Modified Skew-Flap Below-Knee Amputation

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Abstract

Between 1999 and 2001, 35 consecutive patients with diabetes (mean age, 59.4 years) were treated prospectively with a modified skew-flap below-knee amputation. The technique, results, and follow-up are described. By a mean follow-up of 3.5 years, 3 patients required below-knee amputation of the opposite extremity, 4 expired, and 28 were ambulating with a below-knee prosthesis.

The modification has several advantages: A tibialis anterior muscle cushion on the distal end of the tibia prevents bone protrusion; anterior skin flaps made by the initial linear anterior incision prevent tension at the suture line; and oblique myocutaneous flaps avoid muscle trimming and prevent shearing of fascial plexuses at closure, thus improving wound healing.

Robinson and colleagues[1] first described the skew-flap myoplastic below-knee amputation. The advantages claimed were simplicity, ability to fashion flaps of equal length more easily, more favorable blood supply as demonstrated by thermography, and improved stump contour permitting early prosthetic fitting. However, the line of skin closure and the resulting scar ran immediately in front of the beveled anterior border of the tibia, making it a point vulnerable to wound complication with possible bone exposure or protrusion.[2]

We have undertaken skew-flap below-knee amputation with a modification to give cover to the distal tibia with tibialis anterior muscle and to prevent the kinds of complications that occurred in our first patients.

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Patients and Methods

Between 1999 and 2001, 35 consecutive diabetic patients (27 men, 8 women) required below-knee amputation. Mean age was 59.4 years (range, 43-78 years), mean follow-up was 3.5 years (range, 3-5 years), and mean duration of diabetes was 8.6 years (range, 0-20 years). Wagner[3] type IV cases, which include gangrene of the forefoot, were most common (18/35), followed by Wagner V cases (10/35), which include gangrene of the hind foot, and Wagner III cases (7/35), which include osteomyelitis of the bones of the foot along with infection.

Mean vascular index of the affected limb was 0.3 (range, 0-1.1), and that of the unaffected side was 0.43 (range, 0-1). Mean blood glucose, which was 216.6 mg/dL (range, 109-704 mg/dL) at presentation, was controlled to a mean of 173.7 mg/dL (range, 85-385 mg/dL, normal, <126 mg/dL) after surgery. Mean hemoglobin was 9.9 g/dL (range, 6.5-13.5 g/dL; normal range for men, 13.8-17.2 g/dL; normal range for women, 12.1-15.1 g/dL); absolute lymphocyte count was -2269.1 (range, 644-6509; normal range, 1500-4000); serum creatinine was -1.2 mg/dL (range, 0.6-2.2 mg/dL; normal range, 0.8-1.4 mg/dL); total protein was -7.2 g/dL (range, 5.6-9.5 g/dL; normal range, 6.8-8.3 g/dL); and serum albumin was 3.9 g/dL (range, 2.5-5.5 g/dL; normal range, 3.4-5.4 g/dL).

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After providing informed consent, all patients were offered a skew-flap below-knee amputation with modification. In 9/35 patients, a primary skew-flap amputation with modification was performed. In the other 26/35 patients, a primary guillotine amputation was performed 7.5 cm above the ankle when pus from the foot was suspected to have tracked into the leg along the long flexor tendons. Saline dressings were applied to the open guillotine stump twice a day until the wound was healthy, a week at most (mean, 4 days; range, 2-7

Figure 1. Proximal 4 cm of the skin incision on the leg is marked linear.

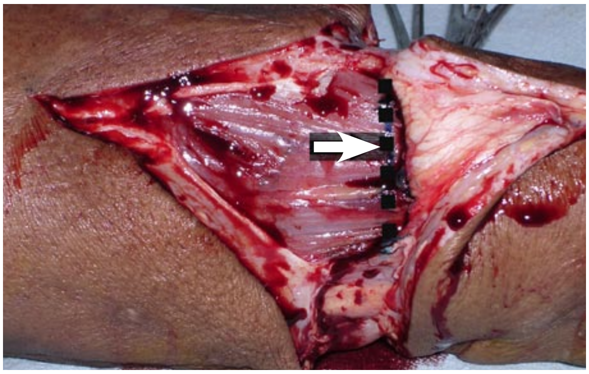

Figure 2. Line at the level of the section of muscles in the anterior compartment of the leg.

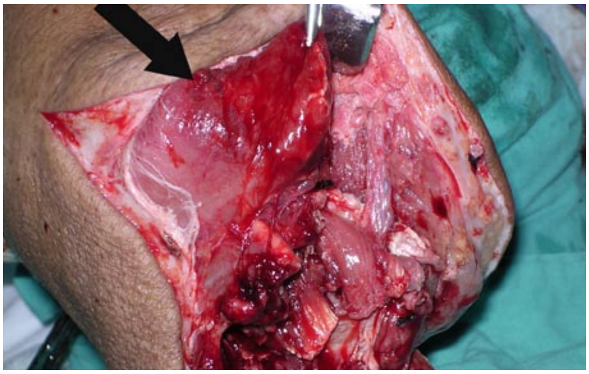

Figure 3. Tibialis anterior muscle wrapped around the distal end of the resected tibia.

