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ORIGINAL ARTICLE

The adipofasciocutaneous gluteal fold perforator flap a versatile alternative choice for covering perineal defects

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Abstract

Aim Perineal defects following the resection of anorectal malignancies are a reconstructive challenge. Flaps based on the rectus abdominis muscle have several drawbacks. Regional perforator flaps may be a suitable alternative. We present our experience of using the gluteal fold flap (GFF) for reconstructing perineal and pelvic defects.

Methods We used a retrospective chart review and follow-up examinations focusing on epidemiological, oncological (procedure and outcome), and therapy-related data. This included postoperative complications and their management, length of hospital stay, and time to heal.

Results Twenty-two GFFs (unilateral $n = 8$; bilateral $n = 7$) were performed in 15 patients (nine women and six men; anal squamous cell carcinoma $n = 8$; rectal adenocarcinoma $n = 7$; mean age 65.5 ± 8.2 years) with a mean follow-up time of 1 year. Of the cases, 73.3% were a recurrent disease. Microscopic tumor resection was achieved in all but one case (93.3%). Seven cases had no complications (46.7%). Surgical complications were classified according to the Clavien-Dindo system (grades I $n = 2$; II $n = 2$; IIIb $n = 4$). These were mainly wound healing disorders that did not affect mobilization or discharge. The time to discharge was 22 ± 9.9 days. The oncological outcomes were as follows: 53.3% of the patients had no evidence of disease, 20% had metastatic disease, 20% had local recurrent disease, and one patient (6.7%) died of other causes.

Conclusions The GFF is a robust, reliable flap suitable for perineal and pelvic reconstruction. It can be raised quickly and easily, has an acceptable complication rate and donor site morbidity, and does not affect the abdominal wall.

Keywords Gluteal fold flap · Perineal reconstruction · Pelvic reconstruction · Abdominoperineal rectum excision · Perforator flap

Introduction

Perineal defects following resection of anal or rectal malignancies present a significant reconstructive challenge. The most common oncosurgical procedures are the extralevator abdominoperineal excision of the rectum (ELAPE) and pelvic exenteration (PE) [1]. Especially in cases of tumor recurrence after initial conservative therapy, tumor excision mostly results in large perineal defects with deep dead space. Growing evidence shows that plastic surgical reconstruction of these defects is beneficial to primary wound healing and recovery [2–4].

Flap reconstruction appears to have several advantages [3, 5, 6]. It contributes healthy, well-vascularized tissue, and increased infection tolerance. It can avoid dead space, prevent fluid collection in dead space, and accelerate wound healing. Faster wound healing might also be accompanied by a decline in wound healing complications, such as the breakdown of enteric anastomoses and the formation of vascular or visceral fistulae.

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The ideal flap should provide enough volume to fill the complex three-dimensional dead space of the pelvis, be easy and fast to harvest, provide a reliable and constant vascular anatomy, and ensure low donor site morbidity [7, 8].

In the past, flaps used to reconstruct perineal defects were muscle or musculocutaneous flaps based mostly on the rectus abdominis, gluteus, or gracilis muscle [9–13]. Recent technical advancements in tumor resection using laparoscopic techniques have significantly reduced abdominal wall morbidity [14–16]. This, along with a number of mostly pre-existing artificial outlets in the abdominal wall have made the use of flaps based on the rectus abdominis muscle less acceptable [17, 18]. In addition, perforator-based regional flaps have been established [19]. The main objectives of these developments were to reduce donor site morbidity and individualize reconstruction. The perineal and gluteal region receives a rich blood supply and has several relevant perforator vessels [20]. This provides scope for a number of perforator-based flaps [7]. One of these is the adipofasciocutaneous gluteal fold flap (GFF), which is based on perforators of the internal pudendal artery [21, 22]. However, the usefulness of the GFF for perineal defect reconstruction after resection of anorectal malignancies is sparsely documented. This may be due to uncertainty about the reliability of the vascularity (especially after extralevator rectum extirpation), about whether the flap provides enough volume to obliterate the dead space, and about its ability to prevent infections [23, 24].

We present our experience of using the GFF for reconstructing perineal defects after resection of anorectal malignancies. We use a retrospective chart review and follow-up examinations focusing on epidemiological, oncological (procedure and outcome), and therapy-related data such as postoperative complications and their management, length of stay, and time to heal.

Patients and methods

Data collection

We conducted a retrospective analysis by reviewing the charts of all cases treated between January 2012 and June 2017. The study inclusion criteria were primary or recurrent malignant anorectal disease treated by either ELAPE or PE and concurrent or delayed reconstruction using a unilateral or bilateral GFF. Patients with vaginal infiltration and the need for partial vaginal wall reconstruction were excluded.

The data were categorized as either demographic, oncological, therapeutic, or outcome-related. Demographic data included age at diagnosis, gender, body mass index (BMI), and concomitant diseases. Oncological data consisted of tumor histology, stage of disease, presentation status (primary or recurrent disease), and, in cases with recurrent disease, the initial treatment (radiotherapy and chemotherapy) performed. Therapeutic data consisted of the oncosurgical resection procedure (ELAPE or PE), the achieved resection margins (R0, R1, R2), the reconstructive procedure (unilateral or bilateral GFF), the neoadjuvant/adjuvant therapy modality, if performed, and the complications and handling thereof. Complications were classified according to the Clavien-Dindo system [25]. Outcome data covered neoplastic events (local recurrent disease and distant metastasis), survival status (no evidence of disease, NED; death from other causes, DOC; died of disease, DOD; locally recurrent disease, LRD; metastatic disease, MD), and dates of death and last follow-up. The follow-up period ran until December 2017. Informed consent and approval for the publication of photographs were obtained from all patients. The Ethics Committee of the University of Freiburg, Germany, approved the study. The design and performance of the study are in accordance with the Declaration of Helsinki.

Statistics

We performed the statistical analysis using the software products R (R Core Team, 2015) and OpenOffice Calc 4.1.1 (Apache, Houston, Texas, USA). To analyze and compare the means of numeric data, we used the two-sided Welch two-sample *t* test. For the statistical analysis of the categorical data, we used either a chi-square test or Fisher's exact test, depending on the number of cases compared. The significance level was set at p value < 0.05. All groups and prognostic factors (gender, age, BMI, preoperative radiotherapy, preoperative chemotherapy, primary disease, recurrent disease, number of flaps, and complications) were analyzed by univariate analysis. A two-sided p value of < 0.05 was assumed as significant.

Reconstruction

Initial staging was performed in line with international guidelines. Tumor staging was performed according to the TNM staging systems of the American Joint Committee on Cancer (AJCC) [26, 27]. The diagnosis was established by biopsy. An interdisciplinary therapy plan was drafted after the case was presented at the interdisciplinary tumor board.

In all but four cases (cases 1–4), patients were referred to the plastic surgery department for a preoperative evaluation regarding flap reconstruction. Information requested from the surgical oncologist for flap-planning decisions included the extent of disease, the planned oncosurgical procedure, and the disease history. The disease history included previous operations prohibiting a GFF or radiotherapy, and relevant concomitant diseases.

