The occasional extensor tendon laceration repair

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Introduction

Rural physicians commonly have patients present to the emergency department with injuries to the hand. Occasionally, these injuries involve extensor tendons. Extensor tendon injuries are more common than flexor tendon injuries, due largely to the fact that extensor tendons are less protected and are more superficially located. The strategy used to manage an extensor tendon injury varies with the location of that injury. For this reason, optimal management of a hand extensor tendon injury requires an understanding of extensor tendon anatomy and function. The other principle regarding extensor tendon injuries is that these injuries should not be underestimated. Care and attention during initial treatment is an important aspect of ensuring good outcome, or at least to minimize deformity. This article reviews extensor tendon anatomy and terminology, and then reviews briefly the management of hand extensor tendon injuries with a focus on repair of lacerated tendons.

Extensor tendon anatomy and terminology

Extension of the wrist and fingers is accomplished via the coordinated efforts of an intricate and interconnected complex of extensor muscles and their terminal tendons (Fig. 1).[1,2] The muscles that make up the extensor tendon complex are located in the dorsal aspect of the forearm, and all are innervated by the radial nerve (C5–C8) (Table 1). The tendons of these extensor muscles form just proximal to the wrist joint, and they then pass into the dorsal aspect of the hand. A dense, thickened, fibrous fascia known as the extensor retinaculum, stretching across the dorsum of the wrist, holds the tendon sheaths down and prevents bowstringing when contraction of the muscles occurs. Another fibrous fascia, known as the extensor expansion, stretches from the metacarpophalangeal (MCP) joint to halfway down the proximal phalanx and functions to hold the extensor tendon down and in a more or less central position.

The 5 muscles that are involved in actually extending the fingers are the extensor pollicis brevis, extensor pollicis longus, extensor indicis proprius, extensor digiti minimi, and extensor digitorum communis (Fig. 1). The extensor pollicis brevis muscle extends the thumb at the MCP, and the extensor pollicis longus extends the thumb at the interphalangeal joint. The extensor indicis proprius muscle extends the index finger, the extensor digiti minimi extends the little (fifth) finger, and the extensor digitorum communis is involved in extending all digits except for the thumb. The 4 extensor digitorum communis tendons share a common muscle origin, which explains why fingers tend to extend together. The tendon of extensor digitorum communis to the little finger is missing in more than 50% of people and is replaced by a the fibrous sheath from the ring finger extensor originating just proximal to the MCP joint. Similar fibrous sheaths connect other tendons of the extensor digitorum to one another. These fibrous sheaths are referred to as juncturae tendinum. They are the reason why one can lacerate a tendon of the extensor digitorum communis muscle proximal to the MCP

joints and still see extension of the involved digit distal to the laceration. The extensor tendons of the extensor digitorum communis muscle inserts at multiple sites, including the base of the proximal, middle and distal phalanges. Halfway down the proximal phalanx the extensor tendons of this muscle trifurcate into a central "slip" and into 2 lateral bands (Fig. 1, Fig. 2). The central slip inserts primarily to the base of the middle phalanx, and the lateral bands insert primarily to the base of the terminal phalanx.

Contributing to, and adding to, the complexity of the extensor tendon mechanism are interconnections with intrinsic muscle (interossei and lumbricals) tendons and with a variety of ligamentous sheaths and bands (e.g., sagittal, retinacular, triangular). The intrinsic muscles contribute to flexion at the MCP joint and extension of the proximal and distal interphalangeal (DIP) joints. A more detailed discussion of these intrinsic muscles, tendons, sheaths and bands is beyond the scope of this article, and the reader is referred elsewhere for more information.[1,2] Suffice it to say, the extensor tendon mechanism is a complicated, somewhat delicate system held in balance by a flexor tendon complex. Injury to either the extensor or flexor tendon complex from trauma, infection, inflammation or degeneration can lead to imbalances that manifest themselves as finger deformity and/or dysfunction in finger movement.

