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Transabdominal–pelvic–perineal (TAPP) anterolateral thigh flap: A new reconstructive technique for complex defects following extended abdominoperineal resection

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Summary *Background:* Abdominoperineal resection (APR) following radiotherapy is associated with a high rate of perineal wound complications. The anterolateral thigh (ALT) flap, combined with the vastus lateralis (VL) muscle, can cover complex perineal and pelvic anteroposterior defects. This is used for the first time transabdominally through the pelvis and the perineum (TAPP) in the infero-posterior directions; this technique has been described and illustrated in this study.
Methods: Among over 90 patients who underwent perineal reconstruction between May 2004 and June 2011, six patients presented high-grade tumours invading perineum, pelvis and sacrum, thereby resulting in a continuous anteroposterior defect. ALT + VL TAPP reconstructions were performed after extended APR and, subsequently, sacrectomy. Patients were examined retrospectively to determine demographics, operative time, complications (general and flap-related), time to complete healing and length of hospital stay. Long-term flap coverage, flap volume stability and functional and aesthetic outcomes were assessed.
Results: Mean operating time of the reconstruction was 290 min. No deaths occurred. One patient presented partial flap necrosis. Another patient presented a novel wound dehiscence after flap healing, due to secondary skin dissemination of the primary tumour. Following

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volumetric flap analysis on serial post-operative CT scans, no significant flap atrophy was observed. All flaps fully covered the defects. No late complications such as fistulas or perineal hernias occurred. Donor-site recovery was uneventful with no functional deficits.

Conclusions: The use of the ALT + VL flap transabdominally is an innovative method to reconstruct exceptionally complex perineal and pelvic defects extending up to the lower back. This flap guarantees superior bulk, obliterating all pelvic dead space, with the fascia lata (FL) supporting the pelvic floor.

Introduction

Radical pelvic surgery is used increasingly to treat locally advanced tumours to achieve long-term survival.[1] Compared to standard abdominoperineal resection (APR), extended extralevator APR[2] is associated with a reduction in circumferential margin (CRM) involvement. The perineal phase of APR is performed via an extended posterior perineal approach in order to create a more cylindrical specimen without a waist and with reduced risk of tumour involvement, with lower local recurrence risk.[1] The rate of perineal wound complications including infection and dehiscence after APR with primary perineal closure varies between 35% and 66%.[3,4] The use of preoperative radiotherapy decreases local recurrence rates[5,6] but doubles the rate of total and major perineal wound complications.[7] Similarly, more extensive perineal excision (such as extended APR associated with sacrectomy or posterior vaginal wall for giant chordomas) may further increase this risk. Various flap techniques may be used to reduce the risk of local wound complications.[8,9] The use of myocutaneous flaps, particularly vertical rectus abdominis (VRAM) or gracilis flaps, reduces the length of hospital stay and the perineal wound complication rate.[10] Gracilis flaps,[11] even if harvested bilaterally, often display insufficient muscle bulk to repair defects post extended APR. VRAM flaps[12] are generally considered the most suitable option in complex perineal and pelvic reconstructions. However, VRAM flaps have a flap failure rate of 3–10%,[13] a major wound complication rate of 15–22%[1,14] and a considerable rate of donor-site morbidity.[13–15]

Oncologic resections in the pelvic and perineal regions often result in challenging defects to reconstruct. The reconstruction should take into account the necessity of a well-vascularised tissue, sufficient bulk to avoid dead space as well a structural support to the pelvic floor to avoid perineal bowel herniation. In the specific case of giant chordomas, or high-grade anorectal tumours, the resection is extended to the sacrum and the lower back, requiring reliable posterior skin coverage. The above-mentioned muscular or musculocutaneous flaps respond to these requirements just in part.

