Use of Adjuvant Techniques Improves Surgical Outcomes of Complex Vertical Rectus Abdominis Myocutaneous Flap Reconstructions of Pelvic Cancer Defects

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Background: Reconstruction of irradiated pelvic defects following oncologic resection requires dead-space obliteration to reduce wound healing complications. Although the vertical rectus abdominis myocutaneous (VRAM) flap is often the best option for pelvic reconstruction following abdominoperineal resection or pelvic exenteration, donor- and recipient-site complications are common. The authors hypothesized that certain adjuvant techniques would improve pelvic VRAM flap outcomes.
Methods: Six technical modifications to improve VRAM flap outcomes were evaluated: fascia-sparing VRAM flap, component separation donor-site closure, inlay mesh abdominal reinforcement, deepithelialized VRAM flap skin paddle, extended VRAM flap, and omental flap plus VRAM flap. Prospectively collected data from consecutive patients with immediate pelvic VRAM flap reconstruction from 2001 to 2009 were analyzed retrospectively. Donor- and recipient-site complications were compared between patients treated with each technical modification and all other study patients.
Results: One hundred eighty-five patients were included (mean follow-up, 25.1 months). Fascia-sparing VRAM flaps resulted in significantly fewer hernias (1.5 percent versus 11.5 percent, $p < 0.01$), with less dehiscence, abdominal bulge, and evisceration. Patients receiving donor-site mesh inlay had fewer postoperative hernias (2.6 percent versus 5.5 percent) but more abdominal laxity/bulge (7.7 percent versus 0 percent, $p = 0.01$). Minor recipient-site dehiscence was significantly lower with omental plus VRAM flaps (11.1 percent versus 32.5 percent, $p < 0.05$) and extended VRAM flaps (7.7 percent versus 30.8 percent, $p < 0.05$). Multivariate logistic regression identified omental plus VRAM flaps as protective against ($p < 0.05$), and increasing body mass index as predictive for ($p = 0.009$), perineal skin dehiscence.
Conclusions: Several technical modifications of VRAM flap reconstruction improve pelvic reconstruction outcomes and should be considered. Further prospective studies will be important to elucidate specific indications for each technique. (*Plast. Reconstr. Surg.* 128: 447, 2011.)

Patients undergoing extensive pelvic resections benefit from flap reconstruction to obliterate dead space with well-vascularized tissue.[1] Rectal or pelvic cancers requiring abdominoperineal resection or pelvic exenteration after radiotherapy[2] have been associated with complication rates of up to 66 percent when immediate flap reconstruction is not performed.[3–9]

The pedicled vertical rectus abdominis myocutaneous (VRAM) flap is often the best option for pelvic reconstruction after abdominoperineal resection or pelvic exenteration because of

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Received for publication December 3, 2010; accepted February 18, 2011.
Presented at the American Society of Plastic Surgeons Annual Scientific Meeting, in Toronto, Ontario, Canada, October 1 through 5, 2010.

DOI: 10.1097/PRS.0b013e31821e6fd2

Disclosure: *The authors have no financial interest to declare in relation to the content of this article.*

its robust vascularity and available soft-tissue bulk.[10,11] Immediate VRAM flap reconstruction has been definitively shown to decrease pelvic/perineal wound healing complications and need for reoperation compared with primary perineal closure.[3,12–26] However, even with immediate flap reconstruction, previous radiotherapy; a large, noncollapsible bony pelvic defect; and dependent location of the defect all contribute to a high frequency of recipient-site complications after reconstruction.[1,19–22]

VRAM flap harvest precludes an additional donor site, as it uses the midline laparotomy required for most pelvic cancer resections, making it more convenient than other flaps, which require an additional incision and have inferior outcomes.[10,23] When compared with thigh-based flaps, such as the anterolateral thigh flap or gracilis myocutaneous flap, the superior complication profile, posterior and caudal reach of the flap, and bulk available for reconstruction make the VRAM flap the optimal choice for immediate pelvic reconstruction.[9,10,23,24] However, because the VRAM flap includes the rectus muscle and fascia, it potentially could increase the risks of abdominal donor-site hernia and bulge.[25]

In an effort to improve both recipient- and donor-site outcomes of immediate pelvic reconstruction, several technical modifications have been made to the VRAM flap technique. We hypothesized that these adjuvant techniques would improve pelvic VRAM flap outcomes. To test this hypothesis, we analyzed data from consecutive patients who underwent immediate pelvic VRAM flap reconstruction at our institution from 2001 to 2009 and compared donor- and recipient-site complications for each technical modification.

PATIENTS AND METHODS

Study Design

We retrospectively searched a departmental database for selected data that had been collected prospectively from all consecutive patients undergoing immediate VRAM flap reconstruction after abdominoperineal resection or pelvic exenteration from January 1, 2001, to August 31, 2009, at the University of Texas M. D. Anderson Cancer Center. This study was approved by M. D. Anderson Cancer Center's Institutional Review Board.

Attending surgeons within a single reconstructive plastic surgery practice performed the operations studied. Use of the technical modifications described below was based solely on the surgeon's decision that the patient would benefit in each case based on specific donor- and recipient-site characteristics (Table 1 and Fig. 1). Informed consent was obtained from all patients, who were treated in the same clinic, with standardized general reconstructive strategy, postoperative care, and follow-up. Patients were excluded from the study if they had received an additional (except omental) flap for reconstruction or had less than 6 months of follow-up.