The existence and location of relevant perforator vessels of the internal pudendal artery in the area between the ischial

tuberosity and the anus were assessed by hand-held Doppler examination on both sides and marked on the skin with the patient lying in a prone position. The inferior gluteal fold at both sides was marked when the patient was standing and represented the center of the flaps. The long axis of the flap can be extended safely to the greater trochanter of the femur. The flap width needed for the primary closure of the donor site was assessed by a pinch test and can generally be up to 8 cm (Fig. 1) a and b.

Patients were positioned in the Lloyd-Davies or jackknife position. The urinary bladder was catheterized and prophylactic IV antibiotics were administered preoperatively.

The resection was performed by the surgical oncology team. Primary subsequent reconstruction of the perineal defect was only performed if a complete tumor resection with acceptable resection margins (R0) could be assumed.

In cases of uncertainty regarding complete tumor resection, delayed reconstruction was performed. Pending clarification, a vacuum bandage was used as a wound dressing. In cases of reconstruction immediately following tumor excision, the preservation of the internal pudendal vessels was re-evaluated by an intraoperative hand-held Doppler examination. The size of the cutaneous defect and the volume of the three-dimensional pelvic dead space were also assessed. The

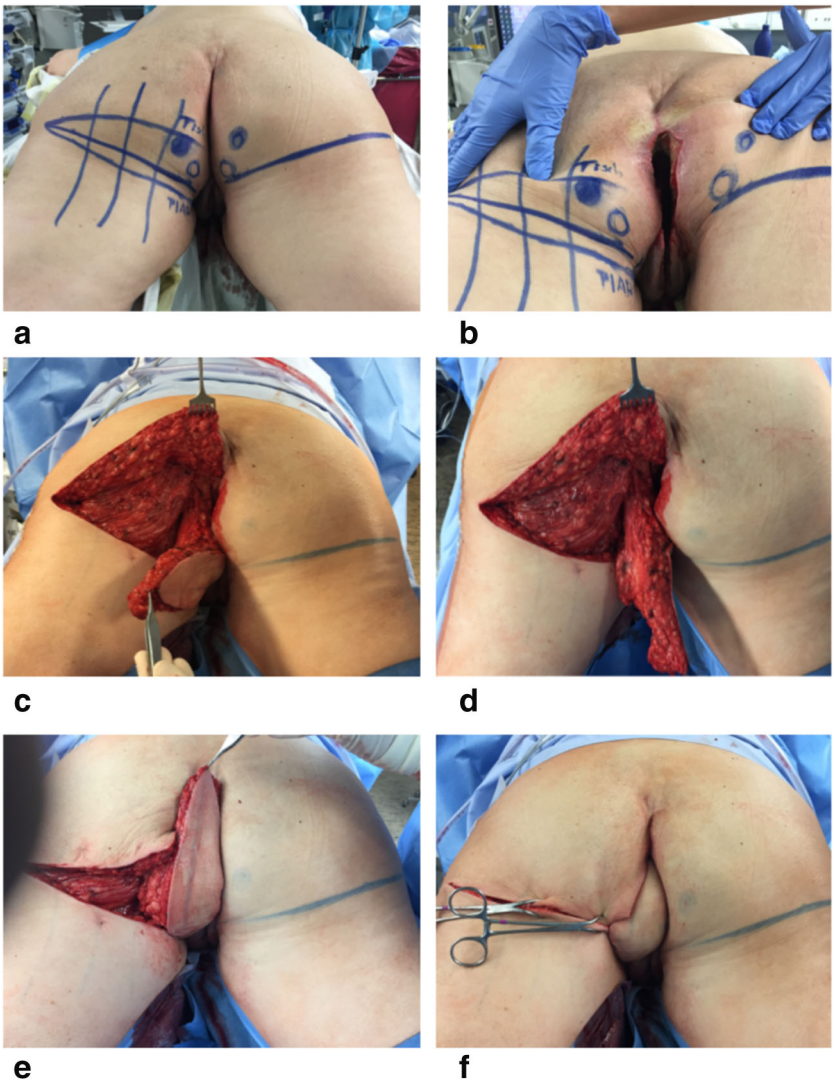

Fig. 1 Reconstruction of a perineal defect by unilateral GFF. Case 1: A 66-year-old patient with recurrent rectal adenocarcinoma after conservative treatment with radiation therapy and chemotherapy. **a** Patient positioned in jackknife position, with presentation after abdominoperineal excision of the rectum. Marked lines are shown in the gluteal fold. The full dot marks the ischial tuberosity. The empty circle marks the perforator artery after hand-held Doppler probe examination. The markings on the left side indicate the width of the flap, and the vertical lines are for orientation during primary wound closure. **b** Presentation of the perineal defect by spreading of the gluteal soft tissue. **c** Prepared GFF after lateral-to-medial harvesting in a subfascial plane. **d** Presentation of the flap volume: Although the patient had a BMI of 24 kg/m^2, a unilateral GFF provided enough volume to fill the pelvic defect. **e** Clockwise rotation of the flap into the defect. **f** Illustration of the donor site, which was suitable for primary closure, and the partly de-epithelialized and buried flap: The defect can be safely reconstructed without tension

formerly provided information about the flap width. The latter was relevant for deciding whether a bilateral flap would be needed to sufficiently fill the space. This decision also depended on the patient's individual build and the corresponding amount of subcutaneous fatty tissue in the flap. The flap harvest began laterally and was performed in a sub-fascial plane that included the remaining amount of the fibrofatty tissue of the ischiorectal fossa, which contains the rich network of perforators of the internal pudendal artery and the accompanying vein. The perforator-containing fibrofatty tissue of the ischiorectal fossa was carefully prepared using a regular intraoperative hand-held Doppler orientation to preserve the perforators of the flap pedicle. Skeletonization of the perforators was strictly avoided. Flap preparation was performed until the flap was mobile enough to be inserted into the defect (Fig. 1 c and d) . The flap was then transposed into the defect and inserted by multilayer interrupted sutures. The skin island of the flap was matched to the defect, so that reconstruction resulted in a tension-free insertion of the flap (Fig. 1e and f). In cases requiring a bilateral GFF, one of the flaps was completely de-epithelialized and buried into the dead space of the pelvic defect (Fig. 2 a–d). Before the flap transposition, suction drains were used at the donor and recipient site. The wound dressing was performed using Omnistrips (Paul Hartmann AG, Heidenheim, Germany).

Postoperative care

After surgery, patients were advised to avoid sitting for 2 weeks. Walking and resting were allowed. Sitting was gradually introduced after 2 weeks. The suction drains were sequentially removed, starting with those at the donor site. Suction drains at the recipient site were sequentially removed when collecting less than 30 ml of wound fluid per day for 2 days. This was to avoid fluid collection at the recipient site.

The urinary catheter was removed on the first postoperative day, and patients were encouraged to walk around. Wound dressings were changed at least twice a week and sutures were removed after 2 weeks. Analgesia was performed according to local protocols, and patients wore compression stockings and took low molecular weight heparin until they were sufficiently mobile.