The anterolateral thigh (ALT) flap is a workhorse for soft-tissue reconstruction and has been successfully used for perineal defects.[16,17] However, it has never been described to cover the anteroposterior defects involving perineum, pelvis up to the lower back. In this article, we analyse our series of reconstructions of lower back and pelvis with ALT flap using an innovative transabdominal approach following abdominoperineal amputation and extensive oncologic surgery. Long-term clinical and radiological follow-up, outcomes and complications are described.

Patients and methods

General patient data

Among over 90 patients who underwent perineal reconstruction admitted to our University Hospital between May 2004 and June 2011, six consecutive patients with advanced perineal and sacral tumours were retrospectively included in this study (Table 1). All cases were reviewed by a multidisciplinary board including general and orthopaedic surgeons, oncologists and radiologists recommending surgical extirpation. Informed consent was obtained from all patients, including approval for photographic documentation.

All patients presented advanced stage tumours (50% primary and 50% recurrent), requiring neoadjuvant or adjuvant radiotherapy (RT). Patient 1 had been previously operated for rectum carcinoma with vaginal fistulas treated by gracilis flaps. This patient finally developed a prominent presacral fistula, thereby requiring a transabdominal flap repair. Patient 6 had an incomplete (R2) resection after a late-stage anal carcinoma. Bone invasion required APR and S4 sacrectomy. Patient 4 did not present recurrence after rectum carcinoma extirpation but developed a huge perineal hernia after APR and demanded for perineal wall reconstruction. Patients 2, 3 and 5 presented giant chordomas invading the sacrum and underwent planned extirpation and reconstruction.

Comorbidities such as diabetes, hypertension, smoke, renal failure, hepatic failure and cachexia were preoperatively assessed. Patients with tumours invading perineum, pelvis and sacrum underwent surgical resection (performed by the team of visceral surgeons); subsequently, a continuous anteroposterior defect was observed in all patients. Patients were admitted to the Plastic Surgery department for soft tissue reconstruction.

Surgical technique

Tumour resection was performed after preoperative planning by computed tomography (CT) scan and magnetic

Table 1 Patient demographics data: patient's age, diagnosis, oncologic treatment, defect location and size, and outcomes (eventual complications, time to healing, and total hospital stay).

	Age/sex	Diagnosis	RT–CT	Oncologic procedure	Reconstruction Timing	Type of Defect	Skin Defect (cm2)	Op time	Outcome	Time of Healing (days)	Hospital stay (days)
1	F/69	Sacral Fistula post Recurrent Rectum Adenocarcinoma	Pre-op RT + CT	APR (R0)	Primary*	Perineal + Pelvic + Lower back	81 (9 × 9)	210	Favourable	14	48
2	M/34	Giant Chordoma	Post-op RT	APR + S3–S5 sacrectomy (R0)	Delayed primary (after VAC®)	Perineal + Pelvic + Lower back	360 (20 × 18)	395	Superficial Necrosis: debridement + fasciocutaneous advancement flaps	38	49
3	M/40	Recurrent Giant Chordoma	Post-op RT	APR + S3 sacrectomy (R0)	Delayed Primary (after VAC®)	Perineal + Pelvic + Lower back	208 (16 × 13)	294	Favourable	15	30
4	F/61	Rectum Adeno Ca with postoperative perineal hernia	Pre-op RT + CT	APR (R0)	Secondary reconstruction	Perineal + Pelvic	–	220	Favourable	10	10
5	M/50	Giant Chordoma	Post-op RT	APR + S3–S4 sacrectomy (R0)	Delayed Primary (after VAC®)	Perineal + Pelvic + Lower back	180 (10 × 8)	280	Favourable	16	21
6	F/55	Recurrent anal epidermoid carcinoma pT4N0R2	Pre-op RT + CT	APR + sacrectomy S4	Delayed Primary (after VAC®)	Perineal + Pelvic + Lower back	160 (16 × 10)	341	Novel dehiscence 1-month post-op debridement + pedicled gracilis and IGA rotational flap. Persistent dehiscence due to skin cancer invasion	90	95