The database was reviewed to determine the VRAM treatment used: standard VRAM flap or one or more of the six technical VRAM flap modifications. All patients identified as being treated with a technical modification were compared with the remaining patients without that one modification (i.e., patients with the fascia-sparing technique were compared with all patients who did not have fascia spared, regardless of other technical modifications used). It was common for patients to have been treated with more than one technical modification based on specific donor- and recipient-site characteristics.

For this study, it was not clinically feasible or appropriate to stratify patients to a single technical modification when more than one adjunctive technique was required. Therefore, the statistical analysis was designed to isolate the benefit of each technical modification across patients.

Table 1. Potential Benefits of Adjuvant Techniques

Technique	Potential Benefits
Extended VRAM flap	Additional flap bulk and/or reach
Fascia-sparing	Less fascial closure tension, lower hernia/bulge rate
Component separation donor-site closure	Less fascial closure tension, lower hernia rate, less need for mesh closure
Mesh fascial closure	Less fascial tension (bridged technique), reinforcement of fascial closure strength
Addition of greater omental flap	Further reduced pelvic dead space, additional vascularized tissue to pelvis
Deepithelialized skin paddle	Bulk and skin redundancy of skin paddle eliminated, greater volume of flap located within pelvis, reduced potential vascular compromise because of transposing large skin pedicle through a tight pelvic outlet, inset deepithelialized skin paddle to pelvic outlet serves as pelvic sling

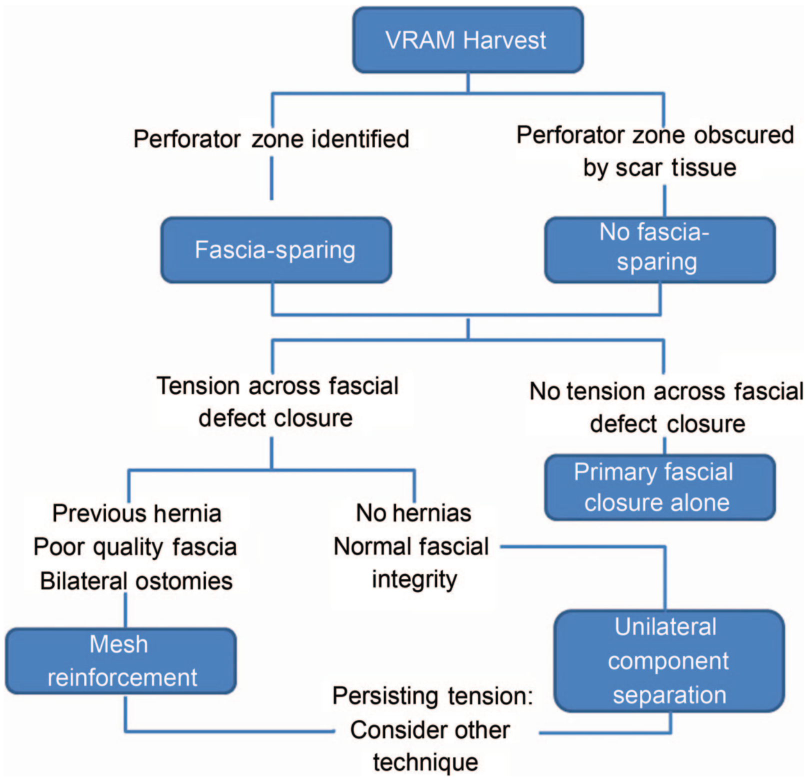

Fig. 1. Algorithm of indications for abdominal donor-site VRAM flap technical modifications.

VRAM Flap Technical Modifications

Techniques Intended to Improve Donor-Site Outcomes

Fascia sparing. Anterior rectus fascia-sparing was defined as the preservation of all anterior rectus fascia peripheral to the lateral/medial row rectus abdominis myocutaneous perforating vessels and was performed on all patients with perforators that could be easily identified (Fig. 2).[26] Fascia-sparing was not performed when previous surgery, adjacent hernia sacs, or significant scarring limited perforator identification or patency.

Component separation. Unilateral component separation was used when the fascial defect created by VRAM flap harvest could not be closed at all or without excessive tension, as determined by the surgeon. This technique was not used in the presence of a hernia or poor fascial integrity. Because most cases required at least one ostomy, a unilateral, ipsilateral technique was used. Component separation for VRAM flap donor-site closure was performed as described previously by Baumann and Butler (Fig. 3).[27]

Mesh reinforcement. Abdominal wall mesh reinforcement was used when fascial closure could not be completed without significant tension for patients with preexisting ventral hernias, previous surgery, or poor fascial integrity. Inlay bioprosthetic mesh reinforcement (without fascial bridging) was used when the overlying fascia was able to be completely approximated over the bioprosthetic mesh. Polypropylene mesh was generally used when the posterior sheath could be completely closed but the anterior fascial defect edges could not be approximated. Abdominal mesh was added to component separation when component release did not allow the fascial layers to be approximated without excessive tension, requiring inlay mesh placement for load-sharing reinforcement, as described previously.[27]

Techniques Intended to Improve Recipient-Site Outcomes

Deepithelialized skin paddle. For patients with thick flaps, narrow pelvic outlets, and tension-free closure of perineal skin flaps, the entire VRAM flap skin paddle was deepithelialized before final transposition into the pelvis (Fig. 4. The deepithelialized VRAM flap paddle was designed to reduce perineal bulk with the legs adducted, serve as a hammock-like pelvic floor repair, and buttress the closure of irradiated perineal skin flaps (Fig. 5).

