Clinical significance of the secondary pedicle amputation of the repair of distal defects with pedicled axial flap

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Abstract
We aimed to explore the clinical significance of the secondary pedicle amputation of the repair of distal defects with pedicled axial flap. Five patients who underwent pedicled axial flap transfer to repair a large area of skin and soft tissue defects in our hospital were included in this retrospective study. Detailed information including general data and clinical data, such as preoperative complication, type of primary wound, the distance between the primary wound and the donor site (cm), postoperative complications, and types of axial flap were collected. The patients had good joint movement at 6 months after pedicle amputation. At 48 hours after transplantation, except for the last patient (NO.5), there were no obvious complications such as blood supply disorder, infection, and incision dehiscence of the patients, and the flaps survived well. Just after pedicle amputation, 3 and 6 months after pedicle amputation, the flaps survived well with good local morphology. Forty-eight hours after operation, part of the distal flap in the last patient (NO.5) was necrotic. After 6 months of pedicle amputation, part of the flap was transferred to the distal wound again. At 6 months after pedicle amputation, these patients could accept local scars even though the scar of the last patient was obvious. The secondary pedicle amputation of the repair of distal defects with axial flap could avoid the compression of the vascular pedicle in the subcutaneous tunnel between the donor site and the primary wound, which may ensure the bold supply and increase the survival rate of the flap.

KEYWORDS
axial flap, oil sand, secondary pedicle amputation
1 | INTRODUCTION

The injury, tumour resection, and other reasons can cause a large area of skin and soft tissue defects, which cannot be healed by itself, so additional skin and soft tissue coverage (skin flap) is needed. We usually classified the types of skin flaps into random flaps and axial flaps according to the form of blood circulation in skin flaps.\(^1\) Pedicled axial flap, also called the arterial flap, contains an artery and accompanying venous system. According to the blood supply type, it can be divided into direct skin and blood vessel flap, muscle space skin and vascular flap, artery stem small branch vascular flap, and so on.\(^1\) The axial flap has rich blood circulation, a high survival rate, and flexible application, which provides an effective and reliable repair option for a large area of skin and soft tissue defects.\(^2\)

Some examples of axial pattern flaps include the following: Nasolabial flap off of the angular vessels, paramedian forehead flap off of the supratrochlear vessels, facial artery musculomucosal flap, and melolabial flap. Liu\(^3\) designed upper frontal facial pedicle flaps based on the inner transverse perforator of the ascending frontal branch of the superficial temporal artery for defect repair after facial tumour removal, the low incidence of complications and easy concealment of the donor site underscore the safe and aesthetically acceptable nature of the procedure. Papa\(^4\) found that M-RIF (middle-retroauricular island flap M-RIF) was a valid surgical option when dealing with non-helical defects of the anterior pinna, it allowed the reconstruction of the defect of the entire anterior surface of the auricle apart from the helix and the lobe and primary donor site closure. In general, axial flaps have a greater width-to-length ratio versus random pattern flaps, full-thickness coverage, durable skin, and excellent cosmetic results. Due to these flaps’ predictable vascular supply, they can provide durable full-thickness skin, which can result in minimal scar tissue and near-normal hair growth. Previous studies reported that flap necrosis was the main complication, which was caused by the following reasons:\(^1\): active infection occurred at the recipient site;\(^2\) there was a compromise in the flap pedicle or inadequate debridement of the wound bed;\(^3\) the patients smoked;\(^4\) and the donor site was the radiation skin area.\(^5,6\)

However, there are several disadvantages in clinical application for these axial flaps. Sometimes, the donor site is far away from the primary wound; honestly, it is a challenge to repair the distal defect with axial flaps. In this situation, it is necessary to separate and destroy the normal tissue between the donor site and the primary wound, which may lead to local scars, texture hardening, etc. Therefore, it is very important to find an appropriate treatment to avoid the destruction of the normal tissue between the donor site and the primary wound. Herein, our study aimed to explore the clinical significance of secondary pedicle amputation of the repair of distal defects with pedicled axial flap.

