Lotus petal flap and vertical rectus abdominis myocutaneous flap in vulvoperineal reconstruction

Hellinga, Joke; Rots, Mathijs; Werker, Paul M. N.; Stenekes, Martin W.

Published in:
Journal of plastic surgery and hand surgery

DOI:
10.1080/2000656X.2020.1828902

Publication date:
2021

Journal of Plastic Surgery and Hand Surgery

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/iphs20

Lotus petal flap and vertical rectus abdominis myocutaneous flap in vulvoperineal reconstruction: a systematic review of differences in complications

Joke Hellinga, Mathijs Rots, Paul M. N. Werker & Martin W. Stenekes

To cite this article: Joke Hellinga, Mathijs Rots, Paul M. N. Werker & Martin W. Stenekes (2021) Lotus petal flap and vertical rectus abdominis myocutaneous flap in vulvoperineal reconstruction: a systematic review of differences in complications, Journal of Plastic Surgery and Hand Surgery, 55:2, 67-82, DOI: 10.1080/2000656X.2020.1828902

To link to this article: https://doi.org/10.1080/2000656X.2020.1828902

Published online: 15 Oct 2020.

JOURNAL OF PLASTIC SURGERY AND HAND SURGERY
2021, VOL. 55, NO. 2, 67–82
https://doi.org/10.1080/2000656X.2020.1828902

REVIEW ARTICLE

OPEN ACCESS Check for updates

Lotus petal flap and vertical rectus abdominis myocutaneous flap in vulvoperineal reconstruction: a systematic review of differences in complications

Joke Hellinga, Mathijs Rots, Paul M. N. Werker and Martin W. Stenekes

Department of Plastic Surgery, University of Groningen, University Medical Center Groningen, Groningen, The Netherlands

ABSTRACT

Background: Vulvoperineal defects resulting from surgical treatment of (pre)malignancies may result in reconstructive challenges. The vertical rectus abdominis muscle flap and, more recently, the fasciocutaneous lotus petal flap are often used for reconstruction in this area. The goal of this review is to compare the postoperative complications of application of these flaps. *Methods:* A comprehensive literature search of the PubMed, MEDLINE and Cochrane Library databases was performed until 6 June 2020. Search terms included the lotus petal flap, vertical rectus abdominis muscle flap and the vulvoperineal area. Articles were independently screened by two researchers according to the PRISMA-guidelines. *Results:* A total of 1074 citations were retrieved and reviewed, of which 55 were included for full text analysis. Following lotus petal flap reconstructions, the complication rate varied from 0.0% to 69.9%, with more complications concerning the recipient site compared with the donor site complications (26.0% versus 4.5%). Following vertical rectus abdominis muscle flap reconstructions the complication rate varied between 0.0% and 85.7% with almost twice the number of recipient site complications compared to donor site complications (37.1% versus 17.8%). *Conclusions:* Overall, the lotus petal flap has lower complication rates at both the donor and the recipient site compared with the vertical rectus abdominis muscle flap. When both options seem viable, the lotus petal flap procedure may be preferred on the basis of the reported lower complication rates.

Abbreviations: APE: abdominoperineal excision; ELAPE: extra levator abdominoperineal excision; LP flap: lotus petal flap; NIH: National Institute of Health; NR: not reported; RCT: randomized controlled trial; VRAM flap: vertical rectus abdominis myocutaneous flap

ARTICLE HISTORY
Received 14 April 2020
Revised 10 September 2020
Accepted 22 September 2020

KEYWORDS
Lotus petal flap; vertical rectus abdominis muscle flap; systematic review; complications; vulvoperineal

Introduction

The surgical treatment of gynecological and colorectal (pre)malignancies may result in vulvoperineal defects that cannot be closed primarily. The ablation leaves a soft tissue defect in an area of the body, where the bacterial count is high. Therefore, it is not surprising that wound infections are often encountered [1]. Besides, most patients receive neo-adjuvant or adjuvant (chemo)-radiotherapy which may cause delayed wound healing and increases the risk of developing wound complications [2]. Wound complications occur in up to 22% of the cases with vulvoperineal wound closure without application of flaps [3]. It has been proven that wound closure using a flap reconstruction helps to decrease the rate of wound-healing problems to 16%, by providing healthy, well-vascularized, and nonirradiated tissue [4–6].

There are several reconstructive options for closure of vulvoperineal defects that cannot be closed by simple wound edge adaptation. One of the most commonly used myocutaneous flaps, is the vertical rectus abdominis myocutaneous (VRAM) flap [7]. This flap has a rich vascularization and offers enough bulk to fill pelvic defects; however, in up to 25% of cases, abdominal wall herniation is described [8]. Abdominal wall herniation in itself carries the risk of bowel strangulation and perforation. The most commonly used fasciocutaneous flap for the reconstruction of vulvoperineal defects in our practice is the lotus petal (LP) flap. This flap is based on the internal and external pudendal arteries and is a versatile flap. Flap harvest does not impair the donor site functionally and leaves a relatively inconspicuous scar. Nevertheless, rates of minor wound complications of 30% and risk of perineal herniation of up to 21% are still at hand [2,9]. Ten years ago the VRAM flap was the most commonly used flap for vulvoperineal reconstruction [6]. Nowadays an LP flap also appears a viable option for reconstruction in the area. In our clinic, we have positive experiences with the LP flap. We experienced the LP flap procedure as a quick and easy to perform procedure, which can be performed in either prone or lithotomy position. Also, the donor site is left with just minimal functional compromises and results in an inconspicuous, easy to hide, scar [10]. Earlier reports show an acceptable major complication rate [11]. Therefore, over the past decade, it has become the first option for reconstruction of vulvoperineal defects. However, the advantages and disadvantages of these reconstructions have never been systematically reviewed.

CONTACT Martin W. Stenekes m.w.stenekes@umcg.nl Department of Plastic Surgery, University of Groningen, University Medical Center Groningen, Groningen, The Netherlands

The purpose of this study is to provide a thorough analysis of the literature regarding post-operative complications following reconstruction of vulvar, perineal or vulvoperineal defects with a VRAM or LP flap. Our goal is to review whether or not there are differences in complications in general and differences between the complications occurring at the donor site and recipient site more specific. We aim to identify evidence-based advantages and disadvantages of each reconstruction procedure. This information can help the plastic surgeon during patient counselling, decision making and follow-up.

Methods

Study selection

This systematic review was performed according to the guidelines of the Cochrane Collaboration and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (www.prisma-statement.org). The protocol was developed *a priori* and registered in the PROSPERO database (CRD42017056537).

Table 1. Search strategies.

Pubmed	("Vulva"[Mesh] OR "Perineum"[Mesh] OR "Colorectal Neoplasms"[Mesh] OR "Genital Neoplasms, Female"[Mesh] OR vulv*[tw] OR perine*[tw] OR rectal[tw] OR pudend*[tw] OR vagina*[tw] OR neovagin*[tw]) AND ("Surgical Flaps"[Mesh] OR flap*[tw]) AND (lotus[tw] OR gluteal[tw] OR rectus abdomin*[tw] OR VRAM[tw] OR myocutan*[tw])
Embase	'vagina'/exp OR 'female genital tract tumor'/exp OR 'perineum'/exp OR 'rectum tumor'/exp OR vulv*:ab,ti OR perine*:ab,ti OR rectal:ab,ti OR pudend*:ab,ti OR vagina*:ab,ti OR neovagin*:ab,ti AND ('surgical flaps'/exp OR flap*:ab,ti) AND (lotus:ab,ti OR gluteal:ab,ti OR 'rectus abdominis':ab,ti OR 'rectus abdominus':ab,ti OR vram:ab,ti OR myocutan*:ab,ti)

The search strategy was conducted in collaboration with an information specialist of the University Medical Center Groningen medical library. The search strategy was developed using the PICO method. The participants ('P') were patients with vulvar, perineal or vulvoperineal defects, the intervention ('I') was either an LP flap or a VRAM flap. The comparison ('C') and outcome ('O') were left open to assure a wide search result. The search strategies are shown in Table 1. An initial literature search was performed on 13 October 2015 in the PubMed and Embase database. The search was updated on 6 June 2020. References of all included studies were screened for eligibility.

The study selection was performed in two rounds: (1) title-abstract round; (2) full-text round. Two authors (J.H. and M.R.) independently assessed all articles retrieved from the search. After each round discrepancies were discussed to reach consensus. In case no consensus was reached, the senior author (M.W.S.) was consulted. If in the first-round inclusion or exclusion criteria could not be assessed from the title and abstract, the study was included for the full-text round. Inclusion- and exclusion criteria are shown in Table 2.

Quality assessment

All full-text selected articles were independently scored by two authors (J.H. and M.R.). The articles by Hellinga et al. [10,11] were scored by the second author (M.R.) and an independent epidemiologist to avoid a conflict of interest. We used the 'Quality Assessment Tool for Case Series Studies' from the National Institute of Health. (NIH; https://www.nhlbi.nih.gov/health-pro/guidelines/in-develop/cardiovascular-risk-reduction/tools/case-control) This tool is based on nine criteria with binary options ('Yes' or 'No') (Figure 1). Follow-up of at least 12 months was regarded adequate, in case of a shorter follow-up, this criterion was answered with 'no'. We determined the

Table 2. Inclusion- and exclusion criteria.

Inclusion	Exclusion
Report of donor and recipient site complications	No new data
Reconstruction of vulvar, perineal or vulvoperineal defects	Less than five cases
Reconstruction with either a VRAM or an LP flap	Another language than English, German or Dutch
	No report of outcomes for each flap type or defect type separately
	No full-text available (exclusion in full-text round)

LP: lotus petal; VRAM: vertical rectus abdominis myocutaneous.

