DIRECT FLAP REPAIR OF DEFECTS OF THE ARM AND HAND*

PREPARATION OF GUNSHOT WOUNDS FOR REPAIR OF NERVES, BONES AND TENDONS

COLONEL JAMES BARRETT BROWN, M.C.
ST. LOUIS, MO.

MAJOR BRADFORD CANNON, M.C.
BOSTON, MASS.

MAJOR WALTER C. GRAHAM, M.C.
SANTA BARBARA, CALIF.

CAPT. CARL E. LISCHER, M.C.
ST. LOUIS, MO.

CAPT. C. PARKE SCARBOROUGH, M.C.
BALTIMORE, MD.

CAPT. WILLIAM BOWDOIN DAVIS, M.C.
BALTIMORE, MD.

CAPT. ANDREW M. MOORE, M.C.
ST. LOUIS, MO.

GUNSHOT, shell fragment and other types of wounds may leave large surface defects and extensive, crippling scars of the arm and hand. These can be repaired with direct abdominal and chest flaps, by using the principle of a short, broad pedicle, which will allow complete mobilization and immediate use of the flap. There is rarely any need for delaying or tubing these flaps.

This procedure has been carried out in a large number of patients, and a valuable saving of patient-hospital-weeks has been possible. Whereas long tubed flaps or delayed flat flaps have been known to require months of preparation, this direct type of flap is prepared in 10–30 minutes, and usually can be detached in 14–20 days. So that, the crippled extremity is freed of its scar by thorough dissection, the flap is prepared accurately, at the same time, the arm is "planted" under the flap, and in 2–3 weeks the arm or hand can be detached from the abdomen and the wound closed. It is soon ready for use, or for any necessary deep work on bone, nerve or tendon.

Bone, nerve and tendon repairs cannot be accomplished successfully through dense scar, because the results of these operations can only be as good as the surface healing. When deep repairs are attempted through excessive scarring, the wounds may break down, and wire, foil, screws, plates and bone grafts may be lost. The procedure outlined here is of marked importance in the preparation of many areas for necessary orthopedic or neurosurgical repairs.

* This article was to have been presented before the Annual Meeting of the American Surgical Association, May, 1945.

