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The Working Man's Hand*

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"THE WORKING MAN'S HAND is his greatest asset. Without it life becomes a burden," Allen B. Kanavel, a former president of this College, and a great surgeon, once said.

I would emphasize first how important the problem of hand injuries is both to the public and to the surgeon, and would stress a few of the principles involved in the care of such injuries and illustrate them with some concrete examples.

The importance and seriousness of this problem can be realized from a few statistics collected from the publications of the National Safety Council and from the reports of various state industrial commissions and industrial groups.

In 1951 (Table I) 9,430,000 accidental injuries occurred in the United States. The estimated cost of all these injuries reached the staggering sum of $7,900,000,000, of which $2,650,000,000, one third, represented the cost of occupational accidents.

Of the 2,100,000 occupational accidents occurring in 1951 approximately one third involved the hand and forearm. Although the relative frequency of injury of different parts of the body varies somewhat in different industries, in different states and in different years, the averages are very similar and indicate that injuries of the hand and forearm constitute approximately one third of all occupational injuries (Table II). While the cost involved in various injuries also varies it parallels fairly closely the percentages which indicate the frequency of involvement of various parts of the body.

*Oration on Trauma, presented at the Clinical Congress, American College of Surgeons, New York, September 24, 1952.

I would simply add one other statistical comment and with no implications except to point out how readily public attention becomes focused on a problem which has certain elements of emotional appeal, and how difficult it may be to arouse interest in a problem of tremendous importance from the standpoint of human welfare and financial loss (Table III).

In the treatment of hand injuries many surgeons have long realized how important it is to utilize the principles of meticulous care and atraumatic technique that have so long been associated with the name of Halsted. Gentle handling of tissues, complete hemostasis, closure of wounds without tension, healing without inflammatory reaction are all of paramount importance when bones have been fractured and displaced, when nerves and tendons have been injured and covering soft tissues lacerated and torn.

How, specifically, can Halsted's teaching be applied in the care of hand injures? First of all, by a routine of first-aid treatment that is limited to the immediate application of a sterile dressing, a compression bandage and immobilizing splint. Secondly, after x-ray and physical examination, carried out in most cases without removal of the first-aid dressing, repair of the wound under the same conditions that one would demand for care of a strangulated hernia or removal of an acutely inflamed appendix—namely, a well equipped operating room and adequate assistance.

In the preparation of the hand for operation an atraumatic technique means assuring a clean surgical wound by the simplest possible method, and one that avoids injury or sacrifice of living tissue. We have found nothing more efficient and satis-

factory than prolonged gentle cleansing with plain white soap and water and irrigation with salt solution *before* excision of hopelessly injured tissues.

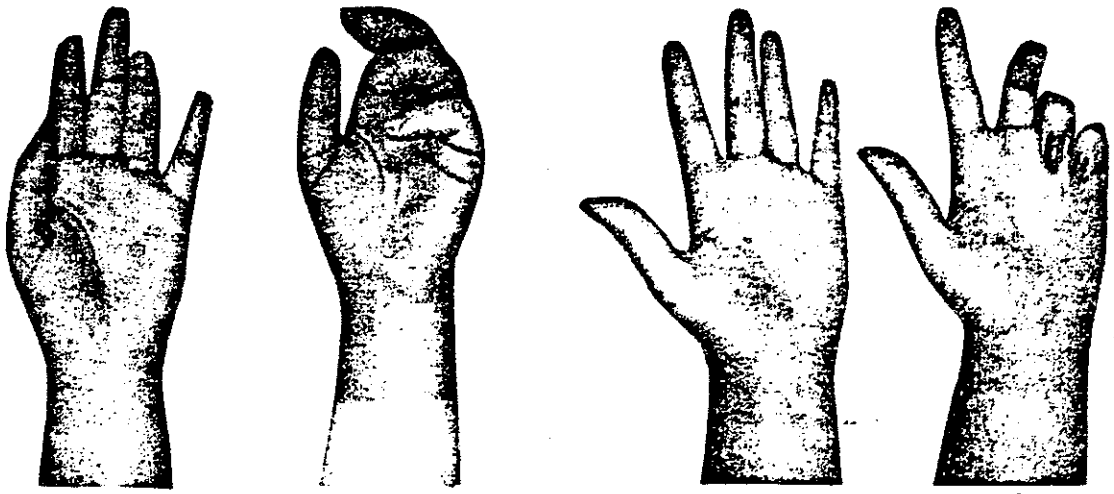
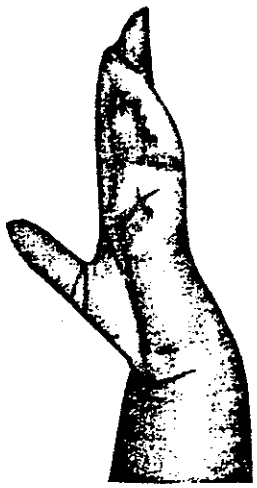


