

Repair of knee deep burn wound with descending genicular artery-saphenous artery perforator flaps in elderly patients (a STROBE-compliant article)

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Abstract

It is difficult to repair knee deep burn wounds in elderly patients. In this study, we observed the therapeutic effects of descending genicular artery-saphenous artery perforator flaps on knee deep burn wounds in elderly patients.

Between December 2013 and February 2018, we repaired knee third-degree burn wounds using descending genicular artery-saphenous artery perforator flaps of 20 × 12 cm to 23 × 13 cm in 56 elderly patients. For the patella and patellar ligament with complete necrosis, the patella and patellar ligament were completely removed, whereas for the patella and patellar ligament with partial necrosis, necrotic parts were removed first. The donor area was repaired using intermediate thickness free skin graft. The 56 patients were 76- to 85 years' old and all had unilateral knee burn.

All flaps survived in the 56 patients. After the follow-up of 2 to 36 months, the flaps were excellent in texture and appearance, and exhibited sensory recovery. In the 8 patients with completely necrotic patella and patellar ligament as well as open knee joint, the weight-bearing function of knee joint was retained, which met patients' requirements of limb salvage and weight-bearing function. In the other 48 patients with partially necrotic patella and patellar ligament as well as open joint capsule, the postoperative flexion and extension of the knee joint were good.

In elderly patients, it is an effective method to repair knee deep burn wounds using the descending genicular artery-saphenous artery perforator flaps.

Abbreviation: NPWT = negative pressure wound therapy.

Keywords: burn, descending genicular artery, knee injury, saphenous branch, surgical flap

1. Introduction

Owing to frailty and tardy response, old people more easily suffer severe burns of the knee region when they warm in winter. If the knee burn wound is large and deep, it cannot be repaired using simple skin graft, local flap, or calf muscle flap.^[1] Moreover, for old people, the risk of microsurgical free flap transplantation is high because their vascular anastomosis conditions are poor and they cannot tolerate long-time anesthesia.^[2,3] Therefore, it is difficult to repair knee deep burn wound in elderly patients, and they usually face a truncation of their legs. Descending genicular artery-saphenous artery perforator flaps have not been widely used in repairing elderly patients' knee deep burn wounds. This

retrospective study aimed to investigate the outcomes of treatment of third-degree burn wounds in the anterior knee region managed by surgical debridement of burned tissue followed by repair using a descending genicular artery-saphenous artery perforator flap.

2. Subjects and methods

We retrospectively reviewed the charts of patients treated at our institution for a third-degree burn wound in the anterior knee region. The study period comprised December 2013 to February 2018. All study methods were approved by ethics committee of the Central Hospital of Hanzhong City (NO:IRB2018-V). All patients enrolled into the study gave written informed consent.

2.1. Clinical data

We included 56 patients with third-degree burn wounds of unilateral anterior knee. They were admitted within 3 days after burn injury. Of the 56 patients, 32 were males and 24 females, with a mean age of 81 years (range 76–85). They were complicated with carbon monoxide poisoning, hypertension, pulmonary heart disease, sequelae of cerebrovascular incidents, or type 2 diabetes mellitus, and they strongly wanted to save their legs. In all the patients, debridement and drainage were performed within 1 week after admission, and the wound sizes were 19 × 11 cm–25 × 15 cm after debridement. For the patella and patellar ligament with complete necrosis, the patella and patellar ligament were completely removed; whereas for the patella and patellar ligament with partial necrosis, necrotic parts

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Table 1
Patients demographics.

Items	Cases (n)	Ratio
Sex		
Man	31	55.36%
Female	25	44.64%
Age, y		
76–80	42	75.00%
81–85	14	25.00%
Duration between injury and admission		
24 h	21	37.50%
1–3 days	35	62.50%
Complications		
Carbon monoxide poisoning	11	19.64%
Hypertension	24	42.86%
Pulmonary heart disease	9	16.07%
Sequelae of cerebrovascular incident	17	30.36%
Type 2 diabetes mellitus	16	28.57%

were removed. The wounds with open knee joint or bone exposure were repaired using descending genicular artery-saphenous artery perforator flaps of 20 × 12 cm–23 × 13 cm. The distal ends of the flaps reached >20 cm below the knee joint. The wounds without bone exposure were repaired using free skin grafts (Table 1).