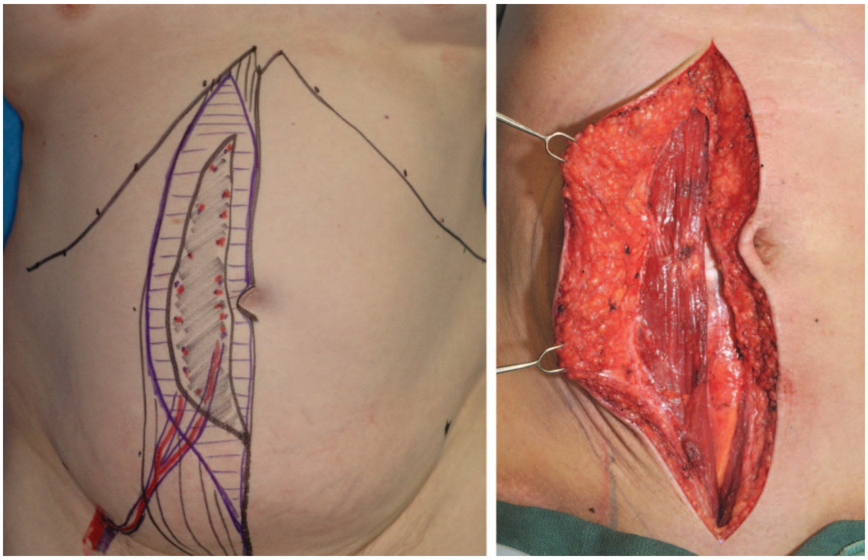

Fig. 2. Fascia-sparing VRAM flap harvest. (*Left*) Preoperative markings showing cutaneous position of the deep inferior epigastric perforator zone representing the limited fascial area to be harvested. The surrounding fascia with *horizontal hashed markings* will be preserved. (*Right*) Midline incision with medial fascia preserved up to the medial row perforators.

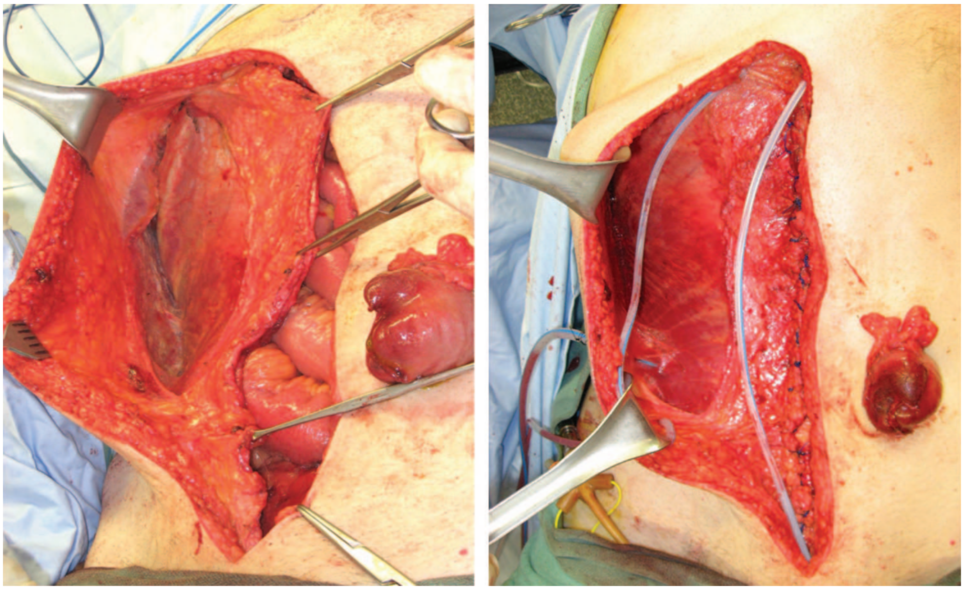

Fig. 3. Component separation donor-site closure. (*Left*) Incision and release of external oblique aponeurosis lateral to the semilunar line allows medialization of the fascial edge brought to the midline with Alice clamps. (*Right*) Fascial closure completed with the aid of unilateral component separation.

Extended VRAM flap. The extended VRAM flap design is supplied by the standard VRAM flap perforator zone with the skin paddle, but not the underlying fascia, extending beyond the costal margin to the anterior axillary line (Fig. 6). The extended VRAM flap provides a greater volume of vascularized tissue to fill the pelvis and can reach more posteriorly oriented pelvic defects. It is indicated when abdominoperineal resection or pelvic exenteration is accompanied by very large dead space and/or extensive perineal skin resection. The inclusion of the entire ipsilateral periumbil-

