This point is the lateral edge of the levator ani, which maintains the

Table 3 Postoperative outcomes

Postoperative complication, *n* (%)※		
CD0	0	(0)
CD1	0	(0)
CD2	10	(67)
Superficial and deep incisional SSI	3	
Organ/space SSI	3	
Urinary infection	2	
Ileus	2	
CD3a	6	(40)
Organ/space SSI	3	
Pelvic fluid collection	3	
CD3b	1	(7)
Postoperative bleeding → IVR	1	
CD4,5	0	(0)
CO_2 embolism, *n* (%)	0	(0)
Reoperation, *n* (%)	0	(0)
Mortality, *n* (%)	0	(0)
Postoperative hospital stays (days), median [range]	53	[29, 97]
Adjuvant chemotherapy, *n* (%)	5	(33)

Numerical data are presented as medians. Values in parentheses are percentages and values in brackets are ranges

CD Clavien−Dindo, *SSI* surgical site infection, *IVR* Interventional radiology, *CO_2* carbon dioxide

※Some are overlapping

Table 4 Pathological outcomes

Histology, *n* (%)		
tub	12	(80)
muc	2	(13)
adeno	1	(7)
Pathological N category, *n* (%)		
(y)pN0	11	(73)
(y)pN+	4	(27)
Radicality, *n* (%)		
R0	13	(87)
R1	2	(13)

Values in parentheses are percentages

tub tubular type, *muc* mucinous type, *adeno* adenocarcinoma

dissection margin. In addition, the levator ani becomes quite thin at this point and thus is easy to penetrate. (2) Maintaining the lateral margin is crucial in sacrectomy. The sacrospinous and sacrotuberous ligament are dissected at the attachment of the ischial spine and ischial tuberosity, which is the lateral edge of these ligaments. The transperineal approach can provide a good surgical view of these ligaments. (3) The internal pudendal vessels must be dissected to maintain the dissection margin. We have clarified the anatomical route of these vessels from the transperineal view [8]. This knowledge is important for reducing the risk of bleeding when tpMIS is performed for such extended pelvic surgery. (4) Transection of the sacrum is performed using a small incision. Thus, the length from the promontory to the posterior edge of the tumor on preoperative imaging is used as a guide for the dissection border at the posterior side, the sacral level is marked on the skin before surgery, and the sacral nerve at the sacral transection level is taped as a landmark.

Superficial and deep incisional SSIs are serious complications after sacrectomy. Imaizumi et al. demonstrated that a wide range of perineal incision is an independent risk factor for superficial and deep incisional SSIs after extended pelvic surgery [14]. In addition, many cases in which sacrectomy is planned involve patients with a history of pelvic CRT; thus, the perineal and gluteal side of the skin are damaged by radiation-induced skin reactions [15–17]. tpMIS for sacrectomy enables the perineal side of the skin incision to be minimized. This approach further enables separation between the lower back side of the clean skin incision near the sacral transection edge and perineal side of the contaminated skin incision near the anus. For this reason, tpMIS would reduce the risk of superficial and deep incisional SSI.

Additionally, major uncontrolled intraoperative bleeding is a feared complication when performing sacrectomy. The low amount of blood loss observed in our study can be attributed to both MIS and tpMIS. Regarding the transabdominal approach, we identified and dissected along the three pelvic sidewall fasciae (ureterohypogastric, umbilical prevesical, and parietal pelvic fascia), which are located in the non-vascular spaces in the pelvic sidewall [18–20]. For the transperineal approach, particularly useful points are located around the pudendal canal because this canal passes through the inferior pudendal vessels. The dissection of this point is demonstrated in a video which is provided as a supplemental file.

The present study was associated with some limitations. First, this was a retrospective study that analyzed a relatively small case series. Second, the follow-up period was insufficient, and oncological safety was not fully assessed. Third, the incidence of CD3a complications was relatively high (40%). This is because in surgery we only inserted one drainage tube at the pelvic floor, and CT was routinely performed every week after surgery. Percutaneous drainage was routinely performed when fluid collection was identified. Fourth, hospital stays are prolonged in Japan because of insufficient development of home medical care, resulting in patients being discharged only after they are able to manage their life alone. Finally, tpMIS for sacrectomy must be performed in centralized, high-volume centers with dedicated multidisciplinary teams and operators, because this approach is technically challenging.

Conclusion

Although the patient cohort in this study is heterogeneous, MIS with tpMIS was associated with a very small amount of blood loss, a low incidence of severe postoperative complications, and an acceptable R0 resection rate. Further studies are needed to clarify the long-term oncological feasibility.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10151-024-02954-y.

Author contributions All the authors contributed to the conception and design of the study. Material preparation, data collection, and analysis were performed by Ito, Otani, Imada, Matsubara, Song, and Kimura. The first draft of the manuscript was written by Naohito Beppu, and all the authors commented on the previous versions of the manuscript. All authors have read and approved the final manuscript.

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Availability of data and material The datasets during and/or analyzed during the current study available from the corresponding author on reasonable request.

Code availability None.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethics approval Ethical approval was waived by the local Ethics Committee of Hyogo Medical University (approval number 2798) in view of the retrospective nature of the study, and all the procedures performed were part of the routine care.

Informed consent Informed consent was obtained from all individual participants included in the study.

Consent to participate Consent to participate from each patient was obtained.

Consent for publication Consent for publication was obtained.

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