Vulvovaginal reconstruction for neoplastic disease

Michael Höckel, Nadja Dornhöfer

Current treatment of neoplastic disease that involves the external female genitalia aims to achieve local disease control, but not to restore form and function of these organs. Despite a growing trend to reduce the extent of surgical resection, impaired quality of life after surgery due to severe sexual dysfunction and disturbed body image is common. We postulate that the integration of surgical techniques for vulvar and vaginal reconstruction into primary treatment would improve aesthetic and functional results and therefore quality of life. We systematically searched the literature for surgical procedures designed and validated for vulvovaginal reconstruction. Various skin flaps, both with random vascularisation and those based on vascular territories (ie, axial pattern, fasciocutaneous, musculocutaneous, and bowel flaps), can restore important parts of vulvovaginal form and function with acceptable morbidity at the donor and recipient sites. Appropriate vulvovaginal reconstruction cannot be achieved by doing a few standardised procedures; rather, it necessitates specialists who are familiar with general principles of reconstructive surgery to master many techniques to select the optimum procedure for the individual patient. Vulvovaginal reconstructive surgery has limitations, particularly achievement of functional restoration in irradiated tissue. Physicians who treat women with neoplastic disease of the external genitalia should be aware of the current state of vulvovaginal reconstructive surgery. Prospective controlled clinical trials are warranted to assess the effect of vulvovaginal reconstruction on morbidity and quality of life after treatment.

Introduction

Malignant disease of the female external genitalia—ie, vulva and vagina—leads to primary and secondary damage. Primary damage is caused by the tumour and its surgical resection; secondary damage results from the late effects of local treatment, particularly radiation-induced fibrosis and necrosis but also scarring after surgery. Vaginal damage leads to functional deficits, whereas vulvar damage is associated with additional aesthetic elements.

Traditional radical surgery for malignant disease of the vulva produces severe anatomic distortion by complete loss of the specific skin contour and exteriorisation of vaginal mucosa. Disfiguration of the external genitalia, which are an important part of a woman’s identity, has a strong negative effect on the patient’s body image and causes permanent trauma. Commonly, functional defects arise, such as loss of vulvar sensation or introital, urethral, and anal stenosis. The resulting sexual dysfunction and disturbances of micturition and defection potentiate trauma from the impaired body image. Radical surgery for malignant disease of the vagina removes receptive vaginal coital function. On the basis of evidence from patients with breast cancer and the reported clinical experience of several centres, including ours, surgical reconstruction of the vulva and vagina (figure 1) might improve morbidity and quality of life after treatment. However, vulvovaginal reconstruction after treatment for neoplastic disease is not part of current standard treatment.

To define the current state of surgical reconstruction for patients with malignant disease of the vulva and vagina, including high-risk precursor lesions, we reviewed the published work. In particular, we assessed the following issues: first, the burden of malignant disease that leads to vulvovaginal aesthetic and functional deficits with standard treatment; second, the established surgical procedures that are applicable to vulvovaginal reconstruction in terms of morbidity at the reconstructive site and donor site and of functional and aesthetic outcomes; and third, how surgical reconstruction compares with non-reconstruction for defined disease states. We present the results of our literature review and propose the most appropriate reconstructive procedures for defined vulvovaginal defects.

Figure 1: Functional restoration of vagina by a sigmoid-colon flap after radical vaginectomy
Disease burden
Squamous-cell carcinoma of the vulva is diagnosed in two women per 100,000 every year in developed countries. Age at diagnosis is commonly 65–70 years. Vulvar intraepithelial neoplasia grade 3 (VIN 3), the most frequent neoplastic disease that damages the vulva, affects seven women per 100,000 every year; mean age at diagnosis is 46 years. VIN 3 is multifocal in about 50% of women. Although the natural history of VIN 3 in terms of regression, persistence, and progression to invasive cancer is undefined, adequate surgical resection is needed: 8–19% occult invasion has been found in VIN samples after resection, and 9% incidence of invasive carcinoma has been identified in untreated patients with VIN. Importantly, the incidence of VIN 3 and invasive vulvar cancer has increased during the past three decades in developed countries, and it is now diagnosed at a younger age. The vulva is an uncommon location for metastases; however, it might be primarily or secondarily damaged by advanced and recurrent malignant disease in adjacent organs, particularly the vagina and anus.