2.2. Surgical procedures

2.2.1. Preoperative preparation. After admission, patients received routine examination and treatment of complications. The positions of descending genicular artery, saphenous branch, and perforating branch were explored using Doppler blood flow detector to design descending genicular artery-saphenous artery perforator flaps.

2.2.2. Wound treatment. After the patients were in spine position and received unilateral subarachnoid block anesthesia or epidural anesthesia, necrotic skin, fascia, patella, patellar ligament, articular cartilage, and meniscus were thoroughly removed followed by drainage of articular cavity hydrops. According to the condition of the wound, stage II repair of wound surface was performed on the patients receiving negative pressure wound therapy (NPWT).

2.2.3. Design, harvesting, and transplantation of the flaps.

According to the size of the wound, the descending genicular artery-saphenous artery perforator flaps with the descending genicular artery as a pedicle were designed at the medial part of the affected limb and above the middle part of the calf. The flaps were harvested as follows: The descending genicular artery was first identified at about 4 cm above the inferior margin of the medial epicondyle of the femur, and in the deep fascia under the triangle concave surface bounded by the vastus medialis, the tendon of adductor magnus and condylus medialis femoris,^[4] then the saphenous branch of the descending genicular artery was identified along the anterior border of the sartorius muscle, and then the saphenous branch of the descending genicular artery was separated by cutting off the section of the sartorius muscle under which the saphenous branch ran, to about 10 cm below the knee joint where the saphenous branch pierced out into the flap. The lengths and widths of the flaps were 1 cm greater than the bone exposure wounds. The pedicled axial flap supplied by the descending genicular artery was harvested from the medial part

Table 2
Surgical techniques.

Items	Cases (n)	Ratio
Operative duration, h		
1.5–2	47	83.93%
2–3	9	16.07%
Wound size after debridement		
19 × 11 cm–22 × 13 cm	24	42.86%
22 × 13 cm–25 × 15 cm	32	57.14%
Flap size		
20 × 12 cm–21 × 12 cm	24	42.86%
21 × 12 cm–23 × 13 cm	32	57.14%
NPWT followed by secondary flap coverage	8	14.26%
One-stage repair	48	85.74%

NPWT = negative pressure wound therapy.

of the affected limb and above the middle part of the calf. The flaps contained the saphenous branch of the descending genicular artery, great saphenous vein, and saphenous nerve. The proximal ends of the grafts reached 5 cm above the knee and distal ends 20 cm below the knee with a width of about 15 cm. The distal end of the saphenous vein was ligated and the disconnected sartorius muscle was sewed and fixed using absorbable sutures. If the blood circulation of the graft was satisfactory after the tourniquet was released, the graft was rotated 75 to 80 degree to cover the anterior knee wound. An ipsilateral thigh intermediate thickness free skin graft was used to repair the donor area (Table 2).

2.3. Postoperative treatment

The affected knee was fixed using a plaster slab at flexion of 10 degree. For the patients whose patella and patellar ligament were completely removed, the affected knee was fixed for 6 to 8 weeks to facilitate the fusion and fixation of the knee joint. For the patients whose patella and patellar ligament were partially removed, the affected knee was fixed for 10 days followed by ambulation and functional training of knee joint flexion and extension.