Results

Over 5.5 years, 22 gluteal fold flaps (unilateral GFF $n = 8$; bilateral GFF $n = 7$) were performed for perineal defects following anorectal tumor excision in 15 patients. Nine out of 15 patients were female (60%). The mean age at the time of surgery was 65.5 years (± 8.2 years), with a range of 53 to 83 years. The mean body mass index (BMI) was 23.5 kg/m^2 (± 2.6 kg/m^2) with a range of 19 to 28 kg/m^2. A variety of comorbidities were identified in the cohort. While 26.7% ($n = 4$) of the patients had no comorbidities, 53.3% ($n = 11$) had more than one. Insulin-dependent diabetes mellitus and arterial hypertension were the most frequent. Tumor histology revealed an anal squamous cell carcinoma in eight patients ($n = 8$; 53.3%) and a rectal adenocarcinoma in seven ($n = 7$; 46.7%). Primary disease was diagnosed in just four cases ($n =$

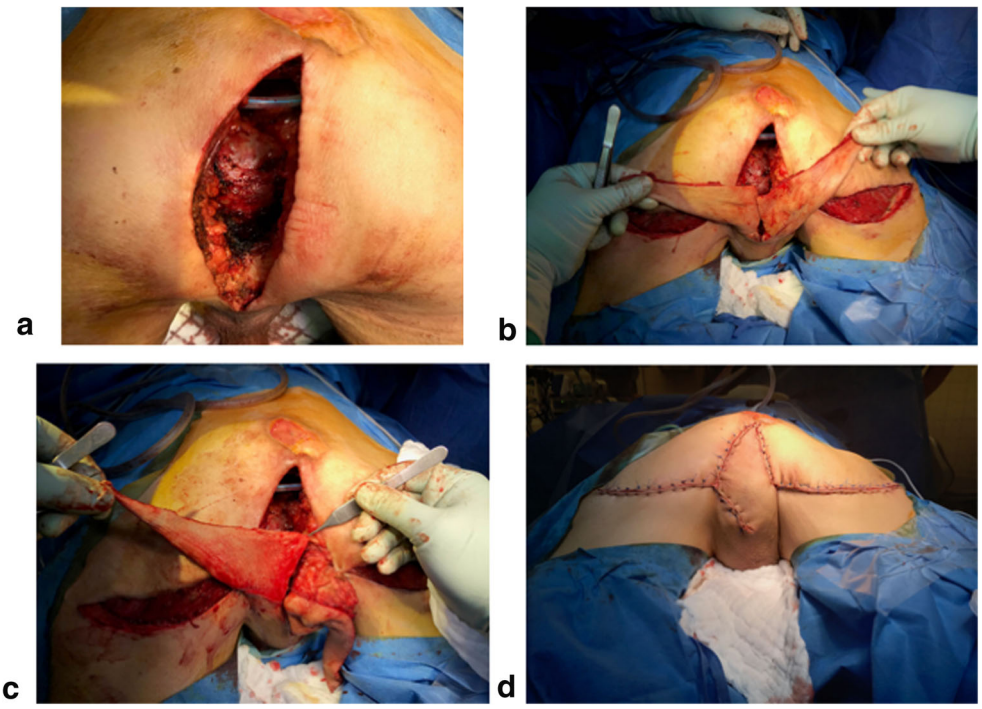

Fig. 2 Reconstruction of a perineal and pelvic defect by bilateral GFF. Case 2: A 67-year-old patient with recurrent rectal adenocarcinoma after conservative treatment with radiotherapy and chemotherapy. **a** Perineal and deep pelvic defect after abdominoperineal excision of the rectum. **b** Prepared bilateral GFF. **c** One flap is fully buried to fill the pelvic dead space after de-epithelialization. **d** Both donor sites are closed primarily without tension. The right flap is rotated into the defect anticlockwise to superficially reconstruct the perineal defect

4; 26.7%). Of those, half were additionally treated by radiotherapy and chemotherapy, while the others received chemotherapy only. The cases presenting with a recurrent tumor (n = 11; 73.3%) had all received radiotherapy, and ten out of 11 cases had also received chemotherapy before. In terms of oncosurgical procedure, we performed either ELAPE (n = 8; 53.3%) or PE (n = 7; 47.7%). We found that the choice of oncosurgical procedure led to no significant differences in the frequency of bilateral or unilateral GFFs for defect reconstruction (chi-square test; p value 0.595). In all but one case, we achieved a microscopic complete tumor resection (R0; n = 14; 93.3%).

The first choice for pelvic floor reconstruction is an omentoplasty, if feasible. As a second choice, we prefer to use vesicopexy or uteropexy to cover the entrance of the pelvis minor. However, in secondary cases with perineal herniation or if one of the abovementioned choices is not feasible, we use a mesh for reconstruction. In our study, omentoplasty was performed in nine cases, a vesicopexy in one case and a mesh in five cases.

A delayed perineal reconstruction was performed in four cases. For those patients, the mean delay to reconstruction was 36 days (± 52.1 days), the median delay was 12 days, and the range was 6 to 114 days. Delayed reconstruction was mostly performed due to uncertainties regarding complete resection after oncosurgical resection (three cases). In the case reconstructed 114 days after tumor excision, the perineal wound was initially closed directly. Following surgery, the patient developed wound healing disorders with local infection. This was treated by repeated debridement and vacuum dressing, and he was eventually presented for reconstruction.

In seven cases, we saw no complications (46.7%). According to the Clavien-Dindo classification for surgical complications, we had two grade I complications, two grade II, and four grade IIIb. All complications were wound healing disorders. We saw no breakdown of enteric anastomoses, no formation of vascular or visceral fistulae, and no instances of deep pelvic abscess formation. Minor complications (grade I and II) were treated successfully in all cases by conservative measures and by second-intention healing. All grade IIIb complications needed a delayed secondary wound closure after wound conditioning. The time from reconstruction to discharge was 22 days (± 9.9 days), with a range of 10 to 49 days. Ninety percent of the patients were discharged after 39 days. We found no significant differences regarding time to discharge between patients with complications of any grade (Student's t test; p value 0.9). The mean postoperative stay for patients without complications was 18.7 days (± 8.0 days), compared to 24.9 days (± 11 days) for those with complications. Although detailed comparisons of the postoperative stay for patients without complications and for patients with minor and major complications revealed a tendency for those with major complications to be hospitalized for longer, they showed no significant differences (one-sided ANOVA test; p value 0.4). As mentioned above, the mean postoperative stay for patients without complications was 18.7 days (± 8.0 days). For those with minor complications it was 22.3 days (+- 3.9 days) and for those with major complications, it was 27.5 days (± 15.8 days). After analyzing the relevant risk factors (gender, age, BMI, preoperative radiotherapy, preoperative chemotherapy, primary disease, recurrent disease, and a number of flaps) for complications or delayed discharge by univariate analysis, we could not find any single significant factor. After a mean follow-up time of 362.2 days (+- 329.9 days) with a range of 38 to 1180 days, the oncological outcomes were that 53.3% of the patients had no evidence of disease (n = 8), 20% had metastatic disease (n = 3), 30% had local recurrent disease (n = 3), and one patient (6.7%) had died of other causes (Table 1).