Assessment of quality of life for patients who had surgery for VIN 3 or vulvar cancer without reconstruction showed severely disturbed body image and substantial sexual dysfunction with disrupted desire, arousal, orgasm, and resolution. The extent of surgical resection has not been correlated to the degree of sexual dysfunction and disturbance of body image. Furthermore, other features of quality of life such as emotional, physical, and social functioning are reduced after surgery for vulvar cancer. Radiotherapy of the vulva is complicated in 5–10% of women by late sequelae of scleroedema of the external genitalia and mons pubis region. Radiation necrosis is rare today, but radiation fibrosis is common and leads to severe sexual dysfunction due to narrowing of the vaginal introitus, abolishing tissue compliance and causing dyspareunia.

Primary carcinoma of the vagina accounts for about 1% of reproductive cancer in women; annual incidence is 0.5 per 100,000 women. Women who are diagnosed with vaginal cancer are younger than those with vulvar cancer: median age at diagnosis is 60 years. Squamous-cell carcinoma is the main histological type. The reported annual incidence of 0.3 per 100,000 women of high-grade vaginal intraepithelial neoplasia (VAIN III) is probably an underestimation because of difficulties in the diagnosis of preinvasive neoplasia. The vagina is more commonly affected by advanced and recurrent cancer in adjacent organs, especially cervical, endometrial, vulvar, urethral, bladder, and rectal carcinoma, than by primary vaginal carcinoma. The frequency of vaginal metastases from endometrial carcinoma, hypheneproma, or gestational trophoblastic disease is higher than that for primary vaginal carcinoma.

We could not find systematic assessments of quality of life after partial or total resection of the vagina for the treatment of malignant disease; this finding is probably due to the low number of affected patients. Wide excision of localised neoplasia, particularly in the proximal part of the vagina, might not affect sexual function. However, complete resection of the vagina abolishes the main features of sexual function. Radiotherapy of the vagina causes clinically overt fibrosis and stenosis in most patients.

Current treatment for cervical carcinoma (irrespective of modality) has the largest effect on quality of life related to vaginal morbidity. For women with stage IB cervical cancer, about 30% of those who have had surgery, with or without adjuvant radiotherapy, or primary radiotherapy have severe vaginal dysfunction. Chemoradiotherapy or, rarely, extended radical surgery for more advanced or recurrent cervical cancer nearly always impairs or abolishes vaginal function. Therefore, cervical cancer causes severe vaginal dysfunction in about six women per 100,000 women every year.

In summary, at least 15 women per 100,000 every year have vulvovaginal damage due to malignant gynecological disease that is managed with standard treatment. Published quality-of-life investigations suggest that most of these patients are severely traumatised from the associated aesthetic and functional deficits.

Vulvovaginal reconstruction
History
Early in the 20th century, women with vulvar cancer underwent perineal soft-tissue resection that was left for secondary healing. More defined radical surgery, including the inguinal regions in the en bloc resection, were developed in the 1930s and 1940s. These radical vulvectomy procedures aimed for primary healing, but was rarely achieved because of excessive wound tension and contamination. Early attempts of vulvar reconstruction in the 1950s and 1960s involved full-thickness and split-thickness skin grafts, random skin flaps, and combinations of these less-elaborate and standardised techniques. Skin grafts were done at that time to create a neovagina after simple or radical vaginectomy and pelvic exenteration. The potential of the Limberg flap—a rhomboid random skin flap developed according to mathematical principles—to reconstruct vulvar defects was realised.

