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A useful work of reference and practical advice.
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Should be compulsory reading for all who ever have to close a wound.
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# TENDON INJURIES OF THE WRIST AND HAND

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THE successful repair of divided tendons has presented the hand surgeon with one of the more difficult aspects of his craft. Accurate approximation of the tendon ends is necessary to ensure smooth healing, but the subsequent recovery of gliding depends on the correct understanding and appreciation of the biomechanics of tendon repair.

Many surgeons have devoted time and energy in research to obtain solutions to the problems with which this subject bristles, and the pioneer work of Mayer, Bunnell, Koch, Mason, Allen, Verdan, Pulvertaft, Peacock and others has answered many of the queries. In general it can be stated that a successful repair can only be anticipated if the surgeon understands and correctly applies the principles of hand surgery.

It has sometimes happened that patients with hand injuries have had their primary operations performed by relatively junior surgeons, not infrequently with indifferent results. Many procedures have fallen into disrepute because the poor results of surgery have not been recognized as being the results of poor surgery. Any instrument as delicate and complex as the hand is truly worthy of the best surgical attention.

Tendon injuries may be caused in a variety of ways, and the cause is often of prime importance in deciding on the correct treatment. Incised wounds, caused by knife or glass injuries are the most favourable, and more often lend themselves to primary tendon repair. Crushing or avulsion injuries cause complicated wounds, and here the prime consideration is to secure early wound healing. The tendon repair is of secondary consideration, and is usually better deferred to a later date.

Similarly, the length of time which has elapsed between wounding and primary wound treatment is of importance in deciding the correct primary treatment of the tendon. A wound more than six or eight hours old is probably never suitable for a primary tendon repair. If the wound is more than 24 hours old, it may sometimes be advisable to perform a delayed wound closure after toilet. One thing is certain, the avoidance of infection by thorough cleansing of the wound and removal of damaged tissues is essential to the recovery of

joint movement and gliding of the tendon, whatever method of repair is contemplated.

The primary operation must always be performed with the subsequent result in view, and not with one eye on the clock. It should be performed for preference under general anaesthesia, though in some cases, a brachial plexus block, or even a peripheral nerve block may be adequate. A bloodless field, afforded by a pneumatic tourniquet, is essential. Release of the tourniquet at the conclusion of the dissection, but before repair of the tendon and closure of the skin is of great value, as the reactive hyperæmia may often give useful information as to the viability of damaged tissue. Wound cleansing at the first operation should be thorough, and should be performed with soap and water. Strong antiseptics, especially tincture of iodine, should never be used. Cetavlon is permissible to remove oil or grease. Incisions should only be extended in accordance with accepted principles, and never further than is absolutely necessary. Straight longitudinal mid-line incisions must always be avoided. The common transverse or oblique wound, seen in the palm or fingers, is best extended in bayonet fashion. Dissection should be careful and sharp. Suture material should be either of fine silk or stainless steel wire, and a simple stitch is quite adequate to secure accurate coaption of the tendon ends (Fig. 1). Hæmostasis must be complete and accomplished by ligation of small vessels.

Finally the hand must be dressed in a compression dressing to prevent oozing and swelling, and the tendon repair relaxed by splintage of the wrist and fingers, using either sheet aluminium splints or plaster of Paris. Elevation for 48 hours prevents œdema. Early movements have never been shown to be helpful, and indeed they are harmful, as has been demonstrated experimentally by Mason and Allen, and by Pulvertaft and others subsequently. Emphasis must be on early healing, and movements are subsequently encouraged by active exercises rather than by passive stretching, though spring or elastic splintage is often useful to stretch adhesions and stiff joints that inevitably result after such injuries and their surgical repair.

