Surgical outcomes of VRAM versus gracilis flaps for the reconstruction of pelvic defects following oncologic resection[☆]

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Summary   *PURPOSE:* Pelvic reconstruction following abdominoperineal resection or pelvic exenteration is associated with signification surgical site morbidity. Immediate pelvic reconstruction with a muscle flap is now the gold standard, associated with reduced perineal morbidity compared to primary closure alone.[2,3] The purpose of the present study was to directly compare outcomes of VRAM and gracilis flap pelvic reconstruction following oncologic resection.
METHODS: A multicenter retrospective review was performed of 88 patients who underwent abdominoperineal resection or pelvic exenteration and immediate pelvic reconstruction, either with a VRAM (N = 61) or Gracilis flap (N = 27). Electronic medical records were analyzed for patient demographics, intraoperative data, and postoperative outcomes. Mortality, minor complication rate, major complication rate and time to complete wound healing was compared between groups.
RESULTS: Overall, there was no significant difference in the minor complication rate (44% gracilis vs 48% VRAM, p = 0.8), major complication rate (19% gracilis vs 13% of VRAM, p = 0.53), 30-day mortality (0% VRAM vs 0% gracilis, p = 1.0) and median time to complete wound healing (68 days vs 67 days, p = 0.19) between the gracilis and VRAM groups. Muscle-only gracilis flaps had a significantly reduced healing time compared to musculocutaneous gracilis flaps (48 days vs 85 days, p = 0.007).

CONCLUSIONS: The workhorse flap in pelvic reconstruction remains the VRAM. While previous studies have alluded to the inferiority of thigh based flaps compared to the VRAM, we demonstrate here that pelvic reconstruction with the gracilis flap can be performed with comparable donor and recipient complication rates and similar time to complete wound healing as the VRAM.

Introduction

Pelvic reconstruction following abdominoperineal resection and pelvic exenteration remains a significant challenge. Perineal wound complications and infection occur in up to 60%[1-3] and 46%[4] of patients respectively. The high morbidity associated with primary closure in these surgeries is a result of the large pelvic dead space which leads to fluid collection and superinfection, a high tension skin closure, and irradiated and poorly vascularized soft tissues.[5-7] Recently, the first systematic review and meta-analysis on pelvic reconstruction following abdominoperineal resection compared primary and muscle flap closure and demonstrated over twice the incidence of perineal wound complications when primary closure was used.[8]

The reconstruction of complex pelvic and perineal defects (Figure 1) with muscle flaps obliterates the pelvic dead space, provides healthy and well-vascularized tissue into an irradiated wound bed, decreases closure tension, and resists infection by increasing oxygen tension and leukocyte delivery.[9-13] The two most common flaps used in pelvic

reconstruction is the Vertical Rectus Abdominus Myocutaneous flap (VRAM) and the Gracilis flap. While the VRAM flap is currently the gold standard for reconstruction, gracilis flaps have emerged as a safe and effective alternative, particularly in the case of bilateral ostomies or when robot-assisted or laparoscopic abdominoperineal resection is performed.[14,15] It is believed that the use of gracilis flaps will only increase in the current era of laparoscopic abdominoperineal resection.

Debate still exists with respect to the optimal method of pelvic and perineal reconstruction, and existing literature is limited by heterogeneity among studies, small study populations, and diverse clinical outcome measures. The purpose of the present study was to directly compare VRAM and gracilis flap reconstruction of pelvic and perineal defects with respect to morbidity, mortality, and rates of healing.

Methods

Patient population

A multicenter retrospective evaluation of patients who underwent immediate VRAM or gracilis flap pelvic reconstruction following abdominoperineal resection or pelvic exenteration was performed. Eighty-eight patients were included from two large tertiary Canadian institutions. Research ethics board approval (#20180095-01H) was obtained to review patient demographics, operative data, and postoperative outcomes. Predetermined outcome definitions were established based on a previous study[16] (Appendix 1). *Minor complications* included recipient and donor site hematomas and seromas not requiring drainage, local infection resolving with antibiotic treatment alone, minor wound dehiscence at donor or recipient sites, and partial flap loss. *Major complications* included fluid collections requiring surgical drainage, major wound dehiscence at donor or recipient sites, and total flap loss. A *major dehiscence* was reported when separation of wound edges necessitated surgical revision. If separation of the wound edges was small enough to allow healing by secondary intention with local wound care or vacuum-assisted therapy (VAC), it was considered a *minor dehiscence*. *Total flap loss* occurred when radical debridement in the main operating room was required to remove large areas of flap necrosis. *Partial flap loss* occurred when small areas of flap necrosis were treated with bedside debridement, local wound care, or VAC therapy. The *time to complete wound healing* was extracted from physician follow-up clinical records according to predefined criteria similar to those reported in previous studies.[4]

Figure 1 Intraoperative photograph of 47-year-old male with a large pelvic and perineal defect following pelvic exenteration surgery.