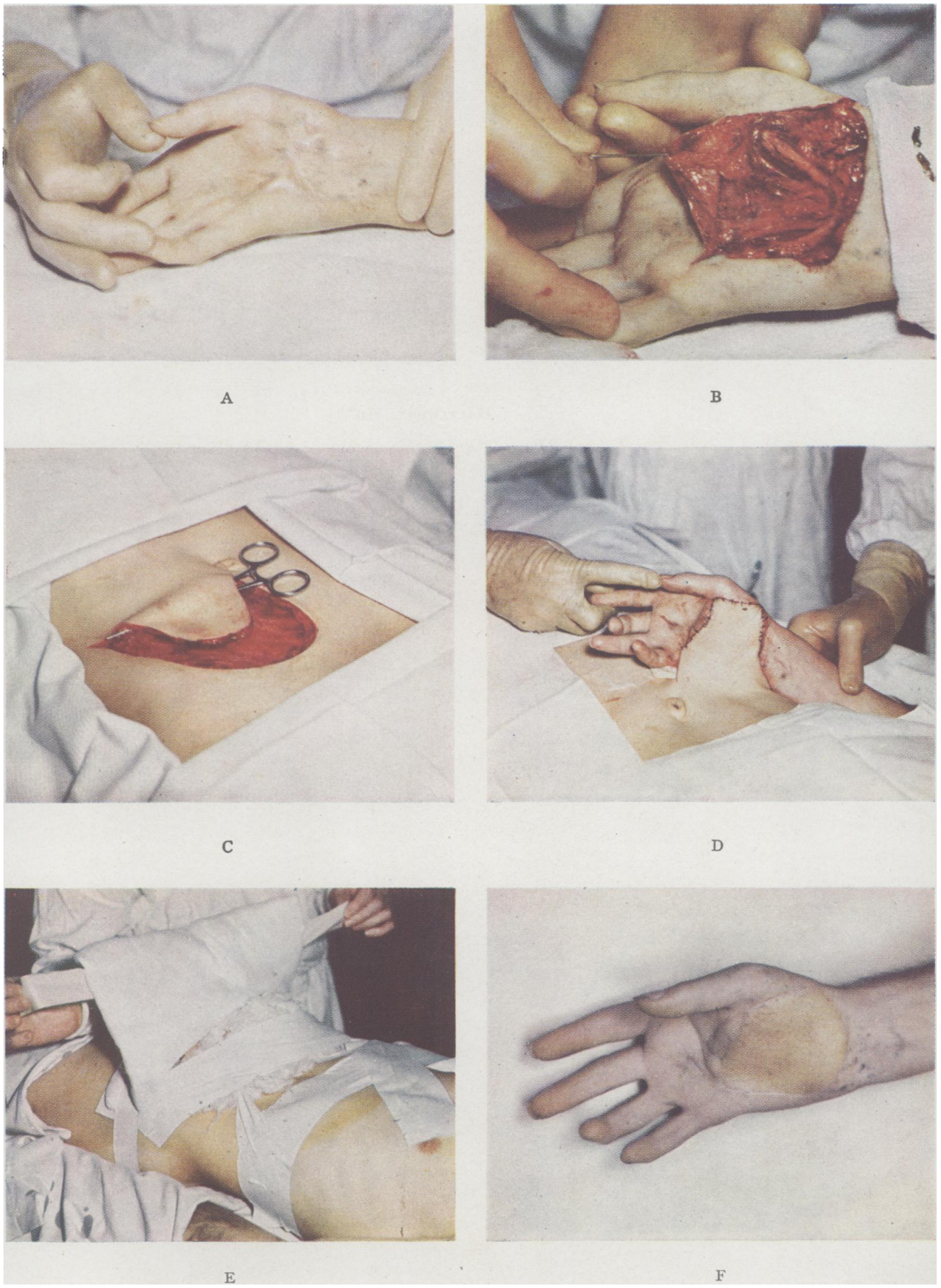


FIG. 1.—A to F.—Multiple shell fragment wounds of hand with resultant fibrosis. Widespread dissection with removal of shell fragments encountered. Repair with direct flap detached in 18 days.

"Surface healing can be only as good as the deep blood and nerve supply. Wounds that are excessively fibrotic, and have a diminished blood supply, often cannot maintain the nutrition of their own skin covering, and a newly transplanted surface over such a wound may not survive. This is seen in radiation burns and in chronic leg ulcers. The same conditions are also seen in gunshot and shell fragment wounds where extensively torn tissues have healed (or attempted to heal) in contracted, dense scar masses, the surfaces of which repeatedly ulcerate. Such wounds may have rough, keratosic surfaces. This may be especially true in 'through-and-through'

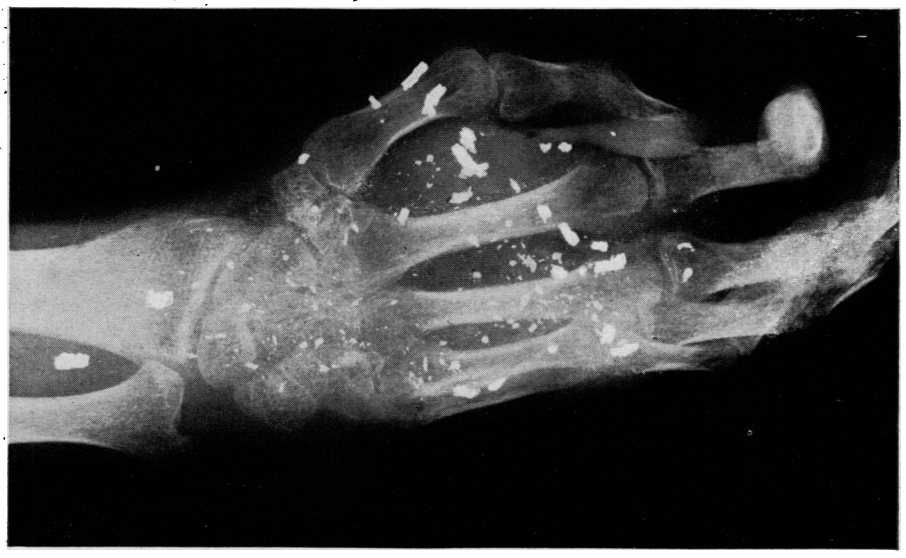


FIG. 1G.—Roentgenogram of hand shown in Figure 1, Color Illustration.

injuries, because the track of scar tissue completely penetrates the area, so that, in a dissection, the surgeon does not encounter a soft, normal bed of tissue.

