An Algorithmic Anatomical Subunit Approach to Pelvic Wound Reconstruction

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Background: Prior radiation therapy, pelvic dead space, and a dependent location contribute to perineal dehiscence rates as high as 66 percent after primary closure of pelvic wounds. Various regional flaps have been described to reconstruct pelvic defects, but an algorithmic pairing of individual flaps to specific anatomical regions has not been described.

Methods: A retrospective review of a prospectively maintained database was performed to identify consecutive pelvic reconstructions from 2010 to 2013 with at least 6 months' follow-up. Pelvic defects and resulting flaps were described by anatomical subunits involved: anterolateral thigh flap for mons, gracilis flap for labia majora and introitus, vertical rectus abdominis myocutaneous flap for vagina and/or perineal raphe, and gluteus musculocutaneous flap for isolated perianal defects.

Results: Twenty-seven women and three men underwent consecutive pelvic reconstruction with a mean age of 60 years (range, 26 to 83 years) and a mean body mass index of 28 kg/m^2 (range, 17 to 40 kg/m^2). Twenty-one patients (70 percent) had prior radiation therapy. In total, 45 flaps were performed according to the subunit principle. Three patients had a minor dehiscence (<5 cm), one patient had a major dehiscence, and one required reoperation for abscess. There were two partial flap losses necessitating débridement and readvancement of the flap. Twenty-five percent of female patients were sexually active after vaginal reconstruction.

Conclusions: The pelvic subunit principle provides an effective algorithm for choosing the ideal pedicled flap for each region involved in acquired pelvic defects. This algorithm is based on individual attributes that make each flap most appropriate for each subunit. Complications were minimal and patient satisfaction with appearance and function was excellent. (*Plast. Reconstr. Surg.* 137: 1004, 2016.)

Acquired pelvic defects present complex reconstructive challenges because of the combination of significant pelvic dead space, the need for perineal soft-tissue resurfacing, and the shear forces associated with the dependent pelvis. Wound healing in this region has historically been poor, with dehiscence rates up to 66 percent and wounds persisting for a median 167 days in the absence of soft-tissue reconstruction.[1–11]

Acquired defects with significant pelvic dead space are most commonly the product of abdominoperineal resections or pelvic exenterations for the treatment of colorectal, gynecologic, and urologic malignancies. The majority of these cases have failed preoperative chemotherapy and radiation therapy, the latter of which further contributes to the inhospitable environment for postoperative wound healing.[12] Other causes of acquired pelvic defects include locally advanced cancers of the genitalia or perineal skin, lichen sclerosus, or necrotizing soft-tissue infections. All of these factors, both alone and in combination, explain the frequent failure of primary perineal wound closure and emphasize the importance of durable and reliable soft-tissue reconstruction.

To achieve primary wound healing and restore urogenital and anorectal function, the location of the defect and the presence of pelvic dead space should dictate the flap(s) selected. Individual flaps have been compared to one another for

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complication rates but without consideration of the numerous defect patterns and multiple flap options. Successful reconstruction of the pelvis mandates an organized algorithmic approach, which can best be achieved by using the principle of anatomical subunits.

PATIENTS AND METHODS

A retrospective review of a prospectively maintained database was performed to identify consecutive pelvic reconstructions from 2010 to 2013 with at least 6 months' follow-up. All cases were performed by the senior author (C.A.C.) at a single institution.

Charts were reviewed for preoperative and postoperative details, and complications were recorded. Minor and major wound dehiscence was defined as less than 5 cm and greater than 5 cm, respectively. Infection was defined as any type of wound-related complication requiring treatment with antibiotics.

Pelvic defects and flaps were paired by evaluating the anatomical subunits involved and the corresponding flap characteristics (Table 1 and Fig. 1). Complications were compared between flap types and between patients with and without radiation therapy. Sexual and urinary function were measured by postoperative survey after 6 months of recovery. A detailed algorithmic flow diagram is provided to demonstrate the clinical factors considered during flap selection (Fig. 2).

RESULTS

The results are summarized in Table 2. Twenty-seven women and three men underwent consecutive pelvic reconstruction, with a mean age of 60 years and a mean body mass index of 28 kg/m^2. Twenty-one patients (70 percent) had prior radiation therapy. Although not included in the subunit principle, our case series also includes 12 external oblique flaps, performed as component separations to facilitate closure of the vertical rectus abdominis myocutaneous donor site (Table 2). Three patients had a minor dehiscence (<5 cm), one patient had a major dehiscence, and one required reoperation for abscess; there were two partial flap losses necessitating débridement and readvancement of the flap. The vertical rectus abdominis myocutaneous flap had a 31 percent complication rate, whereas the gracilis flap was associated with a 20 percent complication rate. There was a 19 percent complication rate among patients with prior radiation therapy and a 33 percent complication rate among those with no history of radiation therapy. None of the complication rate comparisons reached significance.

Twenty-four female patients required partial or total vaginal resection and reconstruction. Sixteen of those patients (67 percent) reported being sexually active preoperatively and six patients (25 percent) reported sexual function after reconstruction by 6 months. All patients reported normal urinary function except one male patient requiring a double-strain protocol to completely empty the bladder after partial sacrectomy, one female patient with detrusor weakness after abdominoperineal resection, and another female patient requiring revision surgery to externalize her urethra after total perineal reconstruction.

Mons Pubis

Methods of mons and vulvar reconstruction have evolved from split-thickness skin grafting to various regional flap options. Most small anterior perineal defects (<20 cm^2) can be closed primarily or with the use of local cutaneous flaps.[13] However, medium size defects (20 to 60 cm^2) or defects with previous radiation exposure will require the use of regional fasciocutaneous or musculocutaneous flaps.[14–17]

The anterolateral thigh flap has been described for mons and vulvar reconstruction and provides the appropriate surface area, soft-tissue thickness, and pedicle reach to be the ideal flap for mons reconstruction.[18] The pedicle length ranges from 16 to

Table 1. Regional Flaps for Pelvic Reconstruction*

Defect	Flap of Choice	Pedicle	Technical Citation
Mons	ALT flap	Descending branch of lateral femoral circumflex vessels	Neligan and Lannon, 2010
Vulva/labia	Gracilis	Medial femoral circumflex vessels	Burke et al., 1995
Vagina	VRAM	Deep inferior epigastric vessels	Campbell and Butler, 2011
	Gracilis	Medial femoral circumflex vessels	Cordiero et al., 2002
Perianal	Gluteal fasciocutaneous flap	Inferior gluteal artery	Arnold et al., 2012

ALT, anterolateral thigh; VRAM, vertical rectus abdominis myocutaneous.
*The table notes the flap of choice for each subunit, that flap's blood supply, and an article that clearly describes the technical approach for each particular flap.