3. Results

Of the 56 patients, 8 had complete exposure of knee joint after debridement because patella and patellar ligament were removed due to complete necrosis. Then we applied NPWT followed by staged repair of wound surface using pedicled descending genicular artery-saphenous artery perforator flaps 1 week later. In the 8 patients, the patella and patellar ligament were completely removed and the knee joint was ankylosed. For remaining 48 patients who had exposure of patella and/or patellar ligament, or joint capsule exposure owing to removal of necrotic parts of patella and patellar ligament, 1-stage repair was performed using descending genicular artery-saphenous artery perforator flaps. According to Lysholm scoring, >95 points were regarded as excellent knee function, 94 to 85 points as good knee function, 84 to 65 points as acceptable knee function, and <65 points as poor knee function. In these 48 patients of this study, 35 patients obtained excellent knee function and 13 acceptable knee function. All flaps survived in the 56 patients. After the follow-up of 2 to 36 months, the flaps were excellent in texture and appearance, and exhibited sensory recovery (Table 3)

Table 3

Outcomes.		
Items	Cases (n)	Ratio
Only weight-bearing function reserved	8	14.26%
Reserved flexion and extension of the knee	48	85.74%
Lysholm score		
>95	12	25.00%
85–94	29	60.42%
65–84	7	14.58%
<65	0	0

3.1. Case 1

A 79-year-old woman with sequelae of cerebral infarction accidentally had carbon monoxide poisoning while heating at home, and fainted in the charcoal fire basin, causing a third-degree burn wound on the anterior side of the left knee. After she was found by her family, the patient was sent to hospital 48 hours later. The physical examination showed that there was a third-degree burn wound of 23×15 cm on the anterior side of the left knee. The burn wound was black and hard as carbonized leather with peritraumatic redness and swelling. The patient had a history of 15-year type 2 diabetes mellitus. Debridement was performed under unilateral subarachnoid block anesthesia 3 days after admission. The patella and patellar ligament were completely necrotic, so the patella, patellar ligament, articular cartilage, and meniscus were thoroughly removed, and the knee joint was opened followed by NPWT with a wound of 23×15 cm. One week later, the ipsilateral pedicled descending genicular artery-saphenous artery perforator flap with a size of 23×13 cm was harvested to cover the defect with open knee joint and exposure of the bone. An ipsilateral ipsilateral thigh intermediate thickness free skin graft was used to repair the donor areas. The affected knee was fixed using a plaster cast with a flexion of the

knee of 10 degree. Postoperative anti-inflammatory, prevention of deep venous thrombosis, and control of blood sugar were routinely performed. The left lower leg was elevated in immobilization. All flaps and skin grafts appeared vital after 10 days and the plaster slab was discarded 7 weeks later. One year after operation, the left knee joint was ankylosed without flexion and extension function, but with the function of weight bearing. The outcome was satisfactory in terms of limb salvage and knee weight-bearing function (Fig. 1).

3.2. Case 2

A 77-year-old man with type 2 diabetes mellitus accidentally had a third-degree flame burn wound on the anterior side of the left knee caused by hot oil. The physical examination showed that the burn wound was black and hard as carbonized leather with full-thickness skin necrosis. Debridement was performed under peridural anesthesia 5 days after admission. Exposure of patella and patellar ligament was seen. Subsequently, an ipsilateral pedicled axial island descending genicular artery-saphenous artery perforator flap of 18×13 cm was harvested to repair the wound with the exposures of patella and patellar ligament. The flap and skin graft appeared vital 9 days after the operation. The function training of knee joint began 2 weeks after operation. The flexion and extension of the left knee joint were good 3 months after operation (Fig. 2).

4. Discussion

In winter, more deep burn wounds occur because of improper heating, especially in elderly people, limb burn is commonly observed after carbon monoxide poisoning. However, the burn commonly occurs on the anterior part of the knee. If the knee burn wound is large and deep, it cannot be repaired using local skin flaps and skin grafts. The ipsilateral retrograde anterolateral