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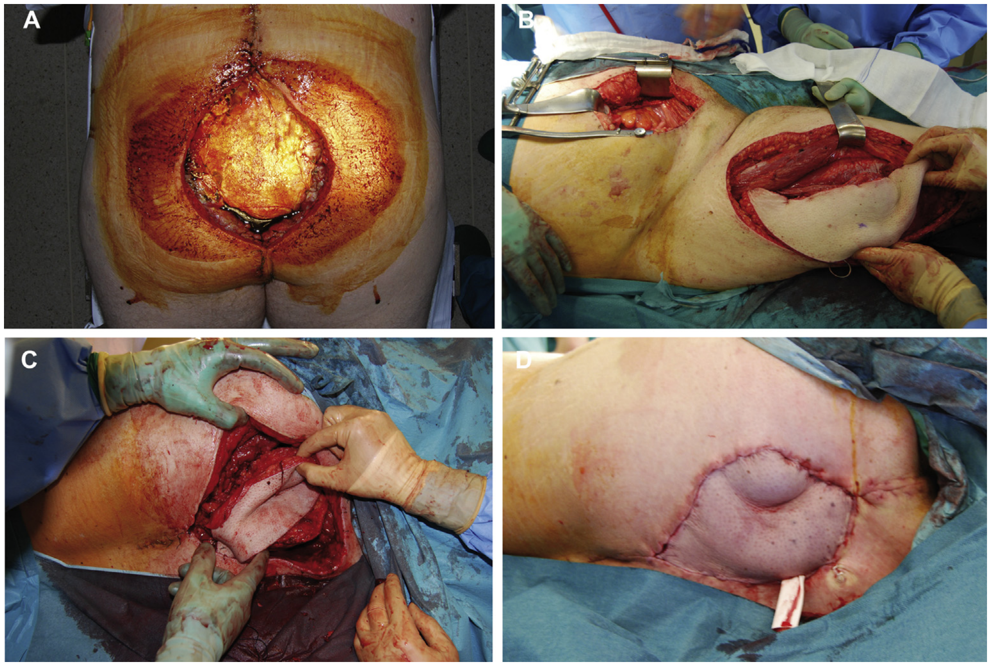

Figure 1 Preoperative defect (A), ALT + VL flap raising (B), transabdominal flap passage (with cranial side of the patient on the left) (C) and defect closure (D).

resonance imaging (MRI). The oncologic resection was performed by a combined anteroposterior approach[18] (Figure 1). APR was started in the supine position, pursuing the pelvic dissection down to the predefined sacrectomy level. Multiple biopsies were harvested for microbiological and histological workup. Iliac vessels were identified with latex tapes. An omental flap was prepared and positioned in the pelvis. After the sigmoid transection, an end colostomy was fashioned and the abdomen was closed. Perineal resection with en bloc sacrectomy was then completed in the prone position with legs abducted. An absorbable mesh was positioned caudal to omentoplasty, and a temporary vacuum-assisted closure (VAC®) was let on place for pathological analysis to be conducted, except in one case (patient 1) where reconstruction was performed immediately after extempore margin results. Resection status was considered R0 if surgical margins were ≥1 mm.[19] Staged reconstructions were performed in five out of six patients (all except patient 1, as described earlier). After placing in the lithotomy position, design and dissection of the ALT flap including the vastus lateralis (VL) muscle and the fascia lata (FL) were performed as described earlier.[20,21] The skin flap was defined around the marked perforators and according to the size of defect. First, a medial exploring incision was made down to the fascia over the rectus femoris muscle. Next, the subfascial dissection was continued laterally towards the intramuscular septum between the VL and rectus femoris muscles, identifying the septocutaneous or muscular perforators, as well as the lateral circumflex femoral (LCF) vessels by Doppler probe. All dissections included the VL muscle and the FL. The vascular pedicle was dissected from distal to proximal until its origin from the deep femoral vessels in order to increase pedicle length (Figure 2). Previous laparotomy incision was reopened (Figure 1b) to perform an abdominal wall opening (5 cm in diameter), lateral to the right rectus abdomini muscle to allow the intra-abdominal passage of the flap. The harvested ALT flap with VL muscle and FL was passed under the rectus femoris and sartorius muscles. Then, it was carefully transferred to the abdominal region passing over the inguinal ligament. The patient was then turned to the right lateral decubitus position. After VAC® removal, the flap was enveloped in a plastic bag and tunnelled through the transabdominal, pelvic and perineal cavity (TAPP) (Figure 1c, 2b and 2c). The flap was then tailored to the defect: FL was used to secure the pelvic floor from bowel herniation, while the VL muscle was used to fill the dead space resulting from the previous resection, and the cutaneous palette was adapted to cover the soft-tissue defect in the lower back (Figure 1d, 2b and 2c). If the posterior skin defect was smaller, then the harvested palette or a posterior skin coverage was not required, and skin epidermisation was performed. Donor site was closed directly in all cases.

