The historical literature of the use of axial vascular pattern flaps from the hypogastric and iliofemoral regions in reparative surgery of the hand is concisely reviewed. Thirty-six iliofemoral (groin) flaps were utilized for delayed primary resurfacing and secondary reconstruction of defects of the hand and forearm. Two flaps (6 percent) were complicated by partial necrosis.

We caution against the immediate resurfacing (within 24 hours of injury) of acute crushed hand wounds by distant flaps. The immediate application of a healthy flap to a soiled or crushed wound invites complications of local tissue necrosis, infection, and subsequent loss of the flap. When distant flaps are indicated for coverage of acute hand wounds, delayed primary coverage following complete removal of all nonviable tissue is a safe and reliable regimen.

It is advantageous to design the serviceable portion of the flap on the distal area of the vascular territory of the groin flap. Thoughtful yet "radical" defatting can be performed on the lateral portion of the groin flap territory. Constructed in this way, the long medial base of the groin flap allows freedom for movement at the wrist and metacarpophalangeal and interphalangeal joints, thus decreasing edema and stiffness.

In the management of soft-tissue defects in the hand requiring distant flap coverage, we choose to utilize the conventional groin flap in preference to the microvascular free flap when both techniques will deliver equal results.

On November 5, 1862, John Wood, of London, England, utilized an axial vascular pattern flap to resurface the wrist and forearm of an 8-year-old girl. 1,2 In the original case report of this "groin flap," 2 he specified the use of "the superficial inferior epigastric vessels as the main source of vascular supply." In 1944, Darrel T. Shaw, of the United States Army Medical Corps, also described a one-stage open abdominal flap based on the superficial inferior epigastric vessels for repair of surface defects of the upper extremity. 3 Subsequently, Shaw and Payne 4 reported a series of one-stage tubed axial-pattern hypogastric flaps for reparative surgery of hand wounds. The first description of the iliofemoral (groin) flap based on the superficial iliac circumflex vessels was that of McGregor and Jackson of Scotland. 5,6

The purpose of this paper is to highlight certain observations made on 36 consecutive groin flaps in reconstructive surgery of the hand. Specific problems that led to unsatisfactory results will be addressed.

CLINICAL MATERIALS

This study consists of 36 consecutive cases of groin flap performed at the Cook County Hospital (1975–1979) and the Walter Reed Army Medical Center (1979–1984). These flaps were utilized for delayed primary coverage or secondary resurfacing of the hand and forearm.

In 10 patients, the flap was utilized for surgical release of first web contractures. In 5 patients, the conventional groin flap was utilized in cases of mutilated hands as a preliminary procedure preceding digit transfer. In 21 extremities, the groin flap was used to resurface other defects of the forearm and hand.

The dimension of the groin flaps in this series ranged from 24 to 36 cm in length and from 8 to 14 cm in width. Primary closure of the donor-site defect in the groin was performed in all cases.
In this series, the 36 groin flaps were utilized in cases of elective reconstructive hand surgery as well as in early surgical treatment of acute hand trauma (Table I).

In 11 patients, the groin flap was used in elective secondary resurfacing procedures 1 month to 2 years after the original injury.

Twenty-five groin flaps were utilized for delayed primary coverage for acute hand trauma in 24 patients (25 extremities). These were not tidy wounds. The majority were crush injuries, avulsion wounds, shotgun wounds, and blast injuries (Table II). In the early treatment of these cases, we utilized the regimen of immediate debridement, frequent wet dressings, and formal redebridement, which was repeated as necessary. Following the staged removal of all nonviable tissues, definitive delayed primary resurfacing of the hand with axial vascular pattern flaps was performed at 4 to 20 days after the initial injury. No immediate primary flaps (within 24 hours of injury) were performed in this series.

Subsequent to the resurfacing of the hand defects, 22 elective reconstructive hand procedures were performed. These are listed in Table III.

### RESULTS AND COMPLICATIONS

The length of follow-up ranged from 6 months to 7 years. All 36 flaps in this series were viable and healthy at the time of initial elevation and application to the hand wounds. Thirty-four flaps (94 percent) went on to uneventful healing with no complications of infection or necrosis. Two flaps (6 percent) were complicated by partial necrosis (Table I).

The first of these two patients sustained a severe crush injury of the right hand, caused by a compression press, which resulted in amputation of all four fingers. These digits were not replantable. The thumb was also crushed but not detached. Five days following injury, a groin flap was applied to the thumb that exhibited borderline vascular viability. Subsequently, the distal half of the thumb became nonviable, and suppuration was noted at the interphase between the necrotic tip of the thumb and the distal portion of the groin flap. Debridement of the necrotic portion of the flap and the distal phalanx of the thumb was performed. The groin flap was attached to the healthy proximal phalanx of the thumb and went on to uneventful healing.

The other case of partial necrosis occurred after division of the base of the flap. The patient had sustained a shotgun wound of the dorsal right upper extremity with bony loss of the distal radius, ulna, and metacarpals. At the initial application of the groin flap, only half the length of this suboptimal recipient site could be covered by the flap. During the first 3 weeks in the postoperative course, no complications of infection or necrosis were noted. However, following division of the base of the groin flap on the twenty-first postoperative day, necrosis of the medial portion of the flap occurred.