A wound was considered completely healed if there was intact skin with no discharge or clinical signs of infection.

Surgical techniques

VRAM flap harvest

The VRAM flap remains the primary modality of pelvic and perineal reconstruction at our institutions. Preoperative planning with the stoma nurse, general surgeon and urologist is essential in order to plan the number of stomas required and whether stoma exteriorization will be transrectus or pararectus. An elliptical pattern is marked from below the costal margin to the arcuate line and the skin island width determined with a pinch test. The flap is harvested superior to inferior preserving the posterior fascia above the arcuate line and the anterior fascia below the arcuate line. The musculocutaneous flap is then rotated transpelvically without releasing its origin from the pubic bone, and reinserted into the perisacral and pelvic fascia. The flap is inset into the defect and a multilayer closure is performed.

Gracilis flap harvest

When pelvic reconstruction with the VRAM is contraindicated (i.e.: bilateral ostomies, laparoscopic APR, scarring etc), the gracilis flap is used. The gracilis flap can be raised either as a musculocutaneous flap using a distally oriented skin paddle or the muscle alone can be raised to recreate the pelvic floor and the perineum closed primarily or with a lotus transposition flap if under tension. Longitudinal medial thigh incisions are made, the gracilis is identified and then harvested distal to proximal. It is released from the pelvic origin, rotated on it's pedicle, and transposed into the defect. In bilateral muscle-only cases, the muscle bellies are sutured to one another as well as the sacrum and pubic bone. The perineal skin is then assessed following reconstruction of the pelvic floor. If there is no tension, it is closed primarily and with any tension a lotus fasciocutaneous flap is performed. If the gracilis is harvested as a musculocutaneous flap, the distal skin panel is inset into the perineal defect and multilayer closure is performed.

Statistical analysis

Statistical analysis was performed using SAS® Version 9.3 software.[17] Descriptive statistics were calculated using Fisher Exact and Chi squared tests for categorical variables and T Tests for continuous variables. Cox proportional hazard ratios and logistic regression were used for multivariate analyses to control for confounding variables. Demographic and clinical characteristics were compared using ANOVA. P values less than 0.05 were considered statistically significant.

Results

Patient population

The study group consisted of 88 patients, 61 (69%) of which underwent VRAM and 27 (31%) of which underwent gracilis

Table 1 Patient demographics.

Patient Characteristics	Gracilis (N = 27)	VRAM (N = 61)	P Value
Age mean (SD)	57 (10.7)	62.4 (11.6)	0.05
BMI mean (SD)	29 (6.8)	27 (6.1)	0.27
Female Gender (N/%)	13 (48%)	47 (77%)	**0.01**
Number of comorbidities (mean/SD)	1.1 (1.2)	1.3 (1.5)	0.54
Abdominoperineal Resection (N/%)	22 (85%)	53 (93%)	0.25
Complete Pelvic Exenteration (N/%)	8 (31%)	18 (32%)	1.00
Neoadjuvant Chemotherapy (N/%)	20 (74%)	52 (85%)	0.24
Neoadjuvant Radiation (N/%)	24 (89%)	54 (89%)	1.00
Etiology of Ablative Surgery			0.22
Rectal Cancer (N/%)	17 (63%)	42 (69%)	
Anal Cancer (N/%)	3 (11%)	11 (18%)	
Vulvar Cancer (N/%)	2 (7%)	5 (8%)	
Cervical Cancer (N/%)	0 (0%)	1 (2%)	
Ovarian Cancer (N/%)	1 (4%)	0 (0%)	
Endometrial Cancer (N/%)	1(4%)	0 (0%)	
Jejunal Cancer (N/%)	1(4%)	0 (0%)	
Urethral Cancer (N/%)	1 (4%)	0 (0%)	
Crohn's Disease (N/%)	1 (4%)	1 (2%)	
Perianal Paget's Disease (N/%)	0 (0%)	1 (2%)	
Comorbidities			
COPD (N/%)	3 (11%)	4 (7%)	0.67
Diabetes (N/%)	6 (22%)	14 (23%)	0.94
Hypertension (N/%)	9 (33%)	25 (41%)	0.50
Chronic Renal Failure (N/%)	1 (4%)	1 (2%)	0.52
Dyslipidemia (N/%)	4 (4.6%)	12 (12.6%)	1.00
Coronary Artery Disease (N/%)	1 (4%)	4 (7%)	1.00
Peripheral Vascular Disease (N/%)	1 (4%)	6 (10%)	1.00
Anemia (N/%)	1 (4%)	4 (7%)	1.00
Arrhythmia (N/%)	0 (0%)	4 (7%)	0.30
Pulmonary Hypertension (N/%)	0 (0%)	2 (3%)	1.00
Ulcerative Colitis (N/%)	0 (0%)	1 (2%)	1.00
Crohn's Disease (N/%)	4 (15%)	3 (5%)	0.19
Smoking Status			
Never Smoker (N/%)	7 (26%)	27 (44%)	0.10
Former Smoker (N/%)	15 (56%)	29 (48%)	0.64
Active Smoker (N/%)	7 (26%)	15 (25%)	1.00