Figure 1. Division of flexor profundus, fifth finger. a. b. Before operation. c. d. e. After operation.

Both during cleansing and repair a bloodless field secured with the aid of a blood pressure cuff inflated to 270 mm. of mercury helps to prevent blood loss, makes possible accurate identification of nerves and tendons, and eliminates the trauma of frequent sponging. When excision of devitalized tissues and identification of injured structures are completed, release of the compressing cuff enables one to recognize bleeding vessels, and check the vitality of skin and subcutaneous tissue. The arm can then be elevated again for a few moments and the compression reapplied to permit completion of the operation in a bloodless field.

Reduction of fractured bones can often be accomplished under direct vision. One would avoid if possible leaving foreign bodies in the hand for bone fixation. In the repair of injured soft tissues one would use the finest possible suture material for ligatures, and for tendon and nerve suture. More and more we have come to realize that simple apposition with a minimum of fine sutures is adequate for tendon and nerve repair, if relaxation of the healing tissues is secured by splinting in an appropriate position. No matter how strong, sutures under tension gradually cut through soft tissues and fail to hold them together. The same strong sutures, even if not under tension, provoke a fibrous tissue reaction that effectively eliminates the free gliding movement of tendons and, in nerves, prevents the downgrowth of nerve fibers across the level of injury.

When repair of deeper structures is completed *closure of the wound* is equally important and essential. If covering tissue has been lost, closure without tension can be attained by the aid of sliding flaps, free grafts, or a pedunculated flap from another part. If, because of loss of tissue, wound closure must be delayed, it is usually wise to delay nerve and tendon repair also until wound healing is complete and repair can be carried out under the most favorable conditions.



So important do we consider it to carry out immediate surgical care of patients with open wounds that we believe one is always justified in putting aside planned procedures in order to care for the emergency case with an open wound. There are instances, obviously, when immediate care cannot be accomplished. The presence of shock, of severe associated injuries, the lack of adequate

facilities may make immediate operation inadvisable. The "golden period" of two or three hours may have elapsed and evidence of bacterial contamination and spread may be present. Most patients with severe burns must wait for definite evidence of the extent of whole thickness destruction of tissue. In such cases careful wound cleansing, application of compression dressings and immobilization may constitute the extent of justifiable treatment. Secondary repair must then await the most favorable moment, when wound healing is complete, when inflammatory reaction and induration have receded, and when the patient's condition warrants the necessary surgical procedure.

During the past 12 months, September 1, 1951, to September 1, 1952, we have seen and cared for 297 patients with injuries of the hand and forearm. Forty-four of these patients were seen within the so-called "golden period," and were cared for immediately. Two hundred fifty-three were seen after varying periods of time following injury and were cared for after wounds were healed and when definitive treatment could be carried out. Many of them, particularly those in the second group, required more than one procedure; the total for the 297 patients was 405; some of these involved long and tedious operations and often prolonged hospitalization and aftercare. All of these patients were cared for at one hospital and by one of the members of our group. In addition to the 297 patients mentioned, another group of 520 patients with less serious injuries of the hand were cared for during the same period as ambulatory patients who did not require admission to the hospital. The majority of these were cared for under local anesthesia.