Major progress for vulvar and vaginal reconstruction was made in the late 1970s with skin flaps based on vascular territories, particularly musculocutaneous flaps, pioneered by McCraw and colleagues. The 1980s saw the advantages of fasciocutaneous flaps that are based on the internal pudendal vessels for restoration of partial and total vulvar and vaginal defects: i.e., reduced tissue bulk and variable donor sites. The most recent developments in reconstructive surgery of the vulva are V-Y advancement flaps, which combine a more favourable aesthetic and functional outcome with reduced donor-site morbidity. The use of bowel flaps for the creation of a neovagina dates back to the beginning of the 20th century. Acceptance
of these procedures as important means to restore vaginal function varied through the decades. Although perforator flaps and free flaps have been successfully used for vulvovaginal reconstruction, these modern surgical techniques have not gained a broader application, except in cases when pedicled flaps have failed.

Reconstructive goals
At present, even the most sophisticated surgical techniques do not restore completely vulvovaginal form and function. Although the achievable reconstructive results are quite crude compared with the normal state without disease, surgical restoration might markedly improve the quality of life of the patient with vulvovaginal damage from malignant disease—particularly in terms of higher self-esteem about body image and rehabilitation of sexuality.

The main aims of vulvar reconstruction are to create two adequately sized sensitive skin folds with a sagittal symmetry and a sufficiently wide and elastic orifice of the (neo)vagina without disturbing micturition and defection when these functions are preserved. Re-establishment of the differentiated vulvar anatomy with preputium, glans, frenula of the clitoris, and labia minora is usually not possible. Furthermore, form and function of the clitoris and bulbæ vestibuli are not restorable. Vaginal reconstruction should enable receptive coital function without dyspareunia. Neovaginas do not usually have a conduit function for menstrual blood or for fertilising sperm. Moreover, lubrication as a vaginal sexual response is beyond the scope of surgical reconstruction. For some women, vulvovaginal reconstruction might be vital; for example, after excessive perineal soft-tissue resection or when ablative surgery is needed for highly irradiated tissue. For these women, closing of the perineal defect by surgical vulvovaginal reconstruction prevents bowel expulsion, and application of therapeutic angiogenesis reduces the complications of massively impaired wound healing.

Secondary aims of vulvovaginal reconstruction are the shortening of hospital stay and rehabilitation time by avoiding larger wound areas of secondary healing. Successful vulvovaginal reconstruction might enable adequate postoperative surveillance of the remaining perineal tissue or pelvic tissue, which otherwise would be inaccessible, that is at risk of recurrence or secondary malignant disease.

The benefits of surgical reconstruction must clearly outweigh its risks. For oncological safety, the tissues transposed into the defect should be free of occult or microscopic residual neoplastic disease. Distant flaps fulfil these prerequisites. However, local flaps should be raised from a tissue compartment that differs from the compartment that has neoplastic disease. Net morbidity from treatment, including surgical reconstruction, must be lower than that from conventional treatment without reconstruction.

Surgical techniques
Table 1 summarises types of reconstructive surgery and specific procedures for vulvovaginal reconstruction. These data have been selected for their precise description of flap characteristics, surgical techniques for flap assessment, and donor-site management.

Full-thickness or split-thickness skin grafting has been advocated for anatomic reconstruction after superficial (ie, so-called skinning) vulvectomy for VIN 3. Skin grafts and buccal grafts that cover a tubulised omentum majus flap have been done for vaginal reconstruction after damage by malignant disease, such as exenteration. Full-thickness skin grafts might be harvested from the groin and split-thickness grafts from the scalp. However, most vulvovaginal defects need skin flaps, and bowel flaps can be an appropriate substitute for a circumferential vaginal defect. Skin flaps for vulvovaginal reconstruction might be raised locally from the perineum or distantly from the thighs or abdominal wall.

Local flaps have either random vascularisation or are based on distinct vascular territories. Random skin flaps must have a base width that is at least 50% of the flap length. Therefore, their functional size, distance of advancement, and arc of rotation are limited. Nevertheless, Limberg flaps, which can be designed according to the tension lines of the donor site, might be useful to cover small vulvar defects. V-Y advancement flaps can be slid to a vulvar defect from cranial (ie, pubolabial), lateral (ie, medial thigh), or caudolateral (ie, gluteal) positions. The pubolabial V-Y amplified flap combines downward advancement with bilateral medial rotation. The medial thigh and the gluteal V-Y flaps can be raised by inclusion of parts of the underlying fascia and muscle (ie, gracilis and gluteus maximus) at their origins, which increases length of advancement and enables coverage of more-extended soft-tissue defects. Sensory innervation of random flaps is not substantially affected by their mobilisation and corresponds to the local dermatome.

