Original Article

Repair of tophus wound of the heel with sural nerve nutrition flap with peroneal artery perforating branch: a retrospective study

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Background: This study was to investigate the clinical effect of a sural nerve nutrition flap with peroneal artery perforator for repairing tophus wound of the heel.

Methods: Over a 5-year period, 7 elderly male patients with tophus ulceration of the heel were admitted with exposed Achilles' tendon, and a chronic unhealed wound. Debridement, expansion and vacuum sealing drainage (VSD) lavage were performed initially, with simultaneous uric acid-lowering treatment. A 4×6–8×10 cm sural nerve nutrition flap with peroneal artery perforator was the secondary repair after further debridement of the wound. Preoperative Doppler ultrasound located the penetrating point of the peroneal artery perforator as the rotation point of the flap, and the line between the midpoint of the Achilles' tendon and the lateral malleolus and the midpoint of the popliteal fossa 5° above the front of Achilles' tendon was the axis. The patients were treated postoperatively with anti-inflammatory, anticoagulant and spasmolytic drugs and other rehydration therapy, and allopurinol was continued to control uric acid. The blood supply and temperature of the flap and wound healing were monitored.

Results: All 7 flaps survived completely after operation, with 1 case of postoperative wound discharge that finally healed after dressing change and 1 case of skin flap redness and swelling, which improved after strengthening anti-infection treatment. All 7 patients were followed up for 6–12 months (average 10 months). The skin flaps were soft in texture, with good color and appearance, and no recurrence of ulceration. The dorsal extension and plantar flexion of the ankle joint were good, and function was satisfactory.

Conclusions: The sural nerve nutrition flap with peroneal artery perforator has double blood supply, strong anti-infective ability, relatively fast tissue healing process, simple operation and high survival rate, making it ideal for repairing tophus wounds of the heel.

Keywords: Peroneal artery perforator; sural nerve flap; tophus; wounds

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Introduction

Increasing prosperity and continuous changes in diet have led to gout becoming the second largest metabolic disease following diabetes mellitus. Gout is directly related to a disorder of purine metabolism or hyperuricemia caused by reduced excretion of uric acid (1,2). In some patients with gout, long-term hyperuricemia leads to crystal deposition in the Achilles' tendon, forming tophus, which can proceed to ulceration, infection, Achilles' tendon exposure, and prolonged wound healing. The application of sural nerve

nutrition flaps to treat skin and soft tissue defects of the foot and ankle, mainly tendon and bone exposure caused by various injuries, has become common in recent years, with good efficacy (3-5). Some study found that the sural nerve nutrition flap with peroneal artery perforating branch has good blood supply and it can reverse to a long distance and can repair large skin defects (6). Sural nerve nutrient flap with peroneal artery perforator has the advantages of convenient cutting, simple operation, large cutting range and repairing large-area defects, it has attracted the attention of clinicians. The surface of a spontaneous tophus wound of the heel has its particularity and there are few clinical reports on how to deal with it and the bet type of flap to use for repair. The sural nerve nutrition flap can repair chronic ulcerative skin defects, wounds caused by trauma and skin defect caused by diabetes of foot and ankle. The sural nerve nutrition flap could be applied for patients with gout to repairing tophus wounds of the heel. We report 7 cases of heel tophus ulceration repaired using a sural nerve nutrition flap with peroneal artery perforator. We present the following article in accordance with the STROBE reporting checklist (available at https://dx.doi.org/10.21037/apm-21-2809).

Methods

Background information

This was a retrospective study of 7 elderly male patients hospitalized in the Department of Hand and Foot Surgery, The Second Affiliated Hospital of Soochow University between May 2015 and August 2020. Their ages ranged from 58 to 72 years (average 66 years). All patients had a history of chronic gout and all had chronic tophus ulceration in the heel of 1–3 months' duration. The ulcers were exudative, and tophus formation was observed around the exposed Achilles' tendon with visible fine tophus particles. Among them, 5 patients had tophus formation in the hand, foot and elbow joints but on ulcer formation, and 2 patients had tophus ulceration in the heel only. All procedures performed in this study involving human participants were in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Ethics Committee of The Second Affiliated Hospital of Soochow University. Because of the retrospective nature of the research, the requirement for informed consent was waived.