Post-operative evaluation

Immediate post-operative monitoring was performed according to the protocol established in our unit (see Table 2). At post-operative day 1, patients were limited to ventral decubitus alternated with lateral decubitus and flap monitoring was performed every 2 h. Standing was allowed from post-operative day 3, with flap monitoring intervals extended to 4 h. Walking was progressively extended from post-operative day 7 and sitting progressively allowed from post-operative day 14 (when stitches were generally removed). Flap monitoring was performed once a day after the first post-operative week. All patients were monitored for post-operative complications, especially infections,

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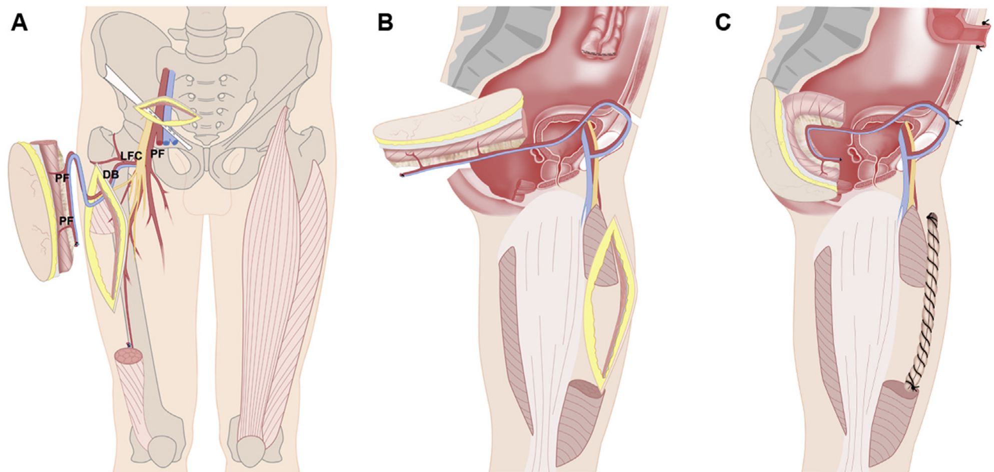

Figure 2 Schematic illustrations showing ALT harvesting (A), transabdominal passage (B) and final flap position (C). The resection shown includes sacrum, perineal floor, descending colon and anorectum (B). Flap passage is generally performed laterally to the bladder, avoiding pedicle kinking or twisting (B, C). Omentum can be used to help filling the most cranial part of the cavity. Fascia lata (not shown for clarity reason) is harvested within the flap and is generally sutured at the level of the pelvic floor to guarantee support avoiding perineal hernias.

Table 2 Post-operative management after TAPP–ALT flap.