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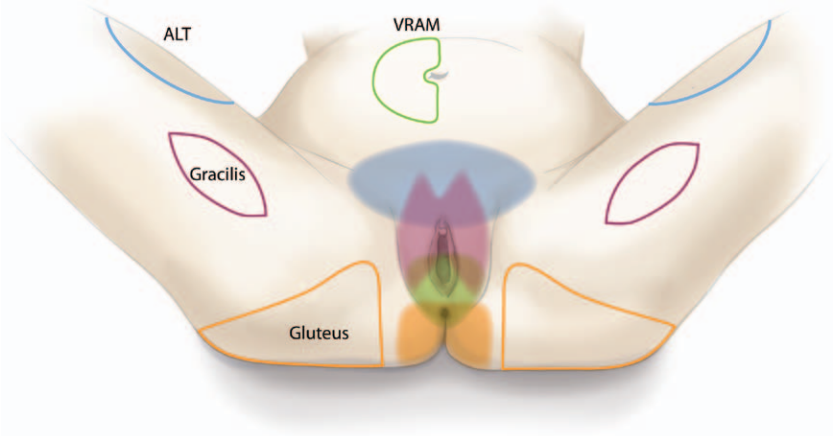

Fig. 1. Diagrammatic representation of the anatomical subunit algorithm for reconstruction of pelvic defects. The anterolateral thigh (*ALT*) flap is preferentially used to reconstruct defects in the region of the mons pubis; the vertical rectus abdominis myocutaneous (*VRAM*) flap is used for vaginal canal reconstruction, the perineal raphe, and larger defects including the perianal space; the gracilis flap is used for reconstruction of the labia majora; and the gluteal fasciocutaneous flap is best used for isolated defects of the posterior perineum.

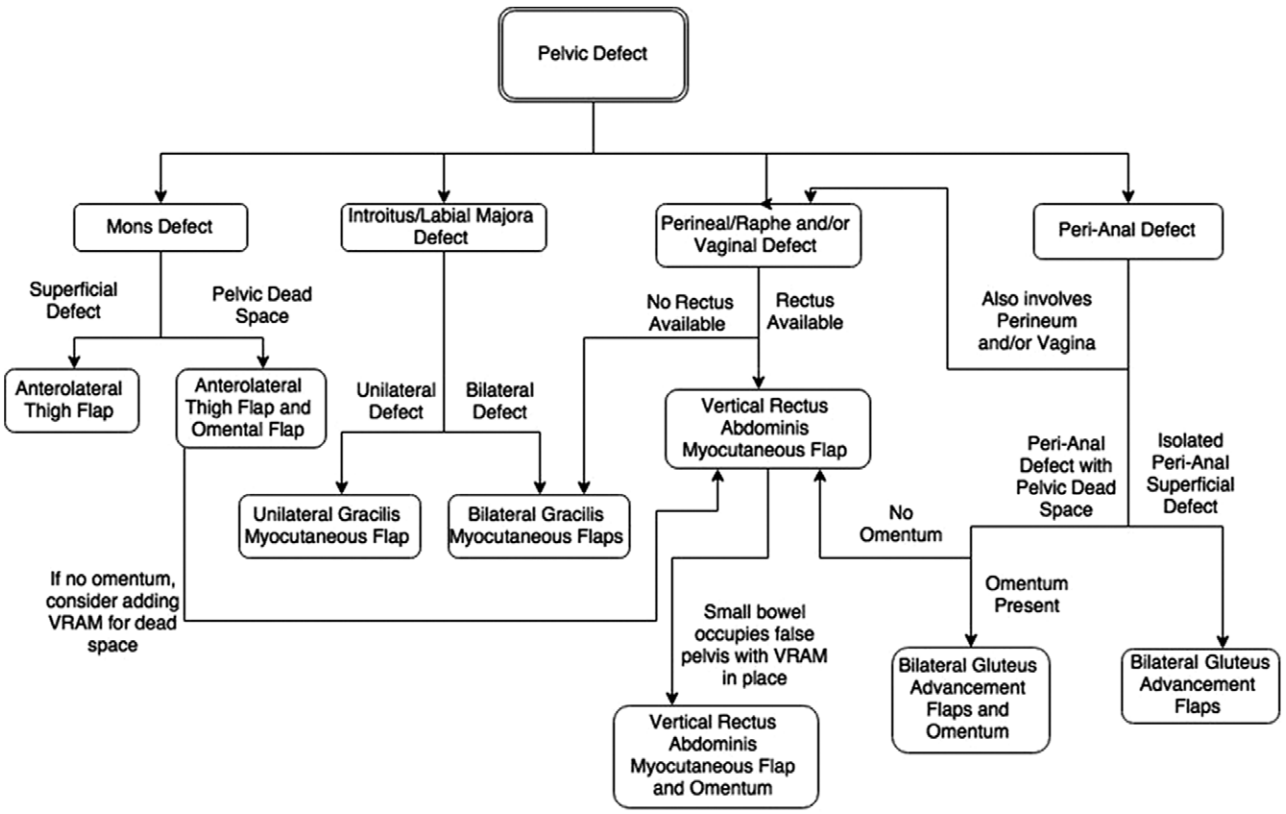

Fig. 2. Algorithm decision tree for reconstruction of pelvic defects. *VRAM*, vertical rectus abdominis myocutaneous.

19 cm, easily reaching the perineum and inferior abdominal wall when directed deep to the rectus femoris and sartorius muscles.[19] The anterolateral thigh is incredibly versatile; it can be designed as a thin fasciocutaneous or bulkier musculocutaneous flap, it can be sensate if harvested with the lateral femoral cutaneous nerve, and its skin paddle can be as large as 20 × 30 cm and can be fenestrated or

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Table 2. Patient Data

Patient	Age at Surgery (yr)	Diagnosis	BMI (kg/m^2)	Comorbidities	Prior XRT	Active Smoker	Defect Location	Extirpative Surgery	Reconstruction	Complications
1	58	Rectovaginal fistula	32	COPD, HTN	No	No	Perineum and posterior vaginal wall	APR	Gracilis musculocutaneous flap	3-cm skin edge separation requiring dressing changes
2	42	Cervical cancer	35	None	Yes	No	Posterior vaginal wall	TPE	1. Fascia-sparing VRAM 2. Component separation	None
3	47	SCCA; hidradenitis	23	COPD	Yes	Yes	Posterior perineum and overlying sacrum	APR, wide local excision of involved skin and subcutaneous tissue, partial sacrectomy (S3/4 level)	1. Extended fascia-sparing VRAM 2. Component separation 3. Transverse back fasciocutaneous flap 4. Bilateral gluteal fasciocutaneous V-Y flaps	None
4	79	Necrotizing fasciitis	34	DM, HTN, obesity	No	No	Posterior perineum and overlying sacrum	Débridement	1. Left gluteus maximus muscle turnover flap 2. Right fasciocutaneous gluteal rotation advancement flap 3. Left gluteal V-Y fasciocutaneous flap 4. Full-thickness skin graft	Partial skin graft loss requiring dressing changes
5	57	Cervical cancer	25.8	HTN	Yes	No	Vaginal canal and vulva	TPE	1. Gracilis musculocutaneous flap 2. Omental flap	3-cm skin edge separation; healed with dressing changes
6	79	Recurrent rectal cancer	19.8	HTN, PVD	Yes	No	Posterior perineum and perineal body	Prior APR; wide local excision of cutaneous recurrence	Bilateral V-Y gluteal fasciocutaneous flaps	None
7	73	SCCA	19.5	None	Yes	No	Mons, vaginal canal, vulva	APR; en bloc resection of involved tissue, including the symphysis pubis, bladder, anterior vagina, anterior vulva, and mons pubis	1. Fascia-sparing VRAM 2. Component separation 3. Omental flap	Abdominal wound abscess and 5-cm skin edge separation
8	77	Rectal cancer	31	Obesity	Yes	No	Posterior perineum and posterior vaginal wall	LAR, small bowel resection	1. Fascia-sparing VRAM 2. Component separation	None
9	70	Rectal cancer	17	None	No	No	Perineum and posterior vaginal wall	APR, en bloc resection of posterior vaginal wall, uterus, cervix, ovaries	1. Fascia-sparing VRAM 2. Component separation	1-cm wound separation, healed with dressing changes
10	83	SCCA	27	None	Yes	No	Mons	En bloc mons resection	Pedicled ALT flap	None
11	51	SCCA	25	HTN	Yes	No	Bilateral labia majora and vaginal canal	En bloc resection of bilateral labia and vaginal canal	Bilateral gracilis musculocutaneous flaps	None
12	59	Bladder cancer	28	HTN	Yes	No	Vaginal canal	TPE	Bilateral gracilis musculocutaneous flaps	None
13	26	Rectovaginal fistula	31	None	No	Yes	Perineal body and rectovaginal septum	None	1. Right gracilis muscle flap 2. Left pudendal artery fasciocutaneous flap	None