Surgical procedure

Tophus resection and debridement

The hand, foot and elbow joint tophi of the 5 patients were treated with first-stage resection, and the incisions were closed after complete resection. In all 7 cases, the chronic tophus-induced ulcer of the heel was debrided completely under balloon tourniquet. The principle of debridement was from the outside to the inside, first removing the inflammatory tissue around the ulcer, and then cleaning up the tophus on the ulcer surface and around the Achilles' tendon. The wound was flushed repeatedly with 5% sodium bicarbonate solution and normal saline. To preserve the continuity of the Achilles' tendon, a negative pressure flushing drainage tube was placed under and on the surface of the Achilles' tendon after thorough debridement. VSD was used to cover the wound, and routine irrigation and drainage were performed generally 7 days after surgery. Allopurinol was administered to control blood uric acid levels.

Flap design

The second stage of ulcer repair was application of a skin flap. Approximately 4–6 cm above the lateral malleolus is the penetrating point of the farthest muscle septal perforator of the peroneal artery. Preoperative Doppler ultrasonography was used to locate the penetrating point of the peroneal artery perforator as the rotation point of the flap. The line between the midpoint of the Achilles' tendon and the lateral malleolus and the midpoint of the popliteal fossa 5° above the front was the axis. According to the size of the wound, an inverted water-droplet flap was designed to be ~1 cm larger than the wound, and in this group was about 4×6–8×10 cm. During the operation, the heel wound was debrided again, and rinsed repeatedly to remove the tophus crystals and complete the debridement. Flap dissection was performed with a new set of instruments. First, the anterolateral flap pedicle was cut to the deep fascia, and the peroneal artery muscular septal perforator was explored between the tendon of the peroneus longus and brevis and the soleus muscle. The diameter of the perforator vessel was ~1.2 mm, without separating the perforator; the perforator was determined as the final rotation point of the flap. Next, the proximal arc of the flap was cut open to expose the sural nerve and the small saphenous vein. The position and axis of the flap is adjusted according to the sural nerve and the small saphenous vein

Figure 1 After primary debridement of gouty tophi wound in the right heel.

so that they were contained slightly posterolateral. The flap was sectioned anteriorly and posteriorly, and separated intact under the deep fascial layer to ensure that the sural nerve was included. The fascial pedicle of the flap remained ~3 cm in width and carried part of the skin pedicle. The peroneal perforator must be protected when the peroneal artery is separated to the pedicle rotation point. At the distal end of the rotating point, the triangular rotating flap with the subdermal vascular network was cut open to reduce the pedicle tension of the flap after rotation and prevent the "cat ear" deformity. The flap covered the ulcer wound of the heel, and the donor area was directly sutured or repaired with skin graft.

Postoperative management

The patient rested in the lateral decubitus position for 1 week after the operation, with appropriate adjustment of position to prevent flap compression. The flaps were kept warm with heat lamps to reduce cold irritation of the blood vessels. Elevation of the affected limb can promote flap blood reflux and reduce postoperative swelling of the flap. Routine treatment of anti-inflammatory, anticoagulation and spasmolytic drugs was administered, with the allopurinol. Uric acid, erythrocyte sedimentation rate (ESR) and C-reactive protein were monitored. When necessary, short-term glucocorticoid therapy was administered to prevent acute gout attack caused by surgical trauma. The flap blood supply and swelling were observed closely; 24–72 h after operation is the peak time of flap swelling, which can be managed by removing stitches as needed. Wound healing was also closely monitored, especially the nature of exudation, and dressing changes increased if necessary. The flap temperature must also be monitored and increased anti-infection treatment administered if there is inflammation. One week after surgery, the wrapped dressing was removed from the donor skin graft area and the survival of the skin graft was observed. Two weeks after surgery, stitches were removed, and the patient was instructed to perform active and passive flexion and extension exercises of the ankle joint.

Results

The incisions of the hand, foot and elbow joints all healed well in the 5 patients with tophus in these joints. The 7 flaps survived well. In one case, there was delayed postoperative wound healing, with white secretions beginning 3 days after surgery. No bacteria were found in the culture and the secretion was considered to uric acid crystalline stone exudate. The patient was given intravenous low-dose glucocorticoid infusion for 3 days, and dressing changes were increased. The wound was dry and healed 3 weeks later. In another case, the skin flap was red and swollen, the flap temperature was slightly high, but exudation was not obvious. It was considered to be an inflammatory response. The redness and swelling were subsided after enhanced anti-infective therapy with linezolid. All 7 patients were followed up for 6–12 months (average 10 months). The skin flaps were soft in texture, had good color and appearance, and there was no recurrence of ulcer. The dorsal extension and plantar flexion of the ankle joint were good, and function was satisfactory.

