Multiple pedicled flaps cover for large defects following resection of malignant tumors with partition concept
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Abstract
Large defects after skin malignant tumors resection were difficult to repair. We introduced a partition concept, in which the large defects were divided into several subunits, and each subunit was repaired by a certain pedicled flap to achieve a complete coverage.

Between May 2012 and Oct 2016, 8 patients with skin malignant tumors underwent radical resection. Prior to surgery, the dimension of the potential defect after tumor ablation was estimated and outlined. After evaluation, the partition concept was applied and the defects were divided into several subunits. Also, the rationality of the choice of pedicled flap was evaluated. Each flap was used to cover its specific subunits defect.

After excision, the defect areas were from 13 cm to 36 cm. Each subunit was designed to be repaired with a pedicled flap, which included local random flap, superficial iliac artery flap, transverse rectus abdominis myocutaneous (TRAM) flap, lateral thoracic advanced island flap, anterolateral thigh (ALT) flap, anteromedial thigh (AMT) flap, and deep circumflex iliac artery (DCIA) flap. Primary closure of both donor and recipient sites was achieved in all patients. All the flaps survived. Flap necrosis was not observed.

Reconstruction of large defects following resection of malignant tumors with multiple pedicled flaps was a reliable method. The partition concept is useful in the reconstruction of large tumor wounds in 1-stage operation.

Abbreviations: ALT = flap anterolateral thigh (ALT) flap, AMT = flap anteromedial thigh (AMT) flap, CT = computerized tomographic scanning, DCIA = flap deep circumflex iliac artery (DCIA) flap, MRI = magnetic resonance imaging, PET = positron emission tomography, pSCC = penile squamous cell carcinoma (pSCC), TRAM = flap transverse rectus abdominis myocutaneous flap.

Keywords: large defect, malignant tumor, partition concept, pedicled flap

1. Introduction
The reconstruction of large wound after skin malignant tumor excision is a challenge in reconstructive surgery and surgical oncology. Primary reconstruction has been shown to reduce the incidence of wound infections and dehiscence. Factors, such as postoperative radiotherapy, hospitalization period, cost of treating, also forced immediate reconstruction. Review of literature shows a number of studies reconstructing large defects. Various options available are skin grafting, artificial dermis, pedicled myocutaneous flaps, and free flaps. To date, a single all-around method has yet to emerge to deal with all sorts of wounds. For instance, skin grafting, where mismatched skin color, loss of elasticity, and graft retraction make it difficult to provide a functional cover and tolerate high dose of postoperative radiotherapy, requires a long dressing time and therefore an extended hospitalization time. Free flap transfers have revolutionized oncologic surgery. Even in the most experienced hands, they are time consuming and often require more technical expertise. Irradiation, previous surgery, and comorbidities can make these operations challenging and less predictable.

Pedicled skin flaps is heavily applied in oncologic and reconstructive surgery with the advantages of simplified procedure and reliable blood supply. However, in many cases, a giant defect or a large defect cannot be covered or covered properly with a certain single pedicled flap. In these situations, high tension, tissue retraction, local tissue deformity, or incomplete coverage may occur. For the above reasons, we introduced a partition concept. In this concept, the oncologic defect was divided into several subunits, and each subunit was repaired by a single pedicled flap. We think this method is especially suitable for the large defect after resection of malignant tumor. Our experience and literature review are presented.

2. Patients and methods
This study had been approved by the Ethics Committee of Sun Yat-sen Memorial Hospital. The cases with oncologic defect which could not be reconstructed with a single pedicled flap were recruited. Between May 2012 and Oct 2016, the partition concept was applied in 8 patients for reconstruction of large oncologic defects located at various anatomical sites. Four females and 3 males with a mean age of 53.125 years (range, 39–65 years) were included in this study. The oncologic tumors...
3. Operative technique

Prior to surgery, the dimension of the potential defect after tumor ablation was estimated and outlined. The sites included perineal region \( (n=2) \), abdomen \( (n=1) \), groin \( (n=1) \), chest wall \( (n=1) \), oyster-chest wall \( (n=1) \), and lower abdomen-perineum \( (n=1) \). After evaluation, the defects were divided into several subunits. In each of the cases, the primary defect was divided into 2 \( (n=6) \) or 3 subunits \( (n=2) \).