Figure 4. Suture line at the end of the operation.

days); then they were removed, and a revision skew-flap amputation with modification was performed.

Most patients had comorbidities, such as hypertension (26/35) and ischemic heart disease (10/35).

Surgical Technique

The gangrenous foot is isolated with a polythene (polyethylene) bag, and its proximal edges are sealed with a sticking plaster. Next, a tourniquet is applied to the thigh and is inflated if needed, after the leg is elevated. The patient's affected limb is prepared with 10% povidone-iodine solution and draped. Broad-spectrum antibiotics (ofloxacin 400 mg once a day, amikacin 500 mg once a day, metronidazole 500 mg every 8 hours for broad-spectrum coverage of organisms or as per culture and sensitivity) are administered at admission and later adjusted as per culture sensitivity from the wound swabs taken from the affected foot. Regional anesthesia (spinal/epidural) is given.

The semicircular skin flaps are marked in the conventional way, described by Robinson and colleagues,[1] except that the proximal 4 cm of the anterior incision is kept linear, and then the incision diverges for the anteromedial and posterolateral flaps (Figure 1). The incision is made along the proposed mark to the deep fascia. Then the muscles of the anterior compartment are dissected from the deep fascia in the distal anterolateral skin flap to the level of the summit of the semicircular flaps (Figure 2) and elevated from the interosseous membrane to the level of the proposed tibial bone cut. The tibia is then cut 2 cm proximal to the anterior marked skin incision, and the anterior crest is beveled further proximally. The rest of the muscles are cut obliquely along the line of the semicircular retracted skin flaps centering at the tibialis posterior muscle such that the tibialis posterior is finally cut at the level of the posterior border of the resected tibia. The muscles are not separated from the deep fascia, thus forming a myocutaneous flap. Mild tension is applied to the anterior tibial and peroneal nerves, which are then sharply divided and allowed to retract. The vessels are cut and ligated with 2-0 silk sutures. The posterior tibial nerve is often accompanied with a vasa nervosa and is therefore ligated and cut under mild tension. The fibula is cut 2 cm proximal to the tibial cut, as described previously.[1] Use of bone hook in the medullary canal of the tibia for dissection posterior to the tibia is avoided, as at times it opens the intramedullary vessels, leading to intraoperative bleeding, and postoperatively creates a hematoma that may form a nidus for infection.

If a tourniquet has been used, it is now deflated. The muscle belly of the tibialis anterior is now wrapped around the distal end of the tibia (Figure 3) and is sutured to the thick fascioperiosteal layer on the anteromedial surface of the tibia. The other muscles, along with the deep fascial layer, are closed along the line of skin incision using interrupted "1" Vicryl sutures over a suction drain, thus preventing any shear in the muscle–fascia interface.

Finally, the skin is closed with interrupted 2-0 nylon sutures (Figure 4). The suture line is covered with an

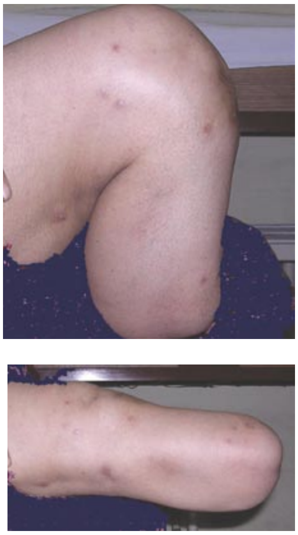

Figure 5. Range of motion of the knee in flexion and extension at 4-year follow-up.

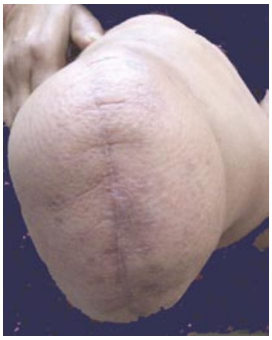

Figure 6. Healed scar and distal end of the stump cushioned by the tibialis anterior muscle at 4-year follow-up.

antiseptic dressing, and a posterior plaster splint is applied to prevent a flexion contracture at the knee.

Postoperative Treatment

Antibiotics (ofloxacin 400 mg once a day, amikacin 500 mg once a day, metronidazole 500 mg every 8 hours for broad-spectrum coverage of organisms or as per culture and sensitivity) were administered for 1 week after surgery. On postoperative day 2, a stump dressing was applied, the suction drain was removed, and knee mobilization was initiated. The patient was trained for non-weight-bearing crutch walking beginning on postoperative day 2. The wound was inspected on alternate days, and the patient was discharged from the hospital after 3 dressings. Sutures were removed 2 to 3 weeks later, depending on wound healing. Patients were advised for prosthetic fitting after stump edema subsided postoperatively.