Typical case

A 68-year-old male patient was admitted to the hospital for more than 2 months due to repeated exudation of the skin and soft tissue of the right heel. The patient had a history of gout for 3 years and a history of tophus formation for 6 months. Physical examination showed tophus formation on the dorsal fibular side of the right foot, ~2 cm ×2 cm in size. The skin and soft tissue of the right heel were broken, with fluid infiltration, and inflammatory granulation. The total wound size was ~5 cm ×5 cm, and there were tophus particles on the surface of the Achilles' tendon. The patient underwent first-stage debridement and cleaning as described (*Figure 1*), followed by peroneal artery perforator sural nerve nutrition flap repair of the wound (*Figures 2-5*). The flap healed well, with a soft texture and no ulcer. The ankle joint had good dorsal extension and plantar flexion, and function was satisfactory (*Figures 6-8*).

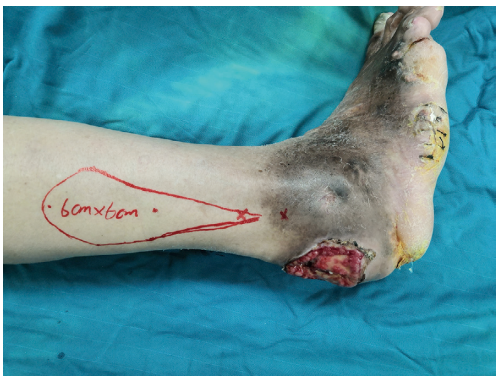

Figure 2 Preoperative flap design.

Figure 3 After debridement of gouty tophi wound in the heel.

Figure 4 Removal of the flap during the operation.

Figure 5 Coverage of the wound with the flap and skin grafting of the donor site.

Figure 6 One month after operation, the flap has survived with satisfactory appearance.

Discussion

Characteristics of heel wounds in elderly gout patients

The elderly are prone to gout, especially males with a ratio of 20:1. There are many causes, such as reduced activity, slow metabolism, tobacco and alcohol addiction, high purine diet, obesity, hypertension and so on. Elderly patients can have a poor understanding of gout management, and may only pay attention to controlling acute gout symptoms, but not to the importance of long-term control of blood uric acid levels (7,8). Compliance is often poor. Chronic hyperuricemia results in deposition of uric acid crystals around the ankle and Achilles' tendon, forming tophus. The heel is often subjected to friction, but lacks effective soft tissue protection and is prone to ulceration. If treatment is not timely, the ulcer is prone to gradually increase, inflammatory granulation proliferates and the Achilles' tendon is exposed. Chronic non-healing of the wound has a great impact on the quality of life of patients. Compared with general traumatic wounds, the heel wounds of elderly gout patients have the following characteristics: (I) mainly in elderly men with chronic gout and many complications, such as diabetes, atherosclerosis and hypertension. Once an ulcer forms, the chance of self-healing is almost nil; (II) if

Figure 7 Six months after operation, ankle dorsiflexion was good.

Figure 8 Six months after operation, ankle plantarflexion was good.

the skin over the heel is broken, the Achilles's tendon will be exposed, which makes it impossible to eliminate the wound by traditional skin grafting. Tophus particles attached to the Achilles' tendon make it difficult for fresh granulation tissue to grow. Even if there is partial granulation of the wound, a skin graft will soon collapse from abrasion; (III) debridement is particularly important because of the extensive tophus around the Achilles' tendon and even in the joints; (IV) weak local anti-infection ability. A skin flap with rich blood supply is needed to ensure rapid wound healing.

Anatomical basis of sural nerve nutrition flap with peroneal artery perforator

In 1992, Masquelet *et al.* (9) reported that the peroneal artery had 3–5 musculoseptal perforators anastomosed with the sural nerve vascular axis. The musculoseptal perforator on the farthest side is closest to the sural nerve and anastomosed most closely. Therefore, a new method for repairing foot and ankle wounds with a distal pedicled neurovascular axis flap was proposed. In 1994, Hasegawa *et al.* (10) pointed out that the farthest anastomotic branch of the peroneal artery and the nutritional vessel of the sural nerve (superficial sural artery) was about 5 cm (4–7 cm) above the lateral malleolus. In 1999, Zhong *et al.* (11) conducted a detailed anatomical study and named this flap a sural nerve nutritional vessel flap. Subsequently, it has been widely used in clinical practice. Along its caudal path, the peroneal artery gives off 3–5 perforating branch arteries to nourish the skin on the posterolateral side of the lower leg. The most distant perforating branch artery is located 5 cm behind and above the lateral malleolus. In the natural state, the perforator arteries are connected by upstream and downstream branches, thus forming a vascular chain network. These vascular networks run parallel to and anastomose with the sural nerve behind the lower leg, and participate in the nutritional vascular plexus of the sural nerve (12). Peroneal artery perforator sural nerve nutrition flap is not only carried peroneal artery distal intermuscular septum perforators, which participate in the traditional sural nerve blood vessels of the chain, but also use the vascular chain network between the peroneal artery perforators to supply blood. This forms the dual blood supply system of the peroneal artery perforator sural nerve nutrition flap, which greatly increases the postoperative healing ability of the flap and the wound surface. At present, the sural nerve nutrition flap has been applied widely in clinical. The sural neurovascular flap has the advantages of simple operation, high survival rate and light injury. It is an ideal flap for repairing soft tissue defects, bone and tendon exposure in the anterior tibial region of the foot, heel, ankle, Achilles tendon and lower leg. We suggest that the flap can be widely used after fully mastering the indications.