As to dermatofibrosarcoma protubersans, the operation consists of a wide local excision with 3–5 cm margins, as deep as reaching the layer of deep fascia (muscular fascia). In other cases, a 2 cm circumferential excision was made beyond the macroscopic affected margin, with vertical excision to the layer of deep fascia (muscular fascia). We marked 6 to 8 sites at margin of and 1 to 2 sites at base of excised specimen, tissue of which was sent to pathology. Apart from the case of recurrent carcinoma of penis, margins in other cases were all found negative. Patients in 2 carcinoma of vulva cases received inguinal lymphadenectomy (operated by gynecologists), whereas the patient in the case of recurrent carcinoma of penis received bilateral inguinal lymphadenectomy (operated by urologists).

The midline of wound or dividing line of anatomy (such as anterior line axillary, inguen) was usually chosen as the boundary between 2 subunits. And then, the candidate pedicled flaps were selected and designed to match the size and shape of the subdefects. All the flaps were adjacent pedicled skin flap, which may be a known axial flap, a perforator flap or a random flap. Usually, the flaps should be frequently used and easy to harvest.

The rationality of the choice of skin flap was evaluated. Each flap was used to cover its specific subunits defect. Long distance jumping repairing should be avoided, neither the pedicles’ overlapping, compression or overstretch. Preoperative Doppler examination was necessary for perforator flaps. A careful surgical procedure was important to ensure the blood supply of flap. Each flap was used to cover the corresponding subdefect. Each subunit was designed to be repaired with a pedicled flap, which included local random flap, superficial iliac artery flap, transverse rectus abdominis myocutaneous (TRAM) flap, lateral thoracic advanced island flap, anterolateral thigh (ALT) flap, anteromedial thigh (AMT) flap, and deep circumflex iliac artery (DCIA) flap.

4. Results

After wide excision, the defect sizes ranged from \( 13 \times 17 \text{ cm}^2 \) to \( 36 \times 23 \text{ cm}^2 \). Two cases were carcinoma of vulva, which repaired by bilateral anteromedial thigh flaps. Three cases were advanced breast cancer, which repaired by TRAM flap, lateral thoracic advanced island flap, and local rotational flap of proximal upper arm. Two cases were dermatofibrosarcoma protubersans, which repaired by ALT flap, DCIA flap, and superficial iliac artery flap. One case was local infiltration of advanced penile squamous cell carcinoma (pSCC), which was repaired by bilateral AMT flap and left DCIA flap.

Primary closure of both donor and recipient sites was achieved in all patients. All the flaps survived with no hematoma, seroma, flap necrosis, or infection observed. One case had fat liquefaction and partial wound dehiscence. In the follow-up period, long-term complications such as hernia, scar contracture, or malformation were not apparent in our observations.

The detailed documentations of the patients were reviewed retrospectively (Table 1).

5. Classical cases

5.1. Case 1

A 65-year-old woman with advanced recurring carcinoma of vulva experienced a progressively enlarged necrotic fester in her perineal region. She received vulvar squamous cell carcinoma resection and local radiotherapy before, but recrudescence was observed. In lithotomy position, the ulcer wound measured 8 \( \times \) 9 cm over the vulvar area with an extensive infiltrating the urethra orifice and vaginal introitus. After extensive perineal resection, the defect was 16 \( \times \) 17 cm. The whole perineal, mons veneris area and bilateral partial inguinal region was involved. The urethra and vaginal wall were partial removed. The defect was divided into 2 parts defined by the middle line, and bilateral pedicled AMT flaps were designed for the covering (Fig. 1).

5.2. Case 2

A 47-year-old woman with advanced recurring breast cancer who was about to get the recurrent tumor removed. The pedicle TRAM flap was designed to repair the defect. Single pedicle TRAM flap had a risk of partial flap loss or fat necrosis\(^{10,11}\) and the shape of bipedicle TRAM flap without a middle incision always could not fit the defect well. Also, the large thoracic wound could be reconstructed with V-Y latissimus dorsi musculocutaneous flap\(^{10,11}\). But skin elasticity of the back was not good as abdomen. So, the estimated defect was designed to be divided into 2 subunits. Each subunit closed by a single raising unilateral pedicle TRAM flap following the chimeric flap principle\(^{12}\) (Fig. 2).

5.3. Case 3

A 51-year-old man presented with a large recurrent mass in the epigastric region that was identified as a dermatofibrosarcoma protubersans in previous surgery 2 years ago. The specimen was resected with a 5 cm margin. A circular large defect was left with the dimension of \( 21 \times 22 \text{ cm} \). A single flap could not be easily found without skin grafting. And the skin of abdominal wall had a definite elasticity. So, bilateral superficial iliac artery flap was planned to cover the defect (Fig. 3).