(*Continued*)

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Table 2. (*Continued*)

Patient	Age at Surgery (yr)	Diagnosis	BMI (kg/m^2)	Comorbidities	Prior XRT	Active Smoker	Defect Location	Extirpative Surgery	Reconstruction	Complications
14	60	Perineal hernia	25	HTN, DM	Yes	No	Posterior perineum	None	Bilateral V-Y gluteal fasciocutaneous flaps	None
15	36	Hidradenitis	27	None	No	No	Mons, bilateral labia majora, posterior perineum	Wide local excision, multiple débridements, VAC therapy	1. Right pedicled ALT 2. Bilateral gracilis musculocutaneous flaps 3. Bilateral V-Y gluteal fasciocutaneous flaps	None
16	72	SCCA	32	None	Yes	No	Vaginal canal	Anterior wall of the vaginal canal	Right fascia-sparing VRAM	None
17	48	Rectal cancer	31	None	Yes	No	Pelvis	Perineal proctectomy	Bilateral gluteus myocutaneous advancement flaps (V-Y)	None
18	56	Clear cell carcinoma	33	COPD	Yes	Yes	Pelvis	TPE	1. Fascia-sparing VRAM 2. Component separation	None
19	78	Cervical cancer	28	None	Yes	No	Pelvis	TPE	1. Fascia-sparing VRAM 2. Component separation	Wound separation, 11 cm
20	38	Vaginal SCCA	28	None	Yes	No	Pelvis	En bloc resection of vulva, rectum, anus, posterior vagina, and sigmoid colon	Fascia-sparing VRAM	None
21	57	Rectal cancer	25	DM	Yes	Yes	Posterior perineum	APR and partial sacrectomy	1. Bilateral gluteus myocutaneous advancement flaps (V-Y) 2. Omental flap	None
22	62	Necrotizing fasciitis	24	CAD, MI, HTN, asthma, cervical/ vaginal cancer	Yes	No	Mons, right labia/vulva	Mons and labia resection	Pedicled ALT	None
23	47	Vulvar SCCA	40	HTN, MI, asthma, CAD, OSA	Yes	No	Right labia and vulva	Labia	Gracilis myocutaneous flap	None
24	61	Rectal carcinoma	28	DM, HTN	Yes	No	Pelvis	TPE	Fascia-sparing VRAM	None
25	65	Hidradenitis	27	HTN, DM	No	No	Perineum and vulva	Total radical vulvectomy	Fascia-sparing VRAM	Partial flap loss
26	64	DFSP	23	HTN, dyslipidemia	No	No	Gluteus	Wide local excision of sarcoma	Bilateral gluteal advancement flaps	None
27	67	Anal cancer	29	HTN, DM	Yes	No	Pelvis	APR with posterior wall of vagina	Fascia-sparing VRAM	None
28	72	Bladder cancer	27	None	Yes	No	Vulva and vagina	Vulvectomy with circumferential anterior vagina	Fascia-sparing VRAM	Partial flap loss
29	41	Rectal cancer	28	None	No	No	Pelvis and perineum	APR with TPE	1. Fascia-sparing VRAM 2. Component separation	None
30	66	Rectal cancer	25	None	No	No	Pelvis and perineum	APR with posterior wall of vagina	1. Fascia-sparing VRAM 2. Component separation	None

BMI, body mass index; XRT, radiation therapy; COPD, chronic obstructive pulmonary disease; HTN, hypertension; APR, abdominoperineal resection; TPE, total pelvic exenteration (removal of bladder, uterus, cervix, vagina, left tube and ovary, rectosigmoid colon, bilateral distal ureters; ileostomy and ileal conduit); VRAM, vertical rectus abdominis myocutaneous; SCCA, squamous cell carcinoma; DM, diabetes mellitus; PVD, peripheral vascular disease; LAR, low anterior resection; ALT, anterolateral thigh; VAC, vacuum-assisted closure; CAD, coronary artery disease; MI, myocardial infarction; OSA, obstructive sleep apnea; DFSP, dermatofibrosarcoma protuberans.

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split depending on the reconstructive need.[19] The fascia lata can be harvested as a component of the flap for greater strength, a feature that may be necessary in cases involving full-thickness defects of the inferior abdominal wall. Moreover, it is relatively tolerant of fecal contamination and maceration—an important requirement in perineal reconstruction.[20] Given these many beneficial attributes, we consider the anterolateral thigh flap our first-line option for soft-tissue reconstruction in the region of the mons.

Case 1

An 83-year-old woman with a history of recurrent squamous cell carcinoma of the anterior vulva presented after a right hemivulvectomy that was closed primarily followed by adjuvant radiation therapy. Two years after the completion of her radiation therapy, she developed a necrotizing soft-tissue infection within the irradiated tissues of the mons that was resected, leaving an oblique 15 × 10-cm defect (Fig. 3) with exposed pubis at the wound base. To reconstruct this defect, a right pedicled anterolateral thigh flap was designed, including a portion of the vastus lateralis muscle. The flap was passed under the rectus femoris and sartorius muscles and delivered to the defect by means of a subcutaneous tunnel. She did not develop any complications and proceeded to completely heal her donor- and recipient-site wounds. Six months after surgery, she was fully healed and ambulatory, having achieved her preoperative level of function.

Vulva and Labia

Defects of the vulva and labia are typically secondary to skin cancer excisions or similar conditions (Bowen disease, extramammary Paget disease). These defects usually result in missing skin and subcutaneous tissue; bone and deeper structures are rarely exposed.

If the wound is not irradiated and is relatively small, a nonmeshed split-thickness skin graft is a good reconstructive option, providing acceptable cosmesis and replacing the thinner soft tissue near the introitus.[21] A skin graft is an especially prudent option if the risk of local recurrence is high. The suprapubic area, within the pubic hairline, is an excellent donor site for vulvar and labial reconstruction; this location eliminates the need for a separate donor site, and the scar is hidden within the hair-bearing skin.[21]

If the vulva and labia have been irradiated or if there are plans for external beam radiation therapy, the risk of skin graft loss is sufficiently high to preclude its use for reconstruction. In addition, many local flap options such as the pudendal flap are frequently included in the irradiation field, preventing this method of reconstruction. In these situations, a regional fasciocutaneous or musculocutaneous flap is an excellent alternative. In situations where the entire unilateral or bilateral labia majora are resected, we prefer to use the gracilis flap, unilateral or bilateral, respectively.[22–24] Although the skin paddle is relatively small, it is adequate for resurfacing the labia and vulva. The short arc of rotation is a frequently cited limitation of the gracilis flap; however, it is easily rotated to the vulvar region.

