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The combined use of pedicled profunda artery perforator and bilateral gracilis flaps for pelvic reconstruction, a cohort study

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This paper has not previously been presented.

Summary

The result of an extra-levator abdominoperineal excision of the rectum is a composite three-dimensional defect. This is performed for locally advanced anorectal cancer, and may involve partial excision of the vagina. The aim of reconstruction is to achieve wound healing, restore the pelvic floor and to allow micturition and sexual function. We aim to evaluate the concurrent use of profunda artery perforator and bilateral gracilis flaps for vaginal and pelvic floor reconstruction.

We performed a retrospective casenote review of patients undergoing pelvo-perineal reconstruction with combined gracilis and profunda artery perforator flaps between July 2018 and December 2019.

Eighteen pedicled flaps were performed on six patients with anal or vulval malignancies. All underwent pre-operative radiotherapy. Four patients had extended abdominoperineal tumour resections, two patients underwent total pelvic exenteration. The median; age was 57 (range 47–74) years, inpatient stay was 22 (11–47) days and the follow-up was 10 (5–21) months. Four patients developed partial perineal wound dehiscence, of which one was re-sutured. One patient had a post-operative bleed requiring radiological embolisation of an internal iliac branch and had subsequent 1cm profunda artery perforator flap loss. All other flaps survived completely. Median time to heal was 4 (1-6) months.

This is the first series reporting combined bilateral gracilis and profunda artery perforator flaps for pelvic reconstruction. The wound dehiscence rate and healing times were expected in the context of irradiation and radical pelvic tumour resection. This is a reliable technique for perineal and vaginal reconstruction with minimal donor site morbidity.

Keywords

Pelvic Exenteration

Pelvic Floor

Pelvic Neoplasms

Perineum

Surgical Flaps

Gracilis Muscle

The combined use of pedicled profunda artery perforator and bilateral gracilis flaps for pelvic reconstruction, a cohort study

Introduction

The result of an extra-levator abdominoperineal excision of the rectum (ELAPE) is a composite three-dimensional defect. ELAPE, performed for either locally advanced rectal cancer or salvage surgery for anal squamous cell cancer, may additionally involve excision of the posterior wall of the vagina. Radical resection for squamous cell carcinoma of cervix, vagina or vulva with rectal infiltration may result in a similar surgical defect. Primary closure of the incisions after neoadjuvant radiotherapy results in chronic, non-healing wounds in 35-51% of cases, whilst perineal hernias develop in around 26% of cases[1,2].

The aim of reconstruction is to achieve wound healing, restore the pelvic floor and to allow micturition and sexual function. The result should also be aesthetically acceptable in the era of cancer survivorship. In order to achieve this, autologous tissue transfer is performed to avoid herniation of the abdominal contents and to recruit well vascularised tissue to obliterate the resultant dead space. Flap reconstruction aims to reduce the risk of infection, dehiscence and the development of a perineal abscess[3-7]. In a recent systematic review of patients undergoing abdominoperineal resection and pelvic exenteration, closure with a flap rather than direct closure was associated with half the rate of perineal wound complications[8]. The potential disadvantages of performing autologous reconstruction are increased operative time, donor site morbidity, and the risk of flap failure. This paper addresses ways of mitigating some of these disadvantages.

Rectus abdominus myocutaneous flaps have been described for pelvic reconstruction since 1984, and have traditionally been favoured when there is significant skin defect and a large dead space due to bulk and ease of transfer[9,10]. However, this sacrifices a major muscle group and may lead to abdominal hernias. Additionally, the location of stomas may preclude rectus abdominus flap raise. Furthermore, if abdominal surgery is performed using minimally invasive techniques, using a rectus abdominus myocutaneous flap negates this advantage completely. Gracilis flaps were first described for perineal and vaginal reconstruction in 1976[11]. The gracilis has the advantage that it can be raised simultaneously with tumour resection in a two-team approach[12,13].

If tumour excision includes the posterior vaginal wall and perineum, squamous epithelium is preferable for a robust reconstruction. Although the gracilis flap can be designed to include a skin paddle, the resultant composite block of tissue does not allow the freedom to inset of the skin and muscle components independently.

In terms of fasciocutaneous flaps, the anterolateral thigh (ALT) flap can be applied for perineal reconstruction. However, given that muscle is required to reconstruct the pelvic floor, the ALT donor site is separate from that required for gracilis harvest. A chimeric flap from the lateral thigh with vastus lateralis muscle has been described for reconstruction after extended abdominoperineal excision[14]. However, we find insetting bilateral gracilis to create a double-breast sling of 'neo' pelvic floor a more anatomically correct method of reconstructing the excised levator complex.