5.4. Case 4

A 53-year-old woman presented with advanced recurring breast cancer. The resection range covered the whole left axilla, partial chest wall, and root of upper arm. The defect was divided into 3 parts defined by anterior axillary line, apical axillary region, which were repaired by left TRAM flap, lateral thoracic advanced flap and local flap of the upper arm (Fig. 4).

5.5. Case 5

A 39-year-old patient presented with an extensive putrescent ulceration of abdominoperineal region infiltrated by advanced pSCC. The tumor had grown gradually over 2 years and originated from a penile mass, which was confirmed as well-differentiated squamous carcinoma by histopathology. The infiltration was from skin of right anterior superior iliac spine.
6. Discussion

In reconstructive surgery and surgical oncology, the flap technique is very important when closing the wound followed by reconstruction. All flaps are based on the patient’s preferences, the defect reconstruction and donor-site morbidity is critical for the recovery and following treatment. How to balance the defect reconstruction and donor-site morbidity is important. To our knowledge, it is the largest defect after the ALTRAP (anterolateral thigh perforator) flap design, to provide customized wound cover for very large defects whilst maintaining direct closure of the donor site. But complications are reduced. The primary defect was divided into several kinds of defect. Second, operation difficulty and operation risk of reoperation due to complications was lower than skin graft design, to provide customized wound cover for very large defects whilst maintaining direct closure of the donor site. But complications are reduced. The primary defect was divided into several kinds of defect. Second, operation difficulty and operation risk of reoperation due to complications was lower than skin graft design, to provide customized wound cover for very large defects whilst maintaining direct closure of the donor site. But complications are reduced. The primary defect was divided into several kinds of defect. Second, operation difficulty and operation risk of reoperation due to complications was lower than skin graft design, to provide customized wound cover for very large defects whilst maintaining direct closure of the donor site. But complications are reduced. The primary defect was divided into several kinds of defect. Second, operation difficulty and operation risk of reoperation due to complications was lower than skin graft design, to provide customized wound cover for very large defects whilst maintaining direct closure of the donor site. But complications are reduced. The primary defect was divided into several kinds of defect. Second, operation difficulty and operation risk of reoperation due to complications was lower than skin graft design, to provide customized wound cover for very large defects whilst maintaining direct closure of the donor site. But complications are reduced. The primary defect was divided into several kinds of defect. Second, operation difficulty and operation risk of reoperation due to complications was lower than skin graft design, to provide customized wound cover for very large defects whilst maintaining direct closure of the donor site. But complications are reduced. The primary defect was divided into several kinds of defect. Second, operation difficulty and operation risk of reoperation due to complications was lower than skin graft design, to provide customized wound cover for very large defects whilst maintaining direct closure of the donor site. But complications are reduced. The primary defect was divided into several kinds of defect. Second, operation difficulty and operation risk of reoperation due to complications was lower than skin graft design, to provide customized wound cover for very large defects whilst maintaining direct closure of the donor site. But complications are reduced. The primary defect was divided into several kinds of defect. Second, operation difficulty and operation risk of reoperation due to complications was lower than skin graft design, to provide customized wound cover for very large defects whilst maintaining direct closure of the donor site. But complications are reduced. The primary defect was divided into several kinds of defect. Second, operation difficulty and operation risk of reoperation due to complications was lower than skin graft design, to provide customized wound cover for very large defects whilst maintaining direct closure of the donor site. But complications are reduced. The primary defect was divided into several kinds of defect. Second, operation difficulty and operation risk of reoperation due to complications was lower than skin graft design, to provide customized wound cover for very large defects whilst maintaining direct closure of the donor site. But complications are reduced.