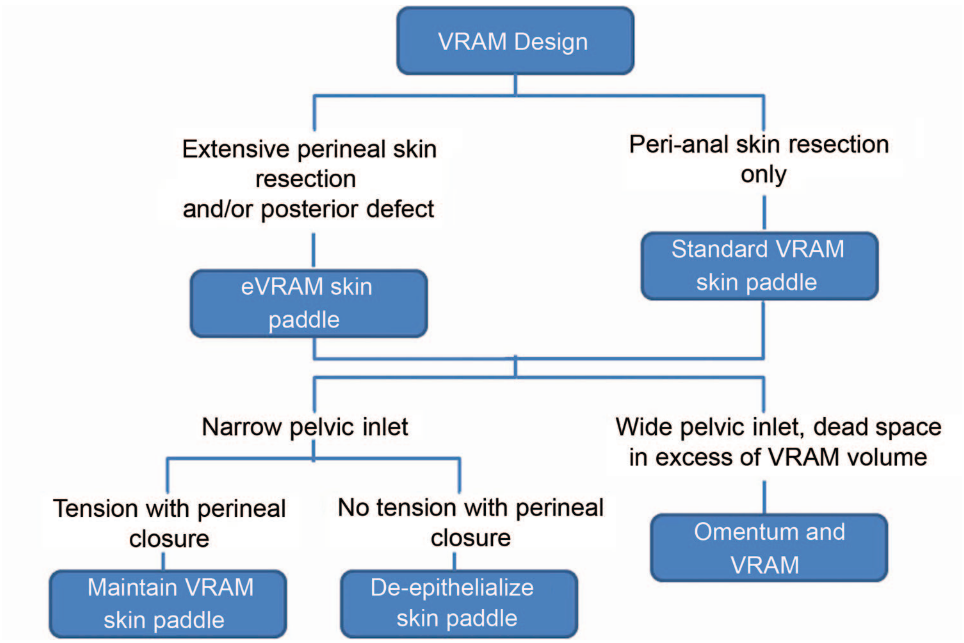

Fig. 4. Algorithm of indications for pelvic recipient-site VRAM flap technical modifications.

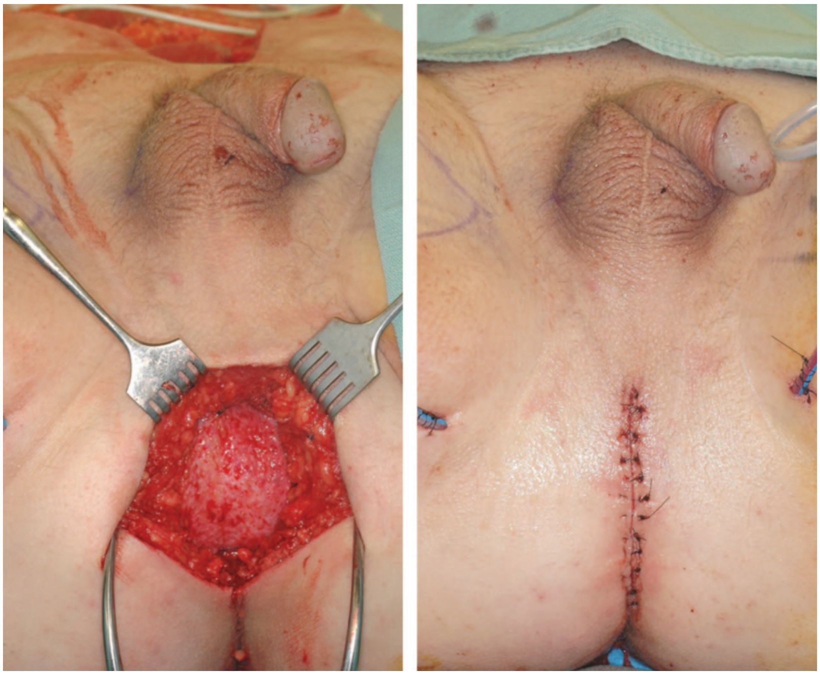

Fig. 5. Deepithelialized VRAM flap skin paddle. (*Left*) Deepithelialized VRAM flap within a perineal defect. (*Right*) Overlying perineal skin flaps closed without tension over the deepithelialized VRAM flap, which allows the volume of the flap to stay within the pelvis to obliterate dead space and provide better pelvic floor support.

ical perforator zone improves the viability of the extended VRAM over oblique designs and brings a greater skin paddle without necessitating a delay procedure.[26,28–30]

Omental flap. A pedicled omental flap was harvested for patients with wide pelvic inlets when the pelvic dead space was not obliterated completely by the VRAM flap alone. The omental flap was

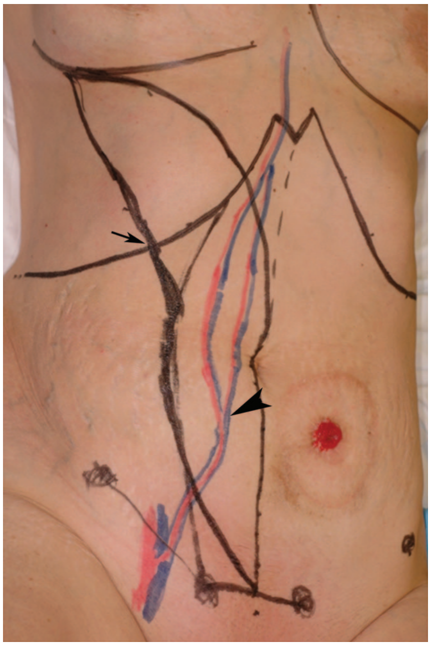

Fig. 6. Extended VRAM flap design. Skin paddle design for an extended VRAM crossing the costal margin with superior border parallel to the rib orientation and reaching laterally to the anterior axillary line. The *black arrow* marks the skin paddle crossing the costal margin, and the *arrowhead* marks the deep inferior epigastric pedicle in the central aspect of skin paddle.

harvested through the existing midline laparotomy incision based on either the left or right gastroepiploic vessels transposed along the paracolic gutter and inset cranial to the intrapelvic VRAM flap reconstruction.