Rather than present a statistical account of the types of injury, the structures involved, the duration of treatment and estimates of disability, I would like to emphasize the principles involved in the surgical care by illustrations of some cases* seen during the past few years, first of patients seen shortly after injury, and secondly of a few cared for after wound healing was complete.

The patient whose hand is pictured in Figure 1 sustained a knife cut of the palmar surface of her left little finger in November, 1950. She noticed immediately that she was unable to flex the finger at the distal joint. A simple compression dressing was applied and she came to the hospital within two hours of the injury. At operation it was found that the deep flexor tendon had been completely divided, the superficial tendon was injured but not divided.

The transverse wound was extended distalward along the ulnar side of the finger so as to expose the distal segment of the divided deep flexor. Through an incision along the distal flexion crease of the palm the proximal segment was secured, and a suture placed in the end of the tendon. With the help of a probe passed through the sheath the suture and tendon were drawn distalward into the finger wound. The ends of the divided tendon were united with two mattress sutures of very fine silk, the wound was closed and the hand splinted in such a position as to relieve tension on the healing tendon.

The wounds healed by primary union. With time and use function improved steadily. The result on January 26, 1952 is shown in Figure 1.

This case is of particular interest to us because it and eight similar cases seen during the past year show that with careful technique and using a minimum of fine sutures it is possible to secure good results after immediate repair of flexor tendons divided within the flexor sheath.

The patient whose hand is shown in Figure 2 sustained a glass cut of the palm on the morning of April 12, 1951, as he was beginning his work with an optical firm. A doctor in a nearby office covered the bleeding wound with a sterile compression dressing and sent him directly to the hospital. The patient had realized that he could not flex his middle finger. There was disturbance of sensation but not complete loss over the adjacent surfaces of middle and ring fingers.

He was taken to the operating room immediately. Under general anesthesia and in a bloodless field it was possible to identify the digital nerves on either side of the injured finger. They were infiltrated with blood but were intact. Both flexor tendons had been divided just at the proximal end of the digital sheath. Both the divided tendons were reunited and the lumbrical muscle laid between them. The wound was closed without drainage.

The result, five and a half weeks after injury, is shown in Figure 2.

This patient (Figure 3) sustained a division of the long flexor tendon of the thumb and of the

*Lack of space necessitates omission of a number of the illustrative cases shown when this paper was presented.

digital nerve on its medial side as the result of a glass cut, April 20, 1951.

An immediate operation was carried out but the patient said, "It was impossible for the surgeon to do a good job because of the profuse bleeding." After the sutures were removed some wound discharge persisted. When she came to us five weeks later, the free end of a suture was still protruding from the unhealed wound. With the aid of a brief anesthetic the suture was removed; and the wound healed promptly thereafter.