"The factors to be balanced in planning satisfactory wound closures in preparation for some subsequent bone, nerve, or tendon repair are, briefly: (1) the preparation of deep tissues to carry adequate minute blood supply to maintain the surface repairs, by the resection of surface and deep scar continued into an area that will furnish satisfactory circulation; and (2) the designing of a surface closure through the use of local flaps, skin grafts, or direct or delayed pedicle flaps."[1]

These direct flaps also may be used within the first few days of the original injury, and tendon and bone fragments can be saved and bone union advanced. This is a marked advantage over the plan of letting wounds collapse and heal, with distortion, so that scar has to be resected and tissues

replaced in position when the repair is undertaken weeks later. This has been recorded,[2] and Colonel E. M. Bricker has reported, by personal communication, that many early flaps have been used successfully in the Plastic Surgery Centers in the European Theater.

Diagnosis and *recording* of arm and hand injuries is extremely important, and a separate note for each finger is required. Sensation in fingers is

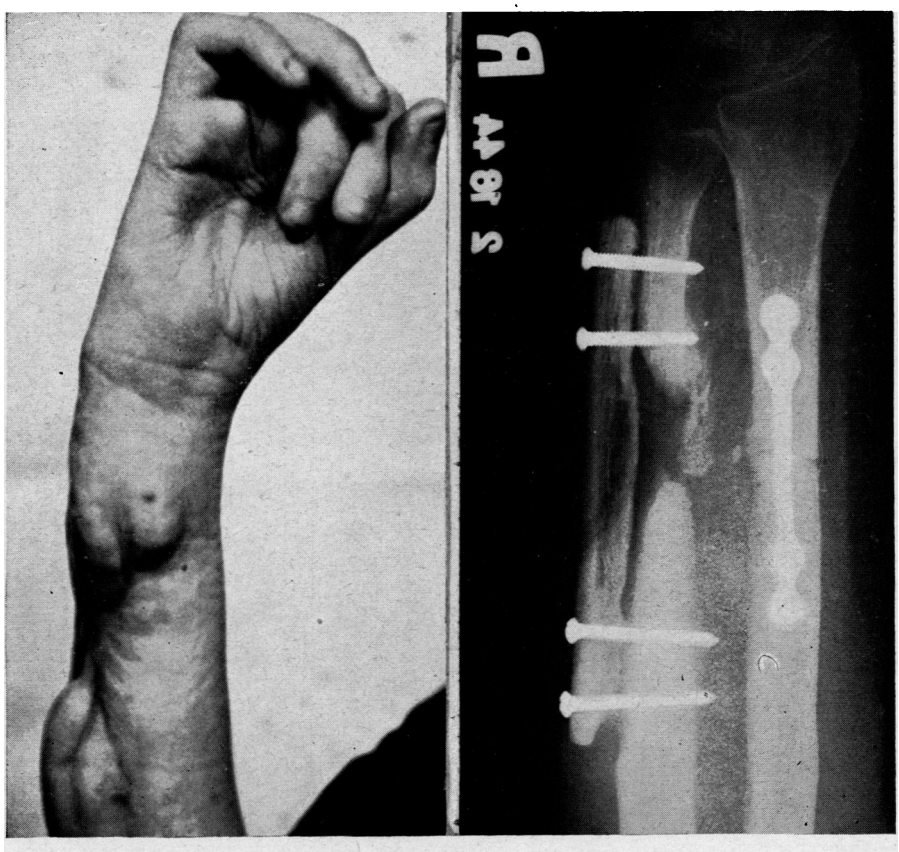


FIG. 2

FIG. 2.—A to F—Shell fragment wound of arm with loss of bone graft from breaking down of the scar. Extensive replacement of soft tissues with direct flap and successful secondary bone graft. A soft-tissue shadow of the flap may be seen also on the roentgenogram.

of paramount importance, and the response to pin-prick is always obtained and recorded. On this point of sensation may depend the decision of trying to save or to remove fingers. This is an evident finding, but one that apparently should have attention called to it frequently. This is often tedious in a flood of patients, many with both hands damaged, but it is *always* done and recorded and the notes referred to in the operating room, because the response cannot be obtained with the patient under an anesthetic.