Outcome Analysis

Patients were counted within each donor- and recipient-site modification group for every technical modification they received. It was therefore possible for patients to be in multiple donor- or recipient-site modification groups. The "control" for each technical modification group consisted of all patients who did not receive that one technical modification but who may have received others.

Patient and diagnostic characteristics were compared between technical modification groups and the overall study population to ensure homogeneity among patient groups. Patient characteristics included age, sex, body mass index, tobacco use, and medical comorbidities (i.e., diabetes mellitus, congestive heart failure, and chronic obstructive pulmonary disease). Diagnostic characteristics recorded included preexisting ventral hernia (confirmed by computed tomography) and previous midline laparotomy, perineal resection, or pelvic irradiation.

Each abdominal donor-site technical modification group was compared with its control for the following postoperative outcomes: abscess, subcutaneous fluid collection, cellulitis, minor (<5 cm in length) or major (≥5 cm in length) dehiscence, bulge, evisceration, hernia, or abdominal site reoperation. Fluid collections included hematomas and seromas identified by physical examination, ultrasonography, or computed tomographic imaging. Bulge was defined as an abdominal convexity not associated with a true fascial deficit according to physical examination or computed tomographic scan.

Each recipient-site technical modification group was compared with control patients without that technique for the following postoperative outcomes: partial or complete flap loss, pelvic abscess, pelvic fluid collection, cellulitis, minor (<5 cm in length) or major (≥5 cm in length) dehiscence, and pelvic site reoperation. Flap loss was considered partial when more than 50 percent of the flap remained viable; otherwise, it was considered total.

Statistical Analysis

Age was compared between technical modification groups using one-way analysis of variance with a Tukey post hoc test for multiple comparisons. Body mass index was analyzed between groups with the Kruskal-Wallis analysis. All other patient and diagnostic characteristics were categorical variables analyzed using the chi-square or Fisher's exact test. Univariate analysis of recipient- and donor-site outcomes between each technical modification group and its control was performed with Fisher's exact test or the chi-square test, as appropriate.

Stepwise multivariate logistic regression analyses were modeled to isolate the impact of each abdominal donor-site technical modification and select patient characteristics that were potentially predictive or protective for bulge, evisceration, and hernia. Recipient-site technical modifications and select diagnostic characteristics were modeled to isolate their individual impact on major or minor pelvic wound dehiscence. Analyses were performed using SigmaStat 3.1 (Systat Software, Inc., Chicago, Ill.).

RESULTS

A total of 185 (76 men) consecutive patients were included. The mean follow-up was 2.1 years (range, 0.5 to 8.5 years). The most common primary diagnosis was rectal adenocarcinoma, followed by perineal squamous cell carcinoma, which together accounted for 70 percent of the cases (Table 2).

At the time of surgery, the mean patient age was 58 years (range, 23 to 85 years) and the mean body mass index was 27 kg/m^2 (range, 17 to 64 kg/m^2) (Table 3). There were no statistically significant differences between technical modification groups for demographics, patient characteristics, or comorbidities (Tables 4 and 5).

Seventy-two percent of patients received preoperative pelvic radiotherapy (mean dose, 52 ± 14.6 Gy) and 78 percent had preoperative chemotherapy. Twelve percent of patients had a preoperative midline hernia and 47 percent had previous abdominal surgery. One hundred thirty-two patients (71 percent) had abdominoperineal resection, whereas 53 patients (29 percent) underwent pelvic exenteration. Forty-one percent of women underwent partial vaginectomy, 90 percent of which were closed with VRAM flaps. Four percent of patients required partial sacrectomy, and 5 percent required partial coccygectomy at the time of resection. There were no differences in diagnostic characteristics between groups (Tables 6 and 7).

Donor-Site Outcomes

One hundred thirty-three patients underwent VRAM flap harvest with the fascia-sparing technique, and 12 underwent unilateral component separation. Thirty-nine patients had mesh reinforcement (30 inlay bioprosthetic and nine polypropylene).

Patients who underwent the fascia-sparing technique had a statistically significant, eight-fold lower incidence of hernias than patients who did not undergo this technique (1.5 percent versus 11.5 percent, $p < 0.01$). There was also a lower incidence of bulge, evisceration, donor-site dehiscence, cellulitis, and reoperation; however, these differences were not significant (Table 8).

Table 2. Patient Oncologic Diagnoses

Diagnosis	No. (%)
Rectal adenocarcinoma	92 (50)
Perineal squamous cell carcinoma*	37 (20)
Transitional cell adenocarcinoma	13 (7)
Prostate adenocarcinoma	11 (6)
Anal adenocarcinoma	10 (5)
Sarcoma	9 (5)
Other†	13 (7)
Total	185 (100)

*Includes vulvar, urethral, and penile squamous cell carcinoma requiring perineal resection.
†Includes colon, vulvar, and urethral adenocarcinoma; anal and rectal melanoma; vaginal squamous cell carcinoma and rhabdomyosarcoma; appendiceal carcinoma; and metastatic thyroid cancer.

Table 3. Patient Characteristics and Comorbidities

	Value (%)
Age, years	
Mean	57.9
Range	22.9–85.8
BMI	
Mean	27
Range	17–64
Hypertension	73 (39.5)
Smoker	35 (18.9)
Diabetes	20 (10.8)
COPD	19 (10.3)
CAD	13 (7.0)
Psychiatric illness	16 (8.6)
Renal insufficiency	13 (7.0)
Liver disease	7 (3.8)
Substance abuse	5 (2.7)
Previous laparotomy	87 (47)
Previous ventral hernia	20 (15.7)

BMI, body mass index; COPD, chronic obstructive pulmonary disease; CAD, coronary artery disease.