Case 2

A 51-year-old woman presented with a history of recurrent squamous cell carcinoma of the labia majora. She had a history of radiation therapy to the area from her initial disease. The recurrence

Fig. 3. Mons defect after resection of irradiated skin because of necrotizing soft-tissue infection in the setting of prior right hemivulvectomy because of squamous cell carcinoma. Mons reconstruction with a right pedicled anterolateral thigh flap. The surface area of the skin paddle can adequately cover large defects of the mons and the pedicle can be passed beneath the rectus femoris and sartorius muscles to easily reach the anterior pelvis.

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involved the bilateral labia requiring an en bloc resection of the bilateral labia majora, distal urethra and vaginal canal, and mons pubis. Because of her irradiation history, skin grafting and local tissue reconstruction were contraindicated; therefore, bilateral gracilis musculocutaneous flaps were used to provide a functional and anatomical reconstruction of the labia and vulvar surface (Fig. 4). The most superior element of the defect was able to be closed primarily. The patient went on to fully heal her wounds, achieving a functional and stable reconstruction.

Vagina and Perineal Raphe

The surgical management of vaginal defects presents the plastic surgeon with multiple reconstructive challenges. In addition to necessitating the creation of a cylindrical structure that must be of adequate size to permit sexual intercourse, flaps used to reconstruct the vagina must also provide adequate vascularized tissue to obliterate pelvic dead space, allow healing of perineal wounds, and prevent herniation of intraabdominal contents.[24]

Fig. 4. Defect involving the bilateral labia majora, distal urethra, distal vagina canal, and mons pubis after resection of recurrent squamous cell carcinoma of the labia in an irradiated field. The defect was reconstructed with bilateral gracilis musculocutaneous flaps to reconstruct the distal vaginal canal and labia majora. The vascular pedicles of the gracilis area are safely outside of the irradiated field from prior treatment.

Another unique aspect of vaginal reconstruction is that the creation of a neovagina is not only necessary to prevent postoperative wound-related complications but also important for the psychological well-being of many women, particularly those who wish to remain sexually active.[25] Therefore, women undergoing pelvic surgery in which part of or the entire vagina must be resected often request a functional vaginal reconstruction.

The most commonly used flap options for vaginal reconstruction include the rectus abdominis and gracilis musculocutaneous flaps, and the internal pudendal and posterior thigh fasciocutaneous flaps. Other less frequently used options include the omental flap with a skin graft, which requires postoperative stent dilation to prevent stenosis; and a tensor fasciae latae flap, which is plagued by lack of pedicle length and an undesirable donor-site scar.[23,26]

A useful algorithm for partial and total vaginal reconstruction was proposed by Cordeiro et al., in which reconstructive flap options are determined by the anatomical location of the vaginal defect.[27] This algorithm has proven to be reliable and useful in our approach to vaginal defects.

Often, vaginectomy defects communicate with the intrapelvic and intraabdominal space as in rectal carcinoma resections. In this instance, flap reconstruction serves a dual purpose: to obliterate dead space and prevent herniation and to provide the patient with a functional neovagina. Bulky flaps provide the appropriate soft-tissue fullness and skin to reconstruct the vagina and perineal raphe. In addition, in our experience, we have found the pedicled omental flap to be useful to close the pelvic inlet to prevent inferior displacement of the intraabdominal viscera. The omental flap can be combined with an additional regional flap to provide muscle for further dead space obliteration and a skin paddle for either external or vaginal canal reconstruction, depending on the defect type.[28] Campbell and Butler demonstrated a decreased perineal dehiscence rate, a decreased fluid accumulation rate, and a lower rate of reoperation when omental and vertical rectus abdominis myocutaneous flaps were used in combination for pelvic/perineal reconstruction compared to when the vertical rectus abdominis myocutaneous flap was used alone.[29] They theorize that the increase in vascularity and soft-tissue volume could be attributable to the improved outcomes.

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Vertical rectus abdominis myocutaneous flaps are our preferred first option for the more common posterior or circumferential vaginal defects to obliterate potential space, prevent pelvic hernias, and provide the appropriate soft-tissue surface area for a functional vaginal reconstruction.[29,30] When bilateral ostomies are present preoperatively, bilateral gracilis musculocutaneous flaps with or without omentum are a second option within the subunit principle.[23,24]

Cases 3 and 4

We present two patients who both required vaginal reconstruction, each of a different nature and requiring flaps from different locations. The first vaginal reconstruction patient is a 70-year-old woman with a history of obstructing rectal cancer after diverting colostomy, chemotherapy, and pelvic irradiation. She then underwent an abdominoperineal resection with an en bloc resection of the posterior vaginal wall with immediate reconstruction using a vertical rectus abdominis myocutaneous flap to recreate the perineum and posterior vaginal wall, and to provide vascularized tissue to the irradiated pelvis and perineum to assist with postoperative wound healing (Fig. 5). The proximal portion of the flap that is visible forms the posterior vaginal wall, whereas the distal portion of the flap is deepithelialized and buried under the irradiated skin flaps to improve wound healing and obliterate dead space.

The second vaginal reconstruction patient is a 59-year-old woman with locally advanced, recurrent urothelial cancer of the bladder status after chemotherapy and pelvic irradiation. She underwent a full pelvic exenteration. Immediate vaginal and perineal reconstruction was performed