Advantages and disadvantages of sural nerve nutrition flap with peroneal artery perforator for repairing tophus wound in the heel

Compared to other repair methods, the advantages and disadvantages of this flap are as follows. (I) The selected location of the flap is the posterolateral leg where the subcutaneous fat layer is thin. Therefore, the flap has good elasticity, and the operation is easy. The anatomical layer is in the deep fascia layer. The layers are clear and the operation time is short. The flap has good wear resistance. This operation does not require secondary plastic surgery,

and for small wounds, the flap donor area can be directly sutured. (II) The flap is adjacent to the heel wound and the ineffective area is small, which can minimize the trauma of the donor area without vascular anastomosis and is suitable for use in primary hospitals. (III) The flap has a dual blood supply without damage to main vessels. The intermuscular septum perforator on the farthest side of the peroneal artery is relatively constant with a relatively small aberration rate. After the flap is cut, the blood supply of the flap is reliable and rich, the anti-infection ability is strong, and the wound healing is relatively fast, which meets the requirements of tophus wound repair. (IV) The flap has a double blood supply and a large incision area, which can cover a large skin and soft tissue defect of the heel. (V) When the flap is removed, the proximal sural nerve should be cut off. Postoperative sensory loss on the lateral side of the back of the foot is a disadvantage. This is the limitation of sural nerve nutrient flap in repairing tophus wound in the heel.

Main points of the operation and auxiliary medical treatment after operation

Operation points and precautions: (I) during tophus wound debridement, flushing is critical. Alternately rinse with 5% sodium bicarbonate solution and normal saline. The sodium bicarbonate solution can dissolve some of the uric acid crystals of the tophus (13), making debridement more effective. Normal saline can clean the wound and clear the visual field, preventing excessive local concentration of sodium bicarbonate solution caused by repeated rinsing of the wound with sodium bicarbonate solution. (II) Preoperative Doppler ultrasound is used to locate the intermuscular septum perforator on the farthest side of the peroneal artery (14), 4–6 cm behind and above the lateral malleolus but shows a certain variation. The rotational point of the flap should be adjusted according to the penetrating point of the perforator. (III) When the flap is cut, the axis line should be between the midpoint of the Achilles' tendon and the lateral malleolus and the midpoint of the popliteal fossa is 5° above the front. Because the vascular chain network of the peroneal artery perforator is located behind and below the fibula, it is more anterior than the axis of the traditional sural nerve nutrition flap, so the incision can be 5° slightly forward. In this way, the flap can carry the chain vascular network between the peroneal artery perforators as much as possible while ensuring that the sural nerve nutritional vascular network is contained in the flap. (IV) At the far end of the rotation point, the triangular rotating flap with the subdermal vascular network is cut open to reduce the pedicle tension of the flap after rotation and prevent "cat ear" deformity. (V) After surgery, allopurinol is administered routinely to control uric acid levels, which are monitored along with ESR and C-reactive protein. Surgical stimulation may induce an acute attack of gout, and short-term low-dose glucocorticoid therapy may be needed to control serum uric acid levels and prevent tophus formation. (VI) Health education, low-purine diet and plenty of water (at least 2 L/day) should be promoted to accelerate the excretion of uric acid, prevent the re-formation of uric acid crystals in the Achilles' tendon, and ensure the healing of the flap and wound surface.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://dx.doi.org/10.21037/apm-21-2809

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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. All procedures performed in this study involving human participants were in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Ethics Committee of The Second Affiliated Hospital of Soochow University. Because of the retrospective nature of the research, the

requirement for informed consent was waived.

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