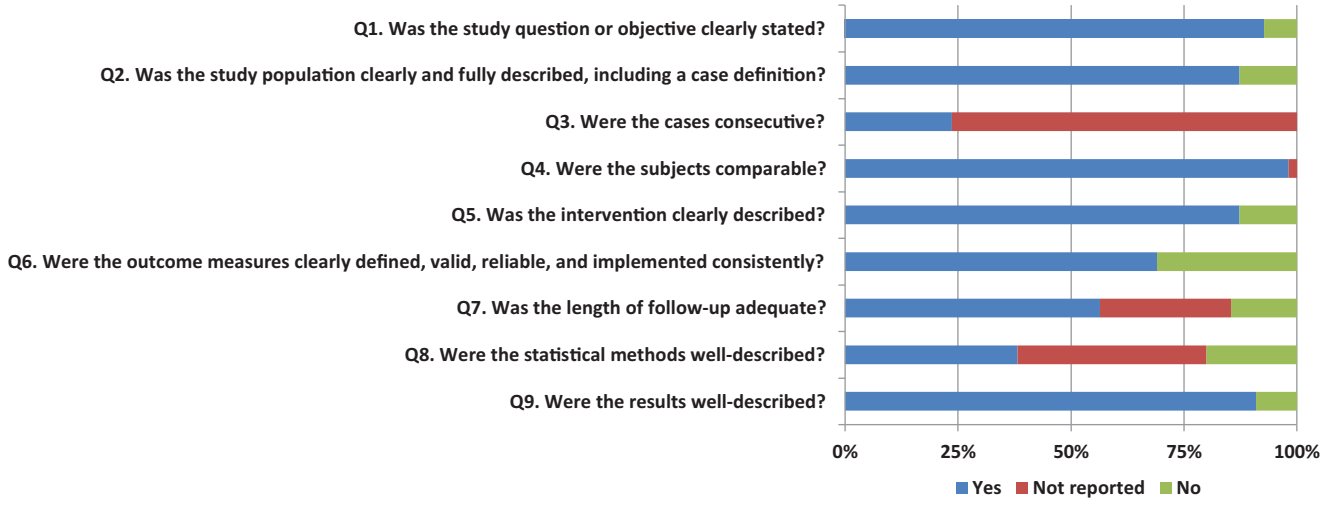

Figure 1. Results of quality assessment.

final score based on the number of times 'yes' was marked. A final score of less or equal than 4 times 'yes' indicated a 'poor' quality, 5–7 times 'yes' 'fair' quality and 8–9 times 'yes' 'good' quality. Discrepancies were handled as described above for both the title-abstract and full-text round. Cohen's kappa was determined to measure the agreement of the quality assessment score between the two authors.

Data collection

Data collection was performed by the first author (J.H.) and cross-checked by the second author (M.R.). We extracted the age, sex, length of follow-up, indication for resection, type of resection, complications, and postoperative sexual function. The number of complications was extracted as an absolute number since the number of complications per patient was mostly not reported. In case the number of patients with complications was also reported, this percentage was also collected. Complications were categorized in reconstruction site complications and other complications. All reconstruction site complications were grouped by donor site and recipient site. The complications were defined as minor and major, based on the Clavien-Dindo classification, in which minor complications required no intervention or only pharmacological treatment and major complications required surgical intervention [12].

Analysis

Data on LP flap and VRAM flap reconstruction were analyzed separately. For each complication, a weighted average was calculated.

Results

Literature search

The search yielded 752 citations in Pubmed and 969 citations in Embase. The reference check included ten extra results. In total, 1731 articles were included. After excluding duplicates, 1074 articles remained. No overlapping subjects were found between studies. After title, abstract and full-text selection 55 articles remained for quality assessment. The flowchart of the selection procedure is shown in Figure 2.

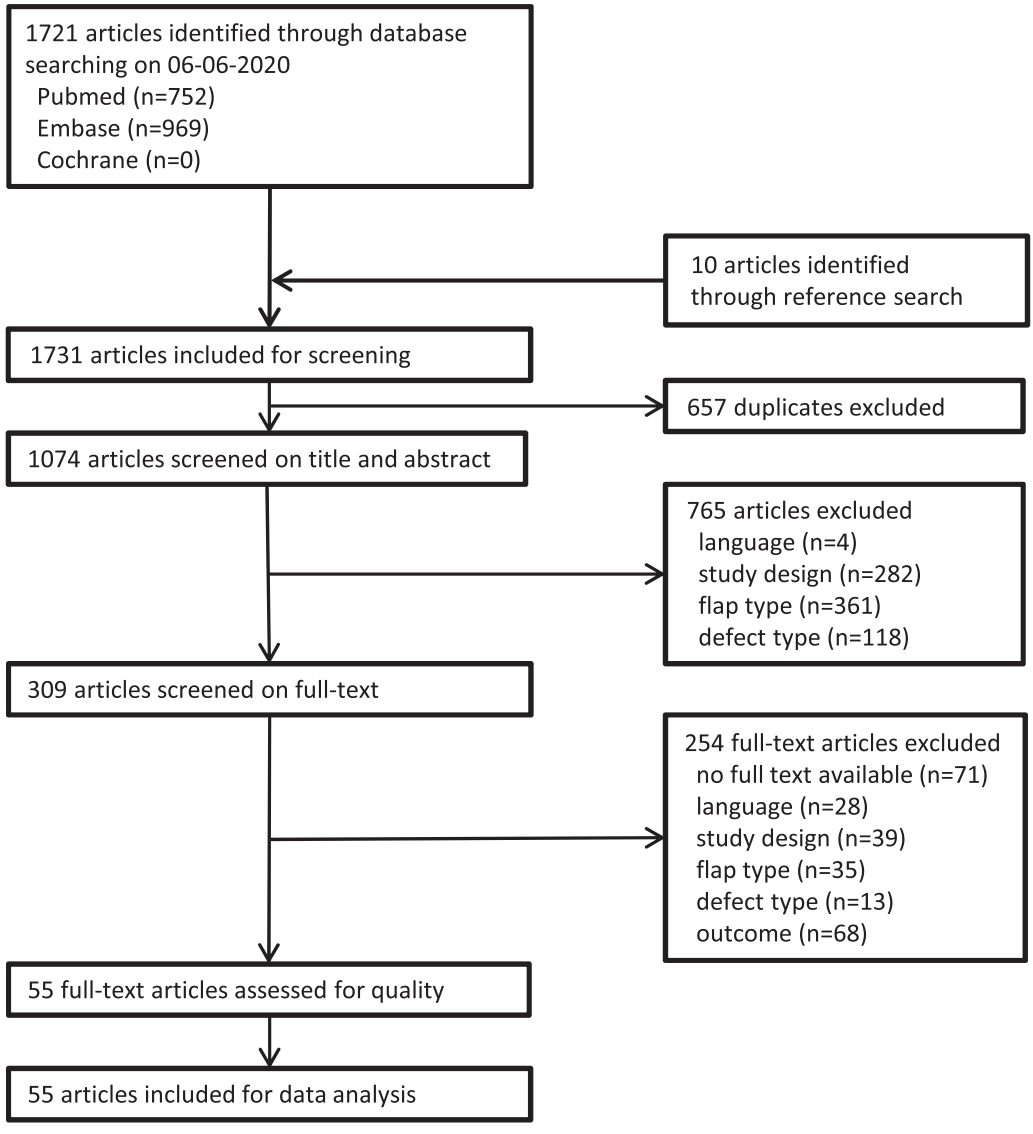

Figure 2. Flowchart of study selection procedure.

Quality assessment

The interrater agreement on the quality assessment score was substantial with an overall agreement of 87.3% (48 out of 55; $\kappa = 0.758$; $p = 0.000$) [13]. Results of the quality assessment are shown in Figure 1 and the overall score of each article is shown in Appendices I and III. The majority of the studies reached a final score of fair ($n = 37$; 67.3%). Fourteen studies (25.5%) scored good and four studies (7.3%) scored poor. Overall, most studies clearly stated their study question ($n = 51$; 92.7%), and results ($n = 50$; 90.9%). The most frequently not reported item was question 3 'Were the cases consecutive?' ($n = 42$; 76.4%).

Study characteristics

LP reconstruction

Sixteen out of the 55 articles described the application of the LP flap for reconstructions. Yii et al. [14] were the first in 1996 to report on reconstruction using the LP flap. All but three of these studies are case series [14–26]. Only Negosanti et al. [27], Confalonieri et al. [18] and Thiele et al. [28] reported a case control study in which a reconstruction with LP flaps was compared with other flaps. About half of the studies (56.3%) were small studies (<20 patients), the largest was that of Confalonieri et al. which included 106 patients [14,18,20–22,24,26–28]. In 62.5% of the studies, only females were included [14,15,17–19,21,23,25–27]. Mean age of the subjects varied between 50.3 years and 79 years [21,22]. Length of follow-up was reported in 56.3% of the studies and varied between a mean of 10 and 84 months (details in Appendix I) [17,18].

VRAM reconstruction

A total of 39 articles described the use of the VRAM flap for reconstruction. The first study on VRAM reconstruction was reported in 1989 by Kroll et al. [29]. Most studies were case series (64.1%), 33.3% were case control studies in which the VRAM flap was compared with primary closure or other flaps, and one randomized clinical trial was reported [30]. Most studies (53.8%) were small (<20 subjects), the largest study group consisted of 114 patients [31]. All but one of the studies reported the mean age of the patients, and age varied between 45 and 70.6 years [29,32,33]. Length of follow-up varied between a median of nine months and a mean of 54 months. Seventeen studies (43.6%) did not (completely) report their length of follow-up [5,25,33–47]. (details in Appendix II)

Table 3. Summary of indication for resection – LP studies.

Indication for resection	Rate (%)
Vulvar/vaginal cancer	77.0
Vulvar dysplasia	10.6
Colorectal cancer	2.7
Anal cancer	1.9
Melanoma	1.5
Benign colorectal disease	1.0
Hidradenitis	0.8
Gender reassignment/pseudohermaphroditism	0.6
Miscellaneous	3.8

LP: lotus petal.

Resection characteristics

LP reconstruction

The main indication for resection in articles were LP reconstruction was performed, were vulvar/vaginal cancer (77.0%) and vulvar dysplasia (10.6). Resection of colorectal or anal cancer was only in 4.6% of the cases indication for reconstruction (Table 3; details in Appendix I). In most cases a total (40.8%) or partial (13.5%) vulvectomy was performed. Kim et al. [22] did not report the exact type of resection and Argenta et al. [15] only reported that extirpative surgery was performed (Table 4; details in Appendix I).

VRAM reconstruction

The main indication for resection preceding VRAM reconstruction, was colorectal cancer (54.3%). Anal cancer was the indication for resection in 15.5% of the cases, uterine or cervical cancer in 9.6% and vulvar or vaginal cancer in 7.0% of the cases (Table 5; details in Appendix II). Three studies did not report the indication for resection [29,48,49]. The main types of resection performed were an abdominoperineal excision (APE) (52.7%) or total exenteration (13.4%) (Table 6; details in Appendix II). Four studies did not report the type of resection performed [38,39,49,50].

Table 4. Summary of type of resection – LP studies.