Discussion

Abdominoperineal excision of the rectum (APER) is the gold standard of treatment for low rectal malignancies and locally advanced primary anal canal tumors [28], and for salvage procedures for anal cancer after conservative treatments have failed [29]. Recently, surgeons have begun performing ELAPE or abdominosacral amputations of the rectum (ASAR) more frequently. In cases of recurrent malignant disease, PE may be indicated. However, these radical approaches result in large and complex perineal and pelvic defects which are a reconstructive challenge [4, 7, 8].

The pelvis is a unique anatomical site. Its cavities are bounded by a bone, and since defects cannot be reconstructed by collapsing soft tissue, primary closure is restricted. Moreover, pelvic cavities are located extraperitoneally, which means the absorptive capacities of the peritoneum will not help in cases of fluid collection in the remaining dead space. Fluid collection carries a high risk of complications such as postoperative wound infections, formation of fistulae, and breakdown of enteric anastomoses. The proximity of the perineal skin to orifices means that it has a high colony count of pathogenic bacteria, which contributes to the high risk of complications [30–32]. The perineal area is also exposed to pressure and friction when a person is lying down, seated, or walking. As a result, complication rates in primary wound closure of perineal defects are reported to be as high as 66% [33]. Moreover, primary closure is significantly associated with the development of a non-healing, chronically draining perineal wound and can delay or restrict adjuvant oncological therapies [18, 33–35].

Wound healing disorders after APER prolong healing, with the median duration being 278 days (range 126–427) [36]. Data on the benefits of a flap-based perineal reconstruction over primary wound closure are still conflicting. Flap-based

Table 1 Demographic, surgical, and oncological data

ID	Age	Sex	BMI	Concomitant diseases	Indication	Recurrent disease	Stage	Preoperative		Oncol. procedure - Pelvic floor recon.	Recon. procedure	Time to reconstr. Procedure	Complications			Postop. stay	Oncol. outcome	Follow-up
								RT	CT		GFF		CD-class.	Type	Management	days		days
1	66	M	24	–	Rectal AC	+	ypT3,pN1b.L0.V0. Pn0.R0	+	+	ELAPE - OP	Unilateral	114	–	–	–	10	LRD	381
2	67	F	27	HepB, liver cir., COPD, artH, IDDM,	Rectal AC	+	ypT3,pN0.L0.V0. pN0.R0	+	+	PE – VP	Bilateral	6	I	WHD	SH	21	NED	68
3	62	F	24	RF, anemia	Anal SCC	+	rpT2,rpN0.L0.V1. pN0.R0	+	+	PE – OP	Bilateral	15	–	–	–	14	MD	370
4	72	F	28	IDDM, artH, TAA, cervical ca., vaginal ca.	Rectal AC	+	pT3,pN0.L0.V0. pN0.R0	+	+	PE - M	Unilateral	9	II	WHD	SH	21	NED	38
5	64	F	24	Liver cir., systLE	Anal SCC	+	yrpT1, pN0. L0. V0. Pn0.R0	+	+	ELAPE – OP	Unilateral	0	IIIb	WHD	DSS	49	DOC	147
6	76	M	21	CHD	Rectal AC	+	rpT3, pN0. L0. V0. Pn0.R0	+	–	ELAPE – OP	Unilateral	0	IIIb	WHD	DSS	11	NED	1180
7	62	F	24	RF, IDDM	Anal SCC	–	ypT0, ypN0, L0. V0. Pn0.R0	+	+	ELAPE – M	Unilateral	0	–	–	–	15	NED	566
8	66	F	24	Splenectomy, ITP, CD	Rectal AC	–	pT3, pN0, L1. V0. Pn1.R0	–	+	PE – OP	Unilateral	0	–	–	–	33	NED	52
9	83	M	22	IDDM, CAR	Anal SCC	+	ypT3, ypN0, L0. V0. Pn0.R0	+	+	ELAPE – OP	Bilateral	0	IIIb	WHD	DSS	25	MD	340
10	60	M	19	HL, HIV, IDDM, NA	Anal SCC	+	ypT3, ypN0, L0. V0. Pn1.R0	+	+	ELAPE – OP	Bilateral	0	II	WHD	SH	19	NED	180
11	53	F	19	–	Anal SCC	+	rpT2, rpN0, L0. V0. Pn1. R0	+	+	ELAPE – M	Bilateral	0	–	–	–	24	NED	798
12	58	M	25	–	Rectal AC	–	ypT1, ypN0. L0. V0. Pn0.R0	+	+	ELAPE – M	Bilateral	0	–	–	–	22	MD	740
13	69	F	25	DVT	Anal SCC	+	pT4, pN0. L1. V1. Pn1.R1	+	+	PE – OP	Unilateral	0	I	WHD	SH	28	LRD	139
14	71	M	22	PC	Rectal AC	–	pT4b, pN0, pM1a. L1. V0. Pn1.R0	–	+	PE – M	Bilateral	0	IIIb	WHD	DSS	25	LRD	317
15	53	F	25	–	Anal SCC	+	ypT2, pN0 (0/25), L0. V0. Pn0.R0	+	+	PE – OP	Unilateral	0	–	–	–	13	NED	117

m male; *f* female; *BMI* body mass index in kg/m^2; *hepB* chronic hepatitis B; *liver cir.* liver cirrhosis; *artH.* arterial hypertension; *IDDM* insulin-dependent diabetes mellitus; *RF* renal failure; *TAA* tachyarrhythmia absoluta; *systLE* systemic lupus erythematosus; *ca.* carcinoma; *CHD* coronary heart disease; *ITP* idiopathic thrombocytopenia; *CD* Crohn's disease; *HL* Hodgkin lymphoma; *CAR* cardiac arrhythmia; *HIV* human immunodeficiency virus; *NA* nicotine abuse; *DVT* deep vein thrombosis; *PC* prostate cancer; *RT* radiotherapy; *CT* chemotherapy; *rectal AC* rectal adenocarcinoma; *anal SCC* anal squamous cell carcinoma; *ELAPE* extralevator abdominoperineal excision of the rectum; *PE* pelvic exenteration; *oncol. procedure* oncological procedure; *pelvic floor recon.* pelvic floor reconstruction; *OP* omentoplasty; *VP* vesicopexy; *M* mesh;

recon. procedure reconstructive procedure; *GFF* gluteal fold flap; *CD class.* Clavien-Dindo classification; *WHD* wound healing disorder; *SH* secondary healing; *DSS* debridement and secondary suture; *time to reconstructive procedure* time between oncological resection and reconstruction in days; *postoperative stay* time from reconstruction to discharge in days; *LRD* local recurrent disease; *DOC* death from other causes; *MD* metastatic disease; *NED* no evidence of disease

reconstruction reduces patient morbidity when compared to primary closure in terms of infective complications, anastomosis breakdown, and fistula formation. This shortens therapy duration and hospital stays and reduces therapy costs [31, 37–41] .