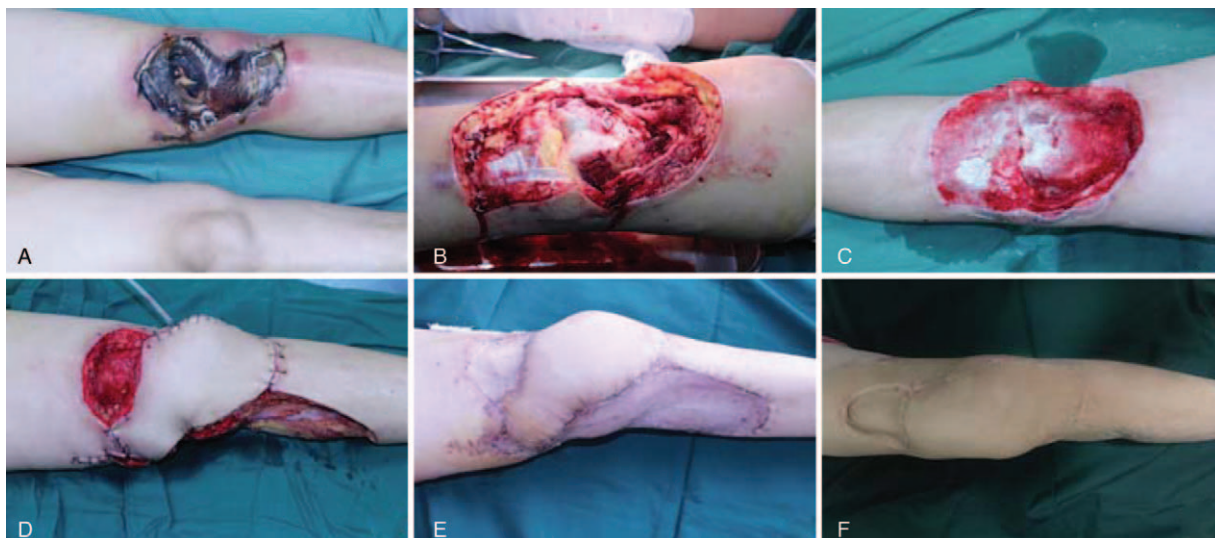


Figure 1. Repair of the burn wound with open knee joint and bone exposure on the anterior side of the left knee using a pedicled descending genicular artery-saphenous artery perforator flap. (The patient underwent NPWT followed by second stage flap repair). (A) Preoperative third-degree burn wound on the anterior side of the left knee. (B) The 23×15 cm wound. The necrotic patella, patellar ligament, articular cartilage, and meniscus are thoroughly removed and the knee joint is opened. (C and D) One week after negative pressure wound therapy, the left descending genicular artery-saphenous artery perforator flap covering the wound with bone exposure, and Note drainage under the flap. (E) Photograph of vital flap and skin graft 10 days after operation. (F) Stiff left knee joint and retained ability to walk. Notes: NPWT = negative pressure wound therapy.



Figure 2. Repair of the burn wound with the exposure of patella and patellar ligament on the anterior side of the left knee using a pedicled descending genicular artery-saphenous artery perforator flap (The patient received 1-stage repair and obtained both weight-bearing function and flexion and extension of the knee). (A) Preoperative third degree burn wound on the anterior aspect of the left knee. (B) Exposure of the patella and patellar ligament, harvested left descending genicular artery-saphenous artery perforator flap (1 indicates vascular bundle of the descending genicular artery-saphenous artery, 2 greater saphenous vein, and 3 skin flap, 4 sartorius muscle, and 5 patella). (C) Transfer of the left descending genicular artery-saphenous artery perforator flap. (D) The repair of the donor area and the wound without bone exposure using contralateral thigh intermediate thickness free skin graft after the transfer of the left descending genicular artery-saphenous artery perforator flap. (E, F, and G) The left knee joint in extension as well as in flexion.

thigh island flap may lead to unsuccessful operation due to the difficulty of vascular anatomy, obstruction of the venous reflux of the flap or the thrombosis of the vascular pedicle.^[5] Moreover, microsurgical free flap transplantation is difficult to apply in elderly people because of their poor anastomosis conditions and their inability to tolerate long time anesthesia and prolonged periods of fixation and immobilization required for cross leg flaps.^[2] For elderly patients with knee burns, if the skin at the medial and posterior parts of the knee and above the middle part of the calf is intact, and the descending genicular artery and saphenous branch are not involved. We used the descending genicular artery-saphenous artery perforator flaps to repair the knee deep burn wounds in elderly patients and obtained encouraging results, thus avoiding an amputation of their legs and retaining function of weight-bearing.