flaps (Table 1). All patients had locally advanced disease, and the majority received preoperative radiation, 54 (89%) of VRAM flaps and 24 (89%) of gracilis flaps. Neoadjuvant chemotherapy was also common, 52 (85%) of VRAM and 20 (74%) gracilis. The groups were adequately matched with respect to demographics (BMI, comorbidities, rates of abdominoperineal resection/pelvic exenteration, rates of radiation/chemotherapy, cancer etiology, and smoking status). The only significant difference between groups was a higher proportion of females in the VRAM group (77% vs 48%; p = 0.01).

Table 2 Intraoperative data.

Patient characteristics	Gracilis (N = 27)	VRAM (N = 61)	P Value
Admission Statistics			
Mean Operative Time (min/range)	512.8 (290-922)	453.1 (230-1091)	0.09
Postoperative ICU admission (N/%)	6 (22%)	6 (10%)	0.18
Mean Length of Hospital Admission (days/SD)	27 (21)	21 (18)	0.20
Sidedness of Flap			**<0.0001**
Bilateral (N/%)	13 (48%)	0 (0%)	**<0.0001**
Left (N/%)	11 (41%)	6 (10%)	**<0.0001**
Right (N/%)	3 (11%)	55 (90%)	**<0.0001**
Ostomy Placement			
Ileal Conduit (N/%)	14 (52%)	5 (8%)	**<0.0001**
Colostomy (N/%)	22 (81%)	53 (87%)	0.53
Ileostomy (N/%)	3 (11%)	5 (8%)	0.70

Table 3 Postoperative data.

Patient Characteristics	Gracilis (N = 27)	VRAM (N = 61)	P Value
Mortality Rate			
Intraoperative Mortality (N/%)	0 (0%)	0 (0%)	1.00
30-Day Mortality	0 (0%)	0 (0%)	1.00
1 Year Mortality (N/%)	2 (7%)	2 (3%)	0.58
3 Year Mortality (N/%)	5 (19%)	7 (11%)	0.50
Total Complication Rate			
Number of Patients with Minor Complications	12 (44%)	29 (48%)	0.82
Number of Patients with Major Complications	5 (19%)	8 (13%)	0.53
Recipient Site (Perineal) Complications			
Partial Flap Loss (N/%)	3 (11%)	4 (7%)	0.67
Total Flap Loss (N/%)	1 (4%)	5 (8%)	0.66
Perineal Minor dehiscence (N/%)	8 (30%)	13 (21%)	0.40
Perineal Major dehiscence (N/%)	4 (15%)	4 (7%)	0.24
Perineal Infection (N/%)	3 (11%)	12 (20%)	0.38
Perineal Hematoma (N/%)	0 (0%)	2 (3%)	1.00
Perineal Seroma (N/%)	2 (7%)	3 (5%)	0.58
Cellulitis (N/%)	1 (4%)	3 (5%)	1.00
Donor site (Abdominal Wall / Medial Thigh) Complications			
Donor Major Dehiscence (N/%)	1 (4%)	3 (5%)	1.00
Donor Minor Dehiscence (N/%)	2 (7%)	5 (8%)	1.00
Donor Infection (N/%)	3 (11%)	4 (7%)	0.67
Minor Necrosis of Wound (N/%)	1 (4%)	5 (8%)	0.66
Other Complications			
DVT/PE (N/%)	3 (11%)	2 (3%)	0.16
UTI (N/%)	1 (4%)	4 (7%)	1.00
Small Bowl Obstruction (N/%)	2 (7%)	4 (7%)	1.00
Ileus (N/%)	2 (7%)	7 (11%)	0.72
Pneumonia (N/%)	0 (0%)	5 (8%)	0.32
Acute Kidney Injury (N/%)	4 (15%)	0 (0%)	0.008
Time to Complete Wound Healing			
Mean Time to Complete Perineal Wound Healing (days/range)	72 (14-235)	120 (22-747)	0.04
Median Time to Complete Perineal Wound Healing (days)	68	67	0.19

