Original Article

Stage I repair of skin and soft tissue defects using lateral femoral perforator free flap in pilon fracture surgery

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Contributions: (I) Conception and design: None; (II) Administrative support: None; (III) Provision of study materials or patients: None; (IV) Collection and assembly of data: None X; (V) Data analysis and interpretation: None; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Background: To investigate the clinical effects of stage I repair of skin and soft tissue defects using lateral femoral perforator free flap in pilon fracture surgery.

Methods: Fifteen cases of pilon fractures were selected from our hospital between April 2013 and January 2017. There were 8 cases of 43-C1, 4 cases of 43-C2 and 3 cases of 43-C3 fractures, as defined by the Miller AO classification. In all cases, severe contusion of skin and soft tissue around the fracture, skin darkening and necrosis, and tissue edema during surgery, led to difficult closure of incision. The skin and soft tissue defects were repaired at stage I by ipsilateral lateral femoral perforator free flap.

Results: Venous crisis occurred in one case, while the other 14 cases survived. During the 6–18 months of follow-up, the function of ankles was satisfactory and the wearing of shoes was not affected by the abnormal foot. The flap color and texture were normal and the protective sensation of the flap recovered. Only a linear scar remained at the donor site and no muscle adhesion occurred.

Conclusions: Stage I repair of skin and soft tissue defects using lateral femoral perforator free flap in pilon fracture surgery apparently decreased postoperative infection and protected the blood supply around the fracture. Hence, it was an effective repair method.

Keywords: Soft tissue defect; perforator flap; pilon fractures

Received: 06 August 2018; Accepted: 14 December 2018; Published: 03 January 2019.

doi: 10.21037/jxym.2018.12.04

View this article at: http://dx.doi.org/10.21037/jxym.2018.12.04

Introduction

Pilon fractures are high-energy injuries involving fractures of articular surface weight-beari and the distal tibial of the metaphysis. The high-energy injuries caused by complex and/or open pilon fractures have high incidence of soft tissue complications, and even led to failure of surgery (1,2). Fifteen cases of 43-C1–C3 pilon fractures with skin and soft tissue contusion and laceration were treated at our hospital between April 2013 and February 2017. The closure of incision was difficult in these 15 patients because of skin darkening before surgery due to severe contusion of skin and soft tissue around the fracture or tissue edema during surgery. We performed stage I repair using lateral femoral perforator free flap to avoid the effects of secondary necrosis, deep infection and exposure of internal fixation due to forced suture of skin after surgery. The function of the ankles and appearance of the flap were satisfactory, and no muscle adhesion occurred during the postoperative follow-up.

Methods

A total of 15 cases were recruited, including 13 males and

2 females. The average age of the patients was 39.3 years. The causes of injury were classified as 11 cases of fall injuries, 3 cases of traffic accidents, and 1 case of heavy object injury. The degree of soft tissue injury around the ankle was classified as 6 cases of soft tissue contusion around the ankle, 1 case of skin necrosis caused by heavy object injury, and 8 cases of local skin necrosis due to lack of bone traction (5 cases were transferred from other hospitals). The interval between injury and surgery was 7–12 days. According to Miller AO classifications, there are 8 eight cases of 43-C1, 4 cases of 43-C2 and 3 cases of 43-C3 fractures.

Surgery technique

Preoperative preparation

Color Doppler ultrasound was used to detect and mark the perforating vessel initiated from the lower segment of the connection between the greater trochanter and the capitulum fibulae (3).

Open reduction and internal fixation of fracture

During surgery, we adopted the posterolateral approach to expose the fractures of the fibula and posterior malleolus, and adopted the anteromedial approach to expose the fractures of the anterior tibia, medial malleolus, and tibiotalicular articular surfaces. First, the reduction and fixation of fibula fracture was performed using a bridging plate of sufficient length to maintain the alignment of the fibula and control rotation. Then the tibia was operated on. The main scope included exposure of the lower tibial fractures and articular surface. The surgery specifically required an anatomical reduction of the articular surface. Autogenous bone or bone substitutes were used to fill the bone defects. The mechanical support of the articular surface was maintained using internal and external anatomical plates or a Falex pin with external stent for fixation. Extensive soft tissue stripping was unnecessary during surgery (4). Anatomical reduction of the articular surface was performed with maximum protection of the soft tissue.