The inferior gluteal artery perforator (IGAP) flap is another alternative, however again it is not easily combined with the harvest of an expendable muscle, the patient must be prone for flap raise, and the donor site may be painful for patients to sit**.**

The profunda artery perforator (PAP) flap is suited for perineal reconstruction as it provides sufficient tissue to restore continuity from the anterior fornix to the posterior introitus. Our preference for pelvic reconstruction is a combined PAP and bilateral gracilis muscle flaps. The PAP flap has the advantage of its donor site allowing access to harvest the gracilis flap. Additionally, it can be inset independently from the gracilis so that losses can be *replaced in kind*[15]. This allows the gracilis to form the pelvic floor, and the PAP flap can reform the vaginal canal. This donor site exploits the laxity of the medial thigh and reliably allows primary closure with minimal disruption to thigh contour[16,17].

We aim to outline our surgical approach, and to evaluate the time to healing, complications and morbidity of combined PAP and bilateral gracilis flaps for pelvic reconstruction. We will report this in line with the STROBE guidelines[18].

Methods

Between July 2018 and December 2019, a retrospective case note review of patients undergoing pelvic reconstructions with combined bilateral gracilis and PAP flaps in our regional plastic surgery unit was performed.

Patients were followed up until they healed and therefore were discharged from plastic surgery. Our primary outcome was time to heal. Our secondary outcomes were complication and re-operation rates and time to return to normal activities.

Surgical procedure

This was a dual team approach with either colorectal surgery or gynaecology colleagues. Flaps were raised synchronously whilst the abdominal approach, either laparoscopic or open, was performed to mobilise the bowel and approach the pelvis from above. The senior author (RMH) is right handed, and had found through his breast reconstruction practice that a right-sided PAP flap is easier to raise. Therefore, with the patient in the lithotomy position, right sided profunda artery perforators were identified with a handheld Doppler as shown in supplementary Figure 3A. The flaps were planned with the longitudinal skin paddle over the posterior portion of the adductor magnus muscle to ensure incorporation of the perforator. The width of the flap was estimated by skin pinch to ensure direct closure. Skin paddle dimensions were approximately 20 x 8 cm. PAP flaps were typically elevated on a single good calibre musculocutaneous perforator dissected through adductor magnus. When dissecting the pedicle towards the profunda artery, in one case we encountered a common perforator with the gracilis muscle, and injury to either needs to be avoided.

The ipsilateral right gracilis flap was easily harvested through the PAP donor site. The contralateral left gracilis flap was elevated through 7 cm proximal and 3 cm distal incisions. The pedicle was dissected to the medial circumflex femoral artery to allow easy rotation without tension or kinking. The obturator nerve was preserved. A tunnel was dissected towards the pelvis adjacent to the inferior pubic ramus where the flaps are ‘parked’ by attaching a rolled-up swab**.** Care being taken not to enter the potential resection field. The left donor site was closed over a suction drain. The whole of the right medial thigh was wrapped in a large waterproof adhesive dressing whilst the resective team came down to complete the perineal resection. If a partial sacrectomy was required, the patient may be turned prone, and the versatility of our reconstructive technique allowed for this as shown in Figure 2.

If the patient is kept in the supine position, after the perineal resection was complete, the resecting team returned to the abdomen to perform the colostomy and close the abdomen. At the same time the gracilis flaps were delivered into the pelvic defect and inset double breasted into any remaining; sacrococcygeal ligaments, coccyx, obturator internus and levator complex to create the 'neo' pelvic floor. Gracilis flap delivery and inset is shown in Figure 1B-C and Figure 2E-G.

In order to avoid kinking of the PAP pedicle and give a greater reach of the flap it is passed deeply through the split adductor magnus towards the origin of the pedicle and then around lateral border of the adductor magnus. This allows the PAP flap was delivered into the pelvis through the same tunnel as the gracilis flap. The PAP flap is sutured to the anterior vaginal wall from cervix or anterior fornix to introitus. Any remaining flap was de-epithelialized and inset to obliterate dead space. PAP flap delivery and inset is shown in Figure 1D-G. A drain was inserted in the common PAP and gracilis donor site and removed when less than 40ml per day.

If the patient is turned prone for the perineal resection, we have found it is often easier to Inset the PAP flaps prior to reconstructing the ‘neo’ pelvic floor with the double breasted gracilis flaps as shown in Figure 2C-D.

Post-operatively, patients were nursed in lateral decubitus position for two weeks and were to avoid sitting upright for prolonged periods four weeks. Early mobilisation was encouraged.