Table 1

| Patient no. | Sex | Age, years | Cause of defects | Preoperative examination | Remote metastasis or deep invasion | Defect region | Size of skin defect, cm | Number of subunits | Flap design | Flap size, cm | Complications |
|-------------|-----|------------|------------------|--------------------------|-----------------------------------|--------------|------------------------|------------------|-------------|---------------|---------------|
| 1           | F   | 65         | Carcinoma of vulva | Abdominal and pelvic MRI | No | Perineal region | 16 x 17 | 2 | Bilateral anteromedial thigh flap | 20 x 9,25 x 8 | None |
| 2           | M   | 51         | Dermatofibrosarcoma protuberans | Abdominal MRI | No | Abdomen | 21 x 22 | 2 | Bilateral superficial iliac artery flap | 16 x 13 x 11 | None |
| 3           | M   | 49         | Dermatofibrosarcoma protuberans | Abdominal and thigh MRI | No | Right groin | 13 x 17 | 2 | Bilateral anterolateral thigh flap, right deep iliac artery flap | 8 x 13 x 15 | None |
| 4           | F   | 47         | Advanced breast cancer | Thoracic and abdominal CT | No | Chest wall | 21 x 18 | 2 | Bilateral TRAM flap | 18 x 10 x 10 | None |
| 5           | F   | 62         | Advanced breast cancer | Thoracic and abdominal CT | No | Chest wall | 20 x 17 | 2 | Bilateral TRAM flap | 18 x 9 x 18 | None |
| 6           | F   | 59         | Carcinoma of vulva | Abdominal and pelvic MRI | No | Perineal region | 19 x 15 | 2 | Bilateral anteromedial thigh flap | 26 x 8 x 27 | Fat liquefaction, partial wound dehiscence |
| 7           | F   | 53         | Advanced breast cancer | Thoracic and abdominal CT | No | Osteo-chest wall | 29 x 18 | 3 | Left TRAM flap, lateral thoracic flap and local rotational flap of proximal left upper arm | 11 x 23 x 30 x 12 x 6 | None |
| 8           | M   | 39         | Local infiltration of advanced penile carcinoma | Abdominal and thigh MRI, whole-body PET/CT | No | Lower abdomen—Perineum | 36 x 23 | 3 | Right anterolateral medial thigh flap, left deep iliac artery flap and left anteromedial thigh flap | 30 x 17 x 27 x 15 x 22 x 10 | None |

CT=computerized tomographic scanning, MRI=magnetic resonance imaging, PET=positron emission tomography, TRAM flap=transverse rectus abdominis myocutaneous flap.
small, which also ensured the operability. Meanwhile, the blood circulation disturbance in a certain area could be prevented. Furthermore, the multiple pedicled flaps, transferred without vascular anastomosis, outclass free flap in terms of postoperative complications, which includes complete flap failure, pseudoaneurysms, and vascular embolization. Third, with smaller donor site wound, the secondary defect can be closed easily. Any risk of incapable of closing the secondary defect goes against the original intention of the partition concept. The donor-site morbidity is reduced.

Though we think the multiple pedicled flaps cover for large defects following resection of malignant tumors with partition concept could be applied widely in wound therapy, it is not an all-round method in large defect repair. In some parts of the body where subject to poor blood supply and lack loose adjacent skin, large skin defects may not be suitable for multiple pedicled flap repair, and the principle thereof.

Reconstruction of large defects following resection of malignant tumors with multiple pedicled flaps was similar with some techniques. The concept of subunits has a long history and is well established in facial reconstruction as the “aesthetic subunit” principle.[22,23] Also, some nonfacial wound reconstruction given expression to partition concept. Zhang et al.[24] used the reverse bipaddle posterior interosseous artery perforator flap to cover large defects of the hand. In their cases, the type A chain-like variant was used to cover defects involving 2 different units of the hand, and the type B “kiss” pattern was required to resurface a large, single unit defect of the hand. Some other reports, such as “double-helix flap to close a massive circular soft-tissue defect,”[25] “multiple V-Y advancement and rotation flaps for a large cheek defect”[26] and “double pedicled perforator flap to close flank defects”[27] embody obvious elements of partition concept. What is more, some literature[28] had reported reconstruction of large defects with multiple pedicled flaps, but only case report, in which skin grafting also be used.

Conceptually, some theories were similar with partition concept introduced in our cases. These theories contained “components separation technique” proposed for repairing large abdominal wall hernias[29] “serial laser excision method” developed for melanocytic nevi larger than 5 mm,[30] “compartmentalization of massive vascular malformations” in which a massive vascular malformation is divided into multiple compartments by changing the direction of the suturing,[31] and “diamond concept” in fracture healing.[32] All these techniques, methods and concepts contained similarities, in which a big issue could be solved by decomposing it into small ones. When decomposed, the small ones could be solved easily and better.

In conclusion, we think the partition concept of closing large defects after skin malignant tumors resection with multiple pedicled flaps proposed an important guideline in our cases. It provided a way of surgical design, as a supplement or an alternative option for the selection of flap for covering large defects after skin malignant tumors resection.
Figure 3. (A) Preoperative view. (B) Operative view. (C) Postoperative view. (D) Seven months later.

Figure 4. (A) Preoperative view with different colors defining defective subunits. (B) Operative view. (C) Postoperative view. (D) Four months postoperative view.
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