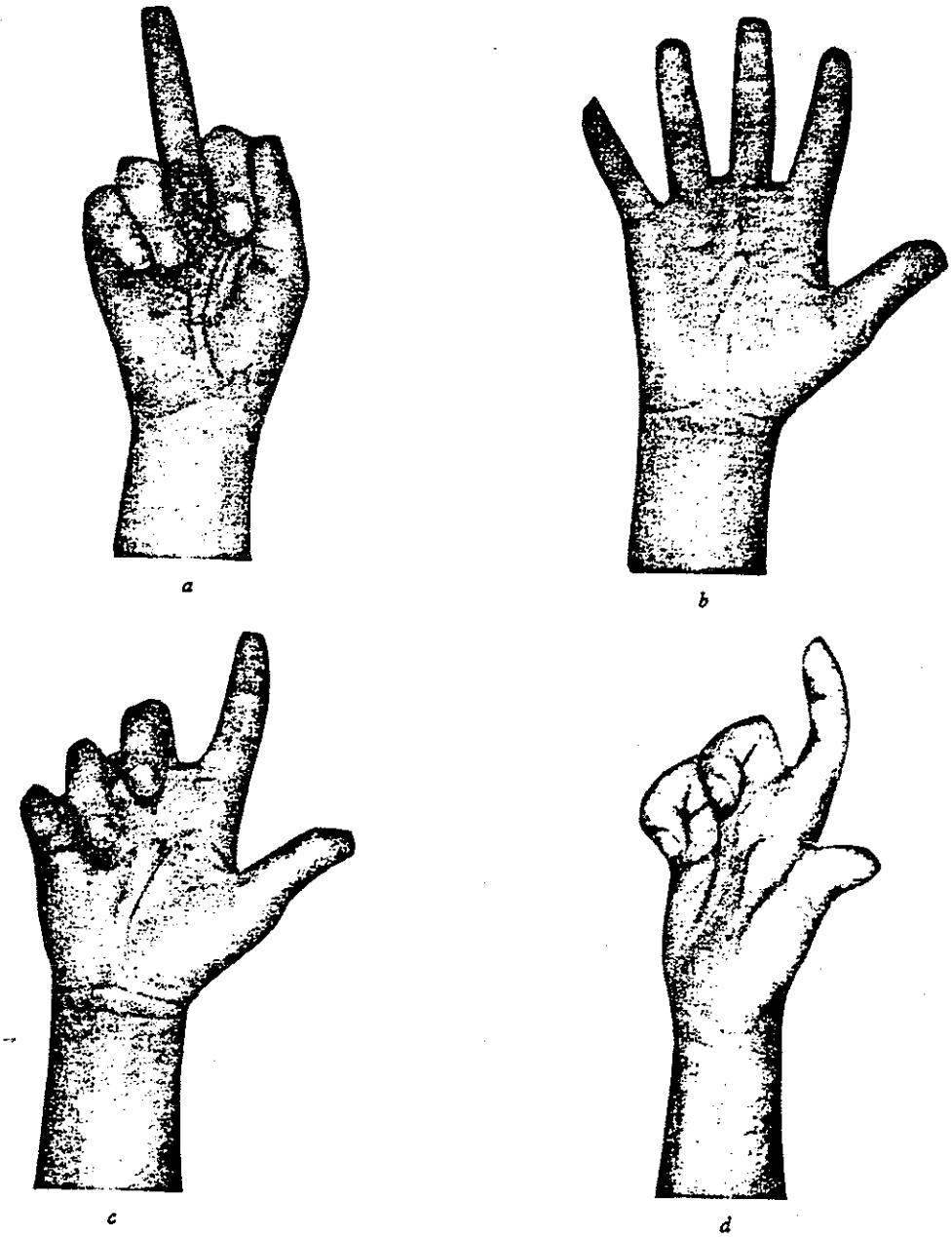
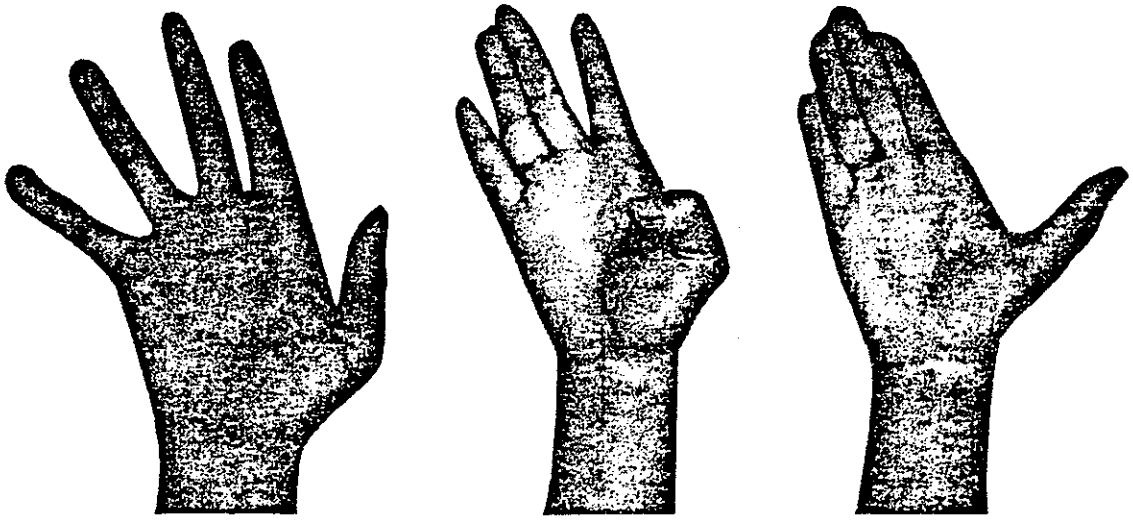