Simplified Designation of Fingers and Joints.—To avoid repeated use of cumbersome terms such as "the metacarpophalangeal joint of the middle finger" or the "distal interphalangeal joint of the index finger," a simple (if drab) method of recording can be used, with relief and speed, namely, the

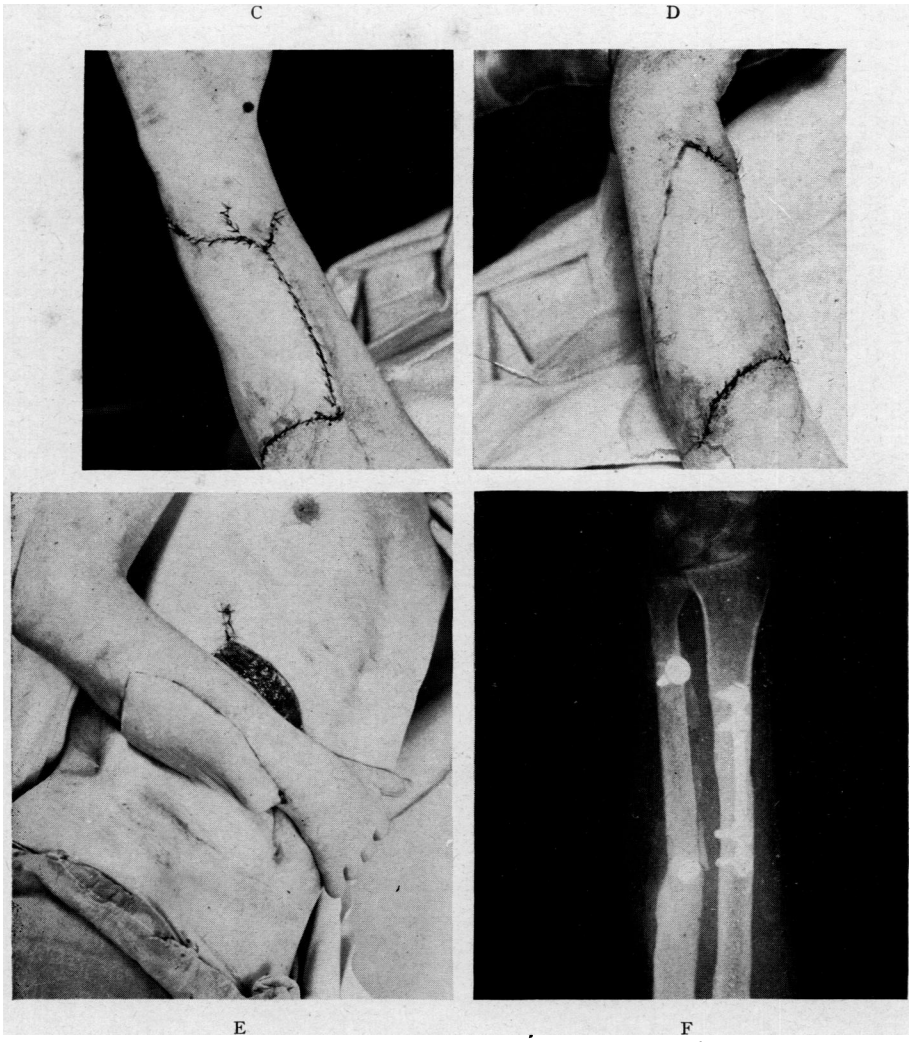


FIG. 2 (Continued)

fingers are simply called 1, 2, 3, 4, and 5 and the joints A, B, and C. Thus, the above long designations become simply "3A" and "2C." If desirable the metacarpals and phalanges are called W, X, Y, Z and "the metacarpal of the ring finger" becomes "4W" and "the middle phalanx of the little finger" becomes 5Y. A simple chart can be used, but seldom has to be