Flap design

The third perforating branch was selected during surgery (5-7). A two-third area of the flap was designed to cover the back of the connection between the greater trochanter and the capitulum fibulae. A perforator vessel was placed near the one-third position in the long axis of the flap, which could correspondingly increase the length of the vascular. The bleeding was stopped using an exsanguination band at the thigh root and then a time count was started. The front side of flap was incised to the shallow loose tissue of fascia lata, and cut up to the lateral femoral intermuscular septa along the anterior-posterior direction. The perforator vessel was carefully separated and exposed between the intermuscular septa. The position of the flap was appropriately adjusted according to the thickness of the vessel and the perforating point. The post side of the flap was incised, separated along the shallow of deep fascia, and the perforating branch was completely exposed. The patient was in a coxa and knee bending position to relax the biceps. The lateral intermuscular space was opened by "S" pull hook. Anatomical separation was performed along its route, during which the muscular branches along the route were ligated up to the trunk of the branch. The position was adjacent to the posterior femoral periosteum. The length of the vascular pedicle was measured and the exsanguination band was released to observe the blood flow of the flap.

Vascular anastomosis

The lateral femoral perforator and the posterior tibial artery underwent end-to-side anastomosis under the operating microscope. Veins accompanied by the perforator and posterior tibia underwent end-to-end anastomosis. The tourniquet was released. The wound was sutured after observation of active bleeding at the flap margin and good superficial venous return in the flap.

Results

Fourteen flaps successfully survived in 15 cases. In 1 case, the flap's artery was anastomosed with the lateral tarsal arteries and the vein was anastomosed with dorsalis pedis vein. Venous compression due to proximal soft tissue edema after surgery led to flap venous thrombosis. The flap survived after surgical exploration and anastomosis of the dorsalis pedis vein with the posterior tibial artery and its accompanying veins. The patients were followed-up for 6–18 months, with an average of 10.4 months. The function of ankles was assessed as satisfactory (*Table 1*) and the wearing of shoes was not affected by the abnormal foot. The flap color and texture were normal, and the protective sensation of the flap was recovered. Only a linear scar remained at the donor site and no muscle adhesion occurred.

Case presentation

A 32-year-old man presented to the hospital with swelling, deformity and dysfunction of the right ankle caused by a high fall. Physical examination at admission showed that the right ankle was fixed with gypsum, the skin around the ankle was swollen and extensively bruised, and a portion of skin at about 3 cm × 5 cm at the medial ankle was darkened and necrotic. The frontal and lateral radiography of the ankle suggested a tibial pilon fracture. The Müller AO classification was 43-C2 (*Figure 1*). The patient received calcaneus traction, raising of the foot, and treatment of swelling after admission. After detumescence of soft tissue swelling around the ankle, we selected posterolateral and anteromedial incisions to restore the fractures of the fibula and distal tibial articular surface under general anesthesia. Plate and screws were used to fix the fractures (*Figure 2*). The posterolateral incision was closed. The anteromedial incision was difficult to close due to the skin and soft tissue defects and swelling of the wound. The internal fixation was exposed. Skin and tissue defects of the anterior ankle were stage I repaired by a lateral femoral free flap. After a year and a half of follow-up, the patient had excellent ankle function. The ankle flap did not affect the wearing of shoes. The donor area only had a linear scar.

Table 1 Treatment results of 15 cases of pilon fractures

Ruedi-Allgower classification	Excellent	Good	Fair	Poor
II	5	2	1	0
III	2	2	1	2

Discussion

With the continuous development of traumatic orthopedic techniques and knowledge, open reduction and internal fixation are currently the first choice of treatment for pilon fractures (8). For cases treated at our hospital, we found rarely wound infection, osteonecrosis infection, internal fixation exposure and other complications due to skin necrosis after fracture surgery (9). Domestic and foreign clinicians believed that the main reasons for these kinds of complications are the following: (I) the blood supply to the skin is poor due to the "skinny" distal tibia. In addition, the pilon fractures have high-energy injuries, which lead to skin necrosis or poor anti-infection ability of soft tissue. The secondary damage due to surgery further aggravates the conditions. (II) The selection of time for surgery is inappropriate (10). (III) Tissue edema is more likely due

Figure 1 Preoperative CT showed severe comminution of distal tibia, and the articular surface was collapsed. Postoperative X-ray showed a good recovery of the distal tibial articular surface.