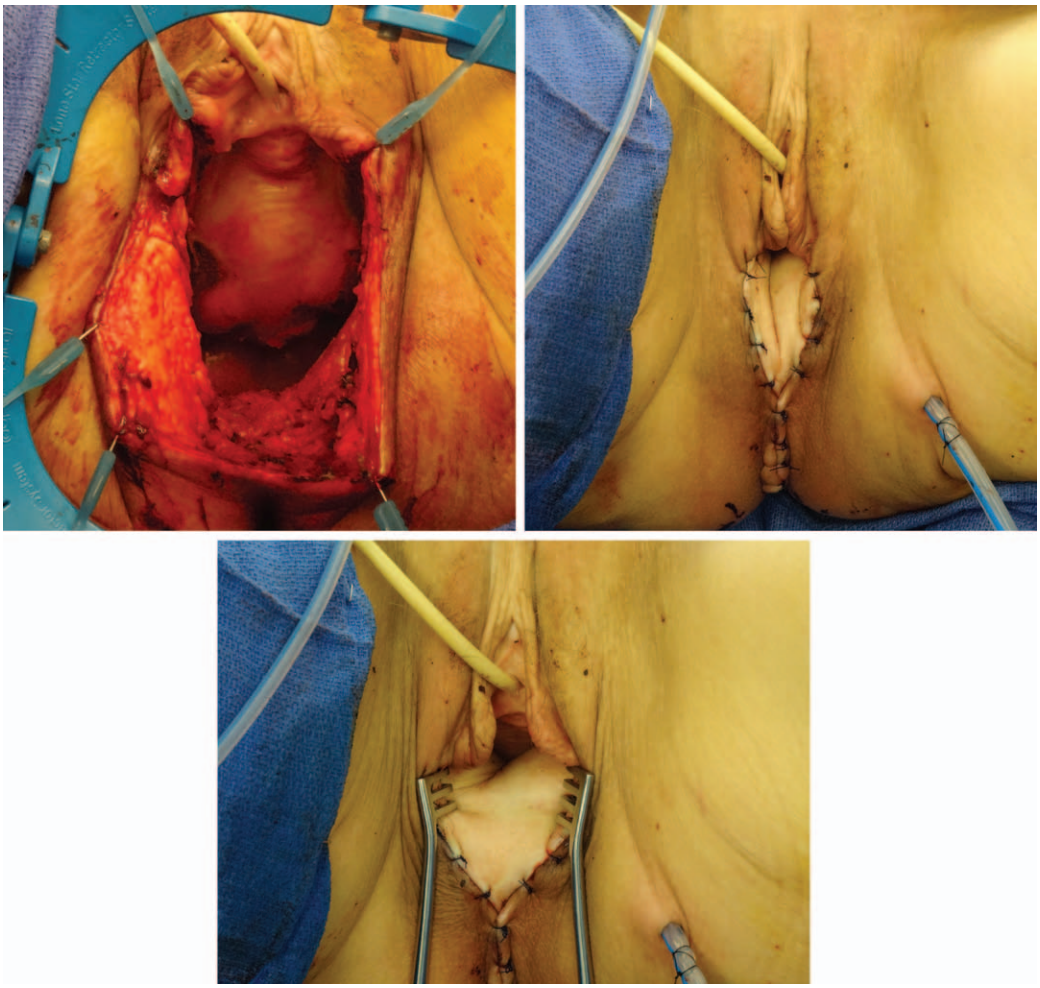

Fig. 5. Vaginal, perineal raphe, and perianal defect reconstructed with vertical rectus abdominis myocutaneous flap. The proximal skin paddle is used for the posterior vaginal wall. The distal skin paddle is deepithelialized and buried underneath irradiated perineal skin flaps to bolster the repair and obliterate potential space.

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with bilateral pedicled gracilis musculocutaneous flaps, which were approximated en face by their skin paddles extracorporeally and rotated into the perineal defect to create the neovagina (Fig. 6). This patient had an abundance of subcutaneous adipose tissue in her thighs, which provided for a bulky flap that filled the pelvis with vascularized, nonirradiated tissue.

Both patients have progressed to fully heal their wounds without any complications. Both patients possess a functional vagina without complaint of donor-site morbidity.

Perianal Defects

Posterior perineal defects limited to the perianal skin can be reconstructed with rectus abdominis musculocutaneous flaps, thigh-based flaps, or buttock flaps. Thigh-based flaps have been shown to have higher donor- and recipient-site complication rates than flaps harvested from the trunk.[30]

Fig. 6. Total vaginal reconstruction with bilateral gracilis flaps in a patient with bilateral ostomies preoperatively. To obliterate pelvic dead space, the distal portions of the gracilis are sutured to the presacral fascia.

Rectus abdominis flaps are useful when this defect is paired with a vaginal defect or extended rectus-based flaps are required for larger defects involving the coccyx and sacrum.[31,32]

Fasciocutaneous gluteal-based flaps are well suited for perianal defects. These flaps may be based on perforators of the gluteal artery with or without a muscle cuff.[33,34] Bilateral gluteal artery perforator fasciocutaneous flaps provide ample tissue for reconstruction of large posterior perineum defects, and preserve the gluteal cleft and spare the gluteus muscle, thus minimizing donor-site morbidity.[35] When the pelvic inlet is wide and/or the pelvic dead space is quite large, the addition of the omentum can be a useful adjunct for pelvic management.

Case 5

A 32-year-old physically active man presented with recurrent rectal cancer invading the coccyx after chemotherapy and pelvic irradiation. He wanted to spare his rectus muscles because of his workout regimen, and the colorectal surgeons anticipated a small cutaneous defect limited to the perianal skin. In the absence of a vertical rectus abdominis muscle, an omental flap was based off the right gastroepiploic pedicle and brought along the paracolic gutter and sutured to the presacral fascia above the level of the coccygectomy (Fig. 7). Bilateral gluteus V-Y advancement flaps were used to reconstruct the perianal defect (Fig. 7). He healed without incident and resumed all physical activity without limitation.

Total Perineal Reconstruction

The anatomical subunit concept can easily be used for the reconstruction of extensive defects that affect multiple pelvic anatomical subunits. The flaps discussed in this article are each based on separate and distinct pedicles, thereby permitting the use of multiple flaps in a single patient, if necessary.

Case 6

A 38-year-old woman presented with a history of Crohn disease and extensive perineal hidradenitis (Fig. 8). Her hidradenitis had failed conservative management consisting of oral and topical antibiotics and conservative drainage and débridement. Her function was severely limited as a result of her condition, preventing her from engaging in sexual relations, impairing her mobility, and causing debilitating pain. Because of the large surface area involved and severe nature of the disease, the excision and reconstruction were approached in a staged fashion. First, a radical

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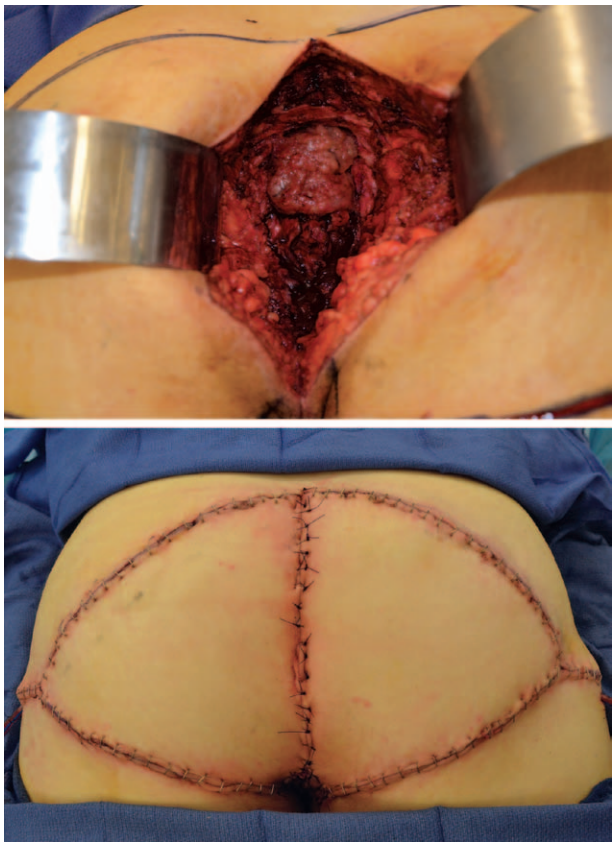

Fig. 7. Isolated perianal defect after abdominoperineal resection and coccygectomy for recurrent rectal carcinoma in a young male patient. Omental flap is used to obliterate pelvic dead space after coccygectomy (*above*). Bilateral gluteus fasciocutaneous advancement flaps were used to reconstruct the isolated perianal defect. The scar pattern recapitulates the gluteal cleft and crease while providing appropriate soft-tissue volume for the reconstruction (*below*).