The extensor tendon system has been divided into 8 anatomic zones (Verdan's zones), which are summarized in Table 2 and shown in Fig. 1. Divi-

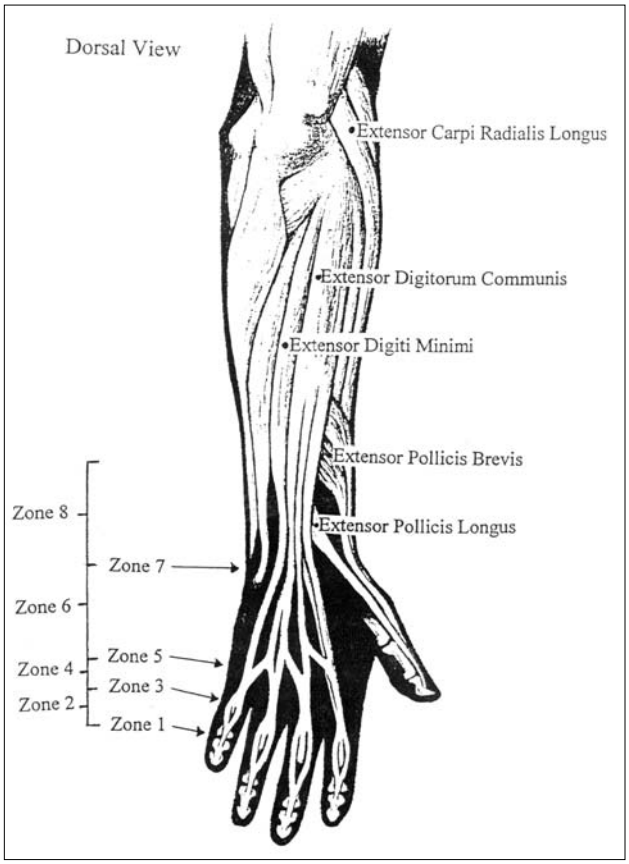

Fig. 1. Extensor muscles and tendons

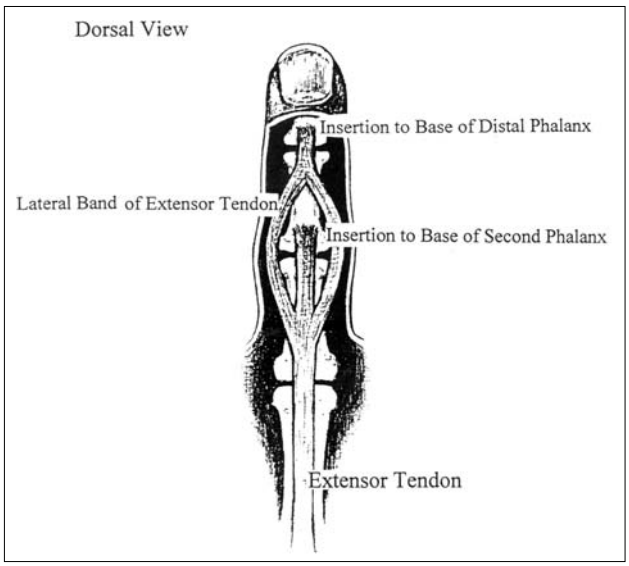

Fig. 2. Finger extensor tendon complex

Table 1. Extensor muscles and function

Extensor muscle	Function
Pollicis	
Brevis	Extends thumb
Longus	Extends terminal phalanx of thumb
Carpi	
Radialis brevis	Extends and abducts wrist
Radialis longus	Extends and abducts wrist
Digitorum communis	Extends wrist joint and non-thumb digits
Indicis proprius	Extends index finger
Digiti minimi	Extends fifth digit
Carpi ulnaris	Extends, adducts wrist

Table 2. Verdan's anatomical extensor tendon zones

Zone	Location	Deformity
I	Distal interphalangeal (DIP) joint	Mallet finger* (a.k.a. baseball or drop finger)
II	Between DIP and proximal interphalangeal (PIP) joints	Mallet finger
III	PIP joint	Boutonniere deformity
IV	Between PIP and metacarpophalangeal (MCP) joints	
V	MCP joint	
VI	Hand between MCP and wrist joints	
VII	Wrist joint	
VIII	Dorsal forearm	

*If left untreated, mallet finger can develop into swan-neck deformity.

sion into anatomic zones is useful conceptually because injuries within each zone are associated with distinctive deformity, dysfunction, treatment strategy and surgical outcome. Only injuries in zones I to VI will be discussed in this paper. Zone VII and VIII extensor tendon injuries are associated with significant retraction of tendons. There is often a need to release the extensor retinaculum (dorsal carpal ligament), multiple tendons may be injured at the same time and the risk of postoperative adhesions is high. For all these reasons zone VII and VIII extensor tendon injuries are best referred on to physicians with more expertise.

Initial approach to extensor tendon injury

The initial approach to an extensor tendon injury should include a full history of the event, including an assessment of the degree of possible contamination. Always ask if the injury is the result of a human bite. Give tetanus immunization if indicated. A history of heavy smoking or drinking may be associated with poorer healing. Provide analgesia for pain (e.g., Demerol 75–125 mg intramuscularly, morphine 3–5 mg intravenously) as needed.