Results

Eighteen pedicled flaps were performed on six consecutive patients with anal, rectal or vulval malignancies. Patient details are shown in Table 1. All underwent pre-operative

radiotherapy. Four patients had extra-levator abdominoperineal tumour resections, two patients underwent total pelvic exenteration. The median; age was 57 (range 47–74) years, inpatient stay was 22 (11–47) days and the follow-up was 10 (5–21) months. Four patients developed partial perineal wound dehiscence, of which three were managed conservatively and one was re-sutured. One patient had a post-operative bleed requiring radiological embolisation of an internal iliac branch and had subsequent 1cm loss of the tip of the PAP flap. All other flaps survived completely. The only donor site complication was a groin seroma following lymphadenectomy. Median time to heal was four (one- six) months. Once healed, all patients were able to resume daily activity at completion of follow up and all were able to micturate normally. There was one patient death six months post-operatively, secondary to disease progression of metastatic vulval cancer.

Complications

In terms of outcome from vaginoplasty, one patient had a tight introitus and another had partial dehiscence at PAP flap inset, managed conservatively. In this relatively short follow up period, we do not have information on return to sexual function.

Discussion

The PAP flap was first described by Hurwitz and Walton in 1980, and is gaining popularity in autologous breast reconstruction[19,20]. In the last 5 years, PAP flaps have been increasingly employed in pelvic reconstruction, either alone or in combination with other pedicled flaps. We believe this is the first report of the PAP flap combined with bilateral gracilis flaps for pelvic reconstruction.

Ciudad et al. performed two cases of unilateral transverse upper gracilis and PAP (TUG-PAP) flaps for pelvic perineal reconstruction in 2016[16]. The same group then published a series of 28 unilateral TUG-PAP flaps, of which six were applied for pelvi-perineal reconstruction[17]. All flaps survived completely, although neither paper included patients

having had radiotherapy. Additionally, neither paper utilised the PAP flaps for vaginal reconstruction, but rather to resurface the perineum.

Jing et al. described a case of using a PAP flap to reconstruct the vulva and part of the vaginal wall[21]. There was no extra-levator abdominoperineal resection or pelvic exenteration and thus no combined gracilis flap. The authors do not state whether there was neoadjuvant chemoradiotherapy. The perineum healed in three months. Chen et al described a single case of bilateral PAP flaps used to reconstruct a vulvectomy defect[22]. In the case there was no radiotherapy, no complications, and time to heal was not documented.

In 2016, Chang et al published a series of 19 PAP flaps in 12 patients with defects following excision of vulval malignancies[23]. One patient had neoadjuvant radiotherapy. Seven of the 19 flaps showed poor wound healing of which two required wound debridement. Time to heal was not documented.

In the same year, Kosutic et al applied the PAP flap to a case of a radiorecurrent anal carcinoma[24]. No simultaneous gracilis flaps were performed. Time to heal and complications were not documented, although acceptable functional and aesthetic outcomes were noted at six and 12 months. The same author reported on a massive perineal defect reconstructed with a combination of a pedicled chimeric ALT flap with vastus lateralis, and pedicled gracilis, PAP and two IGAP flaps[25]. This patient had delayed wound healing at the confluence of the point of the flaps posteriorly. No time to wound healing was documented.

In our series, four of six patients developed wound dehiscence, of which most were conservatively managed. All of our patients had undergone neoadjuvant radiotherapy, five out of six had neoadjuvant chemotherapy, and all had either ileostomies or colostomies. These combine to be high risk patients for malnutrition and wound breakdown[7]. The surgical defects after extra-levator abdominoperineal resection are intrinsically slow to heal due to neoadjuvant radiotherapy, bacterial contamination, large dead space and being subject to

post-operative sitting[7]. Singh et al performed 48 bilateral gracilis flap reconstruction following abdominoperineal resection or pelvic exenteration, and found 40% of patients had a recipient site complication such as wound dehiscence[7].

In our unit, simple abdominoperineal resection patients would undergo bilateral gracilis flaps only, with PAP flaps reserved for particularly large defects post ELAPE or total exenteration requiring squamous epithelium for vaginal or perineal reconstruction. Therefore, our patient cohort represents a group with largest surgical defects and the highest risk of wound complications.

Two of our patients required re-operation, but as the indications were an internal iliac bleed and a groin seroma post lymphadenectomy, principally these complications relate to tumour resection rather than pelvic reconstruction. All wound dehiscence would have been managed conservatively were it not for the concurrent need to manage the chronic seroma in patient 1.

The limitations of this study are low patient numbers, short follow up and a lack of data on patient reported outcome measures. There is no widely used outcome for these cases of pelvic reconstruction. The existing literature frequently does not document whether patients underwent neoadjuvant radiotherapy, nor a time to heal. This makes evaluation of the technique challenging.