Local skin flaps raised from a defined vascular territory, including axial pattern and fasciocutaneous flaps, are applied as pedicled flaps in a peninsula or island design. The vascular anatomy of the extended perineal region allows broad variation of local axial pattern and fasciocutaneous flaps: the adjacent pubic, inguinal, inner-thigh, and gluteal regions have a dense network of epifascial and subfascial arteries and veins. The anterior or posterior labial flaps can be elevated as axial pattern skin flaps, with an anterior base receiving blood supply from the superficial and deep external pudendal arteries or with a posterior base nourished by the posterior labial artery—a terminal branch of the pudenda interna artery. These flaps, also known as bulbocavernosus or Martius flaps, are applied for vesicovaginal or rectovaginal fistula repair. The mons pubis flap, based on the superficial external pudendal artery, provides pliable hair-bearing skin that matches the labia majora. The groin flap, which depends on the superficial circumflex iliac artery,
uses skin for vulvovaginal reconstruction that is otherwise discarded and does not produce additional scars with radical vulvectomy. Both the groin flap and mons pubis flap necessitate a modified groin-dissection technique to preserve the nourishing vessels.

Pudendal thigh flaps\textsuperscript{29,30} take advantage of numerous perineal anastomoses of the terminal branches of the pudenda interna arteries. The pudenda externa, obturator, medial circumflex femoral, and gluteal arteries allow the variation of donor sites, rotating from the gluteal fold to the genitocrural sulcus. The cumulative flap designs resemble the petals of a lotus flower, leading to its alternative name “lotus petal flap”. The lower petal, corresponding to the gluteal sulcus, is mainly applied because the donor-site scar can be hidden in the natural gluteal fold. Local axial pattern skin flaps and fasciocutaneous flaps retain the sensory innervation of the corresponding perineal region. They are suitable for medium-size vulvar and partial vaginal defects. Bilateral flaps are needed for the formation of a complete neovagina.

Distant flaps for vulvovaginal reconstruction are fasciocutaneous or musculocutaneous. The fasciocutaneous anterolateral thigh flap\textsuperscript{31} (with the cutaneous angiosome of the lateral circumflex femoral artery) and the medial thigh flap\textsuperscript{32} (connected to a branch of the superficial femoral artery) have the advantages of being raised outside a vulvar or pelvic radiation field and the supply of a large but non-

### Table 1: Surgical procedures for vulvovaginal reconstruction

<table>
<thead>
<tr>
<th>Grafts</th>
<th>Donor site</th>
<th>Blood supply</th>
<th>Sensory innervation</th>
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<td>Medial thigh V-Y advancement flap, with or without gracilis muscle</td>
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<td>Random</td>
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<td>Gluteal V-Y advancement flap, with or without glutus maximus muscle</td>
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<td>Posterior labial flap\textsuperscript{‡}</td>
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<td>Mons pubis flap\textsuperscript{§}</td>
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<td>Vastus lateralis flap</td>
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<td>Gluteal thigh flap\textsuperscript{</td>
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<td>Terminal branches of inferior gluteal artery</td>
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<td>Gracilis flap</td>
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<td>Anterior cutaneous branches of femoral nerve; cutaneous branch of obturator nerve</td>
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<td>Short gracilis flap</td>
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<td>Terminal branches of obturator artery</td>
<td>Cutaneous branch of obturator nerve</td>
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<td>Rectus abdominis flap\textsuperscript{**}</td>
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<td>Deep inferior epigastric artery</td>
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<tr>
<td>Ileo(cacoecum) flap</td>
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<td>Ileocolic artery</td>
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<tr>
<td>Sigmoid-colon flap</td>
<td>Distant</td>
<td>Sigmoid-colon artery</td>
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NA=not applicable. *Rhomboid flaps. †V-Y amplified sliding flap from pubis. ‡Bulbocavernous flap, Martius flap. §Superficial external pudendal artery flap. ¶Lotus petal flaps, glutal fold (sulcus) flap, Singapore flap. ||Gluteus maximus flap. ** Vertical rectus abdominis flap (VRAM) or transverse rectus abdominis flap (TRAM).
bulky skin island. Musculocutaneous flaps that are suitable for vulvovaginal reconstruction are harvested from the anterior, posterior, medial, or lateral thigh, or from the abdominal wall. They are based on the inferior gluteal, circumflex femoral, and deep inferior epigastric vessels. These flaps carry large skin areas, but are generally bulkier than axial pattern skin flaps and fasciocutaneous flaps. Therefore, they are suitable to cover large soft-tissue defects, particularly in an irradiated recipient site. Tubularisation of the skin island may enable the use of only one flap for the creation of a neovagina. However, thigh flaps for the restoration of a complete circumferential defect must be bilateral in most cases.

