CONTROLLED EARLY AMBULATION OF HEEL SURFACE DEFECTS COVERED BY PEDICLE FLAPS IN LOWER-LIMB AMPUTEES

James H. Herndon, Major, MC*
Alcide M. LaNoue, LTC, MC
Stanley P. Frileck, Major, MC
Amputee and Plastic Surgery Services
Valley Forge General Hospital
Phoenixville, Pennsylvania 19460

ABSTRACT

A program of early weight-bearing for full-thickness pedicle flaps over heel-pad defects is described. This successful program used simple shoe inserts and convalescent shoes, but more important, also utilized an inexpensive pressure gage which aided in the control and distribution of weight-bearing forces on the sole and heel flap. With proper support of the flap, the patient can return to normal activities very early. One patient was able to ski with a foam-injected ski boot. Careful and detailed postoperative monitoring of the patient is necessary to obtain such results. Following surgery, care of the pedicle flap should not be left up to the patient.

INTRODUCTION

Providing controlled ambulation for a patient with a pedicle flap recently applied to a large heel defect is a difficult problem. Two patients, each with a below-knee amputation of one limb and an exposed os calcis on the other were admitted to the amputee service at Valley Forge General Hospital. A review of the literature failed to reveal any recorded experiences concerning the postoperative rehabilitation of patients with pedicle heel flaps. Most papers described the numerous types of skin-graft coverage, a wide variety of different pedicle flaps, and their management and surgical techniques (1,2,3,4,7,9,11). The only comments the authors could find regarding the management of the patient after the flap had healed were: “Most of these cases wore..."
special surgical boots or shoes to provide additional protection until the flap was stabilized" (10), or "The child is advised to wear shoes with a rubber cushion around the graft so that the insensitive skin is not injured and the skin can take shape" (9).

It is important that a young patient recovering from a traumatic war-incurred amputation be returned to normal activity as soon as possible (8). It is virtually impossible to keep such a patient in bed or in a wheelchair for prolonged periods. However, in the cases to be discussed this early return was complicated by the pedicle-flap coverage on the opposite heel. Therefore, in order to ambulate these patients early, we utilized a pressure transducer which had been used successfully for 3 years in fitting and adjusting prostheses. One of the authors (A.M.L.) had learned of this technique while visiting Rancho Los Amigos Hospital. By use of this transducer, and a total-contact shoe insert, we were able to adjust the pressure on the weight-bearing surface of the foot, including the heel-pedicie tissue, and thus avoid the complications of ulceration, blistering, or possibly even sloughing of the flap.

METHOD

As soon as the pedicle flap was inset into its new bed and the wounds healed (usually within 2 weeks following inset), a mold of the entire weight-bearing surface of the patient's foot was made with Foam-O-Cast* (Fig. 1). From this impression a positive mold of plaster was fabricated and used to make a total-contact shoe insert employing a combination of a liquid latex and wood shavings, leather, or plastic (Fig. 2). Appropriate relief was provided for the area of the pedicle.

*Product of Orthopedic Supply, 63 Montrose Avenue, Brooklyn, New York 11206.
The pressure-measuring device used. The transducers are taped to the areas to be measured and the patient then stands with the shoe on. Pressures are read directly off the gage.
flap and any bony prominences. A convalescent-type shoe with complete front and back lacing was used to allow for easy application.

Before the patient was allowed to bear weight and walk, pressure measurements to determine the force being applied to various areas on the plantar surface of the foot were carried out (Fig. 3). The inexpensive instrument used consists of a small plastic balloon (a pressure sensor containing two wires which complete a circuit when in contact), a measurement gage, plastic tubing, a standard 10-cu.-cent. syringe (to inflate the balloon sensor), and a penlight which flashes on when the pressure in the balloon is equal to the force exerted on the insert* by the plantar surface of the foot. No definite predetermined pressures were known to us or desired. It is essential that the flap be in total contact with the insert in order to prevent edema and hemorrhage, but that excessive pressures leading to contusion and ulceration be avoided. Normal foot areas in front of the flap took more pressure than the flap. Friction was controlled by a well-molded insert and a properly fitted high-top convalescent shoe.

The patient was allowed to walk initially with a partial-weight-bearing crutch gait. He started walking for 2 minutes four times daily, checking the flap frequently for irritation. Pressure measurements were also made frequently. The duration of weight-bearing increased at the patient’s own desire as long as the flap remained stable and the patient was comfortable. The crutches were discontinued when he was fully ambulatory which, on the average, was in 2 to 3 weeks.

CASE REPORTS

Case 1. S.C., a 30-year-old male, was injured by a booby-trap explosion in Vietnam on May 18, 1971. He sustained a right below-knee amputation, loss of the fourth and fifth rays of his right hand, and a severe open comminuted fracture of the left os calcis with loss of the heel pad (Fig. 4). He was initially treated with debridement of his wounds and soon thereafter a split-thickness skin graft was applied to his right hand.