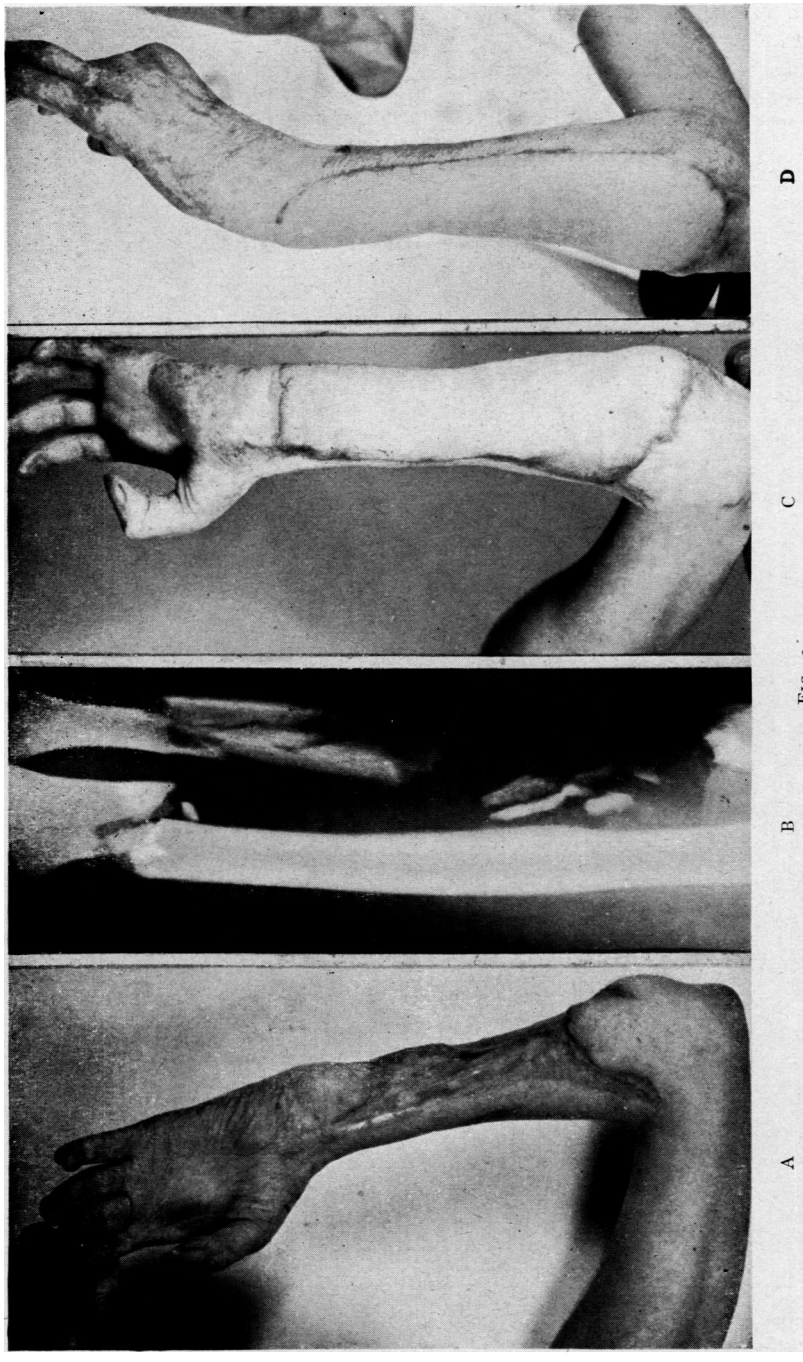
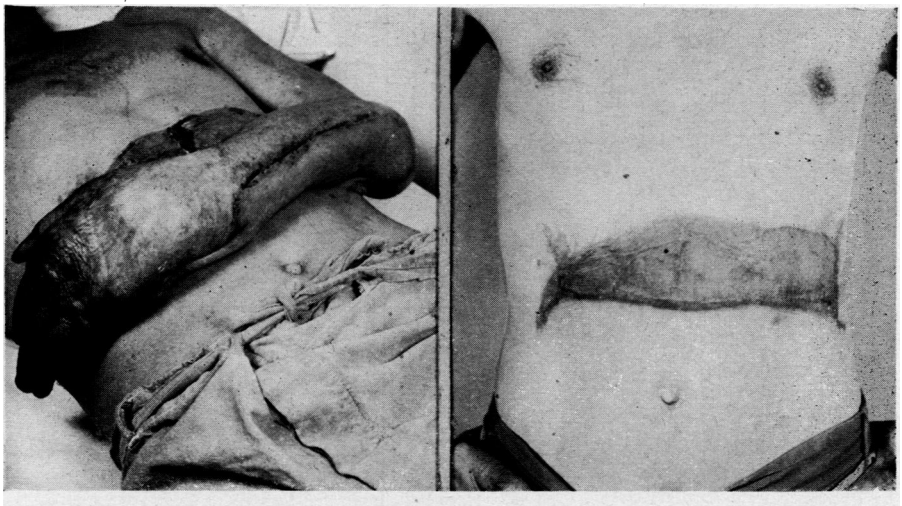