“These septal perforators communicate with vessels of the deep fascia to form a plexus from which branches supply the overlying subcutaneous tissue and skin.[8]”

Results

Sutures were removed a mean of 19 days after surgery (range, 13-23 days). Mean knee range of motion was 118.4° (range, 100°-130°) (Figures 5, 6). No patient experienced extension lag, but 4 patients had 15° of fixed flexion deformity at the knee. Patients received a prosthesis at a mean of 5.2 months (range, 4-7 months), and all patients except 3 (8.6%) were then able to resume full weight-bearing; 2 of the 3 patients were in poor medical condition (full weight-bearing in 10 months), and the third had diabetic retinopathy (full weight-bearing in 12 months). All patients returned to independent functional status at a mean of 6.4 months (range, 4-8 months), except for the 3 patients just mentioned. Thirty-one patients were satisfied with the stump; the other 4, who had flexion contracture of the knee, found walking with the prosthesis difficult. Superficial infection (6 patients) resolved with local wound care and antibiotics. Deep infection (4 patients) resolved after limited suture removal and wound irrigation and care; the wounds were then sutured secondarily. The organisms cultured were *Escherishia coli* (3 patients) and *Klebsiella, Pseudomonas aeroginosa,* and *Staphylococcus aureus* (1 patient each). Two patients had mixed flora with β-hemolytic streptococci and *E coli*. No growth was observed in the cultures of 2 patients. Patients who developed infection had low levels of hemoglobin (<10 g/dL), total protein (<6 g/dL), serum albumin (<3 g/dL), and absolute lymphocyte count (<1500).

Stump shape was conical (34 patients) or cylindrical (1 patient). No patient required stump revision, and the number of surgeries per patient was no more than 2 (primary guillotine amputation, secondary skew-flap amputation with modification).

By the final follow-up (mean, 3.5 years; range, 3-5 years), 3 patients had undergone a below-knee amputation of the opposite extremity and were ambulating with wheelchairs, 4 had expired, and the other 28 did not have any stump complications and were still ambulating independently with the help of a below-knee prosthesis.

Discussion

There have been problems with below-knee amputation, especially for ischemic limbs, because of the high complication rates associated with anteroposterior and long posterior flaps.[4] Most investigators have found good healing in only 70% to 80% of below-knee amputation cases.[5,6] Anterior folding of the posterior Burgess flap causes shearing of its layers, mainly at the fat–fascia interface, which is the weakest point.[7] Hence, the vascularity of the overlying skin is compromised, and the wound may break down.[7] A group of blood vessels extends toward the surface of the body along the fascial septa between muscle groups. These septal perforators communicate with vessels of the deep fascia to form a plexus from which branches supply the overlying subcutaneous tissue and skin.[8] The plexus itself includes a complex arrangement of suprafascial, subfascial, and intrafascial vessels.[9] In addition, thoroughfare vessels within the capillary bed of the fascial flaps permit arteriovenous shunting.[10] Anatomy and distribution of the fasciocutaneous perforators have been described in detail: The lower limb has perforating blood vessels from the anterior tibial, posterior tibial, saphenous, sural, and peroneal arteries that supply the deep fascia and the overlying skin.[11] Clinically, as long as the skin and the subcutaneous tissues are not stripped off the underlying fascia, they will receive an axial pattern of blood supply[7]; long flaps of the leg should be based proximally and raised either medially or posteriorly to accommodate this axial input.[11]

In the present technique, the myocutaneous flap has an oblique cut made across the muscles, with the tibialis posterior muscle at the center of the converging flaps.

This technique (a) prevents creation of excess muscle bulk, which may need trimming at wound closure, and thus reduces surgery time; (b) prevents shearing between various layers at closure, avoiding suture-line pressure that can predispose to ischemia, lowered oxygenation of skin flaps,[12] and impaired wound healing; and (c) does not disturb the blood supply of perforators through the muscles to the fascial plexus supplying the anteromedial and posterolateral flaps.

The proximal 4 cm of the anterior incision (Figure 1), which is kept linear, provides additional skin flaps covering the rotated tibialis anterior muscle, thus preventing tension at the suture line. These flaps are otherwise lost in the divergent incision line of the classical skew-flap amputation. The rotated tibialis anterior muscle forms a muscle cushion, on the distal end of the tibial stump, that prevents the skin/scar tenting that may create pressure sores and/or skin flap necrosis from contact with the prosthesis. We suggest not using the bone hook in the medullary canal of the tibia for retraction or positioning of the stump for better surgical exposure, as it often opens up medullary vessels to bleeding and hematoma, which may predispose to infection.

“This technique...prevents shearing between various layers at closure, avoiding suture-line pressure that can predispose to ischemia. ”

Conclusions

This procedure addresses the shortcomings of the classical skew-flap amputation with muscle cushioning of the distal end of the tibia. The aims of early wound healing and creation of adequate stumps for prosthetic fitting were achieved among our patients.

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