Generally, donor sites of all flap types for vulvovaginal reconstruction can be closed primarily. Musculocutaneous flaps from the thigh for vulvovaginal reconstruction are: rectus femoris;\(^7\) tensor fasciae latae;\(^8\) vastus lateralis;\(^9\) glutal thigh;\(^6\) and gracilis.\(^9\) The short gracilis flap\(^9\) is based only on the terminal branches of the obturator artery instead of the dominant vascular pedicle of the medial circumflex femoral artery; it can therefore be raised with less tissue bulk. The rectus abdominis flap\(^6\) can be raised with a vertical (VRAM) or transverse (TRAM) skin island. The abdominal wall skin, based only on its nourishing perforator vessels from the deep inferior epigastric artery, can be used for vulvovaginal reconstruction (ie, deep inferior epigastric perforator flap).\(^4,5\) Sensation in the musculocutaneous flaps from the thigh can be partly retained if the corresponding sensory nerves are integrated into the elevated flap. However, the patient projects the sensation to the donor site for an extended time (ie, 2 years or longer), which may be disturbing. The rectus abdominis flap is insensate because all sensory nerves are usually dissected when the flap is raised with a skin island.

Neovaginas can be formed by small and large bowel flaps.\(^4,6,14\) Segments of small bowel used for vaginoplasty have to be doubled in lumen by side-to-side anastomoses for volume adjustment. Small bowel is less suitable for vaginal reconstruction in women than large bowel, because of its vulnerability and extensive secretions. Neovaginas from the caecum are technically feasible, but are associated with functional loss of the Bauhin valve and may lead to chronic diarrhoea. Therefore, the preferred procedure is sigmoid-colon vaginoplasty.\(^4\)

### Results of vulvovaginal reconstruction

We analysed reported results for the different procedures for vulvovaginal reconstruction in terms of reconstruction-site morbidity, donor-site morbidity, and aesthetic and functional outcome. Only a few publications were informative in all four criteria of assessment. Studies were generally retrospective, observational, and descriptive. Validated instruments for measurement of the reconstructive outcome were not applied in the studies. Moreover, systematic scoring of complications and sequelae was not done.

Table 2 shows studies that included at least ten patients per vulvar reconstructive procedure.\(^19,23,40-44\) Table 3 shows studies that included at least ten patients per vaginal reconstructive procedure.\(^15,33-39\) If more than one report for a reconstructive procedure has been published, we selected studies with the highest number of patients and most information about morbidity and outcome.