Myocutaneous flaps based on the rectus abdominis muscle (vertical rectus abdominis muscle flap, VRAM) used to be the first choice for pelvic and perineal reconstruction following APER or PE [13, 18, 31, 37, 42]. Although the rectus abdominis–based flaps are a safe and robust reconstructive option, the major disadvantage is donor site morbidity [34]. Furthermore, recent technical advances in tumor resection, such as laparoscopic APER, ELAPE, and PE, have significantly reduced abdominal wall morbidity [14–16]. Although attempts have been made to reduce donor site morbidity by laparoscopically harvesting a pedicled rectus abdominis muscle flap as bulk for the perineal defect in combination with a regional fasciocutaneous flap, the drawbacks for the abdominal wall remain and are supplemented by the donor site morbidity of the regional perineal reconstructive part [43]. However, this approach might be an option in selected cases with no relevant perineal cutaneous defect, no prior radiation therapy, and scope for tensionless primary soft tissue wound closure. The donor site morbidity of the abdominal wall, along with the mostly pre-existing artificial outlets in the abdominal wall, have made it less acceptable to use flaps based on the abdominal wall [17, 18]. However, other regional myocutaneous flaps have been used. Myocutaneous flaps based on the gluteal muscle, mostly in the form of a VY-advancement flap, are robust and have a significant volume but seldom provide enough bulk to fill the deep pelvic dead space [11, 32, 44]. Myocutaneous gracilis muscle flaps are less safe solutions [9, 33]. According to the classification of the muscle and musculocutaneous flaps, the gracilis muscle has a type II vascular anatomy pattern [45]. Only the distalmost part of these flaps reaches the perineal and pelvic defect [46]. This is the least reliable part of the flap in terms of perfusion, and it has a limited amount of soft tissue. An isolated gracilis muscle flap avoids the restrictions of the myocutaneous gracilis flap skin island but has significantly less volume. To provide enough bulk, this flap generally has to be applied bilaterally and combined with regional fasciocutaneous flaps. Therefore, this flap appears to be a suboptimal choice for deep pelvic reconstruction [47].

In recent decades, perforator-based flaps have been shown to offer an alternative [19]. The internal pudendal artery (terminal branch of the internal iliac artery) provides a rich network of perforator arteries that allow surgeons to use different flap designs to overcome local reconstructive challenges [20, 22, 48]. The adipofasciocutaneous GFF is one such flap [21, 23, 24]. The relevant perforators are located in a 6-cm area between the medial border of the gluteus maximus muscle, the vulva, the ischial tuberosity, and the anus. The flap is a type A flap according to the classification of fasciocutaneous flaps [49]. As our study shows, the flap is a robust and reliable flap with several advantages. It does not compromise the abdominal wall, which reduces or avoids accompanying morbidity. It also originates completely outside the usual field of radiotherapy for anorectal malignancies. The last step of oncosurgical resection is usually performed in the jackknife, lithotomy, or Lloyd-Davies position. The GFF can be safely raised in any of these positions, which saves surgery time. However, the Lloyd-Davies position involves less hip and knee flexion than the lithotomy position, which makes flap preparation more challenging. In our cases, we saw no complete or partial flap loss, although 53% of the oncosurgical tumor excisions were ELAPE [23, 24]. The previously described increased risk of venous congestion with these flaps can be attributed to an overzealous skeletonizing of the pedicle in early series, which we strictly avoided [21]. We reconstructed all defects successfully, regardless of the defect size. In seven cases with deep and large defects, we used bilateral GFFs. In all of these, we were able to raise both flaps simultaneously and thus minimize surgery time. We had no indications that the buried flap had failed in any of our cases. However, although others recognize the usefulness of the flap—even for large defects—they still recommend the VRAM flap for the largest defects [24]. The dermis of the buried, de-epithelialized flap may also contribute to pelvic floor reconstruction. Although our study excluded patients with vaginal infiltration, it is worth noting that the GFF can be an elegant reconstructive option for large and deep perineal defects caused by resection of the anal or rectal malignancies and accompanied by a posterior vaginal wall defect. When used bilaterally, the buried GFF can serve as a fasciocutaneous flap for vaginal reconstruction [50]. Others have used the GFF in different, modified ways for vulvar or vaginal reconstruction [51]. However, since very little rectovaginal space remains after rectum-saving oncological procedures, we prefer to use unilateral or bilateral Singapore flaps based on the superficial pudendal artery for posterior vaginal wall reconstruction [52, 53]. These flaps are very thin and can have long dimensions if harvested up to the inguinal region.

In 76.4% of the cases, we had no complications or only minor complications (grades I or II in the Clavien-Dindo system) that did not affect the patient's mobilization or time to discharge. The minor complications were all small wound healing disorders. Four cases had grade IIIb complications, which were mainly large or deep wound healing disorders that

could be managed by debridement and secondary wound suture. These experiences are similar to others [21, 23, 24, 50, 54]. However, although we could see a tendency for delayed discharge in cases of major complications, we could not find a statistically significant difference. We found no independent risk factors for complications or time to discharge, although this may be due to the small number of cases in our series.

As the flap and its pedicle usually lie outside the field of pelvic or perineal radiotherapy, it provides even irradiated cases with healthy, well-vascularized tissue and all the associated benefits.

Inferior gluteal artery perforators (IGAP) are the basis for several alternative flaps for perineal reconstruction [55, 56]. The IGAP flap is comparable to the GFF in terms of flap volume. The main drawback is an extended transmuscular or intermuscular preparation of the nourishing vessels with exposition of the sciatic nerve. Preparation is, therefore, less straightforward, and donor site morbidity might be increased compared to the GFF. Using the IGAP flap as a myocutaneous flap for increased flap volume significantly increases donor site morbidity [57, 58]. However, temporary dysesthesia and hypoesthesia in the buttock and posterior thigh areas is an issue for most flaps in this region, including the GFF [57, 58]. Persistent chronic regional pain especially in the sitting position, as described in isolated cases after IGAP flap harvest, might be attributed to extended sciatic nerve irritation and were not an issue in our study population [58]. Jukubietz RG et al. described an interesting concept for augmenting the flap volume of fasciocutaneous flaps. In three cases of ischial pressure sore, they used a 180° propeller flap based on perforators from the gluteal artery as a reverse flow musculocutaneous flap including a muscle plug to reconstruct deep cavities [59]. This concept could also be used to augment GFF volume in the cases of uncertainty and might prevent a bilateral reconstructive approach in some cases. In cases where a GFF for perineal reconstruction is contraindicated, we prefer the pedicled myocutaneous anterolateral thigh flap [60].

The optimal time for reconstruction is debatable. On the one hand, delayed reconstruction seems oncologically more reliable. However, a deep, open wound might be a risk factor for significant complications. In our study, four patients had delayed reconstruction, mostly due to uncertainties regarding complete tumor resection. We found no significant statistical difference regarding the risk of postoperative complications or in oncological outcomes when comparing the group that underwent delayed reconstruction and the group that did not. However, we do not know how many cases of oncosurgical resection of anorectal malignancies without simultaneous reconstruction were not presented postoperatively because of relevant complications. This is a drawback of our study. In both groups, we found one case of local recurrent disease. Only one case of simultaneous reconstruction presented a microscopic incomplete resection. These results are comparable to others [21, 23, 24].