Patients who underwent component separation had a lower incidence of every donor-site complication studied, with the exception of bulge/hernia. None of these differences, however, was statistically significant (Table 8).

Patients who underwent mesh closure at the time of VRAM flap surgery had a significantly higher incidence of postoperative bulge compared with those without mesh closure (7.7 percent versus 0 percent, $p < 0.01$), but they had a lower incidence of hernia (2.6 percent versus 5.5 percent) and wound dehiscence (2.6 percent versus 8.3 percent) (Table 8). There was no difference in hernia or bulge rate when the mesh used was bioprosthetic versus polypropylene. Twenty percent of these patients had preoperative hernias (compared with 10 percent overall) and 59 percent had previous midline laparotomies (47 percent overall, not significant) (Table 6).

Recipient-Site Outcomes

Fifty-four patients had deepithelialized VRAM flap skin paddles, 25 patients had an omental flap and VRAM flap, and 13 patients had extended VRAM flaps. Patients with deepithelialized VRAM flap paddles demonstrated a lower minor dehiscence rate (20.4 percent) compared with those with a skin paddle (32.8 percent); however, the difference was not significant (Table 9). There was no compromise in flap vascularity and viability, as evidenced by the similar rates of partial flap loss

Table 4. Patient Characteristics and Comorbidities in the Donor-Site Technical Modification Groups

	VRAM Flap Total (%)	Fascia-Sparing VRAM Flap (%)	Component Separation (%)	Mesh (%)	p
No.	185	133	12	39	
Mean age, years	57.7	57.6	62.5	58.7	0.78
Sex (M/F)	76/109	55/78	5/7	17/22	0.97
Mean BMI	27.0	27.6	25.3	27.6	0.92
DM	20 (10.8)	15 (11.3)	0 (0)	4 (10.3)	0.47
CHF	4 (2.2)	4 (3.0)	2 (16.7)	1 (2.6)	0.29
COPD	19 (10.3)	14 (10.5)	1 (8.3)	6 (15.4)	0.82
Smoker	35 (18.9)	21 (15.8)	3 (25.0)	6 (10.9)	0.78

M, male; F, female; BMI, body mass index; DM, diabetes mellitus; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease.

Table 5. Patient Characteristics and Comorbidities in the Recipient-Site Technical Modification Groups

	VRAM Flap Total (%)	Extended VRAM Flap (%)	Omental Flap (%)	Deepithelialized Skin Paddle (%)	p
No.	185	13	25	54	
Mean age, years	57.7	58.1	58.1	58.3	0.89
Sex (M/F)	76/109	6/7	12/13	17/37	0.45
BMI	27.1	28.1	27.7	27.4	0.84
DM	20 (10.8)	1 (7.7)	2 (7.7)	3 (5.5)	0.66
CHF	4 (2.2)	1 (7.7)	2 (7.7)	2 (3.6)	0.44
COPD	19 (10.3)	1 (7.7)	1 (3.8)	5 (9.1)	0.73
Smoker	35 (18.9)	2 (15.4)	7 (27)	7 (12.7)	0.45

M, male; F, female; BMI, body mass index; DM, diabetes mellitus; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease.

Table 6. Patient Characteristics of the Donor-Site Technical Modification Groups

	VRAM Flap Total (%)	Fascia-Sparing VRAM Flap (%)	Component Separation (%)	Mesh (%)	p
No.	185	133	12	39	
Prior surgery	87 (47.0)	55 (41.4)	5 (41.7)	23 (59.0)	0.52
Previous ventral hernia	20 (10.8)	11 (8.3)	0 (0.0)	8 (20.5)	0.10
Chemotherapy	144 (77.8)	104 (78.2)	8 (66.7)	26 (66.7)	0.40

Table 7. Patient Characteristics of the Recipient-Site Technical Modification Groups

	VRAM Flap Total (%)	Extended VRAM Flap (%)	Omental Flap (%)	Deepithelialized Skin Paddle (%)	p
No.	185	13	25	54	
Perineal resection	133 (71.9)	12 (92.3)	18 (69.2)	33 (60.0)	0.17
Prior radiotherapy	128 (69.2)	12 (92.3)	17 (65.4)	36 (65.5)	0.24
Chemotherapy	141 (76.2)	12 (92.3)	19 (73.1)	43 (78.2)	0.49

(3.7 percent) and reoperation (13.0 percent) as compared with those of patients with a skin paddle (3.8 percent and 13.7 percent, respectively).

The addition of an omental flap to VRAM flap pelvic/perineal reconstruction yielded a significantly lower minor dehiscence rate (11.1 percent versus 32.5 percent, $p < 0.05$), fewer fluid collections (0 percent versus 5.6 percent, p = not significant) and a decreased reoperation rate (7.4 percent versus 14.4 percent, p = not significant) (Table 9).

The extended VRAM flap was associated with a decreased incidence of all recipient-site complications, although the differences were not significant (Table 9). Flap viability was maintained, with no partial flap loss, despite using the entire flap for the reconstruction. Ninety-two percent of patients requiring extended VRAM flaps had perineal skin resection and pelvic radiation therapy, compared with 72 percent and 69 percent, respectively, for the entire study population (Table 7).