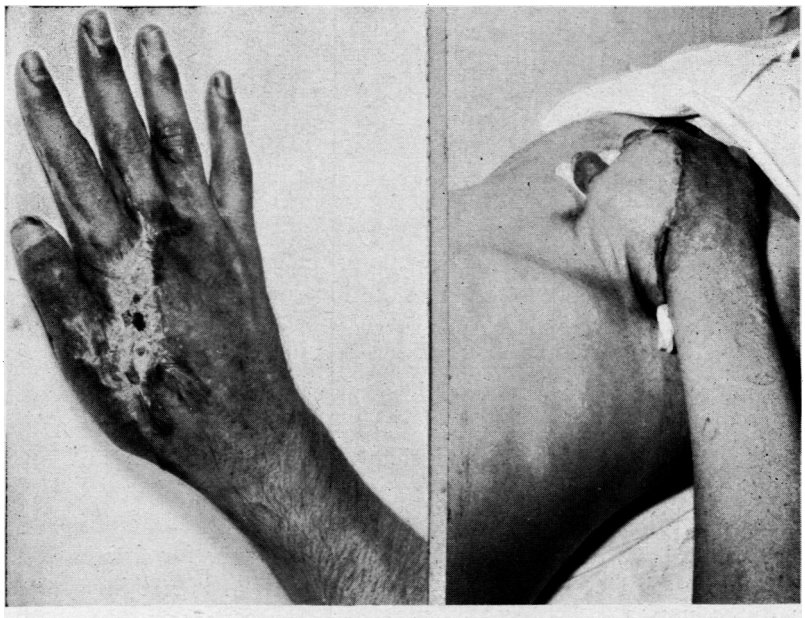
FIG. 3.

FIG. 3.—A to F—Extensive loss of soft tissue and destruction of bone showing widespread replacement of soft tissue in 18 days with a direct flap from the chest and abdomen, preparatory to deep bone and tendon work.



E F

FIG. 3 (Continued)



A B

FIG. 4

FIG. 4.—A to D—Gunshot injury of hand with a direct dorsal flap after separation of thumb from the fingers. No deep work required.

D shows method of internal pin fixation to fix the thumb into position.

Nomenclature is indicated using 1 2 3 4 and 5 for the fingers, A B C for the joints and W X Y Z for the bones.

referred to. The thumb, of course, has no C-joint or Z-phalanx. This is illustrated in Figure 4.

Technic: The open wound is prepared or the scarred area is resected so that adequate minute blood supply is present all around. (For a defect extending around the arm, there is no use doing the entire dissection if the flap cannot reach until it is taken off later.) If the dissection is done under a tourniquet, it is released and hemorrhage is controlled, before the flap is put on (Fig. 1).