Fig. 8. Total perineal reconstruction in a patient with diffuse perineal hidradenitis. The mons pubis region was reconstructed with a pedicled right anterolateral thigh fasciocutaneous flap. The labia majora were recreated with bilateral pedicled gracilis myocutaneous flaps, and the posterior perineum was resurfaced with bilateral inferior gluteal artery advancement flaps.

excision of the hidradenitis was performed, resulting in soft-tissue defects of the mons, bilateral labia majora, and posterior perineum; the labia minora were spared. A wound vacuum-assisted closure device was then applied to encourage the ingrowth of healthy granulation tissue. Regional flaps were planned to provide soft and durable coverage. Reconstruction was then performed according to the anatomical subunit principle. The mons pubis region was reconstructed with a pedicled right anterolateral thigh flap. The labia majora were recreated with bilateral pedicled gracilis musculocutaneous flaps, and the posterior perineum was resurfaced with bilateral inferior gluteal artery perforator flaps. Six weeks after her initial reconstruction, externalization of the urethra was performed by reorienting the gracilis skin paddles through the use of Z-plasties. The final stage was performed 12 weeks after her initial reconstruction and consisted of scar revision, flap liposuction, and advancement of the mons anterolateral thigh flap (Fig. 8). At the conclusion of her reconstruction, the patient was able to engage in sexual intercourse, her mobility and pain were improved, and she had no signs of recurrent disease.

DISCUSSION

We believe the algorithm presented above provides a thoughtful, organized approach for the treatment of a variety of pelvic and perineal defects. Similar to certain theories of facial and nasal reconstruction, the complex three-dimensional surface of the perineum lends itself to a reconstructive approach based on the anatomical subunit principle. Each flap included in the algorithm recruits tissue from a distinct anatomical area and relies on a separate blood supply, permitting use of multiple different flaps in extensive

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defects involving multiple subunits. Following such a plan will provide for a reliable, functional reconstruction and, perhaps most importantly, a healed wound.

Each defect location is paired with its flap of choice based on specific anatomical attributes, aesthetic considerations, and functional implications. The pedicled anterolateral thigh flap can easily reach the inferior abdomen and mons, and its soft-tissue characteristics mimic the pliable, soft tissue typical of the region. The gracilis flap can be rotated to reconstruct the vulva and anterior vaginal canal. The skin paddles can be designed so that the incision lines are located on the typical anatomical boundaries of the vulvar subunits. The vertical rectus abdominis myocutaneous flap is the workhorse for vaginal and perineal raphe reconstruction. It is well outside the zone of irradiation and its bulk can easily obliterate the pelvic dead space. If functional vaginal reconstruction is needed, the soft, pliable skin paddle can be shaped into a neovaginal canal. If resurfacing is not required, the flap can be deepithelialized and placed within the pelvic inlet to obliterate dead space. If additional soft-tissue volume is required, the vertical rectus abdominis muscle can be harvested as an extended flap, reaching to the midaxillary line. Gluteus-based flaps are well suited for reconstruction of the posterior pelvis. They can be designed with or without muscle, depending on the ambulatory status of the patient and the need for volume. The flaps are easily advanced into the defect, and the gluteal cleft can be reproduced when bilateral flaps are used. An omental flap should be included in the reconstruction when additional dead space needs to be filled or when small bowel is visualized slipping into the false pelvis during inset of the abdomen- or thigh-based flap. This is typically more common in female patients and after total pelvic exenteration compared with low anterior or abdominoperineal resection.

Occasionally, microsurgical techniques are necessary for pelvic reconstruction. In the obese patient where all skin paddles are too thick to facilitate pedicled flap reconstruction of the vagina, one option is either a free jejunum flap or a supercharged jejunum flap pedicled on the fourth vascular arcade and supercharged to the second arcade.[36–39] Microsurgical techniques also come into play when a thigh-based flap or abdominally based flap cannot be reliably inset into the defect because of inadequate pedicle length or too much tension on the pedicle. In this situation, the pedicle can be transected and then microsurgically anastomosed to either an interposition vein graft, a pelvic vessel in closer proximity to the defect, or to a saphenous vein loop to the femoral arterial system.[40–42]

Because of pedicle length limitations, the gracilis flap was most commonly used for reconstruction of the adjacent labia majora, which require only a 90-degree rotation. More anterior or posterior reconstructions were typically achieved with an anterolateral thigh flap or vertical rectus abdominis myocutaneous flap, respectively. The anterolateral thigh flap was passed deep to the rectus femoris and sartorius muscles to effectively increase pedicle length when reaching the mons. The gracilis myocutaneous flap was also used as a second option for total vaginal reconstruction as described previously, but this should be evaluated on a case-by-case basis because of the more proximal location of the vaginal canal to be reconstructed relative to pedicle location and the need for a 180-degree rotation of the skin paddles.[7] Taking longer skin paddles to reach the presacral space and using physical examination and indocyanine green laser angiography to evaluate flap viability after rotation are important when performing total vaginal reconstruction with gracilis flaps.

There are several technical maneuvers to minimize donor-site morbidity from flap harvest in these complicated reconstructions. A fascia-sparing technique was used for vertical rectus abdominis myocutaneous flap harvest, and we frequently performed a component separation to assist in abdominal wall closure and minimize donor-site morbidity.[29] In elevating the anterolateral thigh flap, we carefully protected the lateral femoral cutaneous nerve to minimize postoperative neuropathy or neuroma formation and microsurgically repaired motor nerve fascicles when possible for the remaining vastus lateralis muscle. The gluteus advancement flaps were elevated as fasciocutaneous flaps to spare the function of the gluteus muscle, especially the lower half of the muscle belly in all ambulatory patients.[35]

Postoperative activity modification is very important for the success of pelvic soft-tissue reconstruction. The patient is restricted to the supine and lateral recumbent positions changed every 2 hours in a low-pressure bed when not ambulating. Ambulation is permitted on postoperative day 1; however, the patient must logroll to stand from the supine position. The patient is not permitted to sit upright greater than 30 degrees for 3 weeks, after which a graduated sitting protocol is initiated until full activity is permitted

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at 6 weeks after surgery. A physical therapist is consulted to teach the patient how to safely transition from the supine to the standing position. If there are areas of delayed wound healing, the restriction from sitting may be increased until it is certain that the wound is not increasing in size. Complete pelvic rest is required for a minimum of 6 weeks.

In this series, there was no statistically significant difference in flap complication rates with regard to irradiation history (19 percent complication rate with irradiation versus 33 percent without). If the patient has been irradiated, we do not use flaps that include tissue from the irradiation field. This commonly excludes pudendal flaps. The selection of flaps within the anatomical subunit model permits the addition of nonirradiated tissue into the surgical field for reconstruction. Sometimes, the lower abdominal wall has been irradiated, and this may preclude use of the vertical rectus abdominis muscle. Often, these cases also involve a mons resection that will require an anterolateral thigh flap outside the field of irradiation. The timing of reconstruction after irradiation is based on planned oncologic resection of the tumor bed. After traditional long-course neoadjuvant chemoirradiation for rectal cancer, surgical resection and consequently reconstruction typically follow 8 to 12 later weeks in most cases.[43]