The morbidity of the donor site is low**.** Primary wound closure can usually be performed, as was the case in all of our patients. The scar is ideally positioned in the gluteal fold, with a good cosmetic result and low impact on body image (Fig. 3a–b). In most cases, the scar can easily be covered by normal underwear. With one-sided flaps, asymmetry with the contralateral side is an issue. Most of our patients complained about a palm-sized area of numbness distal to the donor site scar. This might be because the inferior cluneal and posterior femoral cutaneous nerves are affected during the subfascial flap preparation. Although all patients suffered from some discomfort at the donor site during mobilization, and more discomfort during the early stages of sitting, they all eventually regained full mobility without discomfort in any position. Persistent dysesthesia, chronic pain syndromes, or discomfort when sitting, as sporadically described in connection with the IGAP flap, were not seen. This might be partly due to the differences between IGAP and GFF patients since the two groups vary in terms of local pretreatment and their expectations. The esthetic result in the perineal

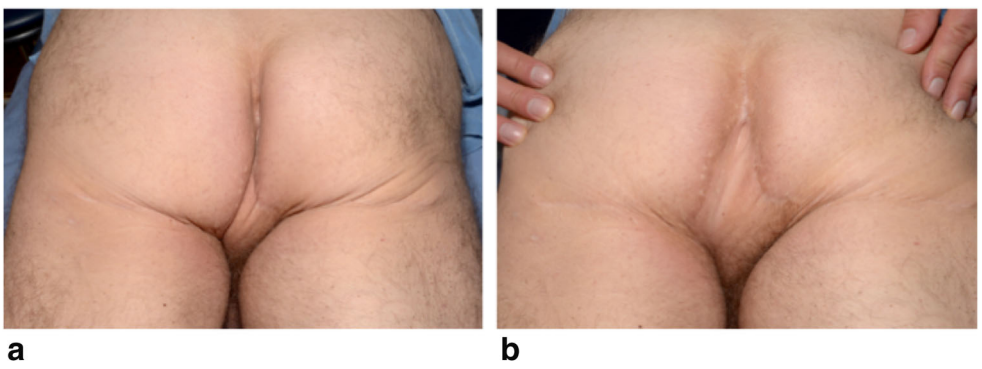

Fig. 3 Postoperative esthetic result after bilateral gluteal fold flap. **a** View of the buttocks in a resting position. **b** View of the buttocks held apart

reconstructed area is acceptable. As the flap is a regional flap, the skin characteristics match the original skin.

Conclusion

Flap reconstruction for complex perineal and pelvic defects after oncosurgical excision of anorectal primary or recurrent tumors is challenging. However, it has definite advantages in terms of accelerated wound healing and lowers morbidity. An interdisciplinary approach to planning is essential for success. The GFF is a robust and reliable adipofasciocutaneous flap. When used bilaterally, it can reconstruct even large and complex defects. It can be easily and quickly raised, offers acceptable donor site morbidity, and does not affect the abdominal wall.

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References

1. West NP, Finan PJ, Anderin C, Lindholm J, Holm T, Quirke P (2008) Evidence of the oncologic superiority of cylindrical abdominoperineal excision for low rectal cancer. J Clin Oncol 26(21):3517–3522. https://doi.org/10.1200/JCO.2007.14.5961
2. Beier JP, Croner RS, Lang W, Arkudas A, Schmitz M, Gohl J, Hohenberger W, Horch RE (2015) Avoidance of complications in oncological surgery of the pelvic region : combined oncosurgical and plastic reconstruction measures. Chirurg 86(3):242–250. https://doi.org/10.1007/s00104-014-2835-6
3. Davidge KM, Raghuram K, Hofer SO, Ferguson PC, Wunder JS, Swallow CJ, Zhong T (2014) Impact of flap reconstruction on perineal wound complications following ablative surgery for advanced and recurrent rectal cancers. Ann Surg Oncol 21(6):2068–2073. https://doi.org/10.1245/s10434-014-3529-5
4. Sinna R, Alharbi M, Assaf N, Perignon D, Qassemyar Q, Gianfermi M, Deguines JB, Regimbeau JM, Mauvais F (2013) Management of the perineal wound after abdominoperineal resection. J Visc Surg 150(1):9–18. https://doi.org/10.1016/j.jviscsurg.2013.02.001
5. Brodbeck R, Horch RE, Arkudas A, Beier JP (2015) Plastic and reconstructive surgery in the treatment of oncological perineal and genital defects. Front Oncol 5:212. https://doi.org/10.3389/fonc.2015.00212
6. Choudry U, Harris D (2013) Perineal wound complications, risk factors, and outcome after abdominoperineal resections. Ann Plast Surg 71(2):209–213. https://doi.org/10.1097/SAP.0b013e31823fac2b
7. Kim JT, Ho SY, Hwang JH, Lee JH (2014) Perineal perforator-based island flaps: the next frontier in perineal reconstruction. Plast Reconstr Surg 133(5):683e–687e. https://doi.org/10.1097/prs.0000000000000146
8. Mughal M, Baker RJ, Muneer A, Mosahebi A (2013) Reconstruction of perineal defects. Ann R Coll Surg Engl 95(8):539–544. https://doi.org/10.1308/003588413x13629960047155,10.1308/rcsann.2013.95.8.539
9. Singh M, Kinsley S, Huang A, Ricci JA, Clancy TE, Irani J, Goldberg J, Breen E, Bleday R, Talbot SG (2016) Gracilis flap reconstruction of the perineum: an outcomes analysis. J Am Coll Surg 223(4):602–610. https://doi.org/10.1016/j.jamcollsurg.2016.06.383
10. Vyas RM, Pomahac B (2010) Use of a bilobed gracilis myocutaneous flap in perineal and genital reconstruction. Ann Plast Surg 65(2):225–227. https://doi.org/10.1097/SAP.0b013e3181c9c434
11. Goi T, Koneri K, Katayama K, Hirose K, Takashima O, Mizutani Y, Baba H, Yamaguchi A (2003) Modified gluteus maximus V-Y advancement flap for reconstruction of perineal defects after resection of intrapelvic recurrent rectal cancer: report of a case. Surg Today 33(8):626–629. https://doi.org/10.1007/s00595-003-2531-5
12. Tan BK, Terence G, Wong CH, Sim R (2012) Lower gluteal muscle flap and buttock fascio-cutaneous rotation flap for reconstruction of perineal defects after abdomino-perineal resections. J Plast Reconstr Aesthet Surg 65(12):1678–1683. https://doi.org/10.1016/j.bjps.2012.07.013
13. Takano S, Newman M, Gill K, Wexner SD (2015) Vertical rectus muscle flap repair for perineal defect: abdominoperineal resection and perineal hernia. J Am Coll Surg 220(6):e89. https://doi.org/10.1016/j.jamcollsurg.2015.02.034
14. Inada R, Yamamoto S, Oshiro T, Takawa M, Fujita S, Akasu T (2014) Case-matched comparison of the short-term outcomes between laparoscopic and open abdominoperineal resection for rectal cancer. Surg Today 44(4):640–645. https://doi.org/10.1007/s00595-013-0611-8
15. Moghadamyeghaneh Z, Phelan M, Smith BR, Stamos MJ (2015) Outcomes of open, laparoscopic, and robotic abdominoperineal resections in patients with rectal cancer. Dis Colon Rectum 58(12):1123–1129. https://doi.org/10.1097/dcr.0000000000000475
16. Vaughan-Shaw PG, Cheung T, Knight JS, Nichols PH, Pilkington SA, Mirnezami AH (2012) A prospective case-control study of extralevator abdominoperineal excision (ELAPE) of the rectum versus conventional laparoscopic and open abdominoperineal excision: comparative analysis of short-term outcomes and quality of life. Tech Coloproctol 16(5):355–362. https://doi.org/10.1007/s10151-012-0851-4
17. Lefevre JH, Parc Y, Kerneis S, Shields C, Touboul E, Chaouat M, Tiret E (2009) Abdomino-perineal resection for anal cancer: impact of a vertical rectus abdominis myocutaneus flap on survival, recurrence, morbidity, and wound healing. Ann Surg 250(5):707–711. https://doi.org/10.1097/SLA.0b013e3181bce334
18. Nelson RA, Butler CE (2009) Surgical outcomes of VRAM versus thigh flaps for immediate reconstruction of pelvic and perineal cancer resection defects. Plast Reconstr Surg 123(1):175–183. https://doi.org/10.1097/PRS.0b013e3181904df7
19. Sinna R, Qassemyar Q, Benhaim T, Lauzanne P, Sabbagh C, Regimbeau JM, Mauvais F (2010) Perforator flaps: a new option in perineal reconstruction. J Plast Reconstr Aesthet Surg 63(11):e766–e774. https://doi.org/10.1016/j.bjps.2010.07.012
20. Hashimoto I, Abe Y, Nakanishi H (2014) The internal pudendal artery perforator flap: free-style pedicle perforator flaps for vulva, vagina, and buttock reconstruction. Plast Reconstr Surg 133(4):924–933. https://doi.org/10.1097/prs.0000000000000008
21. Ragoowansi R, Yii N, Niranjan N (2004) Immediate vulvar and vaginal reconstruction using the gluteal-fold flap: long-term results. Br J Plast Surg 57(5):406–410. https://doi.org/10.1016/j.bjps.2004.02.022