2 | MATERIALS AND METHODS

This study was approved by the ethics committee of The Third Hospital of Peking University (NO. IRB00006761-M2020576), and the informed consent forms were obtained from all patients. From June 2014 to March 2021, five patients who underwent pedicled axial flap transfer to repair large area of skin and soft tissue defects in our hospital were included in this retrospective study.

All operations were performed by the same senior plastic surgeon. The primary wound was treated first, and the standard debridement was performed for the wound with poor healing.\(^7\) Extended resection was performed for tumour patients, and the intraoperative frozen pathological examination was performed at the cutting edge to make sure that the lesion was completely removed. The pedicled axial flap was designed according to the size and location of the wound. And the axial flap was based on the vascular pedicle, then the scope of dissection included the fascial vessels in the subcutaneous fat.\(^8\) The flap was reversed and transferred to the defect area. The distal part of the flap was sutured intermittently with the skin tissue around the primary wound. The donor site (secondary wound) was directly sutured or grafted skin according to the defect size. In this situation, it is necessary to separate and destroy the normal tissue between the donor site and the primary wound, which may lead to local scars, texture hardening, etc. Therefore, it is very important to find an appropriate treatment to avoid the destruction of the normal tissue between the donor site and the primary wound. Herein, our study aimed to explore the clinical significance of secondary pedicle amputation of the repair of distal defects with pedicled axial flap.

Key Messages

- we used oil sand to cover the skin flap between the donor area and the primary wound
- the secondary pedicle amputation of the repair of distal defects with axial flap could avoid the compression of the vascular pedicle
- secondary pedicle amputation of the repair of distal defects with pedicled axial flap may ensure the bold supply and increase the survival rate of the flap
and the flap was repaired properly. The remaining tissue was excised or sutured back to the original donor site (Figure 1). The conventional treatment of axial flap transfer for repairing distal defects is shown in Figure 2.

2.1 | Data collection

Detailed information including general data, such as age, body mass index (BMI), length of hospital stays, and clinical data, such as preoperative complication, type of primary wound, the distance between the primary wound and the donor site (cm), types of axial flap, operation method, and postoperative complications were collected.

At 48 hours and 2 weeks after operation, the survival situation of the grafted flap was observed and recorded, including infection, hematoma, incision dehiscence, and so on; the local morphology after pedicle amputation was observed and recorded. Three and six months after pedicle amputation, the skin colour, texture and local bloating of the defect area, and the area between the defect area and the donor area were observed. Six months after operation, the patients were investigated whether they were satisfied with the treatment effect, including colour, elasticity, texture, and overall effect.

The satisfaction was defined as follows: After repairing the defect with the flap across the joint area, the joint movement is not affected. The degree of scar on the donor area and defect area is acceptable. There is no need to repair the flap again due to swelling. (Table 1)

2.2 | Statistical methods

SPSS 23.0 software (International Business Machines Corporation, Armonk, NY, USA) was used for data analysis. Normally distributed measurement data were expressed as mean ± standard deviation (SD) while non-normally distributed measurement data were expressed as median (interquartile range).

3 | RESULTS

3.1 | General data

A total of five male patients were included, including two cases of chronic infection non-union, 1 case of skin and soft tissue defect after malignant tumour resection, one case of skin and soft tissue defect caused by trauma, and
one case of local skin and soft tissue defect after scar release. The average age of patients was 46.4 years (from 18 to 67). The average BMI of patients was 22.68 kg/m^2 (from 19.00 to 25.71), and the average length of hospital stay was 42.6 days (from 10 to 62). Among them, one patient had a history of local radiotherapy, and one patient had hypertension and coronary heart disease.