We believe the benefits of the PAP flap are straightforward perforator flap raise allowing gracilis harvest through the same donor site. Flap elevation can be performed simultaneously during the open or laparoscopic abdominal approach. The PAP has a wide arc of rotation to allow freedom of inset without tension, and the dimensions of the flap allow sufficient tissue to recreate the vaginal vault. Used in combination with bilateral gracilis flaps, the surgeon can freely inset the squamous epithelium for resurfacing, and recreate a durable pelvic floor without the need for mesh by double breasting the muscle flaps.

The malignancies we encountered did not require excision of the entire vagina in order to achieve oncological clearance, therefore we were able to preserve the anterior vaginal wall. If total vaginectomy was required, we believe our PAP flap of dimensions 20x8cm would likely be amenable to inset in a tubed fashion to recreate the entire vagina[26]. However, we do not have experience of this technique.

Radical pelvic resection results in a composite three-dimensional defect. With the technique described here, we aim to achieve wound healing, function and form, the three principles of reconstruction. Our results demonstrate that the PAP and bilateral gracilis flaps are a reliable option for perineal and vaginal reconstruction. We found minimal donor site morbidity and a well concealed scar. We had a relatively high rate of wound complications, in keeping with the literature in this challenging patient group, particularly in the context of irreversible tissue damage from radiotherapy.

Conflict of interest statement

Funding: None

Conflicts of interest: None declared

Ethical approval: Not required

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Figure legends

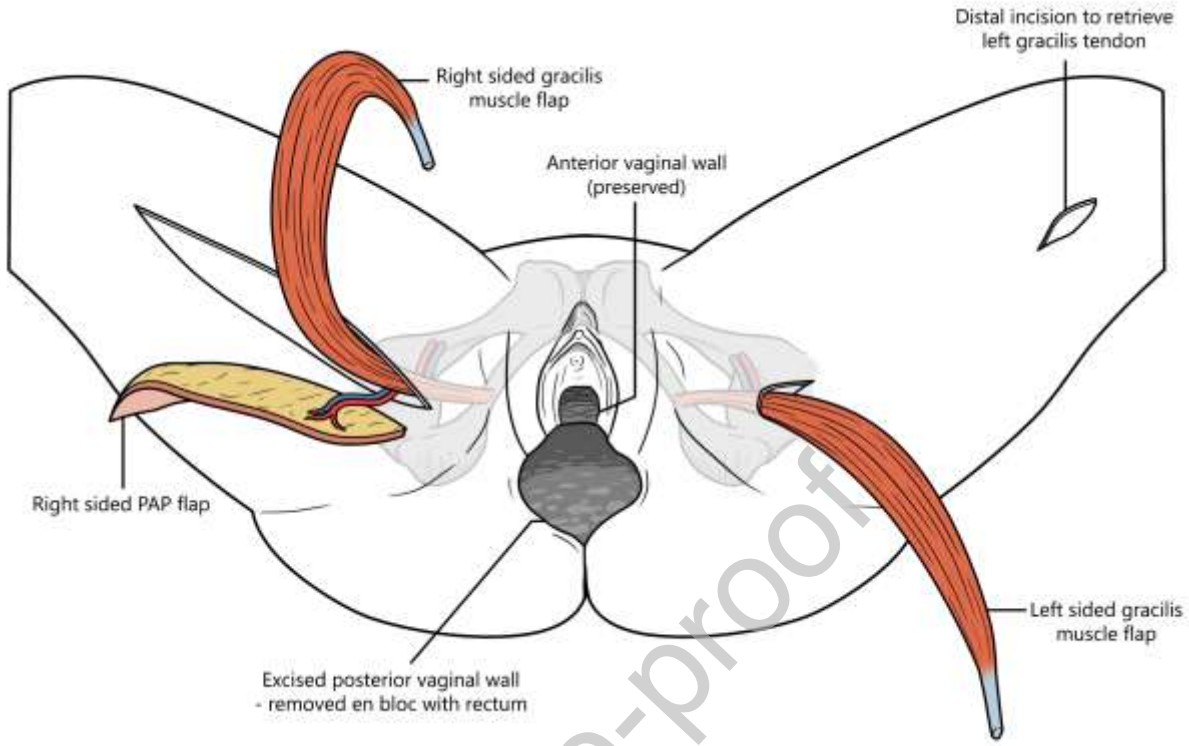

Figure 1. Right sided profunda artery perforator flap and bilateral gracilis muscle flaps raised and inset with the patient in the lithotomy position.