In terms of anatomy, the descending genicular artery is relatively constant and originates from the femoral artery. The saphenous artery directly arises from the descending genicular artery, femoral artery, and popliteal artery in 90%, 7.5%, and 2.5%, of patients, respectively.^[6] The descending genicular artery was separated from the femoral artery at about 4 cm above the inferior margin of the medial epicondyle of femur, and in the deep fascia under the triangle concave surface bounded by the vastus medialis, the tendon of adductor magnus, and the condylus medialis femoris.^[4] The descending genicular artery has 1 or 2

accompanying veins, which directly flow back to the popliteal vein.^[7,8] The descending genicular artery has multiple upward and downward branches in the anterior border of the sartorius muscle.^[9] The downward branches mainly consist of the articular web branch and the saphenous branch. The saphenous branch runs about 10 cm between the sartorius muscle and the gracilis muscle, passes through the deep surface of the sartorius muscle to descend with the saphenous nerve, and then runs out from the deep fascia to the subcutaneous at the distal end of sartorius muscle of the condylus medialis tibiae.^[10] The saphenous branch provides blood supply to the fascia and skin within the size of 20×15 cm below the knee. After ensuring that the vascular axis of the descending genicular artery-saphenous branch is continuous, the flap with the vascular axis of the descending genicular artery-saphenous branch is harvested. The flaps contained the great saphenous vein and saphenous nerve, which promoted venous return of flaps and also retained the sensation of flaps.

The advantages of the descending genicular artery-saphenous artery perforator flaps were: simple procedure, short operation time, low risk of anesthesia and operation as well as supine position without requirement of changes of body position during operation; no damage to important blood vessels and nerves; simple flap design; retention of flap sensation due to the innervation by the saphenous nerve; concealed donor area with similar thickness, texture and color to the recipient area; no

special requirement for postoperative limb placement; and availability of relatively large flap, even across the knee joint. However, the disadvantage of the flap was sensory loss on the inside of the lower leg after operation because of disconnection of saphenous nerve. On the medial malleolus and the inside of the leg, the sensation was temporarily impaired after operation, but it recovered spontaneously after a period of time.

Precautions of the operation can be made through 4 ways. First, it is very important to protect the continuity of the saphenous branch of the descending genicular artery from its starting point to 10 cm below the knee especially under the sartorius muscle when the flap is harvested. Third, for the patella and patellar ligament with complete necrosis, the patella, patellar ligament, articular cartilage, and meniscus were thoroughly removed followed by NPWT, promoting postoperative knee joint fusion and fixation as well as flap and skin graft survival. For the patella and patellar ligament with partial necrosis, necrotic parts were removed. In this study, the articular cavity hydrops was >50 mL in 30 patients. A drainage tube was placed in the articular cavity during debridement and postoperative drainage lasted one week (Fig. 2D). Third, ensuring the integrity of vascular and nerve bundles in the flap pedicle, we create an axial island flap (Figures 2B and 2C). Fourth, for the patients whose patella and patellar ligament were completely removed, the affected knee was fixed for 6 to 8 weeks to facilitate the fusion and fixation of the knee joint and avoid postoperative knee joint dislocation or instability. For the patients whose patella and patellar ligament were partially removed, the affected knee was fixed for 10 days to prevent knee joint stiffness.

5. Conclusion

In summary, the descending genicular artery-saphenous artery perforator flap is an efficient and reliable flap for repair of deep burn wounds of the anterior region of the knee in elderly patients.

Author contributions

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