In addition, there were no significant differences in overall complication rates between flap types, with vertical rectus abdominis myocutaneous flaps associated with an overall 31 percent complication rate and gracilis flaps with a 20 percent overall complication rate. Gluteus flaps were associated with only small draining sites at the new gluteal cleft remedied with wound care. The subunit principle makes flap comparisons difficult, as different flaps were used for different defects. For example, vertical rectus abdominis myocutaneous flaps were used for the posterior vagina and perineal raphe where weight-bearing and shear forces are greatest and with defects with significant dead space, whereas the introitus and mons, reconstructed by thigh-based flaps, were not in the wound-bearing area, with minimal dead space. Gluteus flaps were used in this series for isolated perineal defects only, with less dead space and with omental flaps when available. In the literature, vertical rectus abdominis myocutaneous flaps have outperformed thigh-based flaps in defects of similar size.[30]

In addition to providing a healed wound, a secondary goal of pelvic reconstruction is the restoration of function, namely, the ability to engage in sexual intercourse and to minimize urinary incontinence. Our series showed that 25 percent of female patients engaged in sexual intercourse after 6 months of recovery from partial or total vaginal resection and reconstruction, which is similar to other reported values; Crosby et al. showed that 22 percent of patients were sexually active after partial vaginal reconstruction.[44] Similar to Crosby and colleagues, we believe the most notable predictor of postreconstruction sexual intercourse is the presence of prereconstruction sexual intercourse and patient age. Flaps for vaginal reconstruction should be designed to reproduce appropriate dimensions on average of 10 cm of vaginal circumference and 10 cm of vaginal length.[12] Contracture of the reconstructed vagina occurs most commonly along flap suture lines. This is seen more commonly when the introitus requires reconstruction with multiple flaps than in the posterior vagina alone (as seen in our total perineal reconstruction case in this series). An adult medium vaginal dilator with a water-based lubricant can be used after adjacent tissue transfer for cases where scars between flaps contract, creating stenosis.

Rates of urinary dysfunction after pelvic resection and irradiation for colon cancer vary widely in the literature, from 30 to 77 percent.[45] Our series, by comparison, shows only 10 percent of patients with major urologic complaints after various forms of pelvic resection. One complaint was structural after multiple flaps (anterolateral thigh and two gracilis flaps) contracted to cover the urethra, another after a standard abdominoperineal resection, and the third after partial sacrectomy producing difficulty with voiding. All other patients who maintained their bladder and lower urinary tract eventually regained urinary continence. Our lower urologic dysfunction rate may be the result of diversity in our patient population or a decreased sensitivity in our clinic survey compared with validated models used in studies designed exclusively for postoperative function after cancer treatment.

Although each flap presented in this study has been described thoroughly in the literature, our subunit approach is novel, simplifying a typically very challenging reconstruction. The study is limited in that it is a case series with a small heterogeneous group of patients. However, the wide age range and diverse cause of defects demonstrate that this algorithmic approach can be successfully used to treat a variety of patients in an array of clinical scenarios.

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CODING PERSPECTIVE

Coding information provided by Dr. Raymund Janevicius is intended to provide coding guidance.

14000	Adjacent tissue transfer, trunk; defect ≤10 cm^2
14001	Adjacent tissue transfer, trunk; defect 10.1 to 30.0 cm^2
14301	Adjacent tissue transfer, any area; defect 30.1 to 60.0 cm^2
14302	Adjacent tissue transfer, any area; each additional 30.0 cm^2, or part thereof
15734	Muscle, myocutaneous, or fasciocutaneous flap; trunk
15738	Muscle, myocutaneous, or fasciocutaneous flap; lower extremity
49904	Omental flap

- If a local flap is used for reconstruction, the adjacent tissue transfer codes, 14XXX, are used and are reported by the size of the total defect.
- The vertical rectus abdominis musculocutaneous and gluteal flaps are trunk flaps. Each flap is reported with code 15734.
- Use the lower extremity flap code, 15738, to report each anterolateral thigh and gracilis flap.
- Each flap is reported separately, even though used for the same defect. Thus, a defect reconstructed with a right anterolateral thigh flap, bilateral gracilis myocutaneous flaps, and bilateral V-Y gluteal fasciocutaneous flaps is reported as follows:

15378	Right anterolateral thigh flap
15738-59	Right gracilis myocutaneous flap
15738-59	Left gracilis myocutaneous flap
15734-51	Right V-Y gluteal fasciocutaneous flap
15734-59	Left V-Y gluteal fasciocutaneous flap

- Although "bilateral" flaps are performed, the bilateral modifier, 50, is not used, as codes 15734 and 15738 are not codes that payers, including Medicare, recognize as bilateral. Use modifier 59 in these cases.
- Some payers attempt to bundle all muscle flaps together and allow for only one muscle/fascial flap code per defect. This is incorrect coding, and does not follow American Medical Association Current Procedural Terminology rules. Each muscle/fascial flap should be listed separately.

CONCLUSIONS

Reconstruction of the pelvis and perineum is challenging, and optimal results require a thoughtful, organized approach. The pelvic subunit principle provides an effective algorithm for choosing the ideal pedicled flap for each region involved in acquired pelvic defects, including total pelvic coverage. In using this algorithmic approach, we are able to demonstrate a minimal complication rate for a variety of defects in a complex and challenging group of patients.

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REFERENCES

1. Turza Campbell K, Hedrick TL. Perineal wound healing complications in patients undergoing abdominoperineal resection and pelvic exenteration. Paper presented at: Southeastern Surgical Congress Annual Meeting; February 11–14, 2012; Birmingham, Ala.
2. Butler CE, Gündeslioglu AO, Rodriguez-Bigas MA. Outcomes of immediate vertical rectus abdominis myocutaneous flap reconstruction for irradiated abdominoperineal resection defects. *J Am Coll Surg.* 2008;206:694–703.
3. Goldberg GL, Sukumvanich P, Einstein MH, Smith HO, Anderson PS, Fields AL. Total pelvic exenteration: The Albert Einstein College of Medicine/Montefiore Medical Center Experience (1987 to 2003). *Gynecol Oncol.* 2006;101:261–268.
4. McAllister E, Wells K, Chaet M, Norman J, Cruse W. Perineal reconstruction after surgical extirpation of pelvic malignancies using the transpelvic transverse rectus abdominal myocutaneous flap. *Ann Surg Oncol.* 1994;1:164–168.
5. Yeh KA, Hoffman JP, Kusiak JE, Litwin S, Sigurdson ER, Eisenberg BL. Reconstruction with myocutaneous flaps following resection of locally recurrent rectal cancer. *Am Surg.* 1995;61:581–589.
6. Touran T, Frost DB, O'Connell TX. Sacral resection: Operative technique and outcome. *Arch Surg.* 1990;125:911–913.
7. McCraw JB, Massey FM, Shanklin KD, Horton CE. Vaginal reconstruction with gracilis myocutaneous flaps. *Plast Reconstr Surg.* 1976;58:176–183.
8. Shibata D, Hyland W, Busse P, et al. Immediate reconstruction of the perineal wound with gracilis muscle flaps following abdominoperineal resection and intraoperative radiation therapy for recurrent carcinoma of the rectum. *Ann Surg Oncol.* 1999;6:33–37.
9. Guarner F, Malagelada JR. Role of bacteria in experimental colitis. *Best Pract Res Clin Gastroenterol.* 2003;17:793–804.
10. Larson EL, McGinley KJ, Foglia AR, Talbot GH, Leyden JJ. Composition and antimicrobic resistance of skin flora in hospitalized and healthy adults. *J Clin Microbiol.* 1986;23:604–608.