Type of resection	Rate (%)
Total vulvectomy	40.8
(Vulvo)perineal resection	22.4
Partial vulvectomy	13.5
Extirpative surgery	12.6
APE	4.1
Miscellaneous	6.6

APE: abdominoperineal excision; LP: lotus petal.

Table 5. Summary of indication for resection – VRAM studies.

Indication for resection	Rate (%)
Colorectal cancer	54.3
Anal cancer	15.5
Uterine/cervical cancer	9.6
Vulvar/vaginal cancer	7.0
Anorectal cancer	2.4
Urogenital cancer	1.8
Urethra/bladder cancer	1.5
Sarcoma	1.5
Prostatic cancer	1.4
Benign colorectal disease	1.3
Miscellaneous	3.8

VRAM: vertical rectus abdominis myocutaneous.

Table 6. Summary of type of resection – VRAM studies.

Type of resection	Rate (%)
APE	52.7
Total exenteration	13.4
Exenteration	7.9
Posterior exenteration	7.3
Anterior exenteration	3.9
Extirpative surgery	3.7
Sacral resection	1.3
Groin dissection	1.3
Miscellaneous	8.5

APE: abdominoperineal excision; VRAM: vertical rectus abdominis myocutaneous.

Table 7. Summary of reconstruction site complications – LP studies.

Donor site	Rate (%)	Recipient site	Rate (%)
Wound dehiscence	0.8	Partial flap loss	5.0
Not specified	3.1	Partial wound dehiscence	3.5
Miscellaneous	0.6	Seroma	1.0
		Stenosis	0.6
		Complete flap loss	0.4
		Not specified	13.6
		Miscellaneous	1.9

LP: lotus petal.

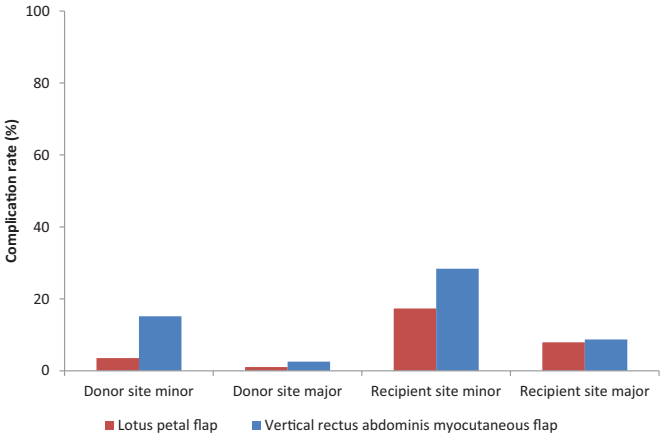

Figure 3. Reconstruction site specific complications.

Complications of reconstruction site

LP reconstruction

The number of patients with any reconstruction site complication following reconstruction with the LP flap varies from 0.0% to 69.9% [11,14,16,22]. All studies on reconstruction with the LP flap reported whether there were complications in either the donor or recipient site, or not. Most complications occurred at the recipient site (26.0% versus 4.5%). The donor site showed mostly minor complications (3.5% versus 1.0% major complications). Main indication for intervention at the donor site was wound dehiscence (60%). For the recipient site also more minor than major complications were reported (17.8% versus 8.2%). Three studies reported no recipient site complications [14,16,22]. Partial flap loss and partial wound dehiscence accounted for most of the reported complications (5.0% resp. 3.5%). Complete flap loss only occurred in 0.4% of the cases (Table 7; details Appendix III). Figure 3 shows the minor and major complication rates of both the donor and recipient site.

VRAM reconstruction

The reported percentage of patients with any reconstruction site complication showed a wide variance from 0.0% to 85.7% [51,52]. Most (59.0%) studies only reported the total amount of reconstruction site complications, and not the complications per patient. Twice as many recipient site complications, following reconstruction with the VRAM flap, were reported compared to donor site complications (39.4% versus 19.3%). In eight (20.5%) studies, no donor site complications occurred [41,49,52–56]. Eight (20.5%) studies did not distinguish between minor and major complications for the donor site [5,7,30,31,39,57–59]. In the remaining studies, minor complications were reported more often than major complications (15.2% versus 2.6%). Partial wound dehiscence and wound infection were the most commonly reported complications of the donor site (7.7% resp. 4.0%). In the study of Sheckter et al. [49] no recipient site complications occurred. Nine (23.1%) studies did not make the distinction between minor and major recipient site complications [30,31,39,42,47,54,57–59]. Minor complications were reported in 28.4% of the cases and major complications in 8.7% of the cases. The most common complication of the recipient site was partial wound dehiscence (10.1%). Also abscess formation (4.5%) and partial flap loss (4.3%) occurred relatively often. Complete flap loss was reported in 2.2% of the cases (Table 8; details in Appendix IV). Figure 3 shows the minor and major complication rates of both the donor and recipient site.

Table 8. Summary of reconstruction site complications – VRAM studies.

Donor site	Rate (%)	Recipient site	Rate (%)
Partial wound dehiscence	7.7	Partial wound dehiscence	10.1
Wound infection	4.0	Abscess	4.5
Incisional herniation	2.2	Partial flap loss	4.3
Miscellaneous	5.1	Wound infection	3.2
		Large wound dehiscence	2.4
		Complete flap loss	2.2
		Stenosis	1.6
		Delayed healing	1.3
		Fluid collection	1.3
		Seroma	1.3
		Superficial epidermiolysis	0.9
		Urethral/urethric damage	0.9
		Miscellaneous	5.0

VRAM: vertical rectus abdominis myocutaneous.

General complications

LP reconstruction

Two studies reported that no general complications occurred [14,28]. Complications reported in other studies were urinary tract infection (1.3%), deep venous thrombosis (1.3%) and cerebrovascular incident (1.3%) (details in Appendix III).

VRAM reconstruction

The most common general complications following VRAM flap reconstruction were urinary tract infection (3.8%), small bowel obstruction (3.2%), parastomal herniation (1.9%) and deep venous thrombosis (1.7%) (details in Appendix IV).

Sexual function

LP reconstruction

Two studies reported the sexual outcome following LP flap reconstruction [17,25]. The study by Ragoowansi et al. [25] reported that 17% of the patients had returned to sexual activity in 6–9 months following the reconstruction. The other study reported that all 'sexual active patients' did not report any problems, however they did not mention the rate of sexual active patients [17].

VRAM reconstruction

Eight studies reported details on postoperative sexual function [36,39,44,47,55,60–62]. Three of the studies used a questionnaire and one study performed a postoperative interview [44,47,61,62]. Rates of return to sexual activity ranged from 26.7–50.0%. However, Casey et al. [39] reported that 18 of the 35 patients were sexually active preoperative and 17 of them were remained active postoperative. The trend showed that younger patients returned more often to sexual activity, however most patients reported a lower quality of their sexual activity. However, Cortinovis et al. [62] reported a higher satisfaction with their sexual activity postoperative.

Discussion

Summary of evidence

Vulvoperineal defects have often been closed with VRAM flaps, however over the last years the LP flap is gaining popularity. Therefore, the aim of this systematic review was to compare the postoperative complications of the LP flap procedure and the VRAM flap procedure for vulvoperineal reconstruction by performing a thorough analysis of literature. Our analysis suggest that patients following the LP flap procedure experience a relative lower number of postoperative reconstruction site complications compared to VRAM flap procedure.

While the LP flap was only described in 1996 by Yii and Niranjan, the VRAM flap was first described for the reconstruction of perineal wounds in 1984 by Shukla et al. [14,63] However, the first articles included in this review on the VRAM flap originate from 1989 [29]. The resulting shorter period of use of LP reconstructions compared to VRAM reconstructions is a clear confounder in our search results. The search included 14 articles on LP flap reconstruction, mainly case series and small study populations, whereas it yielded 39 VRAM flap reconstruction articles, both case series and case controls, and one randomized clinical trial. Our quality assessment scores also showed a lower quality of the LP flap articles compared to the VRAM flap articles. The difference in included articles for both groups and as a result the difference in quality of the articles, may have affected the results of our review.

The indication for resection and type of resection preceding LP flap reconstruction is mainly a gynecological tumor (87.6%) that needed total or partial vulvectomy (54.3%) Colorectal or anal tumors are preceding LP reconstruction only in 4.6% of the patients. In patients of the VRAM flap group the picture is different; 69.8% had a colorectal or anal tumor and 16.6% a gynecological tumor. APE or any type of exenteration was performed in 85.2% of the cases. The difference in indication for and type of resection varies between both groups of patients. This may have caused a selection bias in the application of the flaps. This systematic review revealed that the VRAM flap is more often used following resection of extensive colorectal tumors. This may give the impression that an LP reconstruction is not always feasible for such defects and that the comparison we performed in this review is not a fair one. However, we think that a more appropriate explanation for this difference is that the LP flap was initially only described for vulvar reconstruction. Our group however has very positive experience with the application of LP flaps for reconstruction in the perineal area following APE/ELAPE [10,64]. Each flap of course has its own specific donor site complications. Therefore, when comparing different flaps, only the comparison of generic complications between both reconstruction techniques is relevant for clinical decision making. We are of the opinion that the difference in recipient sites following gynecological respectively anorectal tumor resections does not greatly influence generic donor site complication or flap complication rates. This makes comparison of those techniques, despite the different anatomical reconstruction sites.

The variance in number of patients with one or more reconstruction site complications is smaller following LP flap reconstruction compared to VRAM flap reconstruction (0.0–69.9% versus 0.0%–85.7%). Both reconstruction types show higher number of recipient site complications than donor site complications. However, the percentage of recipient site complications following the LP flap procedure is less than half of that following a VRAM flap procedure. This difference is even larger for reported donor site complications. Both reconstruction procedures show more minor recipient site complications compared to major recipient site complications. The minor/major ratio is a little higher following the LP flap procedure. The types of complications are comparable, but no large wound dehiscences were reported following LP flap reconstruction. Also the total percentage of partial and complete flap loss were lower following the LP flap procedure.

Complications other than those of the reconstruction site were rare, but more frequent following VRAM flap reconstructions. These complications were mostly related to the long operation time of the resection and reconstruction (e.g. urinary tract infection, deep venous thrombosis and small bowel obstruction). No parastomal herniations were reported following LP flap reconstruction which could be explained by the low rate of colorectal resections in this group.