Post-operative Time	Position	Flap monitoring (colour, temperature, refill)
Day 1	In bed. Ventral decubitus alternated with lateral decubitus	Every 2 h
Day 3	Standing allowed	Every 4 h
Day 7	Extended walking	Every 8 h
Day 14	Sitting allowed 15 min 3×/day, gradually extended	Once a day
Between days 14–21	Stitches removal	–

wound dehiscence, delayed healing, fistulas, flap necrosis and donor-site issues. Time to complete healing and hospital stay were obtained and statistically analysed.

Radiological flap volume assessment

A tight radiological follow-up (CT GE Medical Systems Lightspeed VCT, General Electric Corporate, Fairfield, CT, USA; MRI Magnetom Siemens Skyra 3T, Siemens Healthcare, Munich, Germany) was performed for oncologic reasons (3–6–12 months post-operative the first year, then every 6 months). Images were useful to precisely evaluate flap efficiency in terms of dead space coverage and to quantitatively evaluate bulk atrophy over time. We chose to estimate flap volume at 6 months of follow-up and every year post-operatively. Volumetric analysis was performed using calculation-imaging program tools on follow-up CT scans (Carestream Vue PACS, Carestream Health, Rochester, NY, USA) (Figure 2a). The longest follow-up was 54 months and the shortest 6 months. Values were compared to initial flap volume (6 months post-operatively). In each cross section (ranging from 2- to 5-mm thickness), different flap surfaces from caudal to cranial were assessed. The volume for every section (surface × section thickness) was obtained; then summation of the different section volumes yielded the total flap volume (TFV). Measurements were performed by an external examiner, blind to both the study and the different patients.

Results

Outcomes and complications

Mean follow-up was 30 months (6–54 months, median 21). All cases presented advanced tumours with extended pelvic infiltration, requiring extralevator APR and soft-tissue reconstruction. Sacrectomy was performed in four out of six patients. The average surface defect after oncologic procedure was 198 ± 37 cm^2 (average ± SEM, standard error of mean). Patient age ranged from 24 to 69 years (51 ± 5 years; average ± SEM) years. The average reconstruction operative time was 290 ± 29 min (average ± SEM). Pedicle was followed up to its departure from the profunda artery after sacrificing ascending and transverse branches of the LCFA, in order to obtain sufficient length to allow the pedicled transabdominal passage in all cases (up to 12 cm). Patients 1, 3, 4 and 5 healed uneventfully. Patient 2 presented the most extensive defect (Figure 1) and developed a venous congestion on pedicle kinking, despite pedicle revision at 24 h; he developed partial superficial necrosis of the skin paddle, while keeping a viable muscle portion. After debridement, two fasciocutaneous advancement gluteal flaps were used to cover the superficial defect. Patient 6 died of cancer-related reasons 6 months post-

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operatively. This patient originally presented a recurrent anal epidermoid carcinoma with insufficient resection (R2). Patient was cachectic and presented renal failure and hepatic insufficiency. Besides the heavy comorbidities, flap initially showed uneventful healing, while developing a first dehiscence at 1 month post-operative, treated by gracilis flap and fasciocutaneous gluteal rotation flap. This dehiscence turned to be a tumour recurrence, with skin biopsies showing primary tumour invasion. A conservative treatment of the dehiscence was decided and the patient underwent palliative care. When considering time to healing and hospital stay, we excluded this patient from statistical analysis for insufficient long-term follow-up. Among the other patients, average time to healing was 19 $\pm$ 12 days (average $\pm$ SEM), with an average hospital stay of 32 $\pm$ 12 days (average $\pm$ SEM). No further dehiscence, seroma, fistulae or hernias were detected during follow-up (Figure 3). After initial weakness of the anterior thigh muscle compartment in the first 3 months, no donor-site morbidity was present at long term, with normal ambulation in all patients at the end of follow-up (Figure 4). Patients were generally satisfied with the aesthetic outcome. However, patient 4 underwent lipofilling of the flap donor site because of a soft-tissue depression at the scar level 3 years post-operatively.

