Repair of Tendon Injuries of the Hand *

R. E. S. YOUNG, M.D., F.A.C.S., J. M. HARMON, M.D., F.A.C.S.

Columbus, Ohio

AS MODERN INDUSTRY has become more mechanized, serious injuries of the hand have become more common. It is impossible to overestimate the importance of these injuries. It often is said that the most important thing a man has in his pocket is his hand. A working man often is completely dependent on his hands to remain gainfully employed. This discussion is limited to the management of tendon injuries involving the hand.

Several considerations of this problem are obvious to surgeons dealing with industrial injuries. The end results of injuries involving division of one or more tendons have been discouraging. Every incision and every suture placed in a hand is accompanied by some degree of limitation of function, however small. Having treated tendon injuries of the hand with a variety of methods commonly used, we have been discouraged with the end results and have considered other methods for the management of this problem. Our general management in the past has been, for the most part, based on the premise that absolute immobilization of the injured part for a period of time, generally not less than one week, has been most desirable.

We have departed from this management and have attempted repairs in which the injured part is returned to a limited state of function immediately following operation. We are most encouraged with our results and have continued to utilize early mobilization. Before describing our method at length let us review the experience of the past.

Prior to World War I, satisfactory repair of the flexor tendons was almost a rarity. William Stewart Halsted gave us several important principles that remain as valid as when they were postulated. His concept of gentle handling of injured tissues is established. Kanavel [2] offered helpful guidance based upon vast clinical knowledge of this field. His text [3] has served as an invaluable source of information for many years. His work with infections of the hand will, in itself, assure his lasting fame. Meleney demonstrated the importance of identification of the invading organism in all infections, especially those involving the hand.

The work of Sterling Bunnell [1] in the field of reconstruction of hand injuries is well recognized. Antibiotics increased the scope of surgery as well as the opportunities for satisfactory primary repair. Strong chemical antiseptic agents have been replaced by bland detergents and saline irrigation of the depth of the wound.

As experience has increased it has become increasingly apparent that vast differences exist between divisions of the extensor tendons and divisions of flexor tendons. The failure of the flexor tendons to heal without residual stiffness and immobility of the finger is based upon at least two considerations. The work of Mason and Allen [4] demonstrated the alteration of tensile strength in the postoperative period. They have shown that a period of diminished tensile strength is present from three to seven days postoperative. Following a seven-day period tensile strength gradually increases.

The management of flexor tendon injuries has been based on the concept that approximated ends of the cut tendon develop a fibrous union which becomes firm in from

* Submitted for publication July 16, 1959.

seven to 21 days. A fairly well-established mode of treatment of flexor tendon injuries has been immobilization of the involved parts in a position of function, generally employing a bulky pressure dressing which remains in place beyond seven days. Most sutures used in these repairs and in experimental investigations have been fine black silk. An ingenious technic developed by Sterling Bunnell [1] is the wire "pull-out" type suture. Using a second wire the approximating suture is removed at a later date.

In our experience the severed tendon and the severed tendon sheath fuse in a mass of scar tissue resulting in loss of motion with fixation of the tendon to adjacent structures when the part is immobilized for a period of time. Silk sutures are not well tolerated by tendons and usually are found lying in a canal of granulation tissue at the suture line. The tendon responds to this irritation by fusiform or bulbous growth at the point of suture.

The bulbous increased diameter of the tendon and the adhesions to adjacent structures usually defeat the intent of the surgeon.

Our first goal was a suture material that was better tolerated by tendon. We believe that 5–0 chromic catgut on an atraumatic needle is the suture of choice. It is small in diameter, quite pliable and as it becomes moist is more adaptive, fits the needle hole more snugly and is not a permanent suture. The irritation that exists at the start is self limited. It is our observation that bulbous formation of healing is least with 5–0 chromic.

Our second approach was based upon a change of philosophy regarding immobilization. We realize that no living tissue can be approximated and held in place for an extended period of time by the strength or permanence of suture material alone. Suturing as such can ultimately only lay a pathway for healing. Sutures liquefy tissue at pressure points, are extruded and usually are found lying between planes of mobile tissue. There they remain useless, if not detrimental, foreign bodies.

Having chosen a suture that is capable of less immediate strength than silk or wire, we sought a better means of fixation. In this we drew from the earthy experience of the fisherman. As many fishermen-surgeons have learned, a fish pulling against a limber rod at a right angle may be held even if the line is weak, while a fish that can pull in a straight line against the fixed reel will surely be lost. We reasoned that voluntary and involuntary spasms and contractions of muscles pulling against a suture line in a tendon that is held in rigid fixation by dressings or splints will result in repeated trauma to the suture line and frequently to partial or complete tearing. We further reasoned that a tendon suture in a finger free to move would result in the strain of muscle spasm being dissipated by movement.

Method

Following suture of the flexor tendon with a running suture of 5–0 chromic catgut and closure of the skin with interrupted silk sutures, a silk suture is placed through the tip of the fingernail and tied to a rubber band (Fig. 1). The rubber band is pulled gently until the finger rests in a neutral position of partial flexion. The rubber band is then secured to a wrist band of adhesive tape. No dressing is used.