Figure 2. Division of flexor tendons, middle finger. a. Before operation. b. c. d. After operation.

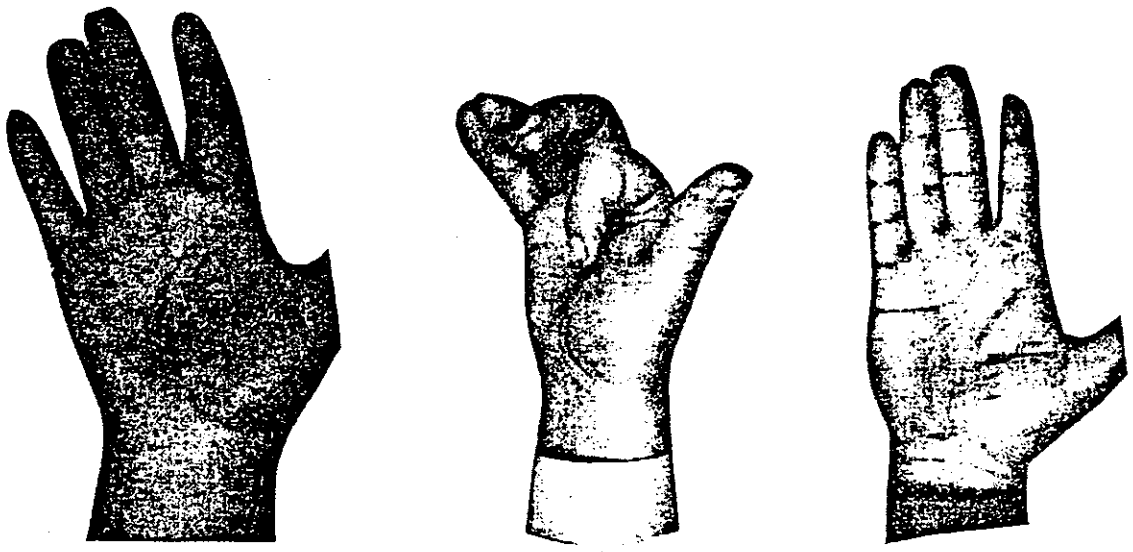
Three months after the injury the inflammatory reaction had subsided. A tendon graft from the foot was then transplanted into the thumb and the divided nerve sutured.

The result three months after operation was carried out is shown in Figure 3, b and c.



a *b* *c*

Figure 3. Division of flexor tendon and medial digital nerve of thumb. a. Before operation. b. c. After operation.



a *b* *c*

Figure 4. Division of flexor tendons and medial digital nerve of index finger. a. After secondary suture of wound. b. c. After tendon grafting operation.

This patient (Figure 4) of Dr. Harvey Allen's was seen 24 hours after he had sustained a lacerated wound with division of the flexor tendons of the right index finger and the digital nerve on the ulnar side. Repair had been undertaken shortly after the injury with the aid of a local anesthetic, but when the open flexor sheath, empty of tendons, was exposed, the operation was discontinued.