Multivariate logistic regression analysis showed that the addition of an omental flap to VRAM flap reconstruction was associated with a more than three-fold reduction in perineal wound dehiscence (odds ratio, 0.292; 95 percent confidence interval, 0.09 to 0.95; $p < 0.05$) (Table 10). Higher body mass

Table 8. Donor-Site Complications as a Function of Donor-Site Closure Technique

	FS (%)	Control (%)*	CS (%)	Control (%)*	Mesh (%)	Control (%)*
No.	133	52	12	173	39	146
Abscess	2 (1.5)	1 (1.9)	0 (0)	3 (1.7)	2 (5.1)	1 (0.7)
Fluid collection	4 (3.0)	1 (1.9)	0 (0)	5 (2.9)	1 (2.6)	4 (2.7)
Cellulitis	3 (2.3)	2 (3.8)	0 (0)	5 (2.9)	1 (2.6)	4 (2.7)
Minor dehiscence	6 (4.5)	4 (7.7)	0 (0)	10 (5.8)	1 (2.6)	9 (6.2)
Major dehiscence	2 (1.5)	1 (1.9)	0 (0)	3 (1.7)	0 (0)	3 (2.1)
Bulge	2 (1.5)	1 (1.9)	1 (8.3)	2 (1.2)	3 (7.7)†	0 (0)
Evisceration	1 (0.8)	1 (1.9)	0 (0)	2 (1.2)	0 (0)	2 (1.4)
Hernia	2 (1.5)†	6 (11.5)	1 (8.3)	8 (4.6)	1 (2.6)	8 (5.5)
Reoperation	16 (12.0)	9 (17.3)	0 (0)	25 (14.5)	7 (18.0)	18 (12.3)
Partial flap loss	7 (5.3)	0 (0)				

FS, fascia-sparing; CS, component separation.
*All VRAM flap patients without technical modification listed.
†$p \leq 0.01$ by Fisher's exact test compared to control without that modification.

Table 9. Recipient-Site Complications as a Function of Recipient-Site Technique

	Deepithelialized Perineal Skin Paddle (%)	Control (%)*	Omental (%)†	Control (%)*	Expanded VRAM Flap (%)	Control (%)*
No.	54	131	25	160	13	172
Partial flap loss	2 (3.7)	5 (3.8)	1 (3.7)	6 (3.8)	0 (0)	7 (4.1)
Abscess	0 (0)	4 (3.1)	1 (3.7)	3 (1/9)	0 (0)	4 (2.3)
Fluid collection	2 (3.7)	7 (5.4)	0 (0)	9 (5.6)	0 (0)	9 (5.3)
Cellulitis	0 (0)	2 (1.5)	1 (3.7)	1 (0.6)	0 (0)	2 (1.2)
Minor dehiscence	11 (20.4)	43 (32.8)	3 (11.1)‡	52 (32.5)	1 (7.7)‡	53 (30.8)
Major dehiscence	6 (11.1)	10 (7.6)	2 (7.4)	14 (8.8)	1 (7.7)	15 (8.7)
Reoperation	7 (13.0)	18 (13.7)	2 (7.4)	23 (14.4)	1 (7.7)	24 (14.0)

*All VRAM patients without technical modification listed.
†VRAM plus omental flap.
‡$p < 0.05$ by Fisher's exact test compared to control without that modification.

Table 10. Multivariate Logistic Regression for Factors Affecting Recipient-Site Dehiscence (Minor and Major Dehiscence)

Variable	Odds Ratio	95% Confidence Interval	*p*
Omental flap	0.292	0.09–0.95	<0.05*
BMI	1.070	1.017–1.125	0.009†
Diabetes mellitus	1.241	0.45–3.4	0.67
Expanded VRAM flap	0.303	0.06–1.5	0.15
Deepithelialized VRAM flap skin paddle	0.760	0.37–1.57	0.46
Prior radiotherapy	1.717	0.84–3.51	0.14

BMI, body mass index.
*$p < 0.05$.
†$p < 0.01$.

Table 11. Multivariate Logistic Regression for Factors Affecting Donor-Site Hernia/Bulge/Evisceration

Variable	Odds Ratio	95% Confidence Interval	*p*
Fascia-sparing	0.659	0.194–1.384	0.189
Mesh inlay	0.244	0.238–2.581	0.689

index was an independent predictor of perineal dehiscence (odds ratio, 1.070; 95 percent confidence interval, 1.017 to 1.125; $p = 0.009$). Multiple regression analysis for donor-site outcomes was underpowered because of the relatively low number of complications (Table 11).

DISCUSSION

In this study, we evaluated the impact of technical modifications designed to minimize the donor-site morbidity and perineal wound complications associated with VRAM flap pelvic reconstruction. Our goal was to describe techniques that are currently being used at our institution that might assist surgeons in the performance of VRAM flap harvest while minimizing donor deficits and producing a healthy flap with significant bulk to decrease recipient-site complications. Our results show that several technical modifications of VRAM flap reconstruction improve pelvic reconstruction outcomes and should be considered. Further prospective studies will be helpful to elucidate specific indications for each technique. To the best of our knowledge, ours is the first comprehensive description of numerous technical modifications to VRAM flap pelvic reconstruction and the first study to report the use of combined VRAM and omental flap harvest to treat large pelvic defects.

The fascia-sparing technique, component separation, and donor-site mesh reinforcement are VRAM flap technical modifications intended to minimize abdominal wall morbidity. A majority of the study patients (72 percent) underwent the fascia-sparing technique. Sparing all fascia peripheral to the medial and lateral row inferior epigastric perforators eased the closure of the donor-site defect and was shown to significantly decrease the incidence of hernia without affecting flap viability.