To summarise, some general statements can be derived. All flaps are fairly safe: frequency of viability is more than 85% and frequency of partial flap loss is 10–30%. Donor-site morbidity ranges from 0% to 4%, and overall flap-related morbidity from 10% to 50%. Gracilis flaps seem to be associated with higher morbidity than other musculocutaneous flaps.\(^5,27\) Gluteal thigh flaps, gracilis flaps, and pudendal thigh flaps raised from the gluteal fold might cause long-term discomfort and pain on sitting. The major complications of bowel vaginoplasties are eversion, prolapse, and anastomotic strictures. Results are generally better for vulvar reconstruction than for vaginal reconstruction. 80–100% of patients are reported to be satisfied with the aesthetic and functional results of vulvar restoration. Aesthetic features are of minor importance in vaginal reconstruction (except in patients with neovaginal prolapse or improperly positioned flaps): the functional outcome mainly determines the success of the reconstructive procedure. From the published data, we conclude that about 50% (range 25–85%) of patients use their neovagina for intercourse; about 20% (range 5–25%) claim inadequacy of neovaginal function. There is no evidence that patients with primary cervical cancer who receive radiotherapy or surgery involving partial vaginectomy will benefit from vaginal reconstruction.

### Comparative studies

We could not find any study of level I and II evidence that addressed vulvovaginal reconstruction for malignant disease in a controlled design either generally (ie, comparison of reconstruction vs non-reconstruction) or specifically (ie, comparison of surgical techniques). All comparative investigations of vulvar reconstruction published to date are retrospective and uncontrolled.

A small study\(^45\) of wide excision for VIN showed good scores of sexual function in four of five women who received vulvar reconstruction by use of local flaps; the researchers suggest that their results are better than those for historical controls. Landoni and colleagues\(^49\) report shorter hospital stay, less wound dehiscence, less introital stenosis, and a lower frequency of urinary stream deviation in 72 patients who had flap reconstruction compared with 77 patients who had direct skin closure after radical vulvectomy. Sexual satisfaction after surgery was reported by 30 of 33 patients in the reconstruction group compared with 15 of 30 in the primary-closure group. Researchers\(^50,51,54\) have suggested reduced wound breakdown and shorter postoperative hospital stay with vulvar reconstruction compared with non-reconstruction. Carramaschi and co-workers\(^12\) reported 26%
local recurrence of vulvar carcinoma in 19 patients who had vulvar reconstruction compared with 42% in 18 patients who did not have reconstruction.

Quality-of-life studies have assessed the effect of vaginal reconstruction versus non-reconstruction in patients treated with exenteration. A prospective longitudinal study showed that patients who received a neovagina had better physical and sexual quality-of-life scores than did those who had no reconstruction. Those without vaginal reconstruction reported a worse body image and regarded themselves less attractive and self-confident than those who had reconstruction.

Studies of the effect of postoperative morbidity, due to reconstructive surgery, on overall outcome have led to inconsistent results. Whereas major complications could be clearly attributed to vaginal reconstruction in some centres, others did not report increased postoperative morbidity.

Vaginal reconstruction with musculocutaneous flaps seems to be associated with a low frequency of intestinal complications. Filling of the pelvis with a tissue bulk of high angiogenic potential reduces the risk of fistula formation, particularly if the patient has had radiotherapy.

### Discussion
Evidence from published studies confirms that conventional surgery or radiotherapy for vulvar, vaginal, and cervical neoplasia is frequently associated with major aesthetic and functional deficits of the female external genitalia, which can severely and permanently affect quality of life.

Current ideas to decrease treatment-related morbidity focus on the minimisation of surgical resection: early localised disease should receive wide excision, rather than resection of the complete organ, for advanced disease, multimodality treatment that allows conservative surgery is proposed. However, neither the adequacy of different reconstructive techniques in patients who have had pelvic exenteration suggest that the inferiorly based rectus abdominis musculocutaneous flap is more effective than the gracilis musculocutaneous flap and pudendal thigh fasciocutaneous flap, mainly because of less flap morbidity and better functional outcome. A study suggested better patient satisfaction for musculocutaneous neovaginas compared with colon neovaginas, which were associated with mucus production and the necessity of dilatation.
wide excision for local disease control nor the improvement in post-treatment quality of life by reducing the extent of surgical resection has been proven convincingly. The following considerations are important in this context. First, vulvar and vaginal carcinomas are frequently associated with multifocal invasive or intraepithelial neoplasia at different locations within the diseased tissue compartment. Second, wide excision (eg, hemivulvectomy) can distort skin contour and symmetry, the main aesthetic elements in the body image of the female external genitalia. Third, radiotherapy of the vagina or the vulva might abolish coital function through fibrosis-associated introital stenosis, vaginal atresia, impaired vaginal-wall elasticity, or dyspareunia.