Sexual dysfunction was rarely reported following LP flap (12.%) as well as VRAM flap application (20.5%) [17,25,36,39,44,47,55,60–62]. We find it surprising that there is so little research on the topic of sexual dysfunction, especially since it concerns surgery in the vulvoperineal area. We suppose that postoperative sexual activity rates could also be influence by area of resection, either vulvar or perineal.

Limitations

As in every systematic review the quality of the available evidence greatly influenced the strength of our results. Especially the LP flap group contained only few high evidence studies with poor scores on the quality assessment. The large variability in indication for resection and low uniformity in presenting the reconstruction site complications also undermined the quality of the results. Also the poor levels of presenting data (e.g. other complications) affected the results presented. Unfortunately, there is a lack of prospective studies. Also, a randomized controlled trial is unethical. At best a properly powered multicenter propensity matched control study may be able to reveal the differences more clearly. Therefore our conclusion should be drawn with care.

We tried to give insight in possible publication bias by drawing a funnel plot. However, more than half of the studies did not report the number of patients with one or more complications. In these studies, the complication rate as percentage of included patients cannot be determined. As a consequence, studies with a complication rate of zero would be overrepresented in a funnel plot. Since the complication rate might depend on reconstruction type, a funnel plot would provide an incorrect representation of publication bias, or even introduce selection bias. Therefore, we decided not to include it in this paper.

We aimed to reduce the language bias by also including Dutch and German language articles, besides English language articles. It is thought that positive results will mainly be reported in English language journals. However, the evidence to support this small effect is weak [65]. Unfortunately, there were no studies available that compared both reconstruction procedures in one study and therefore we were not able to perform a meta-analysis.

Conclusions

This systematic review demonstrated lower complication rates in both the donor site and the recipient site, following the LP flap procedure compared to the VRAM flap procedure. This knowledge could guide the plastic surgeon during counselling and to take the decision for either reconstruction technique. In case in which both reconstruction procedures can be applied, the LP flap procedure should be considered owing to the relatively low complication rates.

Disclosure statement

The authors have nothing to disclose.

ORCID

Joke Hellinga http://orcid.org/0000-0002-4189-6806

References

[1] Althumairi AA, Canner JK, Gearhart SL, et al. Risk factors for wound complications after abdominoperineal excision: analysis of the ACS NSQIP database. Colorectal Dis. 2016;18(7):O260–6.

[2] Winterton RI, Lambe GF, Ekwobi C, et al. Gluteal fold flaps for perineal reconstruction. J Plast Reconstr Aesthet Surg. 2013;66(3):397–405.

[3] Bertucci Zoccali M, Biondi A, Krane M, et al. Risk factors for wound complications in patients undergoing primary closure of the perineal defect after total proctectomy. Int J Colorectal Dis. 2015;30(1):87–95.

[4] Althumairi AA, Canner JK, Gearhart SL, et al. Predictors of perineal wound complications and prolonged time to perineal wound healing after abdominoperineal resection. World J Surg. 2016;40(7):1755–1762.

[5] Chessin DB, Hartley J, Cohen AM, et al. Rectus flap reconstruction decreases perineal wound complications after pelvic chemoradiation and surgery: a cohort study. Ann Surg Oncol. 2005;12(2):104–110.

[6] Devulapalli C, Tong Jia Wei A, DiBiagio JR, et al. Primary versus flap closure of perineal defects following oncologic resection: a systematic review and meta-analysis. Plast Reconstr Surg. 2016;137(5):1602–1613.

[7] Butler CE, Gündeslioglu AÖ, Rodriguez-Bigas MA. Outcomes of immediate vertical rectus abdominis myocutaneous flap reconstruction for irradiated abdominoperineal resection defects. J Am Coll Surg. 2008;206(4):694–703.

[8] O'Dowd V, Burke JP, Condon E, et al. Vertical rectus abdominis myocutaneous flap and quality of life following abdominoperineal excision for rectal cancer: a multi-institutional study. Tech Coloproctol. 2014;18(10):901–906.

[9] Christensen HK, Nerstrøm P, Tei T, et al. Perineal repair after extralevator abdominoperineal excision for low rectal cancer. Dis Colon Rectum. 2011;54:711–717.

[10] Hellinga J, Khoe PCKH, Van Etten B, et al. Fasciocutaneous lotus petal flap for perineal wound reconstruction after extralevator abdominoperineal excision: application for reconstruction of the pelvic floor and creation of a neovagina. Ann Surg Oncol. 2016;23(12):4073–4079.

[11] Hellinga J, Khoe PCKH, Stenekes MW, et al. Complications after vulvar and perineal reconstruction with a lotus petal flap. Ann Plast Surg. 2018;80(3):268–271.

[12] Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg. 2004;240(2):205–213.

[13] Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977;33(1):159–174.

[14] Yii NW, Niranjan NS. Lotus petal flaps in vulvo-vaginal reconstruction. Br J Plast Surg. 1996;49(8):547–554.

[15] Argenta PA, Lindsay R, Aldridge RB, et al. Vulvar reconstruction using the "lotus petal" fascio-cutaneous flap. Gynecol Oncol. 2013;131(3):726–729.

[16] Bodin F, Dissaux C, Seigle-Murandi F, et al. Posterior perineal reconstructions with "supra-fascial" lotus petal flaps. J Plast Reconstr Aesthet Surg. 2015;68(1):e7.

[17] Buda A, Confalonieri PL, Rovati LCV, et al. Better anatomical and cosmetic results using tunneled lotus petal flap for plastic reconstruction after demolitive surgery for vulvar malignancy. Int J Gynecol Cancer. 2012;22(5):860–864.

[18] Confalonieri PL, Gilardi R, Rovati LC, et al. Comparison of V-Y advancement flap versus lotus petal flap for plastic reconstruction after surgery in case of vulvar malignancies: a retrospective single center experience. Ann Plast Surg. 2017;79(2):186–191.

[19] Franchelli S, Leone MS, Bruzzone M, et al. The gluteal fold fascio-cutaneous flap for reconstruction after radical excision of primary vulvar cancers. Gynecol Oncol. 2009;113(2):245–248.

[20] Hashimoto I, Nakanishi H, Nagae H, et al. The gluteal-fold flap for vulvar and buttock reconstruction: anatomic study and adjustment of flap volume. Plast Reconstr Surg. 2001;108(7):1998–2005.

[21] Herraiz Roda JL, Llueca Abella JA, Maazouzi Y, et al. Vulvar reconstruction in vulvar cancer: "lotus petal" suprafascial flap. Gynecol Surg. 2016;13(1):51–55.

[22] Kim JT, Ho SY, Hwang JH, et al. Perineal perforator-based island flaps: the next frontier in perineal reconstruction. Plast Reconstr Surg. 2014;133(5):683e

[23] Misani M, Rovati LC, Confalonieri P, et al. Modified lotus petal flap for vulvo-vaginal reconstruction after resection for vulvar cancer: a single institution experience . Handchir Mikrochir Plast Chir. 2011;43(4):250–254.

[24] Pantelides NM, Davies RJ, Fearnhead NS, et al. The gluteal fold flap: a versatile option for perineal reconstruction following anorectal cancer resection. J Plast Reconstr Aesthet Surg. 2013;66(6):812–820.

[25] Ragoowansi R, Yii N, Niranjan N. Immediate vulvar and vaginal reconstruction using the gluteal-fold flap: long-term results. Br J Plast Surg. 2004;57(5):406–410.

[26] Sawada M, Kimata Y, Kasamatsu T, et al. Versatile lotus petal flap for vulvoperineal reconstruction after gynecological ablative surgery. Gynecol Oncol. 2004;95(2):330–335.

[27] Negosanti L, Sgarzani R, Fabbri E, et al. Vulvar reconstruction by perforator flaps: algorithm for flap choice based on the topography of the defect. Int J Gynecol Cancer. 2015;25(7):1322–1327.

[28] Thiele JR, Weber J, Neeff HP, et al. Reconstruction of perineal defects: a comparison of the myocutaneous gracilis and the gluteal fold flap in interdisciplinary anorectal tumor resection. Front Oncol. 2020;10:668

[29] Kroll SS, Pollock R, Jessup JM, et al. Transpelvic rectus abdominis flap reconstruction of defects following abdominal-perineal resection. Am Surg. 1989;55(10):632–637.

[30] Touny A, Othman H, Maamoon S, et al. Perineal reconstruction using pedicled vertical rectus abdominis myocutaneous flap (VRAM). J Surg Oncol. 2014;110(6):752–757.

[31] Nelson RA, Butler CE. Surgical outcomes of VRAM versus thigh flaps for immediate reconstruction of pelvic and perineal cancer resection defects. Plast Reconstr Surg. 2009;123(1):175–183.

[32] Jain AK, Defranzo AJ, Marks MW, et al. Reconstruction of pelvic exenterative wounds with transpelvic rectus abdominis flaps: A case series. Ann Plast Surg. 1997;38(2):115–123.

[33] Kouraklis G. Reconstruction of the pelvic floor using the rectus abdominis muscles after radical pelvic surgery. Dis Colon Rectum. 2002;45(6):836–839.