In summary, in the group of 25 flaps performed as delayed primary coverage for acute hand trauma, the complication rate was 8 percent (two cases). In the other group of 11 patients with elective secondary resurfacing procedures using the groin flap, no complication was encountered (Table I).

### DISCUSSION

A distant flap may be utilized as a means of primary closure in the management of acute hand injuries with significant loss of skin and...
subcutaneous tissue exposing deep structures, such as tendons, nerves, bone, and joints, or in cases where subsequent reconstructive hand surgery is anticipated. In another category of patients, resurfacing of the cicatricial hand wound with a flap may be performed as an elective secondary procedure.

In the treatment of acute hand wounds, the flap may be utilized as an immediate primary procedure performed within 24 hours after injury or as a means of delayed primary closure of defects following repeated debridement procedures. We do not advocate the use of distant flaps for immediate primary coverage of hand wounds with potentially nonviable tissues. Clean, well-debrided wounds are essential for the successful outcome of delayed primary coverage procedures. Therefore, when early flap coverage is indicated, we adopted the treatment plan of delayed primary resurfacing of the defect following a regimen of repeated debridements. In this series, such coverage was performed at 4 to 20 days after the initial injury (arithmetic mean of 5.5 days). In all cases except one, no infection or necrosis ensued following the initial application of the flap.

On reviewing the literature, it is noted that a complication rate of 67 percent has been reported in cases of immediate primary application (within 24 hours of injury) of groin flaps in crushed hand wounds, whereas, in the same series, the complication rate of groin flaps in cases of late reconstruction (more than 1 month after injury) was 11 percent. In our group of 25 cases of acute hand trauma, the single incidence (4 percent) of postoperative suppuration was associated with the application of a groin flap on a crush wound of the thumb with borderline tissue viability. Schlenker and Averill pointed out that in crush injuries, even without heavy bacterial contamination, tissue viability is a problem. The incidence of infection and necrosis can be reduced by adhering to the principles of treatment of war wounds—delayed primary closure following thorough serial debridements.

Upon division of the base of the axial-pattern groin flap, the concept of axial vascular territory no longer applies. The medial portion of the divided flap behaves as a random-pattern flap based on the blood supply from the injured hand. Thus, one cannot expect routine complete survival of the medial end of the groin flap upon division of its base at the empirical date of 3 weeks if a sizable portion of the flap still remains to be insetted or if the nature of the hand wound precludes rapid neovascularization. Both these unfavorable factors were encountered in one case in our series. The base of the groin flap in this patient was empirically divided on postoperative day 21. Necrosis occurred at the medial end of the detached groin flap, i.e., distal end of the "hand flap."

Wray et al. reported that partial necrosis was encountered in 18 percent of their flaps following the final division of the base of the pedicle. In order to prevent this complication, we believe that it is important to cover as large an area of the hand defect as possible at the initial application of the flap. In the average case, we prefer to divide and immediately inset the flap at the end of the third week. In specific cases, delaying procedures at the base of the groin flap are performed prior to complete division of the flap. This consists of ligation and division of the superficial iliac circumflex vessels under local anesthesia.

The proper design of the groin flap cannot be overemphasized. The course of the superficial iliac circumflex artery provides a central longitudinal axis around which one may design the flap. For the average adult male, this axis corresponds to a line connecting a point on the femoral artery 2.5 cm inferior to the inguinal ligament with another point 2.5 cm inferior to the anterosuperior iliac spine. It is important that the portion utilized for the initial insetting on the hand wound is located at the most lateral portion of the vascular territory (area B and area C in Fig. 1). In the average adult male patient, the lateral border (HK) of the axial vascular territory (area A and area B) is located 5 cm lateral to the anterosuperior iliac spine. Area C is the random, but reliable, portion of the groin flap territory (Fig. 1).

There are advantages in utilizing the lateral portion of the vascular territory. The lateral half of the vascular territory of the groin flap, as compared to the medial half, is relatively thin and may be significantly defatted. This area is also free from the usual pattern of pubic hair. Furthermore, by making full use of the lateral portion of the vascular territory, one will rarely be confronted with a groin flap that falls short of the hand defect. By utilization of the lateral groin as the serviceable part of the flap, a long medial base of the flap will be maintained. This allows freedom of movement of the hand as well as adequate active and passive motion at the wrist.
and metacarpophalangeal and interphalangeal joints. Apart from the prevention of joint stiffness, the above freedom of movement contributes toward minimizing the edema and stiffness in the traumatized hand. This motion regimen of the hand is not as easy when the random abdominal flap is used.

Recent interests were directed at the choice of microvascular free-flap transfer for hand wounds versus the use of conventional distant flaps. For management of soft-tissue deficits in the upper extremity requiring distant flap coverage, a free flap should probably be chosen only for specific indications and special circumstances. The usual problem of major skin coverage of the hand that is not amenable to management by direct closure, skin graft, or local flaps can be effectively treated by a conventional distant flap, such as the staged groin flap. We choose to utilize the conventional groin flap in preference to microvascular free flaps in situations where both techniques will deliver equally good final results.

For resurfacing of the mutilated hand in preparation of microsurgical free-tissue transfer from the foot for reconstruction of the thumb or fingers, the staged groin flap should be used in preference to the free skin flap so as to safeguard against the possible impairment or sacrifice of the remaining vessels in the hand. It is our preference to save the available hand vessels for subsequent use as recipient vessels for the microvascular free toe transfer or wrap-around procedures.

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