Because of the obvious inflammation present when he came to us 24 hours later, the hand was simply protected with a sterile dressing and an

immobilizing splint, and parenteral penicillin given the patient. Five days later simple secondary closure of the wound was carried out. The wound healed by primary union. The appearance on the third postoperative day is shown in Figure 4. On October 24, 1949, a little less than three months after the injury, a tendon graft from the foot was transplanted into the finger to replace the flexor profundus, and the divided digital nerve was reunited.

The result eight months after operation, and six months later, after return to work, is shown in Figure 4.

There are two important reasons for the use of a tendon graft in such an instance. To bring the widely separated tendon ends into apposition would necessitate bringing the finger into marked flexion. The sutured tendon would be under tension and, if healing took place without separation, a flexion contracture of the finger would result. Secondly, since the line of suture would lie within the digital sheath, in the process of healing the tendon would almost certainly become adherent to the surrounding sheath and fail to glide freely back and forth. The use of a tendon graft permits one to carry out suture at the optimum tension and suture of the graft to the proximal segment of the tendon *within the palm*, proximal to the digital sheath, rather than within it.

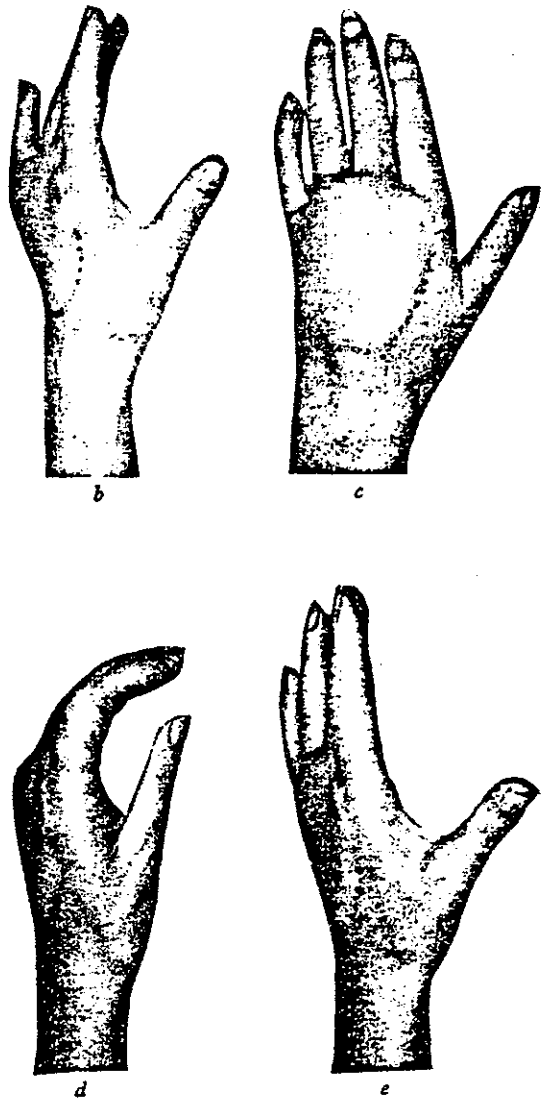
a

Figure 5. Burn from hot plastic material. a. On admission. b. c. After application of flap of skin and subcutaneous tissue. d. e. After tendon grafting.

The patient in Figure 5 sustained a deep burn of the left hand from a hot plastic material November 14, 1951. For three and a half weeks before we saw her the hand was splinted and sulfadiazine was applied daily to the wound. The fixation of the fingers at all the joints, and particularly at the metacarpophalangeal joints, which resulted from this prolonged immobilization was the greatest obstacle encountered in the subsequent effort to secure restoration of function.

She was admitted to the hospital on December 9, and on the following morning the lifeless, parchment-like skin and the dry strips of coagulated tendons underneath were removed. At the same time a flap of skin and subcutaneous tissue was raised from the lower abdominal wall for subsequent transfer to the hand.