Figure 2 Intraoperative view of the donor site and recipient site, the ALTP flap was harvested for the soft tissue defect reconstruction.

Figure 3 Postoperative view of the recipient site.

to extensive dissection of soft tissue during surgery and the relatively long duration of surgery. Moreover, the occupation of internal fixation by plates and screws leads to increased tension of skin, eliciting skin ischemia. (IV) Lack of knowledge of primary care physicians who usually treat with simple plaster brake (5 patients in this group were transferred from other hospitals).

Currently, there is a lack of accurate statistical data in the domestic studies about skin necrosis of surgical incision, exposure of internal fixation and bone infection. According to our clinical observation, incidence of postoperative complications of pilon fracture was significantly higher than that in fractures at other positions. If the soft tissue necrosis led to bone infection, multiple surgeries, such as removing the internal fixation and fixing with other methods, repairing with free flap, iliac bone grafting, etc., were often needed. This caused multiple stresses to the patients, relating to anxiety, medical costs, duration of hospitalization, etc.

In most Pilon fractures, complications, such as difficulties in skin suture, postoperative soft tissue necrosis, bone infection and internal fixation exposure rarely occurred with correct preoperative treatment and standard surgical procedures (8). In pilon fractures without correct preoperative traction, raising the foot and detumescence, or with serious local soft tissue contusion caused by high-energy loss and skin darkening, it was particularly important to follow the basic principles of surgery for pilon fractures in the protection of soft tissue (11). In the treatment of pilon fractures at our hospital, we found that excessive tension of the skin suture not only promoted necrosis of the skin and soft tissue, but also led to ischemia-hypoxia of small vessels in the deep muscle, tendon and bone, because the increased pressure due to the occlusion of these vessels (12). Also, the postoperative anti-infective effects of soft tissue were decreased, while fractures were prone to delayed healing and nonunion. The adhesion of muscle, tendon and joint capsules led to limited ankle function. Severe bone infection, internal fixation exposure and other implications occurred. Most of the postoperative soft tissue defects or wound surface that was difficult to suture in the pilon fracture surgery, the flap were long spindle-shaped with relatively small area. The vascular pedicle for the flap did not need to be excessively long to minimize damage to the donor zone. According to the Miller AO classification, the 15 cases of Pilon fractures at our hospital included 8 cases of 43-C1, 4 cases of 43-C2 and 3 cases of 43-C3 fractures. There were skin defects caused by clearance of full-layer necrosis of local skin or suture difficulty due to severe contusion of soft tissue or tissue edema during surgery. The defects were stage I repaired with lateral femoral flap. The wounds healed well after surgery. No wound necrosis or infection occurred in any case. During the 6–18 months of follow-up, the function of ankles was satisfactory and the ankle flap did not affect the wearing of shoes (*Figure 3*). The flap color and texture were normal, and the protective sensation of the flap recovered. Only a linear scar remained at the donor site, and no muscle hypotonia was observed. Therefore, timely selection of lateral femoral flap repair of small defects of skin and soft tissue in pilon fractures results in fewer injuries and can avert the exposure of internal

fixation, bone infection and limited ankle function caused by skin necrosis.