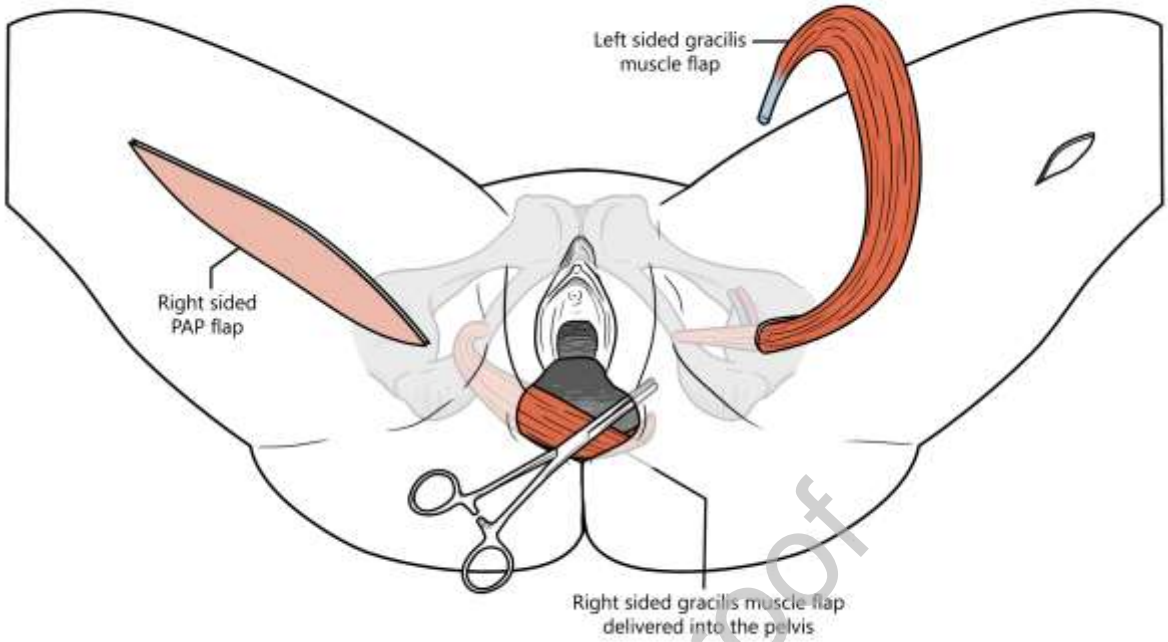

Figure 1a. The right sided donor site shows the profunda artery perforator (PAP) flap inferiorly and gracilis muscle flap superiorly, ready for transfer to the pelvis. The independent pedicles allow complete freedom of inset of the two flaps. The left sided donor site shows the left gracilis muscle harvested through 7cm proximal and 3cm distal incisions.

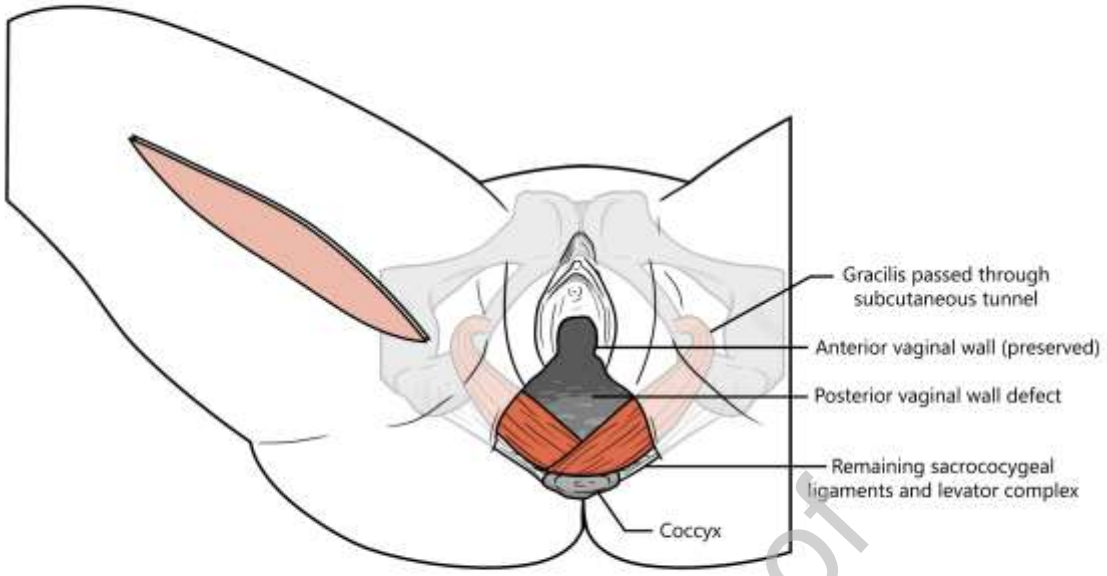

Figure 1b. The right sided gracilis muscle is delivered into the pelvis through a subcutaneous tunnel, followed by the left gracilis muscle. This is performed with the aid of a rolled-up swab. Care is taken to ensure there is no tension or kinking of the pedicle.