An alternative to surgical minimisation is the integration of primary vulvovaginal reconstruction into the treatment of neoplastic disease. Several reconstructive procedures have been designed and validated to restore form and function of the vulva and vagina after partial, total, radical, and extended resection of these organs. However, their application is far from being standard in gynaecological oncology. Evidence from surgery for neoplastic breast disease, and a few uncontrolled studies suggest that primary vulvovaginal reconstruction has high potential to improve treatment outcome.

Here, we aim to alert physicians who care for women with neoplastic disease of the external genitalia to the possibilities of vulvovaginal reconstruction and present these techniques, which have been assessed for aesthetic and functional outcome, reconstruction-site morbidity, and donor-site morbidity. In addition to the proper technical execution of these procedures, the selection of optimum technique for the individual reconstructive situation is crucial to achieve the surgical goals.

On the basis of the published data reviewed and our own experience, we have selected the currently most appropriate reconstructive procedures for classified vulvar and vaginal defects that result from neoplastic disease. Vulvar (figure 2) and vaginal (figure 3) defect categories are defined, considering partial or total loss of these organs. The defect is extended if adjacent organs or tissues have to be included in the resection. Partial vulvar defects are further categorised into anterior commissure, posterior commissure, and lateral (ie, hemivulvar) defects. Extended vulvar defects include either peripheral adjacent tissue (such as the inguinal, mons pubis, perianal, genitocrural, or gluteal regions) or the centrally adjacent vaginal compartment. Any soft-tissue defect that results from wide vulvar excision, hemivulvectomy, total vulvectomy, radical vulvectomy, extended perineal resection, or abdominoperineal exenteration with vulvectomy can be classified in this scheme. Partial vaginal defects are either planar (with further subclassification into anterior and posterior) or circumferential (subclassified into distal and proximal). Release of a vaginal stenosis, closure of a vesicovaginal or rectovaginal fistula, or wide excision of a circumscript VAIN lesion produce a planar defect. Extended vulvar defects are either planar (with further subclassification into anterior and posterior) or circumferential (subclassified into distal and proximal). Partial vulvar defects are further categorised into anterior commissure, posterior commissure, and lateral (ie, hemivulvar) defects. Extended vulvar defects include either peripheral adjacent tissue (such as the inguinal, mons pubis, perianal, genitocrural, or gluteal regions) or the centrally adjacent vaginal compartment. Any soft-tissue defect that results from wide vulvar excision, hemivulvectomy, total vulvectomy, radical vulvectomy, extended perineal resection, or abdominoperineal exenteration with vulvectomy can be classified in this scheme. Partial vaginal defects are either planar (with further subclassification into anterior and posterior) or circumferential (subclassified into distal and proximal). Release of a vaginal stenosis, closure of a vesicovaginal or rectovaginal fistula, or wide excision of a circumscript VAIN lesion produce a planar defect. Extended vulvar resections might lead to a distal circumferential vaginal defect. Radical hysterectomy causes a proximal circumferential defect; total colpectomy and radical colpectomy are associated with total vaginal defects. Extended vaginal defects may include vulvar tissue or perivulvar tissue, the bladder, or the rectum resulting from pelvic exenteration.

For the best available tissue match and reliability of the flaps, we suggest 11 procedures for the reconstruction of classified vulvovaginal defects: Limberg flap; medial
thigh V-Y advancement flap; gluteal V-Y advancement flap; pubolabial V-Y amplified advancement flap; labial flaps (anteriorly and posteriorly based); pudendal thigh flaps; tensor fasciae latae flap; gracilis flap; gluteal thigh flap; rectus abdominis flap; and sigmoid-colon flap. Figures 2 and 3 show the application of these procedures for the vulva and vagina, respectively.