Both groups had similar mean operative times, rates of ICU admission and total length of stay in hospital (Gracilis 513 min vs VRAM 453 min; p = 0.09, Gracilis 22% vs VRAM 20% and Gracilis 27 days vs VRAM 22 days; p = 0.20, respectively) (Table 2). As expected, the gracilis group had more bilateral surgery (15% vs 0%, p < 0.0001) and more ileal conduits (16% vs 6%, p < 0.0001). Most VRAMs were harvested form the right side (90%).

Flap complications

There was no statistically significant difference in minor or major complication rates between gracilis and VRAM groups. Minor complications occurred in 44% of gracilis flaps and 48% of VRAM flaps. Major complications occurred in 19% of gracilis flaps and 13% of VRAM flaps (Table 3). More specifically, there was no difference in the rates of both minor and

Table 4 Subgroup comparison of musculocutaneous to muscle-only Gracilis flap.

Outcome	Gracilis Muscle Flap +/− Lotus Fascicutaneous Flap	Gracilis musculocutnaneous flap using distal skin paddle	P value
Median Time to complete wound Healing (days)	48 days	85 days	*0.007*
Minor Complications (N/%)	5 (31%)	7 (64%)	0.13
Major Complications (N/%)	2(13%)	3(27%)	0.37

major donor and recipient site dehiscence rates between gracilis and VRAM groups (minor dehiscence perineum- 30% vs 21%, p = 0.40, major dehiscence perineum 15% vs 7%, p = 0.24, minor dehiscence donor- 7% vs 8%, p = 1.00, and major dehiscence donor- 4% vs 5%, p = 1.00). Lastly, the rates of partial and total flap necrosis were also similar- 11% vs 7% (p = 0.67) and 4% vs 8% (p = 0.66), for gracilis and VRAM respectively.

Systemic complications

There were no intraoperative or 30-day mortalities in either group. At 3 years, there were 5 deaths in the gracilis group (19%) (1 from viscus perforation, 1 from pneumonia, and 3 from cancer progression) and there were 7 deaths (11%) in the VRAM group (5 cancer progression, 1 cardiac arrest, and 1 infection). Rates of DVT/PE, urinary tract infections, small bowel obstruction, ileus, pneumonia, and acute kidney injury (AKI) were collected and the only statistically significant difference was a greater incidence of AKI in the gracilis group (15% vs 0%; p = 0.008).

Time to complete wound healing

Few studies evaluate the total time to complete wound healing following pelvic reconstruction, which can have significant hospital and societal-perspective cost implications. The mean time to complete wound healing was significantly reduced in the gracilis group (mean: 72 days vs 120 days; p = 0.04), however, when outliers were removed the median time to complete wound healing was approximately the same- 68 days vs 67 days p = 0.19, for gracilis and VRAM respectively.

Musculocutaneous vs muscle-alone gracilis flap

The reliability of the cutaneous skin paddle in a musculocutaneous gracilis flap has been questioned by previous authors.[15] For this reason, a subgroup analysis was performed to compare musculocutaneous to muscle-only gracilis flaps (Table 4). We found a statistically significant reduction in time to complete wound healing when the gracilis flap is harvested without a cutaneous skin panel (48 days vs 85 days, p = 0.007). There was nearly twice the rate of minor and major complications when the gracilis flap was harvested with a skin paddle, though this relationship was not statistically significant.