Spasms or sudden movements of extensor tendons are limited by the rubber band thus restricting complete extension but permitting movement. Movement of the flexor tendon is unopposed by the rubber band but is limited because it strikes an already partially flexed finger that is free to move.

On the first postoperative day the patient grasps the finger tip of the injured finger between the thumb and forefinger of the other hand and passively extends the finger. On release the rubber band brings it back to partial flexion.

This passive motion is increased day-by-day aiming at full motion at the end of

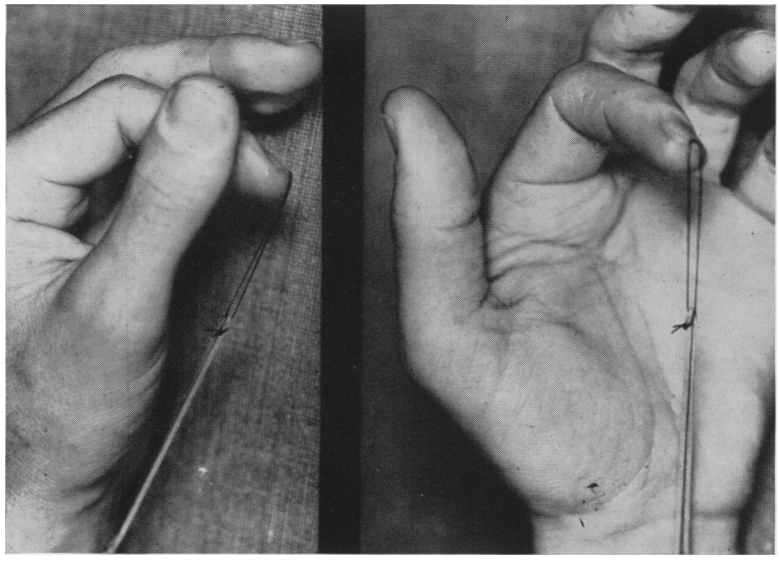

FIG. 1. Photograph demonstrating the use of a rubber band partially immobilizing the finger.

three weeks. No active motion is permitted until the end of the third week when the rubber band is removed. At this time most patients show full motion in active extension and flexion. Physiotherapy is rarely necessary.

In this series we have treated a total of 242 patients. To analyze results we have divided these injuries into three categories:

1. Those which involve the extensor tendons alone.
2. Those which involve division of the flexor tendons alone.
3. Those which involve both the extensor and flexor tendons.

To evaluate the results we have utilized awards granted to patients by the industrial Commission of the State of Ohio as the most accurate and fairest evaluation of permanent disability. Table 1 represents the first group involving division of the extensor tendons alone.

As might be anticipated, results following division of the extensor tendons alone are good. Considering the over-all problem of tendon injuries we might anticipate the best results would be found in injuries of the extensor tendons. Table 2 represents the group of injuries in which the flexor tendons alone were involved.

TABLE 1. *Involvement of Extensor Tendons Only*

Total number of patients	111
Number of patients with no awards	110
Number of patients with awards	1*
Amount of award	$251.00

* In addition to the division of the tendon, one third of the fourth finger was amputated. Payment was made not only for loss of function in regard to the tendon but also for the actual loss of a segment of the finger.

Division of a flexor tendon in the hand represents a more formidable challenge to the surgeon than does an injury to the extensor tendon. Considering results that have been published in this group of injuries, we believe our results are encouraging. In that we have utilized the awards of the Industrial Commission of the State of Ohio as a criterion of evaluation, associated injuries of the hand concomitant with tendon injuries have been included. It is not pos-

TABLE 2. *Involvement of Flexor Tendons Only*

Total number of patients	103
Number of patients with no awards	101
Number of patients with awards	2
Average award to each patient	$231.00

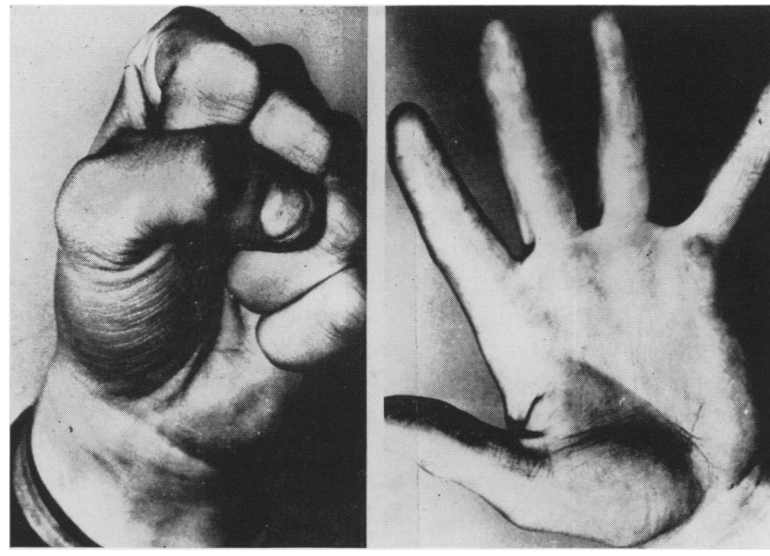

FIG. 2. Demonstration of the mobility of the hand, postoperatively.

sible to separate the actual degree of disability resulting from the tendon injury from associated injuries such as amputation and fractures in this group.

