Original Article

Below-knee Amputation with Medial and Lateral Skin Flaps: Its Usefulness in Critical Limb Ischemia Patients Receiving Maintenance Hemodialysis for Diabetic Renal Failure

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ABSTRACT

Background: Progress in multidisciplinary therapy has led to a trend to avoid below-knee amputation for critical limb ischemia. However, there are still serious cases in which such amputation must be performed. In typical below-knee amputation cases, the surgical wound is most commonly closed using anterior and posterior skin flaps, but delayed healing is not unusual in critical limb ischemia cases. One cause for the delayed healing of wound margins is thought to be the difference in the length and thickness of the wound margins between the anterior and posterior skin flaps.

Methods: Four critical limb ischemia patients who were receiving hemodialysis for diabetic renal failure were treated with below-knee amputation using medial and lateral skin flaps of similar lengths and thicknesses.

Result: All patients achieved satisfactory healing by wound closure.

Conclusions: In critical limb ischemia patients undergoing maintenance hemodialysis for diabetic renal failure, medial and lateral flaps may be a viable option in below-knee amputation provided the patients are not candidates for postoperative prosthesis, such as elderly patients with preoperative gait difficulty.

Key words: artificial dialysis, below knee amputation, critical limb ischemia, diabetes mellitus, renal failure

Introduction

Progress in multidisciplinary therapy has led to a trend to avoid below-knee amputation for critical limb ischemia. However, there are still serious cases in which such amputation must be performed. In typical below-knee amputation cases, the surgical wound is generally closed using anterior and posterior skin flaps and healing subsequently occurs. In critical limb ischemia cases, delayed wound healing is not uncommon due to underlying diabetes and renal failure and tissue damage caused by hemodialysis. Therefore, a surgical method that considers wound healing after below-knee amputation is necessary. When a wound is closed using anterior and posterior skin flaps, delayed healing can occur due to the difference in the length and thickness of the wound margins between these flaps. This study examined critical limb ischemia patients who were receiving hemodialysis for

diabetic renal failure and who underwent below-knee amputation. Herein, we report the effectiveness of wound closure in these patients using medial and lateral skin flaps of similar lengths and thicknesses.

Methods

Subjects

The subjects were patients with foot wounds who (1) were undergoing maintenance hemodialysis for diabetic renal failure; (2) had undergone catheterization of the lower limb, but whose anterior and posterior tibial arteries were occluded peripheral to the ankle joint, making it impossible to improve blood flow and thereby support healing after minor amputation; (3) had undergone below-knee amputation with medial and lateral skin flaps between January 2017 and December 2018 and were in a postoperative follow-up period of at least 6 months; and (4) had gait difficulties preoperatively and were

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not expected to walk postoperatively.

Surgery

The surgical method of Nagashima et al.¹⁾ was followed. Skin incisions were made according to the design shown in Fig. 1, and muscle treatment and other treatments were performed.

Fig. 1. Medial and lateral flaps.

Results

The four subjects were all men with an age range of 70-80 (average, 75.5) years. The treatment period for diabetes ranged from 15 to 40 (average, 31.0) years. The treatment period of hemodialysis ranged from 7 to 10 (average, 8.8) years. The preoperative ankle brachial index of the affected limb was 0.5-1.7. The preoperative skin perfusion pressure of the affected limb was 27/36 (dorsal/plantar foot, mmHg) in one patient but could not be measured in the other three patients due to pain during measurement. All patients had a history of coronary artery disease (Table 1). Postoperatively, all patients achieved satisfactory healing along the entire length of the wound margins and no necrosis was observed in the wound margins.

Cases

Case 1 (Fig. 2): An 80-year-old man

The patient presented to the hospital due to worsening of his left foot gangrene, which was observed one month prior to the initial examination. Gangrene was observed in all toes of the affected foot with severe pain in the initial examination. The tibia was sectioned at 11 cm from the articular surface of the

Table 1. Patient characteristics

Case No.	Age	Sex	Side	Duration of Diabetes (years)	Duration of Dialysis (years)	Ankle Brachial Index	Skin Perfusion Pressure (dorsal, plantar, mmHg)	History of coronary artery disease	Follow-up period after surgery (months)
1	80	M	L	15	10	0.6	-	CABG	26
2	77	M	R	37	7	0.54	-	PTCA	23
3	75	M	R	32	10	1.7	-	CABG	15
4	70	M	L	40	8	0.5	27, 26	CABG	9

Fig. 2. Case 1. An 80-year-old man.
(a) Preoperatively.
(b) Postoperatively.
(c) At 6-months postoperatively.

Fig. 3. Case 3. A 75-year-old man.
(a) Preoperatively.
(b) Postoperatively.
(c) At 13-months postoperatively.

knee, and the fibula was sectioned 1 cm proximal to the level of the tibial cut. Below-knee amputation was completed, and the stump was closed using medial and lateral flaps. Postoperatively, there was neither wound margin necrosis nor dehiscence. The patient has had no recurrent wound development in either lower leg at 2 years and 2 months after the initial surgery.

Case 3 (Fig. 3): A 75-year-old man

The patient had wounds of the right second and third toes one month prior to the initial examination. He was started on a local topical treatment, and his progress was monitored. Subsequently, he developed an infection extending to the plantar compartment and underwent debridement. The tibia was sectioned at 10 cm from the articular surface of the knee, and the fibula was sectioned 1 cm proximal to the level of the tibial cut. Below-knee amputation was completed, and the stump was closed using medial and lateral flaps. Postoperatively, the patient progressed without wound margin necrosis or dehiscence. He has had no recurrent wound development at 1 year and 3 months after the surgery.