3.2 | Surgery-related data and postoperative results

One patient's (NO.1) primary wound was “forehead non-union wound with slow infection (round defect, diameter 1 cm)”, and the distance between the primary wound and the donor site was 8 cm, the type of flap used in this patient was “lateral jaw neck flap” (Figure 3). One patient's (NO.2) primary wound was “defect caused by extensive resection of malignant tumor on the lateral thigh (21 × 7 cm)”, the distance between the primary wound and the donor site was 16 cm, and the type of flap used in this patient was “ilioinguinal flap”. One patient's (NO.3) primary wound was “skin and soft tissue defect of Chin caused by trauma (3 × 4 cm)”, the distance between the primary wound and the donor site was 10 cm, and the type of flap used in this patient was “lateral jaw neck flap”. One patient's (NO.4) primary wound was “defect after neck scar release (25 × 10 cm)”, the distance between the primary wound and the donor site was 15 cm, and the type of flap used in this patient was “trapezius myocutaneous flap”. The last patient's (NO.5) primary wound was “nonunion wound after internal fixation of calcaneal fracture (5 × 5 cm)”, the distance between the primary wound and the donor site was 7 cm, and the type of skin flap used in this patient was “sural neuromuscular flap”. The patient had good joint movement at 6 months after pedicle amputation.

At 48 hours after transplantation, except for the last patient (NO.5), there were no obvious complications such as blood supply disorder, infection, and incision dehiscence of the patients, and the flaps survived well. Just after pedicle amputation, 3 and 6 months after pedicle amputation, the flaps survived well with good local morphology.

Forty-eight hours after the operation, the part of the distal flap in the last patient (NO.5) was necrotic. After 6 months of pedicle amputation, part of the flap was transferred to the distal wound again. At 6 months after pedicle amputation, these patients could accept local scars even though the scar of the last patient was obvious.

4 | DISCUSSION

The conventional treatment of axial flap transfer for repairing distal defects includes subcutaneous tunnel
(dark channel) and open channel (open channel). Both methods need to separate and destroy the normal tissue between the donor site and the primary wound, which would result in local scar and texture hardening. In addition, the accumulation of local vascular pedicles will lead to local tissue bloated and affect the shape. If the wound area was located in the joint activity area, it would lead to obvious discomfort and affect the quality of life of patients. Some patients will choose to receive a second repair operation, but the effect is limited. In this study, the repair process could be divided into two stages; in the first stage, the skin between the donor site and the primary wound would be covered with oil sand; in the second stage, the pedicle of the flap would be cut and repaired, which could avoid the destruction of the normal tissue between the donor site and the primary wound. The pedicled axial flap contains direct supply vessels, which ensure the blood supply of the subdermal plexus and the flap. In addition to the skin area directly supplied by the artery, the blood supply of the skin in the more distal area depends on the deep and superficial vascular plexus. The axial flap has clear advantages in clinical application, including no delay process, abundant tissue, and less elastic retraction. The perforator vessels of the axial flap improve the vascularization of the fasciocutaneous flap and make the axial flap have a larger ratio of length to width. Compared to the flap without direct skin and blood supply, the axial flap has a better survival area and higher survival rate. The flap was similar to the results of previous studies. In addition, due to the strong ability of blood supply and anti-infection, the axial flap has a wide range of applications. For the wound with contamination, the flap can be used for functional reconstruction and organ reconstruction. After the wound has healed, the flap can be used to reconstruct the use of any tissues such as lip, throat, esophagus, breast, scrotum, and vagina. The flap can also reduce the amputation rate. The flap was widely used in the clinic, however, the main defect was that the donor site could not be sutured directly, and the incision needed to be closed by skin grafting.