Defects of the anterior and posterior vulvar commissure can be treated with adjacent Limberg flaps, or with anterior posterior (respectively) labial flaps. For defects that are more peripheral, Limberg flaps are preferred. Whether a unilateral flap is sufficient or bilateral flaps are needed depends on the size of the defect. For the management of lateral and hemivulvectomy defects, unilateral medial thigh V-Y flaps or pudendal thigh flaps are appropriate.

Vulvar reconstruction after total defects needs bilateral versions of these flap types. A preferable alternative is the pubolabial V-Y flap of Moschella and Cordova because only one flap is necessary for restoration of the whole vulva. However, this technique cannot be applied if the groin dissection has to be extended medially. Extended vulvar defects need musculocutaneous flaps such as those of the tensor fasciae latae, gracilis, gluteal thigh, and rectus abdominis. Tensor fasciae latae flaps are the first choice if the soft-tissue defect includes the inguinal region. Gluteal thigh flaps are most appropriate for extended vulvar defects with a posterior orientation that may contain the perianal and gluteal regions. Likewise, rectus abdominis flaps are best suited for anteriorly extended vulvar defects. Gracilis flaps are more versatile with regard to defect orientation, but are reported to be less safe than the other applicable musculocutaneous flaps.

Planar partial vaginal defects can be substituted with anterior or posterior labial flaps or pudendal thigh flaps. Labial flaps are appropriate for functionally important small-volume defects, such as vaginal lesions that result from excision of fistulae. Pudendal thigh flaps supply larger skin islands for vaginal reconstruction, but have a bulkier base compared with labial flaps which may bulge out parts of the vulva after subcutaneous rotation into the vaginal defect. For the management of distal circumferential vaginal defects, bilateral pudendal thigh flaps are currently the most effective option. Bowel flaps are suitable for restoration of vaginal function after a proximal circumferential defect or a total vaginal defect. Sigmoid-colon flaps are preferred over ileocecal and ileal flaps.

For extended vaginal defects created by pelvic exenteration, adequate reconstructive procedures are musculocutaneous flaps, bilateral pudendal thigh flaps, and sigmoid-colon flaps. If the soft-tissue defect after total pelvic exenteration includes parts of the vulva, a bowel neovagina is not appropriate. Reported data suggest that a tubularised rectus abdominis flap is preferable over bilateral gracilis or pudendal thigh flaps. However, the donor site of the abdominal wall cannot be used for urinary or faecal diversion. The potential of a tubularised gluteal thigh flap has not been assessed fully to date.

Previous radiotherapy has a strong restrictive effect on vulvovaginal reconstruction options. The use of irradiated donor tissue should be strictly avoided because of severely impaired wound healing and high risk of wound breakdown as a result of soft-tissue infection. Moreover, radiation-induced fibrosis of the perivaginal tissues will abolish functional reconstruction of the vagina. Therefore, in an irradiated pelvis the formation of a neovagina to allow coital function is achievable only with abdominoperineal exenteration to remove completely the perivaginal tissues.

**Conclusion**

We aim to highlight the potential of modern plastic and reconstructive surgery to lower post-treatment morbidity and improve quality of life for patients with neoplastic disease of the female external genitalia. Vulvovaginal reconstruction is not a few universal procedures: rather, it demands specialists who are familiar with the general principles of reconstructive surgery to master many techniques.
The main limitations of restoration of vulvovaginal function have to be realised, particularly after radiation-induced tissue fibrosis. Furthermore, more adequate studies are needed to assure the full effect of vulvar/vaginal reconstruction with that of primary closure or planned healing by secondary intention in patients undergoing wide excision, subtotal, total, radical, and extended organ resection for defined gynaecological neoplastic disease. Primary endpoints should focus on longitudinal quality-of-life investigations with validated instruments, such as the Female Sexual Function Index and European Organization for Research and Treatment of Cancer quality-of-life C30 (functional assessment of cancer therapy—vulvar). Secondary endpoints may include scored complications, duration of hospital stay, treatment costs, and local tumour control. Further clinical research could investigate different reconstructive procedures for the same category of vulvovaginal damage through prospective controlled trials with similar endpoints.

Conflicts of interest
The authors declared no conflicts of interest.
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