The skin and soft tissue needed for repairing the defects after closed Pilon fracture surgery were relatively long, narrow, and small in area. The requirements for the flap design and incision were relatively extensive. The perforator vessel was located at the center of the flap to ensure normal blood flow. According to our experience, precise cutting of the flap involved the following steps: (I) preoperative positioning: first, the lateral and posterior intermuscular spaces of the thigh were marked according to the point, line, and surface principles of the flap. The perforating point was usually located 13 cm above the capitulum fibulae. Before surgery, the horizontal plane of the perforating vessel was approximately positioned and marked by portable Doppler or color Doppler ultrasonography. (II) The exsanguination band was used to stop the bleeding in the upper thigh, which was convenient for flap dissociation under blood-free visual field. The knee was maintained in a flexed position (6). (III) Design of flap: for flap design, perforator point was placed near the one-third position in the long axis of the flap. The longitudinal two-third area of the flap was placed on the back of lateral intermuscular space of the thigh. The anterior fascia lata was dissected and separated from the front of flap to expose the perforator. In most conditions, the second, third and fourth perforating vessels could be found, and the third vessel was relatively thicker and bigger. The vessel pedicle was 7–9 cm long. The operator then determined whether the position of perforating point was located at the center of the flap, and appropriately adjusted the position of the flap during surgery. Placing the perforating vessel near the one-third of the long axis of the flap could appropriately increase the length of the vessel pedicle (5). (IV) Retrograde separation was performed along the perforating vessel. Two or three thick muscular branches were individually ligated. Bleeding was observed at the flap margin when the vessel was separated to the posterolateral femur with the intact pedicle. Subcutaneous adipose tissue at the anterior flap could be appropriately trimmed to reduce bloating of the flap. (V) The flap artery was about 1.5 mm. The vein was relatively thicker, with a thin wall. The ratio of artery to vein was 1:2. We selected the posterior tibial artery (or anterior tibial artery) and its accompanying veins for anastomosis. There was a relatively large difference in the vascular caliber of flap artery and posterior tibial artery. We performed end-to-side anastomosis to avoid affecting the blood supply to the foot. Inverted anastomosis with dorsal vessel was not recommended. One patient in this group underwent inverted anastomosis with the lateral tarsal arteries and dorsalis pedis vein. The venous return did not flow smoothly due to ankle swelling after surgery. There was relatively severe errhysis at the flap margin. The flap successfully survived after timely vascular exploration and anastomosis with posterior tibial artery and its accompanying veins.

Based on the reports of lateral femoral skin flap by domestic and foreign clinicians, Professor Mingjiang Liu and Xiaodan Xia dissected and investigated human thigh specimens by microscopy between January 2009 and October 2011 (5,6). They obtained anatomical data on the source, number, distribution, type, diameter and pedicle length of lateral femoral perforating vessels, and applied these data to clinical practice with satisfactory results. The advantages of lateral femoral skin flap were as follows: (I) anatomical data showed that the deep femoral artery constantly generated perforating vessels. The second, third and fourth perforating arteries of the deep femoral artery supplied blood to the skin of the lateral lower thigh. Notably, the third perforating branch had large caliber and the vessel pedicle was long. (II) The perforating vessel was parallel to the lateral intermuscular space of the biceps femoris and quadriceps. It was a type of intermuscular-space perforating vessel. It was unnecessary to excise the fascia lata as the vessel position was convenient for incision and dissociation during surgery, since it did not carry muscles or cause quadriceps adhesion. The functional damage to the knee was less. (III) There was little subcutaneous adipose tissue in the lateral area of the middle and lower thigh (13). Combined with the “skinny” feature of the distal tibia, the lateral femoral perforator flap was an ideal donor area. It has advantages such as optimal receptive area after repair, averting need for secondary repair, etc. The disadvantages of lateral femoral skin flap included a lack of nerve branches accompanying the flap and a crawling sensation in the skin after surgery. Additionally, the time for recovery was relatively long and only protective sensation could be restored. A final drawback was the fact that donor area could not be directly sutured if the area of the flap was relatively large, and so suitable for repair of small and mid-sized skin defects.

Conclusions

Stage I repair of skin and soft tissue defects using lateral

femoral perforator free flap in Pilon fracture surgery seemed to decrease postoperative infection and protect the blood supply around the fracture. Hence, it was an effective repair method.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the Guest Editors (Geoffrey Hallock, Juyu Tang) for the series "Perforator Flap" published in *Journal of Xiangya Medicine*. The article has undergone external peer review.

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/jxym.2018.12.04). The series "Perforator Flap" was commissioned by the editorial office without any funding or sponsorship. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Research Ethics Committee of Affiliated Nanhua Hospital of Nanhua University (No. 2013-05-09) and written informed consent was obtained from all patients.

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(English Language Editor: John Gray, AME Publishing Company)

doi: 10.21037/jxym.2018.12.04
Cite this article as: Liu CX, Huang XJ, Zhang B, Xie SL, Liu MJ, Xia XD, Huang XF, Lee KW. Stage I repair of skin and soft tissue defects using lateral femoral perforator free flap in pilon fracture surgery. J Xiangya Med 2019;4:2.