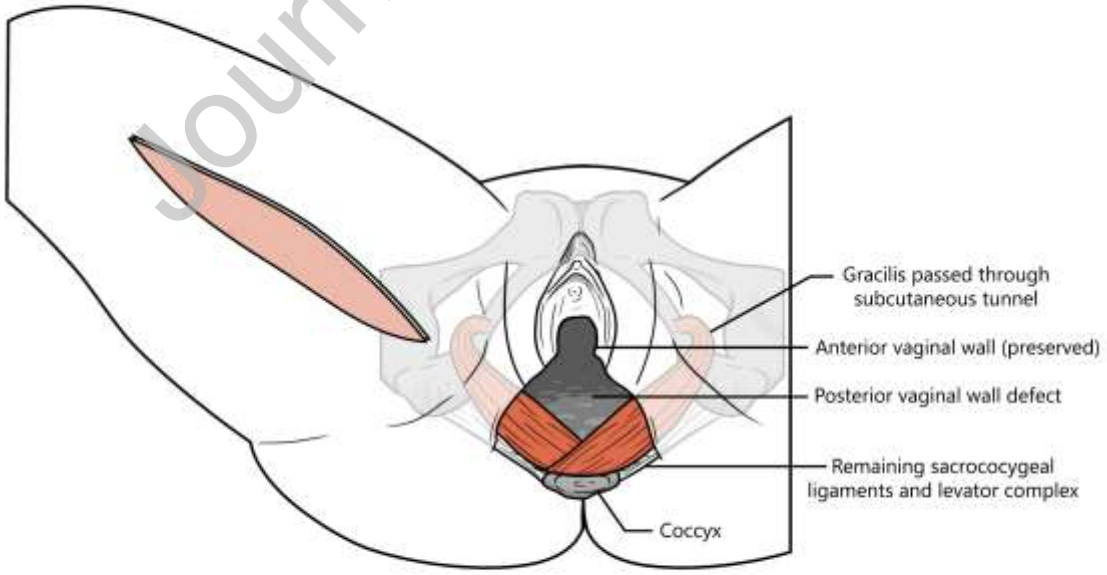

Figure 1c. The gracilis muscles are directed posteriorly within the pelvis and inset double breasted into any remaining; sacrococcygeal ligaments, coccyx, obturator internus and levator complex. This creates the 'neo' pelvic floor. As the muscle remains innervated, atrophy does not occur and hernia formation is reduced.