Note the location, size and depth of wound; viability of tissue around the wound; presence or absence of debris within the wound; and estimate how deep the laceration could have extended into tissue. Stop bleeding by applying pressure over any actively bleeding areas. Carefully document the neurovascular integrity distal to the wound before anesthetizing the area. Carefully document flexion and extension of hand joints particularly those distal to the laceration. Make a decision as to whether or not radiography would be helpful to identify internally embedded foreign bodies (e.g., glass) and/or bony injury. Remove watches and rings.

After examination, inform the patient about the need for cleaning the wound and repairing the tendon injury. Obtain informed consent for the procedure and review potential complications, including infection, bleeding, scarring, adhesions, rupture, stiffness and additional damage to the underlying and surrounding tissue.

Specialized repair

If the tendon injury and wound is judged to be too complicated to handle at the rural facility, make arrangements to transport the patient to another facility for specialized repair after the wound has been cleaned and dressed. If there is going to be any delay in secondary tendon or nerve repair, close the wound before transportation. If tendon or nerve ends are visible, tag them with a short piece of 4/0 nylon suture (± 3 cm) to facilitate subsequent repair. Immobilize the hand in position of function before transfer — MCP joint at 70° flexion with the interphalangeal joints at about 10° flexion. Amputated parts should be saved and transported with the patient. Wrap the amputated part in saline-soaked gauze, place this into a sealed plastic bag, which is then placed into a container filled with ice and water.

Equipment for cleaning wound and repairing extensor tendon

Equipment necessary for managing hand injuries and repairing extensor tendons consists basically of the same equipment one would use to manage any laceration; i.e., a suture set.

Wound care before repair

1. Using sterile technique, clean the wound and surrounding area with an antiseptic skin solution (e.g., chlorhexidine 2% with 4% isopropyl alcohol [e.g., Dexidin 2 Solution], antiseptic isopropyl alcohol pad [e.g., WEBCOL Alcohol Prep] or Betadine Surgical Scrub [7.5% povidone–iodine] and wash it off with sterile sodium chloride solution (0.9%). Butter, mayonnaise or mineral oil will remove oil quite effectively.
2. Make a decision about what kind of anesthesia should be used — local, digital nerve block, metacarpal nerve block, regional nerve block or general anesthesia. No exploration or débridement should be carried out before anesthesia is achieved. For local and nerve block anesthesia 1% or 2% Lidocaine hydrochloride is used. Avoid the use of epinephrine (1:100 000) in the finger. Regional or metacarpal nerve block is recommended if the wound is large or looks complicated.
3. After anesthesia irrigate with copious amounts of sterile saline solution — up to 1 L. Consider taking wound cultures before irrigation if the wound is at high risk for infection — e.g., human bite wound. Apply sterile drapes around the wound area. A bloodless field is very useful, so consider inflating a blood pressure cuff to a level 50 mm Hg above systolic blood pressure for at least the first part of the examination.

Remove obvious foreign bodies, excise any dead tissue, clean or clip off dirty fingernails. Push down on the fully extended digit, and if any weakness in tendon function is detected (i.e., the digit is easily forced into flexion) the laceration should be opened further to allow proper assessment of the tendon damages. Proper exposure of the damaged tendon is very important. Usually this involves extending the laceration in a Z-plasty type fashion, folding the flaps back and holding them in place with a 25-gauge 1.5-in needle until tendon repair is completed (Fig. 3).

General principles regarding repair

Remember that the extensor tendon becomes increasingly thin, flat and difficult to suture the farther out the tendon is. The extensor tendon has a tendency to scar to the skin and bone so it is important to suture the ends carefully together. The exception to this is the zone I extensor tendon laceration, where one can purposely suture subcutaneous skin and tendon together as a way of encouraging the scarring down of the extensor tendon at the insertion site. As a general rule, repair of a tendon is effected with nonabsorbable 4/0 clear nylon or synthetic braided (e.g., Ticron) suture using a modified Kevlar stitch (Fig. 4). When repairing the tendon be sure that both ends of the tendon touch without puckering up on each other. The purpose of the suture is to keep both ends opposed and not to substitute for the disrupted tendon. Remember that tendon collagen does not begin to form for at least 3 weeks after injury, so immobilize all extensor tendon repairs for at least 3 weeks post repair.