[34] Barker JA, Blackmore AE, Owen RP, et al. Prone cylindrical abdominoperineal resection with subsequent rectus abdominis myocutaneous flap reconstruction performed by a colorectal surgeon. Int J Colorectal Dis. 2013;28(6):801–806.
[35] Barker T, Branagan G, Wright E, et al. Vertical rectus abdominis myocutaneous flap reconstruction of the perineal defect after abdominoperineal excision is associated with low morbidity. Colorectal Dis. 2013;15:1177–83.
[36] Bell SW, Dehni N, Chaouat M, et al. Primary rectus abdominis myocutaneous flap for repair of perineal and vaginal defects after extended abdominoperineal resection. Br J Surg. 2005;92(4):482–486.
[37] Berger JL, Westin SN, Fellman B, et al. Modified vertical rectus abdominis myocutaneous flap vaginal reconstruction: an analysis of surgical outcomes. Gynecol Oncol. 2012; 125(1):252–255.
[38] Buchel EW, Finical S, Johnson C. Pelvic reconstruction using vertical rectus abdominis musculocutaneous flaps. Ann Plast Surg. 2004;52(1):22–26.
[39] Casey WJ, Tran NV, Petty PM, et al. A comparison of 99 consecutive vaginal reconstructions: an outcome study. Ann Plast Surg. 2004;52(1):27–30.
[40] Creagh TA, Dixon L, Frizelle FA. Reconstruction with vertical rectus abdominus myocutaneous flap in advanced pelvic malignancy. J Plast Reconstr Aesthet Surg. 2012;65(6):791–797.
[41] Erdmann MWH, Waterhouse N. The transpelvic rectus abdominis flap: its use in the reconstructin of extensive perineal defects. Ann R Coll Surg Engl. 1995;77:229–232.
[42] De Haas WG, Miller MJ, Temple WJ, et al. Perineal wound closure with the rectus abdominis musculocutaneous flap after tumor ablation. Ann Surg Oncol. 1995;2(5):400–406.
[43] Hinojosa MW, Parikh DA, Menon R, et al. Recent experience with abdominal perineal resection with vertical rectus abdominis myocutaneous flap reconstruction after preoperative pelvic radiation. Am Surg. 2009;75(10):995–999.
[44] Holman FA, Martijnse IS, Traa MJ, et al. Dynamic article: Vaginal and perineal reconstruction using rectus abdominis myocutaneous flap in surgery for locally advanced rectum carcinoma and locally recurrent rectum carcinoma. Dis Colon Rectum. 2013;56(2):175–185.
[45] Houvenaeghel G, Ghouti L, Moutardier V, et al. Rectus abdominis myocutaneous flap in radical oncopelvic surgery: a safe and useful procedure. Eur J Surg Oncol. 2005; 31(10):1185–1190.
[46] Petrie N, Branagan G, McGuiness C, et al. Reconstruction of the perineum following anorectal cancer excision. Int J Colorectal Dis. 2009;24(1):97–104.
[47] Smith HO, Genesen MC, Runowicz CD, et al. The rectus abdominis myocutaneous flap: modifications, complications, and sexual function. Cancer. 1998;83(3):510–520.
[48] Chokshi RJ, Kuhrt MP, Arrese D, et al. Reconstruction of total pelvic exenteration defects with rectus abdominus myocutaneous flaps versus primary closure. Am J Surg. 2013;205(1):64–70.
[49] Sheckter CC, Shakir A, Vo H, et al. Reconstruction following abdominoperineal resection (APR): indications and complications from a single institution experience. J Plast Reconstr Aesthet Surg. 2016;69(11):1506–1512.
[50] Loessin SJ, Meland NB, Devine RM, et al. Management of sacral and perineal defects following abdominoperineal resection and radiation with transpelvic muscle flaps. Dis Colon Rectum. 1995;38(9):940–945.
[51] Espinosa-de-Los-Monteros A, Arista-de la Torre L, Vergara-Fernandez O, et al. Contralateral component separation technique for abdominal wall closure in patients undergoing vertical rectus abdominis myocutaneous flap transposition for pelvic exenteration reconstruction. Ann Plast Surg. 2016;77(1):90–92.
[52] Hardt J, Mai S, Weiß C, et al. Abdominoperineal resection and perineal wound healing in recurrent, persistent, or primary anal carcinoma. Int J Colorectal Dis. 2016;31(6):1197–1203.
[53] Nuñez JE, Alvarado NC, Pereira AS, et al. Abdominoperineal resection in anal cancer: reconstruction of the perineum with a myocutaneous flap from the anterior rectus abdominis muscle. Cir Esp. 2011;89:31–36.
[54] Peacock O, Pandya H, Sharp T, et al. Biological mesh reconstruction of perineal wounds following enhanced abdominoperineal excision of rectum (APER). Int J Colorectal Dis. 2012;27(4):475–482.
[55] Shepherd JH, Van Dam PA, Jobling TW, et al. The use of rectus abdominis myocutaneous flaps following excision of vulvar cancer. Br J Obstet Gynaecol. 1990;97(11):1020–1025.
[56] Haverland R, Rebecca AM, Hammond J, et alJ. A case series of robot-assisted rectus abdominis flap harvest for pelvic reconstruction: a single institution experience. J Minim Invasive Gynecol. 2020.
[57] Horch RE, Hohenberger W, Eweida A, et al. A hundred patients with vertical rectus abdominis myocutaneous (VRAM) flap for pelvic reconstruction after total pelvic exenteration. Int J Colorectal Dis. 2014;29(7):813–823.
[58] Gupta V, Lennox GK, Covens A. The rectus abdominus myoperitoneal flap for vaginal reconstruction. Gynecol Oncol Rep. 2020;32:100567.
[59] Stein MJ, Karir A, Ramji M, et al. Surgical outcomes of VRAM versus gracilis flaps for the reconstruction of pelvic defects following oncologic resection. J Plast Reconstr Aesthet Surg. 2019;72(4):565–571.
[60] Pursell SH, Day TG, Jr, Tobin GR. Distally based rectus abdominis flap for reconstruction in radical gynecologic procedures. Gynecol Oncol. 1990;37(2):234–238.
[61] Tei TM, Stolzenburg T, Buntzen S, et al. Use of transpelvic rectus abdominis musculocutaneous flap for anal cancer salvage surgery. Br J Surg. 2003;90(5):575–580.
[62] Cortinovis U, Sala L, Bonomi S, et al. Rectus abdominis myofascial flap for vaginal reconstruction after pelvic exenteration. Ann Plast Surg. 2018;81(5):576–583.
[63] Shukla HS, Hughes LE. The rectus abdominis flap for perineal wounds. Ann R Coll Surg Engl. 1984;66(5):337–339.
[64] Hellinga J, Stenekes MW, Werker PMN, et al. Quality of life, sexual functioning, and physical functioning following perineal reconstruction with the lotus petal flap. Ann Surg Oncol. 2020.
[65] Jüni P, Holenstein F, Sterne J, et al. Direction and impact of language bias in meta-analyses of controlled trials: empirical study. Int J Epidemiol. 2002;31(1):115–123.
[66] Bakx R, van Lanschot JJ, Zoetmulder FA. Inferiorly based rectus abdominis myocutaneous flaps in surgical oncology: indications, technique, and experience in 37 patients. J Surg Oncol. 2004;85(2):93–97.
[67] Combs PD, Sousa JD, Louie O, et al. Comparison of vertical and oblique rectus abdominis myocutaneous flaps for pelvic, perineal, and groin reconstruction. Plast Reconstr Surg. 2014;134(2):315–323.
[68] Pang J, Broyles JM, Berli J, et al. Abdominal- versus thigh-based reconstruction of perineal defects in patients with cancer. Dis Colon Rectum. 2014;57(6):725–732.

Appendix A. Characteristics of included studies with LP flaps

Reference	Study design	No. of patients (no. of women)	Age (years)		Length of follow-up (months)		Indication for resection	Type of resection	Quality assessment score
			Mean	Range	Mean	Range			
Argenta et al. [15]	Case series	59 (59)	59	24–89	NR	NR	Vulvar/vaginal cancer ($n = 39$); vulvar dysplasia ($n = 12$); benign colorectal disease ($n = 5$); hidradenitis ($n = 3$)	Extirpative surgery ($n = 59$)	Good
Bodin et al. [16]	Case series	6 (2)	61.5	47–72	20.5	4–39	Vulvar dysplasia ($n = 1$); colorectal cancer ($n = 3$); prostate cancer ($n = 1$); necrotizing fasciitis ($n = 1$)	APR ($n = 3$); resection of colon or rectum ($n = 1$); debridement ($n = 1$); perianal resection ($n = 1$)	Fair
Buda et al. [17]	Case series	22 (22)	64	44–78	10	2–16	Vulvar/vaginal cancer ($n = 20$); introital stenosis ($n = 2$)	Total vulvectomy ($n = 14$); partial vulvectomy ($n = 3$); (vulvo)perineal resection ($n = 5$)	Fair
Confalonieri et al. [18]	Case control	106 (106)	68.6	43–90	84	6–180	Vulvar/vaginal cancer ($n = 84$) ; vulvar dysplasia ($n = 17$); melanoma ($n = 3$); other ($n = 2$)	Total vulvectomy ($n = 83$); other ($n = 23$)	Good
Franchelli et al. [19]	Case series	33 (33)	66[b]	56–88	NR	NR	Vulvar/vaginal cancer ($n = 31$); vulvar dysplasia ($n = 1$); melanoma ($n = 1$)	Total vulvectomy ($n = 17$); partial vulvectomy ($n = 16$)	Fair
Hashimoto et al. [20]	Case series	10 (9)	59.9	19–82	NR	NR	Vulvar/vaginal cancer ($n = 7$); vulvar dysplasia ($n = 1$); anal cancer ($n = 1$); melanoma ($n = 1$)	Total vulvectomy ($n = 3$); partial vulvectomy ($n = 7$)	Poor
Hellinga et al. [11]	Case series	93 (83)	68.2[b]	18.9–91.9	26.3[b]	5.5–119.7	Vulvar/vaginal cancer ($n = 80$); vulvar dysplasia ($n = 5$); fistula ($n = 7$); herniation ($n = 1$)	(vulvo)perineal resection ($n = 93$)	Fair
Herraiz Roda et al. [21]	Case series	9 (9)	79	65–93	NR	NR–3	Vulvar/vaginal cancer ($n = 8$); vulvar dysplasia ($n = 1$)	Total vulvectomy ($n = 9$)	Fair
Kim et al. [22]	Case series	11 (10)	50.27	8–75	NR	3–84	Vulvar/vaginal cancer ($n = 5$); vulvar dysplasia ($n = 3$); gender reassignment/ pseudohermaphroditism ($n = 3$)	NR	Poor
Misani et al. [23]	Case series	41 (41)	72	53–87	15	4–42	Vulvar/vaginal cancer ($n = 37$); vulvar dysplasia ($n = 4$)	Total vulvectomy ($n = 31$); partial vulvectomy ($n = 4$); (vulvo)perineal resection ($n = 6$)	Fair
Negosanti et al. [27]	Case control[a]	17 (17)	71.8	39–86	NR	NR	Vulvar/vaginal cancer ($n = 10$); vulvar dysplasia ($n = 5$); melanoma ($n = 1$); sarcoma ($n = 1$)	Total vulvectomy ($n = 11$); partial vulvectomy ($n = 6$)	Fair
Pantelides et al. [24]	Case series	7 (4)	59	38–77	24	2–57	Colorectal cancer ($n = 3$); anal cancer ($n = 4$)	(vulvo)perineal resection ($n = 1$); APR ($n = 5$); posterior exenteration ($n = 1$)	Fair
Ragoowansi et al. [25]	Case series	40 (40)	57	45–76	16	3–48	Vulvar/vaginal cancer ($n = 38$); hidradenitis ($n = 1$); recto-vaginal fistula ($n = 1$)	Total vulvectomy ($n = 16$); partial vulvectomy ($n = 22$); excision fistula ($n = 1$); excision hidradenitis ($n = 1$)	Fair
Sawada et al. [26]	Case series	5 (5)	64	56–72	18	7–32	Vulvar vaginal cancer ($n = 3$); vulvar dysplasia ($n = 1$); melanoma ($n = 1$)	Total vulvectomy ($n = 3$); partial vulvectomy ($n = 2$)	Fair
Thiele et al. [28]	Case control[a]	12 (5)	66.2	49–83	16	4–31	Colorectal cancer ($n = 7$); anal cancer ($n = 4$); other ($n = 1$)	APR ($n = 11$); other ($n = 1$)	Good
Yii et al. [14]	Case series	8 (8)	58.6	27–76	NR	3–NR	Vulvar/vaginal cancer ($n = 7$); vaginal stenosis ($n = 1$)	Total vulvectomy ($n = 4$); partial vulvectomy ($n = 3$); release of stenosis ($n = 1$)	Poor

[a]Control group are other flaps.
[b]Median.
APR: abdominoperineal resection; LP: louts petal; NR: not reported.