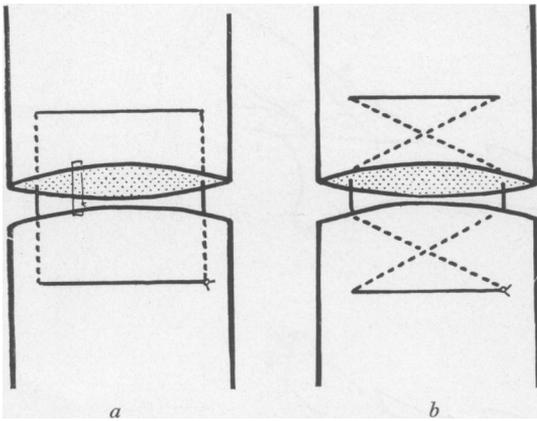


FIG. 1.—Tendon suture. (a) Mattress suture. (b) Modified mattress suture.

### Extensor Tendon Injuries

Most divided extensor tendons unite readily after repair, due to their adequate blood supply, the loose paratenon which surrounds them and the absence of tight fibrous tendon sheaths. After repair they should be immobilized in the relaxed position for about four weeks, that is, longer than for the flexor tendons. The reason is that they are relatively weaker in action, and if the scar at the suture line is subject to early strain, it will stretch and lead to slight lengthening and subsequent loss of function.

### Extensor Tendon Division at the Wrist and Dorsum of Hand

Most types of wound here lend themselves to primary tendon repair, except those with gross contamination, established infection or skin loss. Skin closure is rarely a problem, as the dorsal skin is so loose and elastic, and the tendon ends can be trimmed back to good tissue, which may produce slightly increased tension on closure, though this is not necessarily a bad thing.

If the fibrous tendon sheath on the dorsum of the carpus is damaged, it is sometimes wiser not to repair it, if by so doing the suture line in the tendon were to be under pressure. This might cause ischaemic necrosis or adhesion and mar the result.

After repair of such injuries, splintage should be in the relaxed position for one month. The wrist and metacarpophalangeal joints of the fingers should be included. The interphalangeal joints need not be extended, but may be allowed free, and flexion movements encouraged. This applies to all extensor tendon division at or proximal to the metacarpophalangeal joints.

Movements are subsequently regained by active exercises, warm-soapy water washing and olive-oil massage. A night splint should be worn

for a further period if there is any tendency to an extension lag. The recovery of full flexion often takes some months.

### Extensor Tendon Division Near the Metacarpophalangeal Joints

It has sometimes been stated that tendon repair at this level is not necessary. Although the presence of junctura tendinum may prevent serious retraction, they do not prevent some separation, and they are not always present in the double tendons of the index and little fingers. It is always preferable to ensure perfect tendon apposition by suture, and continue with splintage of the wrist and metacarpophalangeal joints as outlined above.

### Division of Extensor Tendons on the Back of the Proximal Phalanx and at the Proximal Interphalangeal Joint

Lacerations on the back of the finger in this situation are extremely likely to divide the tendon, either partially or completely. It is important to recognize tendon division, even when clinically the movements of the finger seem normal, for especially with middle slip division at the proximal joint, the tendon division often passes unrecognized in the initial stage, and it is only later that the development of an extensor lag or the ugly 'Boutonniere' deformity leads to the discovery of the tendon damage. Repair in the initial stage is easy, and is almost always successful. Splintage for one month, with the proximal joint extended, allowing the distal joint to flex slightly is the correct treatment. Secondary repair is possible up to some weeks after injury, provided that the joints show a full range of passive movement. Once deformity has occurred it has to be overcome by elastic splintage prior to tendon repair, and if the proximal joint cannot be fully extended passively, then it avails nothing to repair the tendon. If the middle slip cannot be sutured, it is necessary to secure tendon continuity by the insertion of a small tendon graft, rather than mobilize the lateral slips and sew them over the back of the proximal joint. This is a good operation in young patients, but in elderly people the risk of proximal joint stiffness is very great. As previously indicated, some loss of extension is of less importance than loss of flexion.