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11. Robson MC, Heggers JP. Bacterial quantification of open wounds. *Mil Med.* 1969;134:19–24.
12. Cronjé HS, Van Zyl JS. Resurfacing the vulva and vagina. *Int J Gynaecol Obstet.* 1988;27:113–118.
13. John HE, Jessop ZM, Di Candia M, Simcock J,Durrani AJ, Malata CM. An algorithmic approach to perineal reconstruction after cancer resection: Experience from two international centers. *Ann Plast Surg.* 2013;71:96–102.
14. Burke TW, Morris M, Roh MS, Levenback C, Gershenson DM. Perineal reconstruction using single gracilis myocutaneous flaps. *Gynecol Oncol.* 1995;57:221–225.
15. Loree TR, Hempling RE, Eltabbakh GH, Recio FO, Piver MS. The inferior gluteal flap in the difficult vulvar and perineal reconstruction. *Gynecol Oncol.* 1997;66:429–434.
16. Goi T, Koneri K, Katayama K, et al. Modified gluteus maximus V-Y advancement flap for reconstruction of perineal defects after resection of intrapelvic recurrent rectal cancer: Report of a case. *Surg Today* 2003;33:626–629.
17. Hui K, Zhang F, Pickus E, Rodriguez LF, Teng N, Lineaweaver WC. Modification of the vertical rectus abdominis musculocutaneous (VRAM) flap for functional reconstruction of complex vulvoperineal defects. *Ann Plast Surg.* 2003;51:556–560.
18. Zeng A, Qiao Q, Zhao R, Song K, Long X. Anterolateral thigh flap-based reconstruction for oncologic vulvar defects. *Plast Reconstr Surg.* 2011;127:1939–1945.
19. Gravvanis AI, Tsoutsos DA, Karakitsos D, et al. Application of the pedicled anterolateral thigh flap to defects from the pelvis to the knee. *Microsurgery* 2006;26:432–438.
20. Yu P, Sanger JR, Matloub HS, Gosain A, Larson D. Anterolateral thigh fasciocutaneous island flaps in perineoscrotal reconstruction. *Plast Reconstr Surg.* 2002;109:610–616; discussion 617.
21. Friedman J, Dinh T, Potochny J. Reconstruction of the perineum. *Semin Surg Oncol.* 2000;19:282–293.
22. Lacey CG, Stern JL, Feigenbaum S, Hill EC, Braga CA. Vaginal reconstruction after exenteration with use of gracilis myocutaneous flaps: The University of California, San Francisco experience. *Am J Obstet Gynecol.* 1988;158:1278–1284.
23. Soper JT, Larson D, Hunter VJ, Berchuck A, Clarke-Pearson DL. Short gracilis myocutaneous flaps for vulvovaginal reconstruction after radical pelvic surgery. *Obstet Gynecol.* 1989;74:823–827.
24. Salgado CJ, Chim H, Skowronski PP, Oeltjen J, Rodriguez M, Mardini S. Reconstruction of acquired defects of the vagina and perineum. *Semin Plast Surg.* 2011;25:155–162.
25. Morley GW, Lindenauer SM, Youngs D. Vaginal reconstruction following pelvic exenteration: Surgical and psychological considerations. *Am J Obstet Gynecol.* 1973;116:996–1002.
26. Kusiak JF, Rosenblum NG. Neovaginal reconstruction after exenteration using an omental flap and split-thickness skin graft. *Plast Reconstr Surg.* 1996;97:775–781; discussion 783.
27. Cordeiro PG, Pusic AL, Disa JJ. A classification system and reconstructive algorithm for acquired vaginal defects. *Plast Reconstr Surg.* 2002;110:1058–1065.
28. Tran NV. Scrotal and perineal reconstruction. *Semin Plast Surg.* 2011;25:213–220.
29. Campbell CA, Butler CE. Use of adjuvant techniques improves surgical outcomes of complex vertical rectus abdominis myocutaneous flap reconstructions of pelvic cancer defects. *Plast Reconstr Surg.* 2011;128:447–458.
30. 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;123:175–183.
31. Baumann DP, Butler CE. Component separation improves outcomes in VRAM flap donor sites with excessive fascial tension. *Plast Reconstr Surg.* 2010;126:1573–1580.
32. Abbott DE, Halverson AL, Wayne JD, Kim JY, Talamonti MS, Dumanian GA. The oblique rectus abdominal myocutaneous flap for complex pelvic wound reconstruction. *Dis Colon Rectum* 2008;51:1237–1241.
33. Wagstaff MJ, Rozen WM, Whitaker IS, Enajat M, Audolfsson T, Acosta R. Perineal and posterior vaginal wall reconstruction with superior and inferior gluteal artery perforator flaps. *Microsurgery* 2009;29:626–629.
34. Boccola MA, Rozen WM, Ek EW, Teh BM, Croxford M, Grinsell D. Inferior gluteal artery myocutaneous island transposition flap reconstruction of irradiated perineal defects. *J Plast Reconstr Aesthet Surg.* 2010;63:1169–1175.
35. Arnold PB, Lahr CJ, Mitchell ME, et al. Predictable closure of the abdominoperineal resection defect: A novel two-team approach. *J Am Coll Surg.* 2012;214:726–732; discussion 732–733.
36. Ozkan O, Akar ME, Ozkan O, Colak T, Kayacan N, Taskin O. The use of vascularized jejunum flap for vaginal reconstruction: Clinical experience and results in 22 patients. *Microsurgery* 2010;30:125–131.
37. Ozkan O, Akar ME, Ozkan O, Mesci A, Colak T. Microvascular augmented pedicled jejunum transfer for vaginal reconstruction using a laparoscopy-assisted technique. *Microsurgery* 2008;28:671–675.
38. Chen HC, Chana JS, Feng GM. A new method for vaginal reconstruction using a pedicled jejunal flap. *Ann Plast Surg.* 2003;51:429–431.
39. Emiroğlu M, Gültan SM, Adanali G, Apaydin I, Yormuk E. Vaginal reconstruction with free jejunal flap. *Ann Plast Surg.* 1996;36:316–320.
40. Oswald TM, Lineaweaver WC, Hui K. Recipient vessels for microsurgical flaps to the groin and pelvis: A review. *J Reconstr Microsurg.* 2006;22:5–14.
41. Garvey PB, Clemens MW, Rhines LD, Sacks JM. Vertical rectus abdominis musculocutaneous flow-through flap to a free fibula flap for total sacrectomy reconstruction. *Microsurgery* 2013;33:32–38.
42. Filobbos G, Chapman T, Khan U. Split anterolateral thigh (ALT) free flap for vulva reconstruction: A case report. *J Plast Reconstr Aesthet Surg.* 2012;65:525–526.
43. Monson JR, Weiser MR, Buie WD, et al.; Standards Practice Task Force of the American Society of Colon and Rectal Surgeons. Practice parameters for the management of rectal cancer (revised). *Dis Colon Rectum* 2013;56:535–550.
44. Crosby MA, Hanasono MM, Feng L, Butler CE. Outcomes of partial vaginal reconstruction with pedicled flaps following oncologic resection. *Plast Reconstr Surg.* 2011;127:663–669.
45. Bregendahl S, Emmertsen KJ, Lindegaard JC, Laurberg S. Urinary and sexual dysfunction in women after resection with and without preoperative radiotherapy for rectal cancer: A population-based cross-sectional study. *Colorectal Dis.* 2015;17:26–37.

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