Table 1: Information of patients

| Patients | Gender | Age (year) | BMI (Kg/m²) | length of hospital stay (day) | Preoperative complication | Primary wound | Distance between the primary wound and the donor site (cm) | Type of flap | Survival situation of skin flap within 48 h after operation | Survival situation of skin flap at 3 mo after operation | Survival situation of skin flap at 6 mo after operation |
|----------|--------|------------|-------------|-------------------------------|--------------------------|--------------|----------------------------------------------------------|-------------|----------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|
| 1        | male   | 56         | 19.00       | 38                            | local radiotherapy       | forehead non-union wound with slow infection (round defect, diameter 1 cm) | 8             | lateral jaw neck flap                                     | Good         | Good                                                    | Good, local scars could be accepted                       |
| 2        | male   | 61         | 23.60       | 62                            | hypertension and coronary heart disease | defect caused by extensive resection of malignant tumour on the lateral thigh (21 × 7 cm) | 16            | ilioinguinal flap                                        | Good         | Good                                                    | Good, local scars could be accepted                       |
| 3        | male   | 67         | 25.71       | 10                            | None                     | skin and soft tissue defect of Chin caused by trauma (3 × 4 cm) | 10            | lateral jaw neck flap                                     | Good         | Good                                                    | Good, local scars could be accepted                       |
| 4        | male   | 30         | 24.51       | 55                            | None                     | defect after neck scar release (25 × 10 cm) | 15            | trapezius myocutaneous flap                              | Good         | Good                                                    | Good, local scars could be accepted                       |
| 5        | male   | 18         | 20.57       | 48                            | None                     | non-union wound after internal fixation of calcaneal fracture (5 × 5 cm) | 7             | sural neurovascular flap part of the distal flap         | Good         | Good, local scars were obvious                           | Good, local scars were obvious                           |

Acland et al. described the medial saphenous vein flap of the knee joint in 1981. The flap was based on the saphenous artery and could be used as a free flap and axial flap. It could be very large (the width of 8–10 cm and the length of 30 cm), and it was widely used in the clinic, however, the main defect was that the donor site could not be sutured directly, and the incision needed to be closed by skin grafting. The common complications of the use of axial flap include vascular complications. Any mistakes, such as...
flap design, peeling process, or insertion technique, might result in partial or complete necrosis of the flap, especially for the relatively large flap. In addition, infection, incision dehiscence, continuous subcutaneous effusion in the donor site and primary wound, and wound non-union are all complications related to axial flap.

In this study, we did not strip the subcutaneous tissue between the donor site and primary wound, which would bring the following benefits: the destruction of normal tissue was reduced, the formation of the local scar was reduced, the congestion of the vascular pedicle between the donor site and the primary wound was reduced, and the morphological damage was avoided, so the long-term benefits were clear. Previous studies have found that the volume of the subcutaneous tunnel was 3 to 5 times that of the nutrient pedicle, and the stripping range was large, and the cost of injury was high. In this study, the ilioinguinal flap was used to repair the skin defect after excision of extensive Paget's disease of penis and scrotum. The flap survived well and had little effect on penile deviation. After operation, the flap survived well, and penile deviation was less affected.

The secondary pedicle amputation of the repair of distal defects with axial flap can avoid the compression of the vascular pedicle in the subcutaneous tunnel between the donor site and the primary wound, which could ensure the bold supply and increase the survival rate of the flap. Li et al. found that the flaps of the two-stage pedicle amputation with flap reconstruction operation survived well, and the skin colour was normal after the operation. In the past clinical application, many flaps would be repaired after pedicled transfer operation, such as direct flap, clinical flap, and clinical finger flap. In general, the flap survived well and had little effect on penile deviation. After operation, the flap survived well, and penile deviation was less affected.

There were some limitations in our study as follows:

1. Considering this was a single-centre respective study, our sample size was limited, and there was no control group. A prospective study with a larger sample size will be needed.
2. The operation process of different organs and different types of skin flap transplantation was not the same: we did not describe it in detail.

5 | CONCLUSIONS

In this study, we used oil sand to cover the skin flap between the donor area and the primary wound to reduce the loss of the skin flap between the donor area and the primary wound, which could ensure the bold supply and increase the survival rate of the flap.

DATA AVAILABILITY STATEMENT

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

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