Radiological follow-up and flap volumetric quantitative analysis

No signs of dead space, liquid collection and partial or total flap necrosis were noticed during imaging follow-up. Moreover, flap pedicles were still visible in angioCTs, confirming vessel patency and efficient flap vascularisation up to 4 years post operation (Figures 3 and 4). In all patients, a volumetric analysis of TAPP flaps over time was performed and resumed in a graph (Figure 5). An average flap volume (average of volumes at different time points) of each patient was calculated, ranging from 1343 cm^3 (patient 3) to 4543 cm^3 (patient 2) with a global average of 2727 $\pm$ 433 cm^3 (average $\pm$ SEM) (Figure 5). No flaps showed significant flap atrophy. However, patient 2 showed a trend towards volume reduction, due to the compression exerted on the flap from the recurrence of the tumour since the second follow-up year.

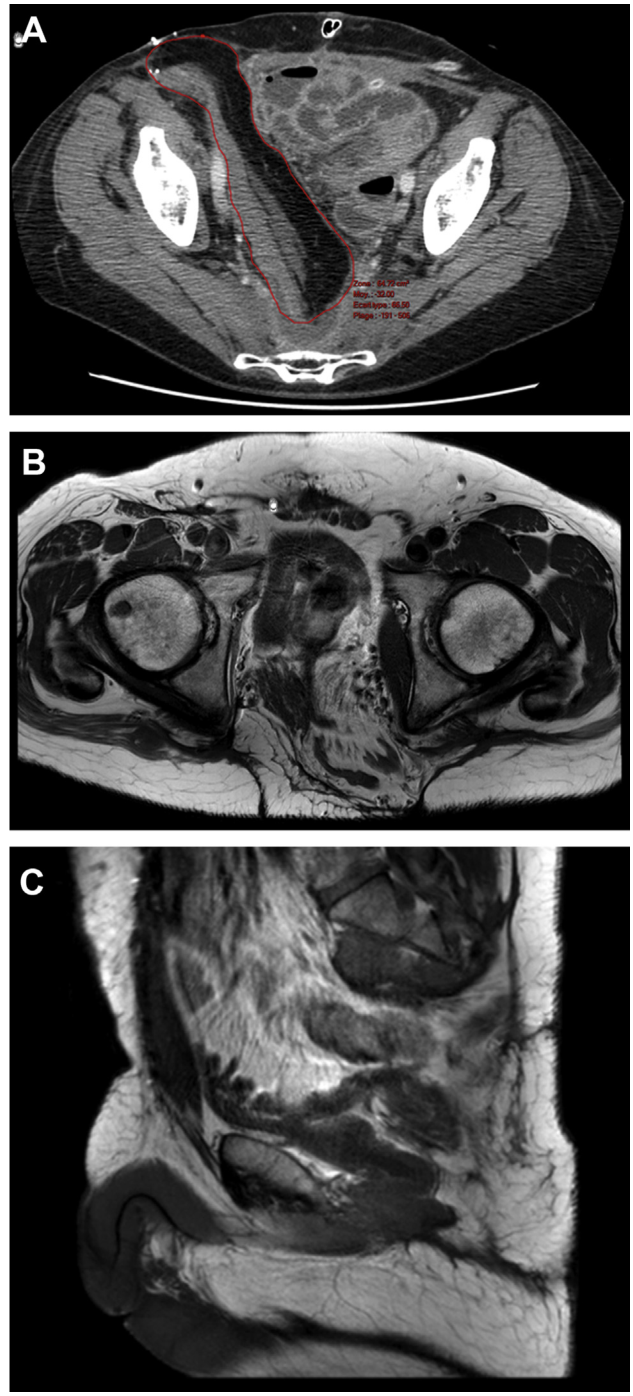

Figure 3 Radiological volumetric analysis with an example of flap surface measurement (A). MRI (patient 2, 1 year post-operatively) confirming flap stability over time with no collections or dead space without bowel herniation. Both ALT + VL flap and omentum flap participate in filling the anteroposterior defect (B,C).