22. Yii NW, Niranjan NS (1996) Lotus petal flaps in vulvo-vaginal reconstruction. Br J Plast Surg 49(8):547–554. https://doi.org/10.1016/S0007-1226(96)90132-0
23. Pantelides NM, Davies RJ, Fearnhead NS, Malata CM (2013) The gluteal fold flap: a versatile option for perineal reconstruction following anorectal cancer resection. J Plast Reconstr Aesthet Surg 66(6):812–820. https://doi.org/10.1016/j.bjps.2013.02.010
24. Winterton RI, Lambe GF, Ekwobi C, Oudit D, Mowatt D, Murphy JV, Ross GL (2013) Gluteal fold flaps for perineal reconstruction. J Plast Reconstr Aesthet Surg 66(3):397–405. https://doi.org/10.1016/j.bjps.2012.09.026
25. Clavien PA, Barkun J, de Oliveira ML, Vauthey JN, Dindo D, Schulick RD, de Santibanes E, Pekolj J, Slankamenac K, Bassi C, Graf R, Vonlanthen R, Padbury R, Cameron JL, Makuuchi M (2009) The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg 250(2):187–196. https://doi.org/10.1097/SLA.0b013e3181b13ca2
26. Nielsen LB, Wille-Jorgensen P (2014) National and international guidelines for rectal cancer. Colorectal Dis 16(11):854–865. https://doi.org/10.1111/codi.12678
27. Scott-Conner CE, Christie DW (1995) Cancer staging using the American Joint Committee on Cancer TNM system. J Am Coll Surg 181(2):182–188
28. Okaro AC, Worthington T, Stebbing JF, Broughton M, Caffarey S, Marks CG (2006) Curative resection for low rectal adenocarcinoma: abdomino-perineal vs anterior resection. Colorectal Dis 8(8):645–649. https://doi.org/10.1111/j.1463-1318.2006.01045.x
29. Habr-Gama A (2006) Salvage abdominoperineal resection and perineal wound healing in local recurrent or persistent anal cancer. Tech Coloproctol 10(4):382; discussion 382. https://doi.org/10.1007/s10151-006-0314-x
30. Nisar PJ, Scott HJ (2009) Myocutaneous flap reconstruction of the pelvis after abdominoperineal excision. Colorectal Dis 11(8):806–816. https://doi.org/10.1111/j.1463-1318.2008.01743.x
31. Butler CE, Gundeslioglu AO, Rodriguez-Bigas MA (2008) Outcomes of immediate vertical rectus abdominis myocutaneous flap reconstruction for irradiated abdominoperineal resection defects. J Am Coll Surg 206(4):694–703. https://doi.org/10.1016/j.jamcollsurg.2007.12.007
32. Holm T, Ljung A, Haggmark T, Jurell G, Lagergren J (2007) Extended abdominoperineal resection with gluteus maximus flap reconstruction of the pelvic floor for rectal cancer. Br J Surg 94(2):232–238. https://doi.org/10.1002/bjs.5489
33. Wang ED, Conkling N, Xu X, Chern H, Finlayson E, Varma MG, Hansen SL, Foster RD, Hoffman WY, Sbitany H (2015) Perineal flap reconstruction following oncologic anorectal extirpation: an outcomes assessment. Plast Reconstr Surg 135(1):176e–184e. https://doi.org/10.1097/prs.0000000000000837
34. Sunesen KG, Buntzen S, Tei T, Lindegaard JC, Norgaard M, Laurberg S (2009) Perineal healing and survival after anal cancer salvage surgery: 10-year experience with primary perineal reconstruction using the vertical rectus abdominis myocutaneous (VRAM) flap. Ann Surg Oncol 16(1):68–77. https://doi.org/10.1245/s10434-008-0208-4
35. Devulapalli C, Jia Wei AT, DiBiagio JR, Baez ML, Baltodano PA, Seal SM, Sacks JM, Cooney CM, Rosson GD (2016) Primary versus flap closure of perineal defects following oncologic resection: a systematic review and meta-analysis. Plast Reconstr Surg 137(5):1602–1613. https://doi.org/10.1097/prs.0000000000002107
36. Ferenschild FT, Vermaas M, Hofer SO, Verhoef C, Eggermont AM, de Wilt JH (2005) Salvage abdominoperineal resection and perineal wound healing in local recurrent or persistent anal cancer. World J Surg 29(11):1452–1457. https://doi.org/10.1007/s00268-005-7957-z
37. Chessin DB, Hartley J, Cohen AM, Mazumdar M, Cordeiro P, Disa J, Mehrara B, Minsky BD, Paty P, Weiser M, Wong WD, Guillem JG (2005) Rectus flap reconstruction decreases perineal wound complications after pelvic chemoradiation and surgery: a cohort study. Ann Surg Oncol 12(2):104–110. https://doi.org/10.1245/ASO.2005.03.100
38. Tei TM, Stolzenburg T, Buntzen S, Laurberg S, Kjeldsen H (2003) Use of transpelvic rectus abdominis musculocutaneous flap for anal cancer salvage surgery. Br J Surg 90(5):575–580. https://doi.org/10.1002/bjs.4073
39. Petrie N, Branagan G, McGuiness C, McGee S, Fuller C, Chave H (2009) Reconstruction of the perineum following anorectal cancer excision. Int J Color Dis 24(1):97–104. https://doi.org/10.1007/s00384-008-0557-2
40. Althumairi AA, Canner JK, Gearhart SL, Safar B, Fang SH, Wick EC, Efron JE (2016) Risk factors for wound complications after abdominoperineal excision: analysis of the ACS NSQIP database. Colorectal Dis 18(7):O260–O266. https://doi.org/10.1111/codi.13384
41. Althumairi AA, Canner JK, Gearhart SL, Safar B, Sacks J, Efron JE (2016) Predictors of perineal wound complications and prolonged time to perineal wound healing after abdominoperineal resection. World J Surg 40(7):1755–1762. https://doi.org/10.1007/s00268-016-3450-0
42. Pang J, Broyles JM, Berli J, Buretta K, Shridharani SM, Rochlin DH, Efron JE, Sacks JM (2014) Abdominal- versus thigh-based reconstruction of perineal defects in patients with cancer. Dis Colon Rectum 57(6):725–732. https://doi.org/10.1097/dcr.0000000000000103
43. Agochukwu N, Bonaroti A, Beck S, Liau J (2017) Laparoscopic harvest of the rectus abdominis for perineal reconstruction. Plastic Reconstr Surg Glob Open 5(11):e1581. https://doi.org/10.1097/gox.0000000000001581
44. Benito P, De Juan A, Cano M, Elena E (2008) Reconstruction of an extensive perineal defect using two modified V-Y flaps based on perforators from the gluteus maximus muscle. J Plast Reconstr Aesthet Surg 61(9):e1–e4. https://doi.org/10.1016/j.bjps.2007.06.012
45. Mathes SJ, Nahai F (1981) Classification of the vascular anatomy of muscles: experimental and clinical correlation. Plast Reconstr Surg 67(2):177–187. https://doi.org/10.1097/00006534-198167020-00007
46. Chong TW, Balch GC, Kehoe SM, Margulis V, Saint-Cyr M (2015) Reconstruction of large perineal and pelvic wounds using gracilis muscle flaps. Ann Surg Oncol 22(11):3738–3744. https://doi.org/10.1245/s10434-015-4435-1
47. Persichetti P, Cogliandro A, Marangi GF, Simone P, Ripetti V, Vitelli CE, Coppola R (2007) Pelvic and perineal reconstruction following abdominoperineal resection: the role of gracilis flap. Ann Plast Surg 59(2):168–172. https://doi.org/10.1097/01.sap.0000252693.53692.e0
48. Abood A, Niranjan NS (2014) Perineal reconstruction: from lotus petal to "canopy". An alternative to the standard surgical algorithm. J Plast Reconstr Aesthet Surg 67(5):738–739. https://doi.org/10.1016/j.bjps.2013.12.012
49. Cormack GC, Lamberty BG (1984) A classification of fasciocutaneous flaps according to their patterns of vascularisation. Br J Plast Surg 37(1):80–87. https://doi.org/10.1016/0007-1226(84)90049-3
50. Ayestaray B, Proske YM (2015) Perineal and posterior vaginal wall reconstruction with a superior gluteal artery dual perforator-pedicled propeller flap. Microsurgery 35(1):64–67. https://doi.org/10.1002/micr.22279
51. Nakamura Y, Ishitsuka Y, Nakamura Y, Xu X, Hori-Yamada E, Ito M, Onizawa S, Kawachi Y, Otsuka F (2010) Modified gluteal-fold flap for the reconstruction of vulvovaginal defects. Int J Dermatol 49(10):1182–1187. https://doi.org/10.1111/j.1365-4632.2010.04578.x