Seven days later the superficial dessicated portion of the third and fourth metacarpal bones was chiseled away, the flap was raised again from the abdominal wall and spread out over the raw surface. As soon as the flap was healed physical therapy was carried out for four weeks to help secure mobility of the stiff fingers.



b *c* *d* *e*

On June 9, 1952, the flap was raised on its ulnar side and tendon grafts from the foot inserted under the flap to replace the destroyed extensor tendons

Figure 6. Electrical burn of hand and forearm. a. b. On admission to hospital one month after injury. c. Two days later. d. Six days later. e. f. Two months later.

of the four fingers. At the end of three weeks physical therapy was again begun and the patient returned to work nine weeks after the final operation.

This man (Figure 6) who has been under the care of Dr. Harvey Allen, sustained severe electrical burns of the right upper extremity and of the occipital region, June 12, 1952. He was first seen 30 days after the injury. In the meantime he had been given penicillin and the dressings had been changed daily.

Donald Wells, of Hartford, in 1929* pointed out the importance of early excision of destroyed tissue in such cases, and the principle has been repeatedly emphasized by many others. Obviously unnecessary delay in removing necrotic tissue leads to further destruction, and to widespread infiltration of muscles, tendon sheaths and joint capsules with inflammatory exudate. The coagulation and subsequent organization with extensive

*Treatment of Electric Burns by Immediate Resection and Skin Graft. Annals of Surgery, 1929, 90:1069.

fibrous tissue formation is a potent factor in holding in a constricting vise structures whose free movement is essential for the function of the hand.

The patient was admitted to hospital July 16 and on the same day a surgical excision of destroyed tissue was carried out. Only two days later skin grafts were laid over the raw surfaces and the initial dressing was done four days later—six days after his admission to the hospital. The hand is now healed (Figure 6. e. f.) and much remains to be done, for the patient has lost flexor tendons and several inches, at least, of his median nerve, but we are hopeful that he will eventually secure a usable hand.

The next patient, whose hand is shown in Figure 7, and whose treatment has been carried out from the beginning by Dr. Michael Mason, sustained a crushing lacerated wound of his right hand in a "wood shaper", November 2, 1949.

All the flexor tendons, the digital branches of ulnar and median nerves and the proximal phalanx of the thumb were divided. The thumb was left attached only by a narrow flap of skin and subcutaneous tissue.

The immediate operation consisted of careful excision of devitalized tissue, suture of all the di-