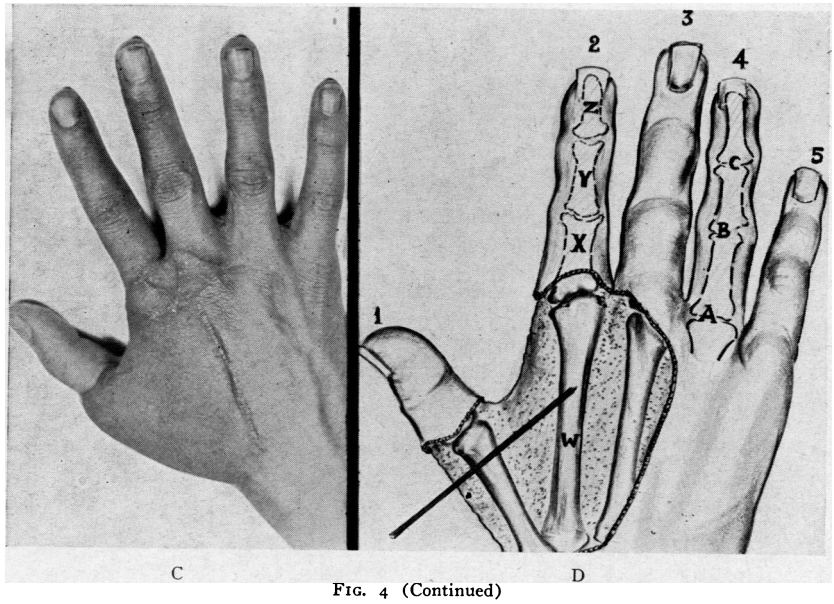


FIG. 4 (Continued)

The flap is located in a suitable, comfortable place on the abdomen or chest. For a hand, it is most often in the lower quadrant on the same side, avoiding pubic hair if possible. For the volar surface, the pedicle is usually up towards the chest, and for the dorsal surface, it is usually down, toward the inguinal region. This is, of course, determined by the freedom of movement of the joints, but it is not necessary to put the hand clear across the abdomen. The position of the upper arm and elbow alongside the body and on level with the bed is the most comfortable for hand flaps.

The flap is raised on the principle of a broad, short base, and is designed to fit the defect, but with an over-all additional allowance for shrinkage, which is roughly one-third (Fig. 1). The pattern material is not important, but pliofilm or celluloid are usually available.

The bed of the flap is usually reduced in size with sutures along the edge, and often the remaining defect is grafted with a split-graft. The closed wound makes for easier convalescence and easier care during it—but it is not an essential.

The flap is sewed in loosely along its base with a few interrupted fine

sutures and then is closed around its two or three sides with deep fine sutures and a few skin sutures.

Firm fixation is obtained with a few large strips of adhesive—not plaster of paris—and a cotton waste pressure dressing is put on that can be turned back for easy inspection of the circulation of the flap.

Pressure dressings on these flaps are very important, to prevent venous stagnation and the inspection should be done an hour after operation and in the evening, and as often as necessary. Gentle pressure will save more flaps than any other procedure providing, of course, that the position is correct and that there are no kinks (Fig. 1).

Throughout the period of fixation the dressings are kept fresh and clean and adequate dressing service is essential; the success of many flaps has been dependent on nurses in the dressing room, and certainly the comfort of the patient has been possible only through their work.

Splints may be necessary to prevent retraction and collapse of hands and they easily can be used while the arm is in place by having neatly cut aluminum splints with or without extensions for elastic traction on the fingers. Traction may be from the fingernails or from skeletal wires. *Internal wires* are often used to fix fingers or metacarpals in position, during the period of attachment if external splinting or fixation will not suffice (Fig. 4).

Thumb rotation is always important and is maintained whenever possible. If rotation is not possible, abduction and extension can be relied on.

Donor areas are selected, as mentioned, for comfort, to avoid pubic hair, to give the best type of skin. On the hand thin skin of the inguinal region or even of the thigh is preferable for fingers and the palm.

Free Skin Grafts versus Flaps.—It is worth noting that on the fingers and on the palm, free skin grafts are preferable to flaps if they can be used; and in *some* patients, even if there is some question, free grafts will be used rather than bulky flaps. Free full-thickness grafts from the neck are valuable on the dorsum of fingers, to obtain the best pad.[4]

Cross arm flaps are used when the good thin skin of the arm is thought to be necessary to secure function in a finger or the thumb web.