Discussion

Generally, in below knee amputation, consideration is given to the load on the stump from a prosthesis and the anterior and posterior flaps are commonly used for wound closure. When the anatomical vascular distribution of the lower limb is evaluated, particularly in critical limb ischemia, it must be noted that if an anterior flap with thin skin and low muscle volume is dissected and elevated to achieve a long length, blood flow can be easily impaired at the suture area corresponding to the peripheral flap. Since the blood flow of the anterior flap is less stable than that of the posterior flap, a long posterior flap (longer posterior than anterior) (Fig. 4) as described by Burgess et al.²⁾ tends to be used. However, when

Fig. 4. Long posterior flap.

two flaps of different lengths are sutured together, a dog ear deformity can easily occur, which surgeons are hesitant to excise considering the flap blood flow. Even if surgeons minimize the excision of the dog ear deformity, the posterior flap bends due to small gathers that form when anterior and posterior flaps of different lengths are sutured together (Fig. 5). The adaptation of the suture area becomes poor, and the contact area of the suture surface is decreased. It is also disadvantageous for wound healing when the microvasculature of the skin becomes compressed by the bending of the skin. When patients have critical limb ischemia with unstable blood flow, necrosis of the wound margin can potentially occur due to even such mildly impeded blood flow. In addition, an anterior flap is thinner than a posterior flap, and if excessive soft tissue is present in the cut edge of the posterior flap, closure of the suture area becomes poor. Such a situation can result in delayed healing, and caution is therefore necessary. In contrast, when the length and thickness of the medial and lateral flaps (Fig. 5) differ only slightly, suturing is

Anterior flap

Posterior flap

Fig. 5. Small wrinkles on the skin of the wound margin that form when anterior and posterior flaps of different lengths are sutured together.

relatively easy and the stress on the wound margin is predicted to be small. Even if the wound margins of the anterior and posterior flaps are designed to be of the same length, impeded blood flow becomes a concern due to the large extent of tibial dissection for the anterior flap. For the medial and lateral flaps, the anterior surface of the lower leg becomes the anterior margin of the suture area, and the dissection of the anterior tibial surface, which can cause impaired blood flow, is minimized. The skin flaps are over the muscles on the medial and lateral sides; therefore, the flap blood flow is thought to be more stable than that of the anterior and posterior flaps. As a result, the risk for delayed healing and dehiscence from wound margin necrosis can be minimized, particularly in limb ischemia patients with unstable blood flow in the wound margins. Whereas anterior and posterior flaps have largely different lengths and thicknesses, such wound margin differences were not seen between the medial and lateral flaps in the four patients in our study. As a result, suturing was easily performed and all patients had satisfactory healing without wound margin necrosis.

Tracy³⁾ and Persson et al.⁴⁾ reported the use of sagittal flaps in below-knee amputation using medial and lateral flaps. In addition, Falstie-Jensen et al.⁵⁾ analyzed 140 diabetic patients who had undergone below-knee amputation and found that sagittal flaps had significantly fewer complications, such as delayed wound healing and re-amputation, compared with long posterior flaps. Nagashima et al.¹⁾ examined 13 patients in whom sagittal flaps were used in below-knee amputation due to poor blood circulation. They reported that sagittal skin incisions facilitated easier muscle and blood vessel treatment compared to anterior and posterior flap incisions because the surgical field was expanded longitudinally. The cross-section of the lower leg is normally not circular but wider anteroposteriorly than mediolaterally. From the perspective of the ratio of flap width to length, Au⁶⁾ indicated that the blood flow is more stable in flaps created medially and laterally than in those created anteriorly and posteriorly. Thus, in below-knee amputation, closure using medial and lateral flaps is more advantageous than that using anterior and posterior flaps because of its simpler, easier procedure and more stable blood flow. The disadvantage of this method is that the suture area is

in the middle of the stump, which increases the risk of complications such as ulceration and wound dehiscence in the context of prosthesis loading. In our study, all four patients treated using medial and lateral flaps were elderly and had preoperative gait difficulty due to disuse. No wound dehiscence or ulceration occurred over the long term, in part because they were not candidates for postoperative ambulation using prosthesis. When a prosthesis is worn on the suture area, the difference in the incidence of complications, such as ulceration, between the medial-lateral flap technique and the anterior-posterior flap technique remains unclear. However, if the goal is postoperative prosthetic ambulation, then careful examination is necessary when considering the indications for this method.

Diabetes and renal failure are both risk factors for peripheral artery disease. Prognosis is known to be poor in critical limb ischemia patients with peripheral artery disease that has become more severe.⁷⁾ If hemodialysis is performed, wound healing may be delayed due to the progression of peripheral vascular calcification.⁸⁾ As mentioned earlier, the effectiveness of the method used in this study has been reported in patients with ischemic limbs. Our literature search did not yield any previous studies focusing on patients who were receiving maintenance hemodialysis for diabetic renal failure. However, our study suggests that this method is useful in critical limb ischemia patients with maintenance hemodialysis for diabetic renal failure, particularly if the patients are elderly and have low postoperative activity levels.

Conclusion

Below-knee amputation using medial and lateral flaps may be considered a viable option for critical limb ischemia patients undergoing maintenance hemodialysis for diabetic renal failure, provided they are not candidates for postoperative prosthesis, such as elderly patients with preoperative gait difficulty.

Conflict of Interest

All authors declare no conflict of interest related to this manuscript.

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