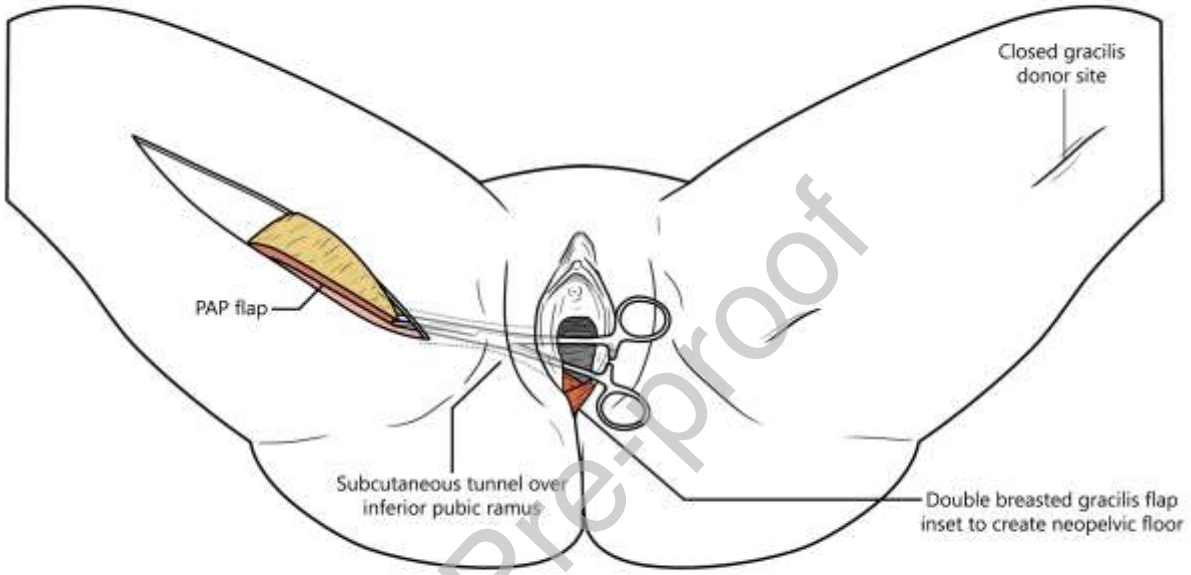

Figure 1d. The profunda artery perforator flap is delivered into the pelvic defect over the inferior pubic ramus via the same subcutaneous tunnel as the right gracilis flap.

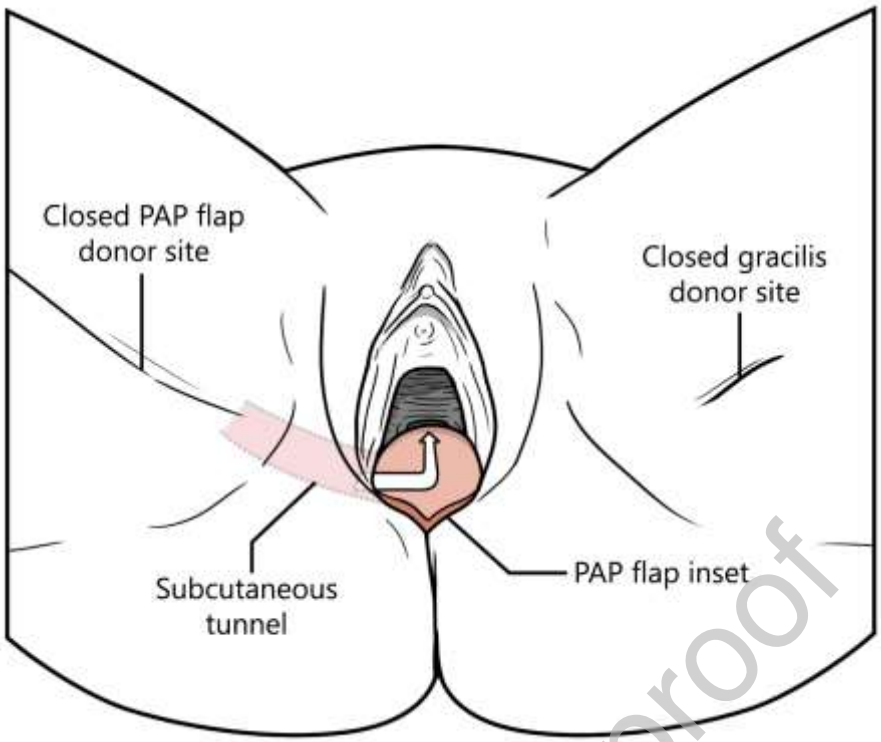

Figure 1e. The profunda artery perforator flap is delivered through the defect, and will then be turned through 180°. The flap is of sufficient size to reconstruct the vagina from cervix or anterior fornix to introitus. Any redundant flap will be de-epithelialized and inset to obliterate dead space within the pelvis.

Figure 1f. Final appearance with donor sites closed over suction drains.