Discussion

APRs involve the sacrifice of anal and perineal region, descending colon, with confection of end colostomy. If in the majority of cases, primary closure is achieved and the pelvis can be filled using an omental flap. A myocutaneous flap repair is needed when APR is extended to the sacral level ending up in total pelvis exenteration (TPE).[22] The goals of reconstruction are to provide a stable and vascularised soft-tissue coverage to fill the anterior–posterior dead space, to recreate structural support to pelvic viscera and to ensure adequate wound healing while maintaining a cosmetically acceptable appearance. Considering the complexity of these defects, surgical reconstruction is often a challenging task for plastic surgeons. The gracilis muscle flap, supplied by the medial circumflex femoral artery, while being useful for small perineal defects reaching the distal portions of the pelvis, is inadequate for large defects.[22] Bilateral V–Y gluteal advancement or rotation musculocutaneous flaps have been described to cover perineal defects after TPE.[1,8,23] These flaps display sufficient bulk to

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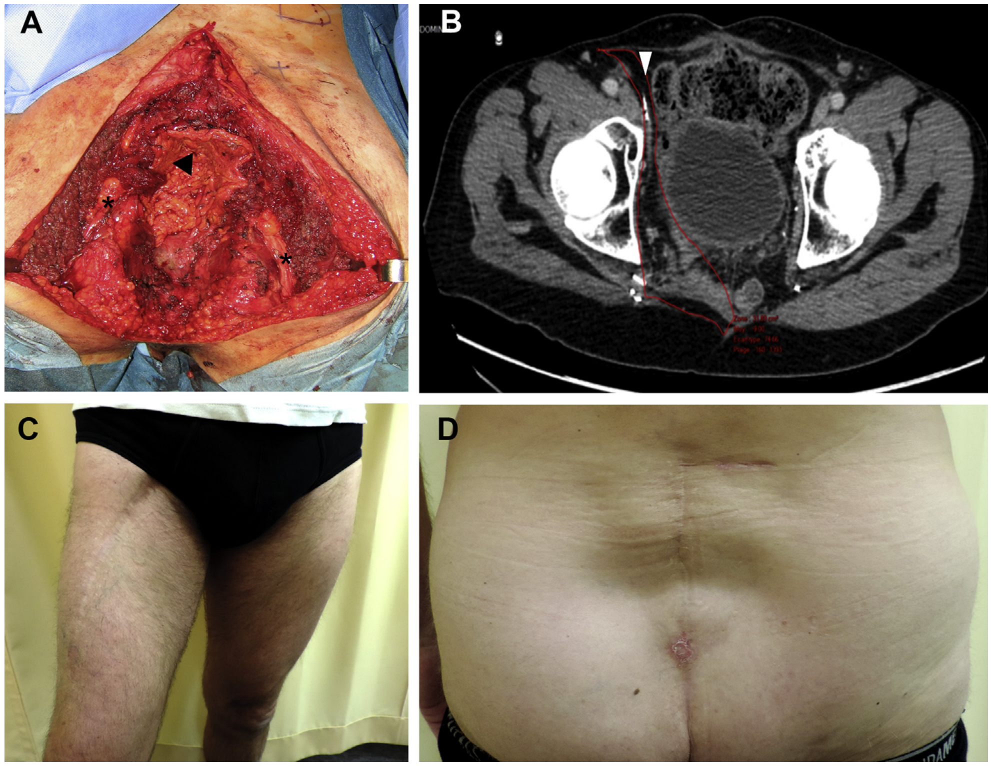

Figure 4 Post-oncological resection exposing sacrum, covered by an omental flap (black arrow head) and sciatic nerves (*). Both gluteus maximus have been resected laterally (top left) (A). AngioCT at 4 years post-operatively showing patent flap pedicle (white arrow head); the flap forms the posterior abdominal wall; the external skin coverage was preserved and used for posterior supplementary closure (B). Donor site at 4 years post-operatively. (C). Absence of posterior abdominal wall herniation in valsalva (D).