Appendix B. Complications of included studies with LP flaps.

Reference	Total number of complications (% patients with complications)[a]	Complications donor site			Complications recipient site			General complications
		Minor	Major	Specification	Minor	Major	Specification	
Argenta et al. [15]	21 (NR)	0	0	None	14	7	Partial flap loss ($n = 7$); partial wound dehiscence ($n = 12$); stenosis ($n = 2$)	Deep venous thrombosis ($n = 1$)
Bodin et al. [16]	0 (0.0)	0	0	None	0	0	None	NR
Buda et al. [17]	2 (9.1)	0	0	None	1	1	Partial flap loss ($n = 2$)	NR
Confalonieri et al. [18]	14 (13)	0	0	None	NR	NR	Partial flap loss ($n = 5$); partial wound dehiscence ($n = 7$); wound infection ($n = 2$)	NR
Franchelli et al. [19]	7 (21.2)	0	0	None	6	1	Partial flap loss ($n = 2$); seroma ($n = 5$)	NR
Hashimoto et al. [20]	2 (20.0)	0	1	Wound breakdown ($n = 1$)	0	1	Hematoma ($n = 1$)	NR
Hellinga et al. [11]	65 (69.9)	15	0	Not specified ($n = 15$)	48	17	Not specified ($n = 65$)	NR
Herraiz Roda et al. [21]	3 (NR)	0	0	None	3	0	Partial wound dehiscence ($n = 2$); stenosis ($n = 1$)	Urinary tract infection ($n = 1$); cerebrovascular accident ($n = 1$)
Kim et al. [22]	0 (0.0)	0	0	None	0	0	None	NR
Misani et al. [23]	4 (9.8)	0	2	Wound breakdown ($n = 2$)	2	0	Partial flap loss ($n = 1$); complete flap loss ($n = 1$)	NR
Negosanti et al. [27]	3 (17.6)	0	0	None	0	3	Partial wound dehiscence ($n = 3$)	NR
Pantelides et al. [24]	2 (28.6)	0	1	Hematoma ($n = 1$)	0	1	Delayed healing ($n = 1$)	NR
Ragoowansi et al. [25]	8 (15.0)	1	0	Hypertrophic scar ($n = 1$)	5	2	Partial flap loss ($n = 6$); complete flap loss ($n = 1$)	NR
Sawada et al. [26]	3 (40.0)	1	0	Wound infection ($n = 1$)	2	0	Partial flap loss ($n = 1$); wound infection ($n = 1$)	NR
Thiele et al. [28]	8 (66.7)	0	1	Partial wound dehiscence ($n = 1$)	2	5	Partial wound dehiscence ($n = 3$); wound infection ($n = 2$); delayed healing ($n = 1$); abscess ($n = 1$)	None
Yii et al. [14]	0 (0.0)	0	0	None	0	0	None	None

[a]Total number of complications of the reconstruction site reported and percentage of patients with one or more complications.
LP: lotus petal; NR: not reported.

Appendix C. Characteristics of included studies with VRAM flaps

Reference	Study design	No. of patients (no. of women)	Age (years)		Length of follow-up (months)		Indication for resection	Type of resection	Quality assessment score
			Mean	Range	Mean	Range			
Bakx et al. [66]	Case series	37 (22)	58[c]	28–85	19[c]	1–72	Colorectal cancer ($n = 16$); analcancer ($n = 9$); persisting wound ($n = 4$); unknown ($n = 8$)	APR ($n = 7$); exenteration ($n = 3$); sacral resection ($n = 13$); soft tissue resection ($n = 4$); groin dissection ($n = 6$); secondary wound closure ($n = 4$)	Fair
Barker JA et al. [34]	Case control[a]	12 (7)	69	50–84	NR	6–50	Colorectal cancer ($n = 12$)	APR ($n = 12$)	Good
Barker T et al. [35]	Case series	55 (24)	65[c]	38–84	NR	NR–30 days	Colorectal cancer ($n = 40$); anal cancer ($n = 15$)	APR ($n = 55$)	Good
Bell et al. [36]	Case series	31 (18)	55[c]	30–77	9[c]	1–27	Colorectal cancer ($n = 11$); anal cancer ($n = 17$); giant generated condyloma ($n = 1$); perineal herniation ($n = 1$); degenerative haemartoma ($n = 1$)	APR ($n = 30$); perineal herniation repair ($n = 1$)	Fair
Berger et al. [37]	Case series	46 (46)	53	30.4–77.7	NR	NR	Vulvar/vaginalcancer ($n = 23$); uterine/cervicalcancer ($n = 23$)	Total exenteration ($n = 35$); anterior exenteration ($n = 7$); posterior exenteration ($n = 4$)	Fair
Buchel et al. [38]	Case series	73 (47)	56.1	28–79	NR	NR	Vulvar/vaginalcancer ($n = 6$); uterine/cervicalcancer ($n = 6$); colorectal cancer ($n = 40$); analcancer ($n = 9$); benign colorectal disease ($n = 3$); sarcoma ($n = 4$); melanoma ($n = 1$); radiation necrosis ($n = 4$)	NR	Fair
Butler et al. [7]	Case control[a]	35 (28)	54.3	13.8[d]	3.2 years	2.3 years[d]	Colorectal cancer ($n = 30$); anal cancer ($n = 5$)	APR ($n = 35$)	Good
Casey III et al. [39]	Case control[b]	41 (41)	54.7	13.1[d]	28.9[e]	NR	Anorectal cancer ($n = 23$); urogenital cancer ($n = 18$)	NR	Fair
Chessin et al. [5]	Case control[a]	19 (17)	56.5	32–74	NR	NR	Colorectal cancer ($n = 12$); anal cancer ($n = 7$)	APR ($n = 19$) of which 15 combined with vaginetomy	Fair
Chokshi et al. [48]	Case control[a]	17 (14)	62[c]	38–72	11.5	1–60	NR	Total exenteration ($n = 17$)	Fair
Combs et al. [67]	Case control[b]	49 (26)	54.7	11.7[d]	25.6	29.3[d]	Vulvar/vaginal cancer ($n = 4$); uterine/cervical cancer ($n = 8$); colorectal cancer ($n = 16$); anal cancer ($n = 7$); prostate cancer ($n = 1$); urogenital cancer ($n = 1$); squamous cell carcinoma ($n = 4$); benign colorectal disease ($n = 1$); sarcoma ($n = 6$); presacral abscess ($n = 1$)	APR ($n = 17$); exenteration ($n = 16$); pelvic resection ($n = 6$); (vulvo)perineal resection ($n = 3$); groin dissection ($n = 7$)	Good
Cortinovis et al. [6]	Case series	16 (16)	56[c]	29–75	24[c]	3–99	Vulvar/vaginal cancer ($n = 1$); uterine/cervical cancer ($n = 3$); colorectal cancer ($n = 7$); anal cancer ($n = 2$); melanoma ($n = 2$); botryoid rhabdomyosarcoma ($n = 1$)	Partial vulvectomy ($n = 13$); total vulvectomy ($n = 3$); anterior exenteration ($n = 1$); posterior exenteration ($n = 10$)	Good
Creagh et al. [40]	Case series	37 (23)	60[c]	33–86	54	3–108	Colorectal cancer ($n = 37$)	Extirpative surgery ($n = 37$)	Good
Erdmann et al. [41]	Case series	12 (8)	48.4	19–72	18.7	NR	Vulvar/vaginal cancer ($n = 1$); urethra/bladder cancer ($n = 1$); colorectal	APR ($n = 7$); exenteration ($n = 1$); resection of colon or	Fair

(*continued*)

Continued.