Detaching flaps can usually be done in 14–20 days. The edge is usually sewed in accurately, but may be left open to be adjusted later. If this plan is followed, the detaching can be done simply under local anesthesia. Partial detaching can be done as indicated, severing part of the pedicle on two to three occasions. Delaying the base of the pedicle by making a regular delayed flat flap out of it is done, if there is a relative small attachment and if there has to be a large wrap-around or further let-in of the flap. This is carried out as a typical delayed flat flap and, of course, makes final detachment delayed.

The donor site can often be closed primarily or later, or may be left to heal. Grafting is done if it has not been done at the first operation or if too much more defect has been left when the arm is detached. There have been no gross complaints about the donor sites.

Double pedicles are occasionally used as are also pockets, and tubes.

Tubes, of course, are necessary for thumb reconstruction. But for the general mass of gunshot and shell fragment wounds the direct, nondelayed, nontubed flap is applicable.

Thinning flaps is necessary quite often. This fat is not a total detriment because it is this same fat that may make possible any deep work that is necessary. Flabby flaps on the palm, however, may prove to be about worthless for function.

Sensation develops surprisingly well in many flaps and, of course, depends on the presence of nerves in the area; if they are completely blown out, anesthesia will persist.

The following examples of the use of flaps are included as part of the text.

Figure 1 illustrates one of the most distinguishing features of war wounds —that is the lesions produced by shell fragmentation. The irregular, rough, sharp pieces of metal twist and swerve through tissue tearing up nerves, vessels and tendons and shattering bones.

The soft tissue of the palm and the thumb web has become board-like and the thumb fixed, and the roentgenograms show the reason for the loss of softness with the multiple fragments having been driven into the tissues.

Dissection of the scar is done through the whole area, and some of the fragments are shown on the gauze. The skin in this instance has to be taken to get rid of the deep scar.

A direct (or immediate, or nondelayed, or nontubed) flap is raised on the abdomen with the base up and from a thin-skin, hairless area.

The hand is planted in the flap, the arm and hand anchored with adhesive, and a cotton mechanics waste pressure dressing applied.

The hand is taken loose 16 days later and the edge is put down accurately. The abdomen is grafted at this stage, in this instance.

In this flap, fortunately, normal sensation developed and through it a secondary operation for suture of nerve slips to the fingers and for rotation of the thumb was done, with excellent function resulting.

Figure 2 illustrates a badly scarred forearm and the failure of a bone graft put in through dense scar—because the deep repairs can only be successful if the wound heals and does not break down.

Following removal of the bone graft (done elsewhere) the widespread scar was moved down to a good minute blood supply. A direct flap was designed and raised and the arm "planted" in it. Eighteen days later the flap was detached and wrapped further around the arm and sewed in place. The abdomen was grafted. A successful bone graft was put in through the flap and a satisfactory result obtained.

Figure 3 shows massive replacement of soft tissues of forearm in two operations with a direct flap, in 18 days' time. Abdomen grafted when flap was put on and closed when flap was detached.

This patient had asked that his arm be removed. Through this flap the wrist was fused and two tendon transplants were done to give a worth while result far superior to any prosthesis.

Figure 4 illustrates a direct dorsal flap that permits normal enough function so that the two procedures of dissecting the scar and putting the flap in place and detaching the flap 14 days later are all that is necessary.

Internal wiring to maintain separation of the thumb from the fingers during time of attachments to abdomen is shown in diagram.

Method of abbreviated recording, fingers, joints and bones by figures and letters is shown.

Conclusions are outlined in first paragraph.

REFERENCES

Surface Repair of Compound Injuries. Jour. Bone and Joint Surg., **26**, 16–22, July, 1944.
Skin Grafting of Burns. Brown and McDowell; J. B. Lippincott, 1944.
Repair of Surface Defects of the Foot. ANNALS OF SURGERY, **120**, 417–430, October, 1944.
Free Full-thickness Grafts from the Neck. ANNALS OF SURGERY, 121, 639–643, May, 1945.