52. Pusic AL, Mehrara BJ (2006) Vaginal reconstruction: an algorithm approach to defect classification and flap reconstruction. J Surg Oncol 94(6):515–521. https://doi.org/10.1002/jso.20489
53. Woods JE, Alter G, Meland B, Podratz K (1992) Experience with vaginal reconstruction utilizing the modified Singapore flap. Plast Reconstr Surg 90(2):270–274. https://doi.org/10.1097/00006534-199290020-00016
54. Staiano JJ, Wong L, Butler J, Searle AE, Barton DP, Harris PA (2009) Flap reconstruction following gynaecological tumour resection for advanced and recurrent disease–a 12 year experience. J Plast Reconstr Aesthet Surg 62(3):346–351. https://doi.org/10.1016/j.bjps.2007.12.050
55. Grinsell DG, Morrison E, Tansley PD (2013) The inferior gluteal artery myocutaneous flap with vascularized fascia lata to reconstruct extended abdominoperineal defects. Plast Reconstr Surg 132(5):836e–840e. https://doi.org/10.1097/PRS.0b013e3182a3c0cd
56. Hainsworth A, Al Akash M, Roblin P, Mohanna P, Ross D, George ML (2012) Perineal reconstruction after abdominoperineal excision using inferior gluteal artery perforator flaps. Br J Surg 99(4):584–588. https://doi.org/10.1002/bjs.7822
57. Morrison EJ, Shoukath S, Tansley P, Grinsell D (2013) Donor site morbidity of an islanded inferior gluteal artery myocutaneous flap with vascularized fascia lata. J Plast Reconstr Aesthet Surg 66(7):962–967. https://doi.org/10.1016/j.bjps.2013.03.003
58. Godbout E, Farmer L, Bortoluzzi P, Caouette Laberge L (2013) Donor-site morbidity of the inferior gluteal artery perforator flap for breast reconstruction in teenagers. Can J Plast Surg 21(1):19–22
59. Jakubietz RG, Jakubietz MG, Jakubietz DF, Koehler G, Zeplin PH, Meffert RH, Schmidt K (2009) Ischial pressure sores: reconstruction using the perforator-based reverse flow musculocutaneous 180 degrees propeller flap. Microsurgery 29(8):672–675. https://doi.org/10.1002/micr.20678
60. Wong S, Garvey P, Skibber J, Yu P (2009) Reconstruction of pelvic exenteration defects with anterolateral thigh-vastus lateralis muscle flaps. Plast Reconstr Surg 124(4):1177–1185. https://doi.org/10.1097/PRS.0b013e3181b5a40f