Table 3 is an analysis of 26 cases which were found to have involvement of both the flexor and extensor tendons.

TABLE 3. *Involvement of Both Extensor and Flexor Tendons*

Total number of patients	26
Number of patients with no awards	20
Number of patients with awards	6*
Average award to each patient	$733.44

* Three of these six patients received payment owing to amputation of fingers in addition to the tendon injuries of the fingers.

Of six patients who received awards from the Industrial Commission, three had associated amputations of portions of the fingers. It is obvious, then, that degree of disability as represented by the awards of the Industrial Commission is not solely related to the result of the tendon injuries as the disability. Payment allowed for these amputations has been included in the total.

We cannot overestimate the importance of the most meticulous surgical technic in the management of this difficult problem. All cases were cared for in the operating rooms of adequately-staffed hospitals. A properly-applied tourniquet is a *sine qua non*. Repair of tendon injuries should be carried out under general anesthesia. A detailed account of the operative technic of a representative case is included in this discussion.

Operative Procedure

This patient had been injured by a power lawnmower and sustained multiple lacerations with severed tendons and incisions into the bone of fingers of the right hand (thumb not involved). The right hand was scrubbed with soap and water. The wounds were irrigated with saline. The hand was draped in a sterile manner and a tourniquet was applied to the arm.

The index finger was lacerated to the first interphalangeal joint with division of the flexor digitorum profundus tendon. Repair was accomplished with a running suture of 5–0 chromic catgut. A second laceration of the index finger at the second interphalangeal joint extended from the skin to the bone. At this point a fracture of the middle phalanx of the finger was reduced and maintained with interrupted 1–0 plain catgut sutures. Repair of the second division

of the tendon was accomplished with a running suture of 5–0 chromic catgut.

The middle finger was lacerated midway between the metacarpal phalangeal joint and the first interphalangeal joint with division of the flexor sublimis tendon. The tendon was repaired with 5–0 chromic catgut sutures. A second laceration of the middle finger extended through the first interphalangeal joint with division of the sublimis and profundus tendons. A part of the joint capsule was excised here. Repair of the tendons was accomplished using 5–0 chromic catgut sutures. A third laceration involving the middle finger was found midway between the first and second interphalangeal joints. This laceration extended through the flexor profundus tendon, the bone and the extensor tendon. The extensor tendon was repaired with running sutures of 5–0 chromic catgut. The bone was held in place with a loop of 1–0 plain catgut. The flexor tendon was repaired with a running suture of 5–0 chromic catgut. A fourth laceration involving this same finger at the level of the second interphalangeal joint extended through the flexor profundus tendon and involved the joint capsule. The tendon again was repaired with a running suture of 5–0 chromic catgut. A fifth laceration of this finger in the terminal phalanx was found. A fracture of the distal phalanx was reduced and held in place with an interrupted 1–0 plain catgut suture.

The ring finger was lacerated between the first and second interphalangeal joints, dividing both flexor sublimis and profundus tendons and involving the bone. The fracture of the middle phalanx was reduced and held in place with interrupted sutures of 1–0 plain catgut. The flexor tendons were repaired running sutures of 5–0 chromic catgut. A second laceration involving the tip of the terminal phalanx was noted. A fracture of the terminal phalanx was present, which was reduced.

A laceration of the tip of the little finger involved the bone. The fracture of the distal phalanx of the little finger was reduced.

Closure of the skin was then accomplished using interrupted 5–0 black silk sutures. At this point black silk sutures were placed through the nails of the four involved digits. There was no involvement of the thumb. Rubber bands were tied to the sutures which had been placed through the nails of the involved fingers. The rubber bands were then attached to a wrist band. The patient's postoperative condition was satisfactory (Fig. 2).

Summary

We have presented a series of 242 patients with divisions of extensor and flexor tendons.

We have presented results following repair of these injuries, using awards granted by the Industrial Commission of the State of Ohio as a guide to the degree of disability which has remained following these injuries.

We have proposed a method of repair of tendon injuries which offers the greatest advantage in the form of early mobilization of the injured part with certain safeguards in regard to the hazard of separation of the sutured ends of the tendon.

Bibliography

1. Bunnell, Sterling: Primary Repair of Severed Tendons: Use of Stainless Steel Wire. Am. J. Surg., **47**:502, 1940.
2. Kanavel, A. B.: Dupuytren's Contraction with a Description of the Palmar Fascia, Review of the Literature and a Report of Twenty-nine Surgically Treated Cases. Surg., Gynec. & Obst., **48**:145, 1929.
3. Kanavel, A. B.: Infections of the Hand. A Guide to the Surgical Treatment of Acute and Chronic Suppurative Processes in the Fingers, Hand and Forearm. Ed. 5, Philadelphia, Lea and Febiger, 1925.
4. Mason, M. L. and H. S. Allen: Rate of Healing of Tendons. Ann. Surg., **113**:424, 1941.