Six weeks after injury the patient arrived at Valley Forge General Hospital. The left heel pad was absent and the os calcis was covered with infected granulation tissue. He was placed in skin traction for his right below-knee amputation. In order to get the patient walking a pylon was made for his open amputation, and his left foot was placed in a short-leg walking cast. After the patient had achieved some success in walking, a split-thickness skin graft was applied to his left heel (4 weeks after admission to Valley Forge General Hospital). The graft

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Pneumatic Transducer Pressure
Ave., Paramount, Calif. 90723.
FIGURE 6.—Outline of flap on posteromedial surface of long below-knee amputation stump.

FIGURE 7.—Pedicle flap attached to involved heel. Patient was maintained in plaster in this position for 3 weeks.
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Healed well and in 3 weeks the patient was again ambulatory in a short-leg walking cast and pylon (Fig. 5).

Four months after his original injury the patient underwent a cross-leg pedicle flap to cover his left heel (Fig. 6 and 7). The distal posteromedial calf of the right below-knee stump was the donor site of the flap. After an initial delay the flap was divided and inset at 3 weeks. The flap was successful and in less than 1 month the patient underwent an Ertl revision of his below-knee amputation (5). He was left with an excellent stump measuring 8½ in. in length from the medial tibial plateau.

Two weeks after the revision the patient was started on a progressive ambulation program with a convalescent boot and insert as previously described (Fig. 8). The patient's flap tolerated this program very well. After about 2 months, he began to develop hyperkeratosis at the distal edge of the flap which he controlled with a pumice stone (Fig. 9). However, it was not until we increased the weight borne in this area that the hyperkeratosis disappeared (Fig. 10).

Sensation slowly returned to the flap. By 6 months the patient had sensation to touch and pinprick in an area one centimeter wide about the circumference of the flap and sensation to deep pressure throughout the rest of the flap (Fig. 11). New inserts were made to allow the flap to heal and function properly.

Additional protection until healed is advised to wear shoes that the insensitive skin is (9).

Recovering from a traumatic normal activity as soon as possible such a patient in bed or however, in the cases to bed by the pedicle-flap covering to ambulate these patients which had been used successfully. One of the authors while visiting Rancho Los Angeles, and a total-contact shoe bed on the weight-bearing surface tissue, and thus avoid the possibly even sloughing of tissue.

Into its new bed and the sloughing inset, a mold of the patient's foot was made with Foampositive mold of plaster was used. Shoe insert employing the shavings, leather, or plastic for the area of the pedicle flap.

venue, Brooklyn, New York 11206.

![Image Description](image1.png)

| 8.2.—Example of a worn insert made of liquid latex and wood shavings. Note perspiration stains everywhere but in the area of the pedicle flap. |

![Image Description](image2.png)

| Figure 8.—Patient standing in prosthesis and convalescent shoe during measurement of pressure across heel flap and remaining sole of foot. |
flap to bear increasing amounts of weight until a final total-contact insert without any attempt to unweight the flap was completed at 8 months after surgery. Also, by this time the patient was wearing regular high-top shoes. During this entire period the patient was active and working. He has returned to full military duty as an instructor in the armor school.

Figure 9.—Healed pedicle flap with enlarging area of hyperkeratosis at distal suture line. Hyperkeratosis was kept to a minimum with daily use of a pumice stone.

Figure 10.—Healed pedicle flap with full weight-bearing and even distribution of forces across plantar surface of foot. Hyperkeratosis has disappeared.
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Cost Reduction Program, Bull.

![Figure 11.4](image)

**Figure 11.**—Sweat test demonstrating early sweating for width of 1 cm. about periphery of flap. The slightly darker areas are positions where sweating has occurred.

**Case 2.** G.B., a 21-year-old male, was wounded by a booby-trap explosion in Vietnam on January 13, 1971. He sustained a traumatic below-knee amputation of his left leg, severe soft-tissue damage to his right heel pad, and open fractures of the talus and os calcis, with injury to the posterior tibial artery, nerve, and vein. After initial debridement of the wounds, he was placed in skin traction and transferred to Valley Forge General Hospital.

The patient was maintained in skin traction for his left open below-knee stump. He was fitted with a pylon and placed in a right patellar-tendon-bearing cast over the open wounds and exposed os calcis. The heel pad was absent. Immediate ambulation was begun.

On February 22, 1971, a split-thickness graft was applied to his right heel. The patient had been walking for about 3 weeks and was independent. As soon as the skin graft was healed the patient was again ambulated in a patellar-tendon-bearing cast and a pylon. On April 1, 1971, he underwent an Ertl revision of his stump, and 2 weeks postoperatively was ambulatory in a pylon (5). At this time he was fitted with a convalescent boot and a contoured insert to protect the skin graft on the right heel. The skin graft continued to break down. (Fig. 12).