### Flexor Tendon Division

The decision as to whether or not to perform a primary tendon repair depends on the factors previously outlined. In cases of doubt, it is always better to close the skin and to perform a secondary repair, rather than risk the disaster of skin necrosis or infection in complicated or soiled wounds. The first essential is always to secure

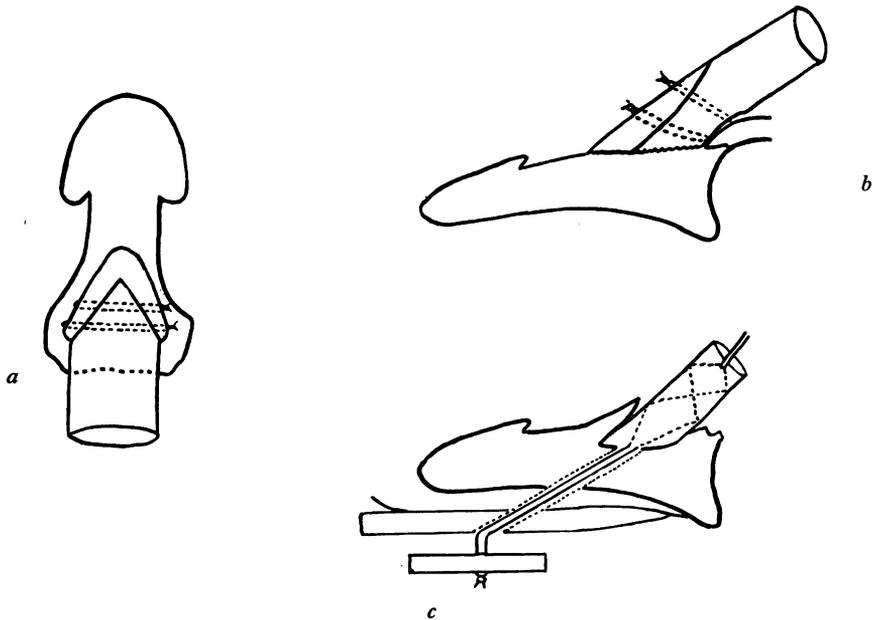


FIG. 2.—Methods of attaching tendon graft to distal phalanx. (a) Allen. (b) Mason. (c) Bunnell.

early healing by complete closure of the wound at the first operation.

After repair of flexor tendons at any level, the wrist, hand and fingers should be immobilized in a compression dressing and a dorsal splint in a position of mid-flexion to relax the flexor tendons. The patient must be instructed not to attempt finger movements.

#### Flexor Tendon Division at the Wrist

Both primary and secondary repair can give excellent results. Tendon grafting is seldom required, for small gaps can be overcome by the use of segments of adjacent tendons. Where all the tendons are divided at the same level, they can be repaired. The loose paratenon surrounding them enables them to heal without adhesion, and to function independently.

If the damage to the tendons is widespread, adhesion is more likely to develop, and the result may be improved by suturing the profundus tendons only, and attaching the divided superficial muscles to the profundus muscles higher up, thus reducing the bulk of tendon at the suture line.

Occasionally a better result may be obtained, particularly where there has been loss of tissue, by suturing the superficial muscle above to the profundus tendons.

When repairing tendon division in the carpal tunnel, it is essential to repair only the profundus tendon, and to excise the sublimis, for the tendency to form adhesions in the carpal tunnel is as great

as it is in 'no-man's land' (see below), as the combination of a small unyielding space, occupied by a large volume of tendon substance, is virtually the same.

#### Tendon Division in the Palm

Here primary repair is the method of choice, for the profundus and sublimis suture lines can be separated by paratenon or by the lumbrical muscle, and independent tendon action can be secured, giving a normal pattern of finger flexion.

#### Tendon Division in 'No-Man's Land'

It is in this area from the distal palmar crease to the insertion of the sublimis tendons, that there is the greatest division of opinion as to the wisdom of performing primary tendon repair. It is here that ill-advised or inexpertly performed repairs have in the past given the worst results. There can be no doubt that the correct plan, in almost every case, is to close the wound, and perform a secondary repair later. This usually means the insertion of a free tendon graft.