Reference	Study design	No. of patients (no. of women)	Age (years)		Length of follow-up (months)		Indication for resection	Type of resection	Quality assessment score
			Mean	Range	Mean	Range			
							cancer ($n = 6$); benign colorectal disease ($n = 4$)	rectum ($n = 3$); cystectomy ($n = 1$)	
Espinosa-de-los-Monteros et al. [51]	Case series	10 (7)	53	34–64	15	1–46	Colorectal cancer ($n = 10$)	Exenteration ($n = 10$)	Fair
Gupta et al. [58]	Case series	5 (5)	52.2	41–71	NR	0–20	Vulvar/vaginal cancer ($n = 1$); uterine/cervical cancer ($n = 2$); melanoma ($n = 1$); vaginal stenosis ($n = 1$)	Partial vulvectomy ($n = 1$); total vulvectomy ($n = 1$); exenteration ($n = 3$);	Fair
Haas, de et al. [42]	Case series	26 (17)	52	29–74	22	NR	Urethra/bladder cancer ($n = 2$); colorectal cancer ($n = 12$); anal cancer ($n = 7$); prostate cancer ($n = 1$); anorectal cancer ($n = 1$); sarcoma ($n = 3$)	Exenteration ($n = 26$)	Fair
Hardt et al. [52]	Case control[a]	7 (7)[e]	56[c,e]	36–74[e]	27.3/11.7[f]	20.9–92.1/2.0–35.6[f]	Anal cancer ($n = 7$)	APR ($n = 7$)	Fair
Haverland et al. [56]	Case series	6 (4)	69.2	57–79	9.2[c]	5–12	Vulvar/vaginal cancer ($n = 2$); colorectal cancer ($n = 2$); vesicovaginal fistel ($n = 1$); complex pelvic organ prolapse ($n = 1$)	Total vulvectomy ($n = 1$); APR ($n = 2$); anterior exenteration ($n = 1$); posterior exenteration ($n = 1$); vesicovaginal fistula repair ($n = 1$)	Fair
Hinojosa et al. [42]	Case series	15 (8)	61	9[d]	NR	NR	Colorectal cancer ($n = 14$); anal cancer ($n = 1$)	APR ($n = 15$)	Fair
Holman et al. [44]	Case series	51 (41)	62.2	32.4–86.8	NR	NR	Colorectal cancer ($n = 48$); anal cancer ($n = 3$)	APR ($n = 34$); abdominosacral resection ($n = 11$); debulking ($n = 6$)	Fair
Horch et al. [57]	Case control[a]	100 (38)	63.35	12.26[d]	26.3	20.45[d]	Vulvar/vaginal cancer ($n = 5$); urethra/bladder cancer ($n = 1$); uterine/cervical cancer ($n = 2$); colorectal cancer ($n = 73$); anal cancer ($n = 15$); prostate cancer ($n = 3$); melanoma ($n = 1$)	APR ($n = 86$); total exenteration ($n = 12$); resection of colon or rectum ($n = 2$)	Good
Houvenaeghel et al. [45]	Case series	46 (41)	52.7	26–72	NR	NR	Vulvar/vaginalcancer ($n = 2$); uterine/cervical cancer ($n = 24$); colorectal cancer ($n = 7$); anal cancer ($n = 11$); muller blastoma ($n = 1$); melanoma ($n = 1$)	Total vulvectomy ($n = 1$); APR ($n = 11$); total exenteration ($n = 11$); anterior exenteration ($n = 11$); posterior exenteration ($n = 10$); total colpohysterectomy ($n = 1$); atypical resection ($n = 1$)	Fair
Jain et al. [32]	Case series	15 (12)	45	16[d]	24.3	6–58	Vulvar/vaginalcancer ($n = 2$); uterine/cervical cancer ($n = 1$); colorectal cancer ($n = 10$); anal cancer ($n = 1$); benign colorectal disease ($n = 1$)	APR ($n = 5$); total exenteration ($n = 1$); posterior exenteration ($n = 9$)	Fair
Kouraklis et al. [33]	Case series	11 (NR)	70.6	63–79	NR	NR–24	Colorectal cancer ($n = 8$); gynaecologic ($n = 3$)	Radical pelvic surgery ($n = 11$)	Fair
Kroll et al. [29]	Case series	7 (NR)	NR	NR	NR	NR	NR	APR ($n = 7$)	Poor
Loessin et al. [50]	Case series	15 (3)	52	26–83	32[c]	6–56	Colorectal cancer ($n = 7$); anal cancer ($n = 1$); prostate cancer ($n = 1$);benign colorectal disease ($n = 4$); sarcoma ($n = 2$)	NR	Good
Nelson et al. [31]	Case control[b]	114 (72)	58	12[d]	24.2/18.0[c]	20.6[d]	Vulvar/vaginal cancer ($n = 2$); urethra/bladder cancer ($n = 10$); colorectal cancer ($n = 75$); anal cancer	APR ($n = 46$); exenteration ($n = 2$); total exenteration ($n = 23$); anterior	Good

(*continued*)

Continued.

Reference	Study design	No. of patients (no. of women)	Age (years)		Length of follow-up (months)		Indication for resection	Type of resection	Quality assessment score
			Mean	Range	Mean	Range			
							($n = 16$); prostate cancer ($n = 9$); unknown ($n = 2$)	exenteration ($n = 8$); posterior exenteration ($n = 35$)	
Núñez et al. [52]	Case series	6 (0)	36.3	30–42	26.5	2–41	Anal cancer ($n = 6$)	APR ($n = 6$)	Fair
Pang et al. [68]	Case control[b]	9 (3)	53.1	12.3[d]	178.6days	45.1 days[d]	Colorectal cancer ($n = 6$); anorectal cancer ($n = 2$); sarcoma ($n = 1$)	APR ($n = 9$)	Fair
Peacock et al. [54]	Case control (met mesh)	5 (1)	68[c]	48–74	29	23–35	Colorectal cancer ($n = 5$)	APR ($n = 5$)	Good
Petrie et al. [46]	Case series	14 (9)	63.9	47–81	9[c]	NR	Colorectal cancer ($n = 10$); anal cancer ($n = 4$)	APR ($n = 14$)	Fair
Pursell et al. [60]	Case series	22 (NR)	49.9	24–82	16.3	3–36	Vulvar/vaginal cancer ($n = 4$); uterine/cervical cancer ($n = 17$); colorectal cancer ($n = 1$)	Total exenteration ($n = 18$); anterior exenteration ($n = 3$); posterior exenteration ($n = 1$)	Fair
Sheckter et al. [49]	Case control[a,b]	9 (29[e])	57.94[e]	NR	421 days[e]	322 days[d,e]	Colorectal cancer ($n = 27$); anal cancer ($n = 17$); benign colorectal disease ($n = 4$); sarcoma ($n = 1$); melanoma ($n = 1$); hamartoma ($n = 1$); traumatic perineum ($n = 1$)[e]	APR ($n = 51$)[e]	Fair
Shepherd et al. [55]	Case series	16 (16)	55	25–77	29[c]	4–72	Vulvar/vaginal cancer ($n = 16$)	Partial vulvectomy ($n = 3$); total vulvectomy ($n = 6$); total exenteration ($n = 1$); anterior exenteration ($n = 4$); posterior exenteration ($n = 2$)	Fair
Smith et al. [47]	Case series	22 (NR)	52[c]	14.2	NR	NR	Vulvar/vaginal cancer ($n = 2$); urethra/bladder cancer ($n = 2$); uterine/cervical cancer ($n = 17$); colorectal cancer ($n = 1$)	Total exenteration ($n = 16$); anterior exenteration ($n = 4$); posterior exenteration ($n = 1$); excision vaginal stenosis ($n = 1$)	Fair
Stein et al. [59]	Case control[b]	61 (47)	62.4	11.6[d]	NR	NR	Vulvar/vaginal cancer ($n = 5$) ; uterine/cervical cancer ($n = 1$) ; colorectal cancer ($n = 42$) ; anal cancer ($n = 110$) ; benign colorectal disease ($n = 1$) ; perianal m. paget ($n = 1$)	APR ($n = 53$) ; exenteration ($n = 18$)	Fair
Tei et al. [61]	Case series	14 (13)	65.5[c]	45–78	14.5[c]	3–41	Anal cancer ($n = 14$)	APR ($n = 14$)	Fair
Touny et al. [30]	RCT	30 (9)	53.5[c]	26–68	25[e]	6–48[e]	Colorectal cancer ($n = 30$)	APR ($n = 30$)	Good

[a]Control group is primary closure.
[b]Control group are other flaps.
[c]Median.
[d]Standard deviation.
[e]Value for all study patients (no specific value for only VRAM-reconstruction patients available).
[f]Survivor versus non-survivor group.
APR: abdominoperineal resection; NR: not reported; RCT: randomized controlled trial; VRAM: vertical rectus abdominis myocutaneous.

Appendix D. Complications of included studies with VRAM flaps

Reference	Total number of complications (% patients with complications)[a]	Complications donor site			Complications recipient site			General complications
		Minor	Major	Specification	Minor	Major	Specification	
Bakx et al. [66]	15 (NR)	5	2	Wound infection ($n = 2$); partial wound dehiscence ($n = 1$); incisional herniation ($n = 4$)	7	1	Wound infection ($n = 1$); partial wound dehiscence ($n = 2$); seroma ($n = 4$); ongoing bleeding ($n = 1$)	Small bowel obstruction ($n = 1$); urostomy necrosis ($n = 1$)
Barker JA et al. [34]	8 (50.0)	1	0	Incisional herniation ($n = 1$)	5	2	Partial wound dehiscence ($n = 3$); partial flap loss ($n = 2$); complete flap loss ($n = 1$); sinus formation ($n = 1$)	Metastatis ($n = 2$); retracted stoma ($n = 1$); parastomal herniation ($n = 1$)
Barker T et al. [35]	15 (27.3)	0	1	Wound infection ($n = 1$)	11	3	Wound infection ($n = 1$); partial wound dehiscence ($n = 5$); large wound dehiscence ($n = 1$); partial flap loss ($n = 2$); complete flap loss ($n = 2$); hematoma ($n = 1$); excess granulation ($n = 1$); sinus formation ($n = 1$)	Myocardial infarction ($n = 1$)
Bell et al. [36]	10 (32.3)	3	0	Weakness abdominal wall ($n = 2$); abscess ($n = 1$)	3	4	Flap disunion ($n = 1$); partial flap loss ($n = 3$); stenosis ($n = 2$); scarring of vaginal wall ($n = 1$)	Urine retention ($n = 2$); urine fistula ($n = 1$); shock ($n = 2$)
Berger et al. [37]	45 (NR)	22	0	Partial wound dehiscence ($n = 22$)	22	1	Partial wound dehiscence ($n = 3$); partial flap loss ($n = 2$); complete flap loss ($n = 1$); abscess ($n = 14$); stenosis ($n = 3$)	NR
Buchel et al. [38]	14 (NR)	2	0	Wound infection ($n = 2$)	11	1	Partial wound dehiscence ($n = 2$); partial flap loss ($n = 7$); complete flap loss ($n = 1$); abscess ($n = 2$)	Small bowel obstruction ($n = 1$); retained drain ($n = 1$)
Butler et al. [7]	27 (NR)	NR	NR	Partial wound dehiscence ($n = 6$); incisional herniation ($n = 2$); delayed healing ($n = 1$)	14	4	Partial wound dehiscence ($n = 9$); large wound dehiscence ($n = 3$); complete flap loss ($n = 1$); abscess ($n = 3$); perineal herniation ($n = 2$)	Parastomal herniation ($n = 4$)
Casey III et al. [39]	13 (31.7)	NR	NR	Unknown ($n = 4$)	NR	NR	Vaginal fistula ($n = 1$); flap loss or dehiscence ($n = 5$); unknown ($n = 3$)	NR
Chessin et al. [5]	5 (NR)	NR	NR	Wound infection ($n = 2$)	2	1	Wound cellulitis ($n = 1$); partial wound dehiscence ($n = 1$); abscess ($n = 1$)	Deep venous thrombosis ($n = 2$); small bowel obstruction ($n = 3$); unknown ($n = 1$)
Chokshi et al. [48]	35 (NR)	13	0	Wound infection ($n = 7$); partial wound dehiscence ($n = 6$)	35	1	Large wound dehiscence ($n = 7$); complete flap loss ($n = 2$); abscess ($n = 10$); enterocutaneous fistula ($n = 3$); ventral herniation ($n = 14$)	Deep venous thrombosis ($n = 2$); urinary tract infection ($n = 3$); small bowel obstruction ($n = 1$)
Combs et al. [68]	34 (NR)	14	1	Partial wound dehiscence ($n = 13$); large wound dehiscence ($n = 2$)	9	10	Partial wound dehiscence ($n = 12$); large wound dehiscence ($n = 1$); partial flap loss ($n = 4$); complete flap loss ($n = 2$)	NR
Cortinovis et al. [62]	3 (12.5)	2	1	Partial wound dehiscence ($n = 1$); incisional herniation ($n = 1$); abscess ($n = 1$)	0	1	Stenosis ($n = 1$)	Parastomal herniation ($n = 1$); pelvic abscess ($n = 2$); atelectasis ($n = 1$); pulmonary inflammation ($n = 1$), ileovaginal fistula ($n = 1$); urinary retention ($n = 1$); sepsis ($n = 1$); intestinal fistula ($n = 1$); urethral stenosis ($n = 1$)

(*continued*)

Continued.