On July 7, 1971, the first stage of an abdominal pedicle jump flap was carried out using the left forearm as the carrier. On August 6,
1971, the flap was inset into the right heel (Fig. 13). Three weeks later the flap was divided in stages and inset into the heel defect. The patient was then fitted with a patellar-tendon total-contact prosthesis on the left and a convalescent boot with insert on the right.

This patient was our first experience with this method and we intended to proceed very slowly. We felt hesitant about introducing a weight-bearing program on the right foot too early because of the new anesthetic pedicle tissue combined with a hypesthetic sole of the foot secondary to the posterotibial nerve injury. However, the patient became more uncooperative the longer he was in the hospital and was often seen walking without any support. His heel flap with the total-contact insert and a properly fitting shoe withstood this activity well. At the time of the patient's discharge, 3 months after inset of the flap and following a long AWOL period, the flap was intact with some hyperkeratosis at the distal suture line (Fig. 14).

DISCUSSION

The achievement of full weight-bearing without breakdown of a recently applied full-thickness pedicle flap that is devoid of sensation is difficult. Very little information is recorded in the literature, but the problems of trauma to an anesthetic area on the weight-bearing surface of the foot are well known to surgeons working with the lower limb.

FIGURE 12.—Heel defect covered by split thickness skin graft. Patient ambulatory in convalescent shoe and contoured insert, but breakdown of the skin graft persisted.
FIGURES 13a,b.—Patient in plaster with pedicle jump flap attached to left arm as carrier and inset into involved heel. He remained in this position for 3 weeks.
Because of the severe multiple injuries associated with the below-knee amputations in our two patients, the necessity and benefits of getting these war-injured men out of bed and walking independently as soon as possible were evident. Each patient had full loss of his only remaining heel pad and required pedicle coverage. Each was fully ambulatory without support within 4 weeks after surgery.

Several materials were used in the fabrication of the shoe inserts. Those made of liquid latex and wood shavings worked the best for the authors. They had the advantages of easy fabrication, exact contouring, and softness. However, their main disadvantage was that they absorbed perspiration and had to be changed frequently. To avoid this problem plastic inserts were tried, but after a short period of time they tended to flatten and had to be replaced. They also required a longer period of time for fabrication and adjustment. Metal inserts or any of the newer materials such as polyurethane foam or plastazote have not been tried. The inserts used were made by our orthotics shop personnel and the podiatrist under the direction of the authors.

Two major causes of skin breakdown are excessive pressure and friction. These problems are faced daily in treating amputees with total-contact hard-shell sockets. They are compounded by the presence of an area of anesthetic skin which can develop sloughs, ulcers, or blisters before the patient is aware that damage is being done. By the use of inexpensive pressure-sensing devices, the forces on the flap can be measured and the insert adjusted to the surgeon's desires. Also, while the patient is hospitalized, the pedicle tissue can be inspected frequently and adjustments made as needed.

These techniques of measuring interface pressures and pressure distributions have been advanced recently by investigators studying amputees (6,12). Physicians and the related professions treating amputees are well acquainted with the problems of excessive pressure and friction on soft stump tissues in a prosthesis. The problems of inter-
face pressure and friction between a stump and a prosthesis are similar to those between a heel covered by pedicle tissue and the patient’s shoe. In the stump the skin and soft tissues are freely movable; so also are they in the pedicle flap. The fibrous septae that are attached to the os calcis in a normal heel pad and prevent excessive mobility of the heel are absent. By use of a well-fitted high-top shoe with a posterior tongue and lacing and a molded insert, friction on the heel flap can be minimized. Interface pressures can be controlled by the means described. However, the data obtained are only relative to pressures measured over the rest of the foot. Exact measurements, in pounds per square inch, were not obtained and laboratory investigation is needed to obtain such data and define their meaning in practical terms. Only then will the physician have available the proper tools to determine exactly what interface pressures are harmful or beneficial to different soft tissues.

In the cases reported the forces on the flap were initially kept small. To avoid edema, contact was obtained but the amount of weight that could be borne through the newly applied pedicle flap was not known. The flaps were carefully watched each day and, when no breakdown was noted, the weight distributed over the flap was gradually increased. It was found that as long as friction was minimized the flaps could tolerate more pressure than had been anticipated. In the first patient, who was followed closely, it was noted that as the loads on the flap were increased, i.e., the weight distributed more evenly on the entire plantar surface of the foot, the hyperkeratotic area that had developed disappeared. Before he returned to duty, the patient was wearing an insert that allowed an even distribution of forces across the plantar

Figure 15a,b.—Patient being fitted with foam-injected ski boot, and walking immediately after without difficulty.
surface of the foot. He was most comfortable with this prescription and was wearing standard high-top shoes.

The first patient also wanted to participate in the amputee ski program. He used a foam-injected Rosemont boot. For the initial fitting the patient's foot with the insert was placed in the boot and foam was injected (Fig. 15). The patient was comfortable in the boot and skied without any damage to the flap.

REFERENCES