Discussion

The paucity of literature on muscle flaps in pelvic reconstruction was illustrated in a recent meta-analysis by Devulapalli et al demonstrating only 10 studies of appropriate methodological quality: 8 on VRAM and 2 on gracilis flap reconstruction.[8] Nelson et al published one of the most widely cited papers in pelvic reconstruction in 2008, where 114 VRAM were compared to a heterogeneous group of 19 thigh flaps, only 9 of which were gracilis flaps, and all of which were musculocutaneous. They reported a comparatively high minor and major complication rate for thigh flaps (74% and 42%, respectively) compared to the VRAM group (57% and 14%) going on to conclude superiority of VRAM-based pelvic reconstruction, making it the gold standard. Johnstone et al.'s meta analysis of 11 studies would later corroborate these findings, showing that the overall rate of any perineal wound or flap complication was significantly lower with VRAM (35.8%) compared to the gracilis flap reconstruction (52.9%).[18]

Despite convincing evidence from Shibata,[14] Chong,[15] and Persichetti[19] that gracilis flaps can be performed safely and effectively in the context of immediate pelvic reconstruction, it remains a second line flap due to the perceived notion of VRAM superiority. To many, gracilis flap harvest is limited to when the rectus muscles are unavailable for harvest, such as when bilateral ostomies are exteriorized through the rectus sheath and when there is abnormal scarring or a large ventral hernia. However, as plastic surgeons find themselves entering an era of laparoscopic and robotic abdominoperineal resection, there will likely be a shifting focus to thigh based flaps to decrease abdominal morbidity. As such, a critical evaluation of thigh based flap outcomes and their comparison with the current gold standard is necessary.

Contrary to the work of previous authors, our study shows that gracilis flaps can be performed with comparable rates of minor complications, major complications, mortality and time to complete wound healing compared to VRAM flaps. We believe our relatively low minor and major complication rate for gracilis flaps (44% and 19%) compared to those reported in previous studies, reflects our paradigm shift of harvesting our gracilis flaps without the skin paddle. We showed almost a 2-fold increase in minor and major complication rates, as well as a significant increase in time to complete wound healing, when the gracilis was harvested with a distal skin paddle, compared to without. These findings, echoes the work of others, who argue that the skin island of the gracilis flap, reliant on skin perforators from the proximal muscle belly, provide notoriously unreliable perfusion. In fact, Chong et al reported minor and major complication

rates as low as 19% and 6% when only the gracilis muscle was used and the perineum was closed primarily.[20]

This study has important limitations deserving mention. In addition to the limitations inherent to the retrospective design of the study, significant surgeon selection-bias exists with respect to both the ablative and reconstructive planning for each patient. Large, prospective studies will be required to further elucidate risk factors for postoperative complications, particularly the long term complications such as abdominal hernia rates that are not captured in the scope of the present review.

Conclusion

To the best of our knowledge, this is the first study to directly compare VRAM and gracilis flaps with respect to morbidity, mortality and time to complete wound healing following abdominoperineal resection. We demonstrate that both flaps can be performed with comparable safety and efficacy in the reconstruction of complex pelvic and perineal defects. Our current practice is use the gracilis flap when VRAM harvest is contraindicated (bilateral ostomies, laproscopic APR, scarring, previous VRAM harvest, ventral hernia etc). We begin by measuring the pelvic floor defect and then harvest unilateral or bilateral gracilis muscles accordingly. Once inset, if the perineal wound can be closed with no tension, primary closure is performed. With any closure tension, we elevate a unilateral lotus fasciocutnaeous flap to resurface the perineum.

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Conflicts of interest

None of the listed authors have conflicts of interest or any disclosures.

APPENDIX 1.   Outcome definitions

- *Major complications*
  - fluid collections requiring drainage
  - major wound dehiscence at donor or recipient site
  - total flap loss
- *Minor complications*
  - recipient and donor site hematoma and seroma not requiring drainage
  - local wound infection requiring abx alone
  - minor wound dehiscence at donor or recipient site
  - partial flap loss
- *Major dehiscence*
  - separation of wound edges requiring secondary surgical wound closure

- *Minor dehiscence*
  - separation of wound edges requiring local wound care including VAC therapy.
- *Total flap loss*
  - flap necrosis requiring operative debridement
- *Partial flap loss*
  - flap necrosis requiring bedside debridement, dressing changes or VAC therapy
- *Time to Complete Wound Healing*
  - Defined as intact skin with no discharge or clinical signs of infection documented by the operating surgeon.
  - Patients who had a fully healed wound but had a sinus tract that was not infected but periodically drained fluid were NOT considered completely healed.

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