The finger is exposed through a lateral incision along the line joining the dorsal extremities of the flexion creases. The tendon sheath is exposed, and the majority of it removed, leaving adequate pulleys in front of the shafts of the bones. If the pulleys are damaged during the removal of an adherent tendon, they should be repaired using a small piece of tendon graft.

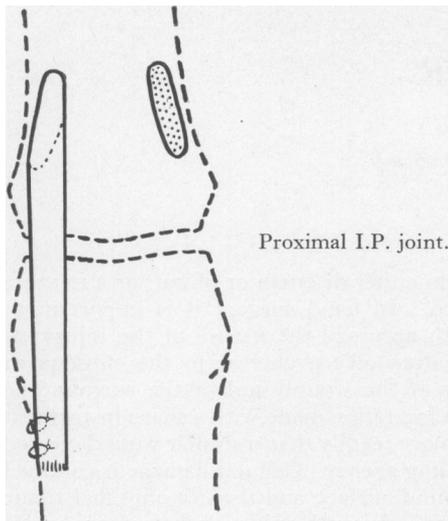


FIG. 3.—Suture of sublimis slip.

The graft most often used is the palmaris tendon, but a toe extensor is very satisfactory.

The distal end is fixed by one of the methods shown in Fig. 2 by making a junction between the graft and the stub of the profundus tendon, the bone in contact with the end of the graft being roughened first. Alternatively the end of the graft is buried in a small hole made with a chisel or gouge, and a Bunnell pull-out suture threaded through a hole drilled through the nail.

The proximal attachment of the graft should be made by a lacing suture, as the difference in size of the graft and the motor tendon precludes simple end-to-end junction of the tendons.

In clean incised wounds, seen in the first hours after injury, primary repair in the hands of an experienced operator can and does give excellent results. Minimal handling of the tissues, and sharp dissection are essential. The profundus tendon only should be repaired and the sublimis excised, leaving only a small slip on one side sutured to the proximal phalanx to prevent subsequent hyperextension of the proximal interphalangeal joint (Fig. 3). The fibrous tendon sheath must be excised clear of the suture line in the tendon for about one-quarter of an inch both proximally and distally. Skin closure must be neat and accurate, and primary skin healing is essential. Immobilization in the relaxed position is carried out for three weeks.

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For Further Reading see page 261.

Verdan and Madsen have used fine stainless steel pins to transfix the tendon at a little distance from the suture line, and thus prevent retraction due to involuntary or accidental movements during the period of immobilization. Temporary transfixion has been found essential in the performance of the actual suturing, but has not been used by the author as a routine post-operatively. Occasionally a secondary tenolysis is necessary to release adhesions which are blocking movements.

Primary tendon repair works best in the flexor pollicis longus where there is only one tendon in the sheath, and where an imperfect or incomplete flexion range is often functionally adequate.

Even if primary repair fails, it does not prejudice the insertion of a tendon graft later should this be necessary.

Primary tendon grafting, though successful in some hands, cannot be recommended for general use, for it seems logical to suppose that if the case is unsuitable for a primary tendon repair, then it is equally unsuitable for a primary tendon graft, and it would seem better to close the wound and perform a secondary repair.

#### Tendon Division Distal to the Insertion of the Sublimis

Occasionally it is possible to repair distal division by advancement of the divided tendon, so as to place the suture line at the normal insertion of the profundus, and fix it by one of the accepted techniques (Fig. 2). This is only possible if division occurs within half-an-inch or so of the distal insertion. Greater distances produce too much tension, and should be repaired in the usual way by direct suture.

After advancement or tendon repair at this level, it is wise to remove the fibrous sheath to prevent adhesion at the suture line.

#### Disinsertion of Flexor Profundus

This is an injury of sportsmen, particularly football players, in which a forcible extension of the actively flexed finger leads to a rupture of the profundus tendon at or near its insertion into the terminal phalanx. Its recognition presents no difficulty, and treatment consists of repair as soon as possible after injury. Reattachment is best effected by the technique illustrated in Figure 1. The wrist and fingers should be immobilized for three weeks as after distal tendon suture.