When the rectus fascia was of poor quality or significantly scarred by previous surgery or an adjacent hernia sac, mesh inlay was used to assist with tension-free fascial closure after VRAM flap harvest. Patients who underwent mesh inlay abdominal donor-site closure were twice as likely as the overall study population to have had a preoperative hernia and, consequently, more likely to have postoperative complications. This likely is related to the donor-site tissue conditions and resultant surgeons' decision to use mesh. All bioprosthetic mesh repairs were completely covered by fascia without bridging, and there was no difference in bulge rate between synthetic and bioprosthetic mesh repairs. This suggests that any potential stretch of bioprosthetic mesh material itself was not the direct cause of bulges. Even though their 7.7 percent postoperative bulge rate was higher than that of other study patients, it was lower than their 20.5 percent hernia rate before VRAM flap harvest. The use of mesh to aid fascial closure allowed for abdominal wall reinforcement without increased infection or fluid collection in this series. We currently use bioprosthetic rather than permanent synthetic mesh for this patient population because of the bacterial contamination with concomitant bowel resection and colostomy required with cancer resections in these cases.[31]

Twelve patients had excessive fascial tension after VRAM flap harvest, with preserved fascial quality, no preexisting hernias, and no intervening scar tissue. Therefore, they underwent unilateral component separation, which was well tolerated. The low complication rate of component separation demonstrates that release of the external oblique can be used with VRAM flap harvest without adding significant morbidity or devascularizing the remaining rectus fascia. However, the possible need for a second ostomy at the index or subsequent operations should be considered. We typically limit the release inferiorly to the arcuate line so that a right ostomy can be placed below this point.[27]

Techniques developed to decrease recipient-site complications include deepithelialization of the VRAM flap skin paddle and primary perineal closure, the addition of an omental flap, and extended VRAM flaps. Deepithelialization was performed for patients with thick VRAM flaps and a relatively narrow, rigid pelvic outlet when the overlying perineal skin flaps could be closed without tension over the deepithelialized paddle. This technique allows greater pelvic dead space obliteration and may limit potential vascular compromise of the skin paddle by maintaining a greater volume of the flap in the pelvic space than in the perineum. We observed that a bulky skin paddle inset to the perineal skin surface and a shorter suture line were associated with a nonsignificant reduction in dehiscence that healed rapidly because of the presence of vascularized dermis at the wound base, consistent with the benefits of vascularized tissue supporting irradiated flaps.[32]

An omental flap was added to VRAM flaps in cases where patients had a wide pelvic outlet that was not completely obliterated by the VRAM flap alone (13 percent of cases). Historically, the use of the omental flap alone after pelvic resection has been shown to result in more wound complications and longer healing time when compared with VRAM flaps.[15,18,33,34] However, when VRAM and omental flaps were combined in our series, there was a significant reduction in minor perineal dehiscence, a decrease in fluid collections, and a lower reoperation rate compared with VRAM flaps alone. The additional vascularity and soft-tissue volume provided by the omentum are likely responsible for these improvements in recipient-site outcomes.

Alterations of the classic VRAM flap skin paddle to increase the reach of the transferred tissue have been described.[1,35] The extended VRAM flap[30] used in the current study provides an increase in flap volume and skin surface area for abdominoperineal resection or pelvic exenteration defects requiring a large skin resection and/or posteriorly positioned defects involving the coccyx and sacrum. Of the 13 patients described here, one had a minor dehiscence and another had a major dehiscence requiring operative repair. No other recipient-site complications were noted, and partial flap loss was not observed. This technique safely transfers additional skin and fat with a greater reach and without increased donor- or recipient-site morbidity compared with the standard VRAM flap.

The review of these six adjunctive techniques in this patient series defines their recommended use with VRAM flap elevation and reports operative outcome improvements. Limitations of this study include the retrospective data analysis, the necessary grouping of techniques between patients treated with and without a particular technique, and potential selection bias based on defect severity. Other well-designed studies attempting to analyze the benefits of VRAM flap versus primary closure reported similarly unavoidable selection bias.[16,17] Conversely, the fact that the higher risk patients who purposely underwent these techniques performed similarly or better in many categories speaks to the power of these techniques in reducing donor- and recipient-site morbidity.

CONCLUSIONS

Select technical modifications to VRAM flap reconstruction of pelvic defects are useful to improve donor- and recipient-site outcomes. In particular, total VRAM flap deepithelialization represents a promising approach to flap inset in select patients where perineal closure tension is minimal. The use of these techniques should be considered when reconstructing irradiated pelvic exenteration or abdominoperineal resection defects. Further prospective studies will be important to further determine the value of each technique and the specific indications and patient selection criteria.

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ACKNOWLEDGMENTS

This research is supported in part by the National Institutes of Health through M. D. Anderson's Cancer Center Support grant CA016672. The authors thank these current and former M. D. Anderson attending surgeons from the Department of Plastic Surgery for contributing cases to this series: Drs. Donald Baumann, Elisabeth Beahm, Melissa Crosby, David Chang, Pierre Chevray, Jeffrey Friedman, Patrick Garvey, Matthew Hanasono, Lior Heller, Stephen Kronowitz, Howard Langstein, Michael Miller, Scott Oates, Gregory Reece, Justin Sacks, Roman Skoracki, Mark Villa, and Peirong Yu. The authors also thank Dawn Chalaire from the Department of Scientific Publications for assistance in editing this article.

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