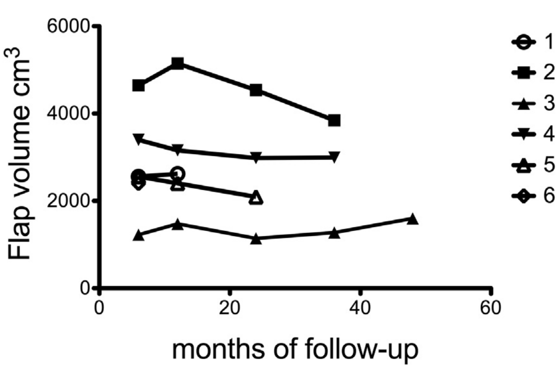

Figure 5 Graph of volumetric flap analysis showing volume stability over time.

reconstruct the pelvic floor,[24] but a complete inner coverage is restricted by limited mobility of the flap. Moreover, they depend on superior or inferior gluteal arteries, which are often sacrificed during oncologic resection.

The transpelvic vertical rectus abdominis myocutaneous (VRAM) flap is generally used for reconstructions after pelvic exenteration involving sacrum and pelvic reconstruction.[22,25,26] However, It is usually avoided in patients who have undergone laparotomy because of the significant donor-site morbidity such as fascial dehiscence, hernia and imbalance of truncal core muscular support.[27,28] Moreover, the muscle and skin paddle may be insufficient to fill the pelvic dead space, even if combined with omental flaps. Free flaps can be a further choice, but access to recipient vessels at the wound site may be challenging, and previous radiotherapy may have severely damaged recipient vessels.[25]

All of our patients presented huge defects requiring a considerable amount of muscular tissue to fill an anteroposterior pelvic defect and to reconstruct the perineum. Moreover, in four out of six patients, the defect extended up to the posterior skin. For these reasons, we used ALT flaps associated with the VL muscle and FL, thus creating a composite myocutaneous flap. This flap has a long vascular pedicle and a large skin paddle and can be raised with musculocutaneous perforators feeding the muscle. Because of its long pedicle and large arc of rotation, the flap can be transferred to cover the posterior defect. By including the VL, we could obtain a superior muscle bulk when compared to a myocutaneous VRAM flap, and the fixation of FL into the pelvis ideally prevented perineal herniation or posterior wall herniation after sacrectomy (Figure 4). All patients underwent radiotherapy (three preoperative, three postoperative; cfr Table 1), with the flaps guaranteeing healthy vascularised tissue. In one of our patients, where defect size was massive (Figure 1), partial skin paddle necrosis had to be debrided and external surface was covered by fasciocutaneous gluteal advancement flaps. As mentioned earlier, the recurrent complications in patient 6 are probably because the oncologic disease was widespread, which ultimately leads to premature patient death.

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In all the other patients, the cutaneous palette survived and was used to monitor flap viability. Radiological follow-up confirmed flap stability and limited or absent atrophy over time, assuring coverage and support avoiding dead space (Figures 3 and 4).

This reconstructive solution is mainly indicated in those patients where huge anteroposterior perineal–pelvic defects are present, and traditional reconstructions would be insufficient. Moreover, the transfer method may be complicated and indications should be carefully weighted. This explains the limited number of patients included in the study. However, besides the low absolute numbers, long-term results at follow-up confirm the reliability and the effectiveness of this innovative technique.

Conclusions

We believe that the TAPP–ALT composite flap can be an extremely useful tool in complex reconstructions after extended APR or TPE and should be the flap of choice in the case of previous laparotomies that may preclude VRAM flaps. Moreover, this flap provides healthy tissue from non-irradiated fields, abundant muscle padding and a stronger pelvic support using the FL, with minimal donor-site morbidity when compared to the VRAM.

Conflict of interest

None.

Acknowledgements

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