Reference	Total number of complications (% patients with complications)[a]	Complications donor site			Complications recipient site			General complications
		Minor	Major	Specification	Minor	Major	Specification	
Creagh et al. [40]	17 (NR)	5	0	Partial wound dehiscence ($n = 4$); umbilical necrosis ($n = 1$)	6	6	Wound infection ($n = 2$); partial wound dehiscence ($n = 3$); large wound dehiscence ($n = 4$); partial flap loss ($n = 1$); ongoing bleeding ($n = 1$); necrotic sacretomy ($n = 1$)	Myocardial infarction ($n = 1$); parastomal herniation ($n = 3$); ulnar nerve palsy ($n = 1$); cardiac arrhythmias ($n = 4$)
Erdmann et al. [41]	2 (16.7)	0	0	None	0	2	Partial flap loss ($n = 2$)	NR
Espinosa-de-los-Monteros et al. [51]	0 (0.0)	0	0	None	0	0	NR	Shock ($n = 1$)
Gupta et al. [58]	3 (60.0)	NR	NR	Partial wound dehiscence ($n = 1$); wound infection ($n = 1$)	NR	NR	Rectovaginal fistula ($n = 1$)	Deep venous thrombosis ($n = 2$); urinary tract infection ($n = 4$); ileus ($n = 7$); small bowel obstruction ($n = 4$); pneumonia ($n = 5$)
Haas, de et al. [42]	16 (NR)	2	1	Wound infection ($n = 2$); incisional herniation ($n = 1$)	NR	NR	Delayed healing ($n = 9$); partial flap loss ($n = 1$); complete flap loss ($n = 2$); enterocutaneous fistula ($n = 1$)	NR
Hardt et al. [52]	7 (85.7)	0	0	None	6	1	Wound infection ($n = 6$); partial flap loss ($n = 1$)	NR
Haverland et al. [56]	1 (16.7)	0	0	None	0	1	Abscess ($n = 1$)	Small bowel obstruction ($n = 1$); pyelonephritis ($n = 1$)
Hinojosa et al. [43]	10 (NR)	3	0	Partial wound dehiscence ($n = 3$)	6	1	Wound infection ($n = 1$); partial wound dehiscence ($n = 5$); abscess ($n = 1$)	Urinary tract infection ($n = 1$); ileus ($n = 1$); ostomy ulceration ($n = 1$)
Holman et al. [44]	14 (NR)	NR	NR	NR	10	4	Partial flap loss ($n = 3$); abscess ($n = 7$); stenosis ($n = 4$)	NR
Horch et al. [57]	17 (NR)	NR	NR	Unknown ($n = 6$)	NR	NR	Complete flap loss ($n = 2$); unknown ($n = 9$)	NR
Houvenaeghel et al. [45]	16 (NR)	5	1	Wound infection ($n = 4$); incisional herniation ($n = 1$); mesh dehiscence ($n = 1$)	5	5	Partial wound dehiscence ($n = 6$); large wound dehiscence ($n = 1$); partial flap loss ($n = 1$); complete flap loss ($n = 1$); abscess ($n = 1$)	Major surgical ($n = 9$); minor surgical ($n = 3$); parietal ($n = 7$); medical ($n = 5$)
Jain et al. [32]	6 (26.7)	1	0	Wound infection ($n = 1$)	3	2	Delayed healing ($n = 2$); wound infection ($n = 1$); partial wound dehiscence ($n = 1$); partial flap loss ($n = 1$)	NR
Kouraklis et al. [33]	2 (NR)	1	0	Hypogastric bulge ($n = 1$)	0	1	Ongoing bleeding ($n = 1$)	Gastrointestinal bleeding ($n = 1$)
Kroll et al. [29]	2 (28.6)	0	1	Incisional herniation ($n = 1$)	1	0	Pedicled damage ($n = 1$)	NR
Loessin et al. [50]	9 (53.3)	1	0	Wound infection ($n = 1$)	5	3	Partial flap loss ($n = 2$); hematoma ($n = 1$); abscess ($n = 1$); sinus formation ($n = 3$); urethral disruption ($n = 1$)	NR
Nelson et al. [31]	154 (NR)	NR	NR	Wound infection ($n = 4$); cellulitis ($n = 7$); partial wound dehiscence ($n = 13$); large wound dehiscence ($n = 3$); incisional herniation ($n = 4$); abscess ($n = 4$); fluid collection ($n = 8$); seroma ($n = 6$); haematoma ($n = 2$); other ($n = 8$)	NR	NR	Wound infection ($n = 6$); cellulitis ($n = 5$); partial wound dehiscence ($n = 37$); large wound dehiscence ($n = 6$); partial flap loss ($n = 6$); complete flap loss ($n = 1$); seroma ($n = 7$); abscess ($n = 7$); fluid collection ($n = 14$); perineal herniation ($n = 1$); other ($n = 5$)	Urinary tract infection ($n = 11$); parastomal herniation ($n = 8$); small bowel obstruction ($n = 6$); other ($n = 25$)
Núñez et al. [52]	2 (33.3)	0	0	None	2	0	Seroma ($n = 1$); sinus formation ($n = 1$)	NR

(*continued*)

Continued.

Reference	Total number of complications (% patients with complications)[a]	Complications donor site			Complications recipient site			General complications
		Minor	Major	Specification	Minor	Major	Specification	
Pang et al. [68]	14 (NR)	0	1	Incisional herniation ($n = 1$)	12	1	Delayed healing ($n = 1$); wound infection ($n = 5$); partial wound dehiscence ($n = 6$); ongoing bleeding ($n = 1$)	Small bowel obstruction ($n = 1$)
Peacock et al. [54]	4 (NR)	0	0	None	NR	NR	Wound infection ($n = 1$); complete flap loss ($n = 1$); hematoma ($n = 1$); sinus formation ($n = 1$)	Ileus ($n = 1$)
Petrie et al. [46]	13 (78.6)	2	0	Sinus formation ($n = 1$); delayed healing ($n = 1$)	8	3	Superficial epidermiolysis ($n = 4$); partial wound dehiscence ($n = 3$); lymphocutaneous fistula ($n = 1$); urethral/urethric damage ($n = 3$)	Urinary tract infection ($n = 1$); urine retention ($n = 1$); pneumonia ($n = 1$)
Pursell et al. [60]	21 (NR)	10	2	Wound infection ($n = 3$); partial wound dehiscence ($n = 9$)	7	2	Wound infection ($n = 3$); partial flap loss ($n = 3$); complete flap loss ($n = 1$); vaginal fistula ($n = 1$); prolaps neovagina ($n = 1$)	Ischemic leg ($n = 1$)
Sheckter et al. [49]	0 (0.0)	0	0	None	0	0	None	Failure to thrive ($n = 1$); delayed viscous injury ($n = 1$)
Shepherd et al. [55]	4 (NR)	0	0	None	3	1	Partial flap loss ($n = 2$); complete flap loss ($n = 1$); abscess ($n = 1$)	Deep venous thrombosis ($n = 1$); urinary tract infection ($n = 3$); pulmonary embolus ($n = 1$)
Smith et al. [47]	25 (NR)	5	4	Wound infection ($n = 5$); partial wound dehiscence ($n = 2$); large wound dehiscence ($n = 2$)	NR	NR	Partial flap loss ($n = 1$); complete flap loss ($n = 1$); hematoma ($n = 1$); stenosis ($n = 5$); vaginal fistula ($n = 1$); urethral/urethric damage ($n = 7$)	NR
Stein et al. [59]	63 (NR)	NR	NR	Wound infection ($n = 4$); partial wound dehiscence ($n = 5$); large wound dehiscence ($n = 3$); necrosis ($n = 5$)	NR	NR	Wound infection ($n = 12$); partial wound dehiscence ($n = 13$); large wound dehiscence ($n = 4$); partial flap loss ($n = 4$); complete flap loss ($n = 5$); seroma ($n = 3$); hematoma ($n = 2$); cellulitis ($n = 3$)	Deep venous thrombosis ($n = 2$); urinary tract infection ($n = 4$); small bowel obstruction ($n = 4$); ileus ($n = 7$)
Tei et al. [61]	16 (NR)	5	2	Large wound dehiscence ($n = 2$); incisional herniation ($n = 3$); sensory disorders ($n = 2$)	9	0	Superficial epidermiolysis ($n = 6$); stenosis ($n = 3$)	Small bowel obstruction ($n = 1$)
Touny et al. [30]	24 (NR)	NR	NR	Wound infection ($n = 6$); incisional herniation ($n = 6$); burst abdomen ($n = 3$)	NR	NR	Delayed healing ($n = 3$); wound infection ($n = 3$); partial wound dehiscence ($n = 2$); abscess ($n = 1$)	Deep venous thrombosis ($n = 3$); shock ($n = 1$)

[a]Total number of complications of the reconstruction site reported and percentage of patients with one or more complications.
[b]Value for all study patients (no specific value for only VRAM-reconstruction patients available); (p) pre-surgery; (i) intra-operative.
NR: not reported; VRAM: vertical rectus abdominis myocutaneous