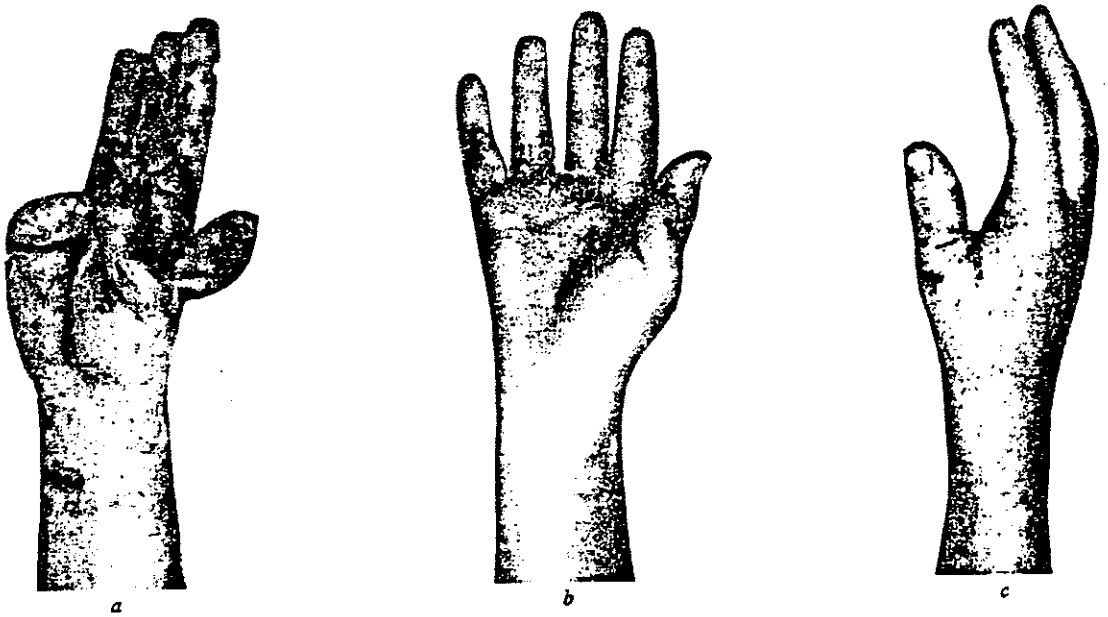


Figure 7. Severe crushing injury with fractures, multiple division of nerves and tendons. a. Immediately after injury. b. c. Fifteen days later.

vided nerves and wound closure. Fifteen days later the wounds were soundly healed.

On March 27, 1950, approximately five months after the injury, a bone graft was placed in the thumb at the site of division and partial loss of the proximal phalanx. On August 23, 1950, tendon grafts from the foot were transplanted into index and middle fingers. On January 12, 1951, tendon grafts were transplanted into ring and little fingers.

Sensation returned to the fingers fairly rapidly after the injury. The excellent return of flexor function in index and middle fingers and beginning return in ring and little fingers is shown in photographs made March 27, 1951 (Figure 7).

It is hardly necessary to add that in many surgical centers all over this nation and in Canada, from the east coast to the west, from Montreal and Toronto to the Gulf, and in many widely separated hospitals of the Veterans Administration, members of this College, working both as individuals and in groups, are securing equally good and often better results for patients with injured hands.

In closing I would paraphrase Kanavel's aphorism by saying, "The working man's hand is his greatest asset," and by adding that with skillful and wisely directed care and particularly in the hours immediately following injury, even seriously injured hands can be saved for useful function.

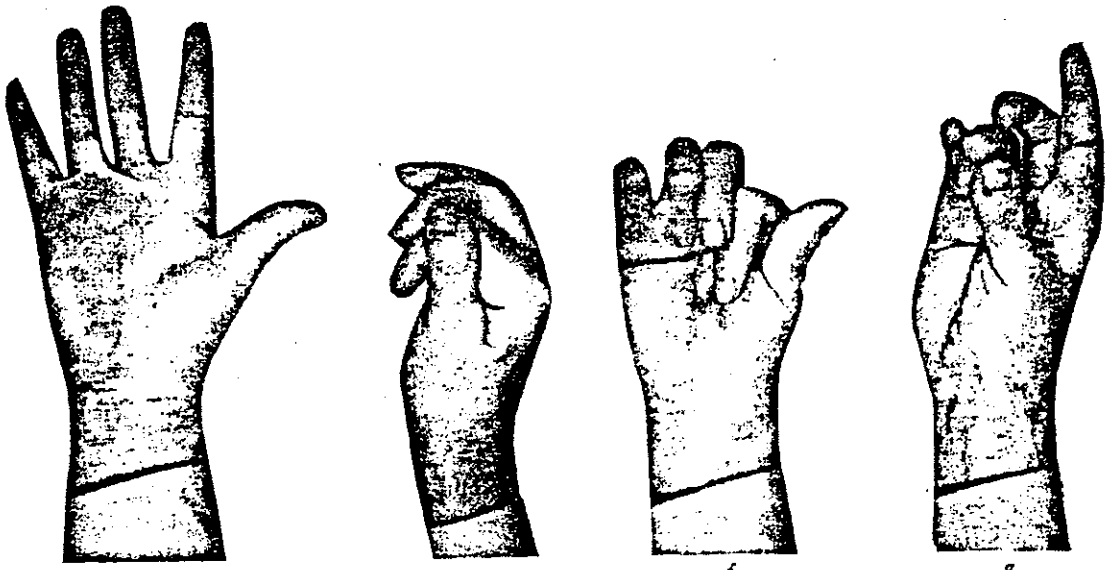


Figure 7. d. e. f. g. Eight months after transplantation of tendon grafts into index and middle fingers, and two and a half months after transplantation of grafts into little and ring fingers.