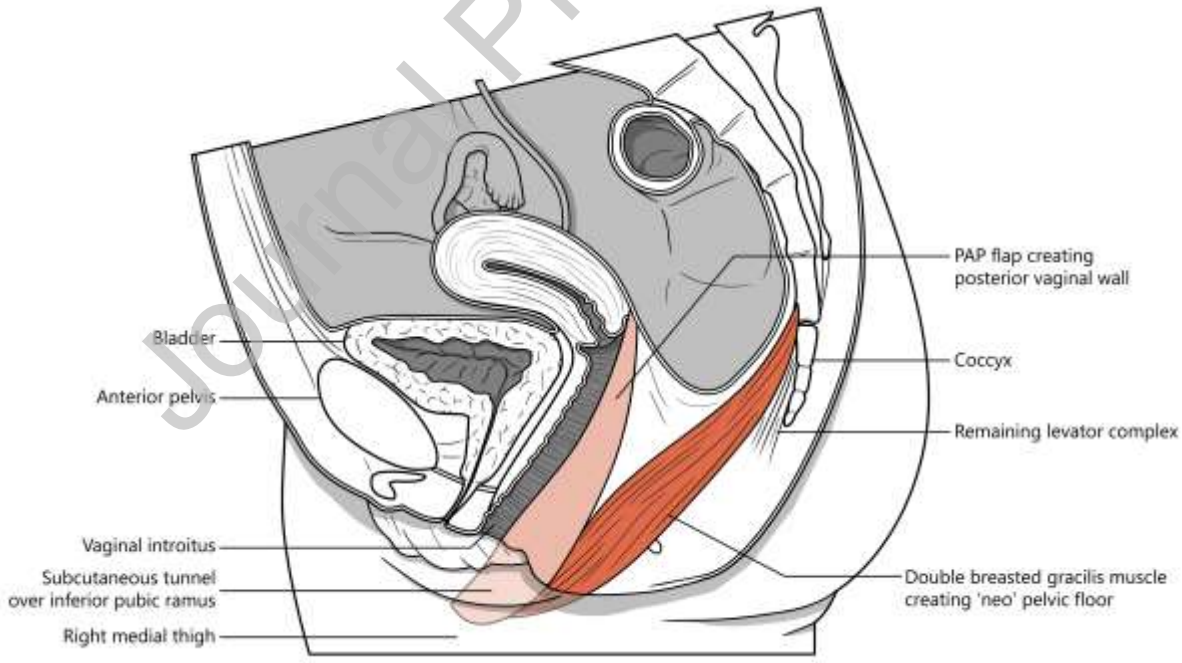

Figure 1g. Sagittal view of final flap inset. The right medial thigh is depicted with skin and fascia removed to indicate original location of flaps.

Figure 2. Right sided profunda artery perforator flap and bilateral gracilis muscle flaps raise and inset with the patient in the prone position, illustrating the versatility of the technique.

2a. The defect following extra-levator abdominoperineal excision of the rectum, with the patient in the prone position.

2b. The right sided profunda artery perforator and gracilis muscle flaps are shown before transfer to the pelvis.

2c. The profunda artery perforator flap is delivered into the pelvis and inset to form the posterior wall of the vagina.

2d. The distal tip of the profunda artery perforator flap is inset adjacent to the cervix.

2e. The bilateral gracilis flaps are delivered through tunnels dissected adjacent to the inferior pubic rami. The muscle flaps are retrieved with the aid of a rolled-up swab attached to the distal end of the muscle.

2f. The gracilis flaps are inset double breasted to create the 'neo' pelvic floor.

2g. The final appearance of the reconstructed pelvic floor. The soft tissue of the intergluteal cleft is then closed without tension over the muscle.

Patient	Age (years)	Gender	Neoadjuvant chemora	Type of tumour	Tumour resection	Complication(s)	Reoperation 1	Reoperation 2	Length of inpatie	Time to heal (month	Vaginal outcome

			dio-therapy						**nt stay**	**s)**	
1	74	Female	Yes	Recurrent anal SCC	Laparoscopic ELAPE with posterior vaginectomy and open left groin lymphadenectomy	1) Perineal wound dehiscence managed conservatively 2) Groin/thigh seroma	Re-suturing of perineal wound and drainage of left groin seroma	Groin seroma requiring decortication, skin graft and topical negative pressure dressing	41 days	4	Tight introitus and persistent urinary tract infections
2	59	Female	Yes	Recurrent anal SCC	Laparoscopic ELAPE and posterior vaginectomy	Perineal wound dehiscence managed conservatively	n/a	n/a	19 days	6	
3	63	Female	Yes	Anal adenocarcinoma	Laparoscopic ELAPE and posterior vaginectomy	Perineal wound dehiscence managed conservatively	n/a	n/a	47 days	5	No vaginal complications
4	53	Female	Yes	Anal SCC	ELAPE with posterior vaginectomy, left pelvic lymphadenecto	Perineal wound dehiscence managed conservativel	n/a	n/a	11 days	3.5	

					my	y					
5	55	Female	Radiotherapy only	Recurrent metastatic vulval cancer	Total pelvic exenteration, ilial conduit formation, bilateral pelvic lymphadenectomy, radical vulvectomy, pubic bone resection	n/a	n/a	n/a	12 days	1	
6	**47**	**Male**	**Yes**	**Anal SCC**	**Total pelvic exenteration and ileal conduit formation**	**Day 14: Massive perineal bleed**	**Day 14: Wound exploration, embolisation of bleeding branch of the internal iliac artery.**	**Day 18: Debridement and re-suturing of the wound; bilateral gracilis all viable, loss of distal 1cm of PAP flap-trimmed**	**25 days**	**4**	**n/a**

Table 1. Patients undergoing pelvic reconstructions with combined bilateral gracilis and profunda artery perforator flaps

SCC, squamous cell carcinoma; ELAPE, extra-levator abdominoperineal excision of the rectum; PAP, profunda artery perforator