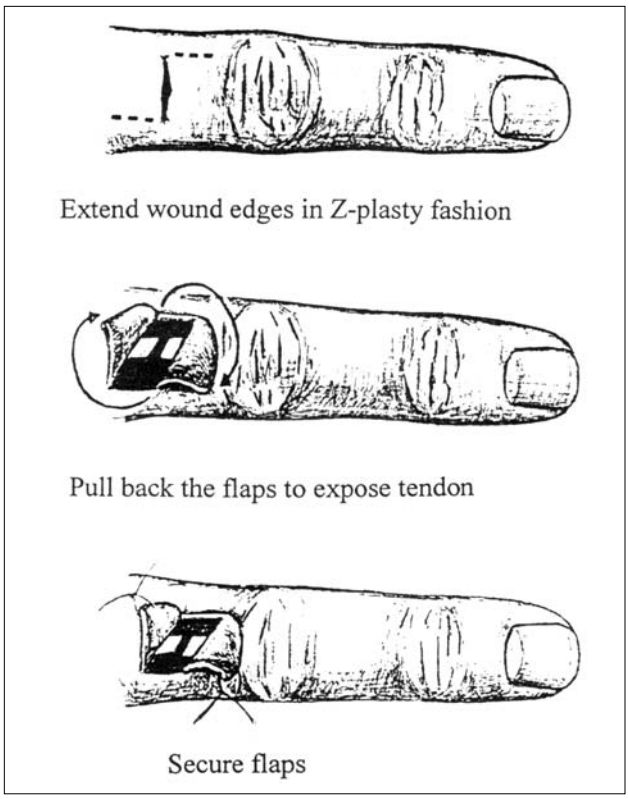

Fig. 3. Open up laceration to expose tendon.

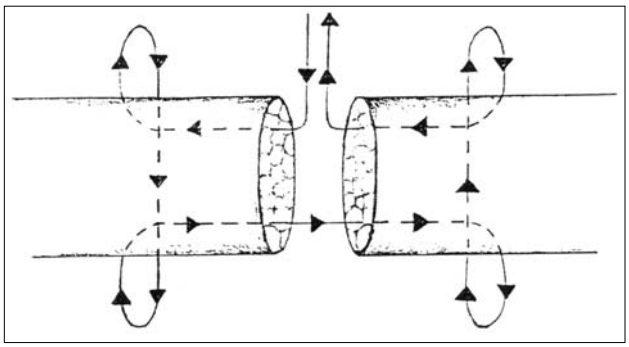

Fig. 4. Modified Kevlar suture technique

Repair technique(s)[1,3,4]

Zone I — mallet finger

Zone I extensor tendon injury manifests itself as a mallet finger deformity; also known as a baseball finger or drop finger (Fig. 5). The DIP joint has a

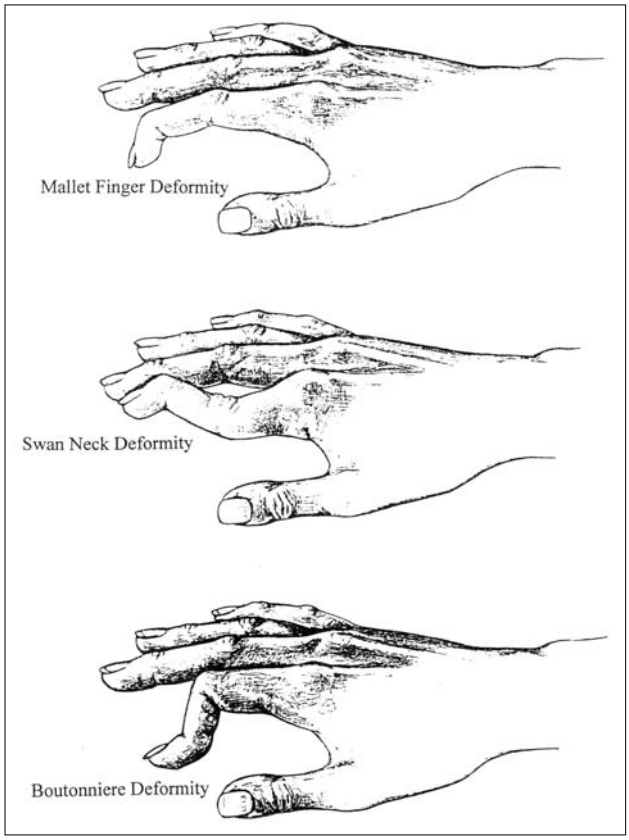

Fig. 5. Acquired finger deformities

flexion deformity, and the patient is unable to extend it when asked to. The basic mechanism underlying a mallet finger deformity is that insertion of the extensor tendon to the base of the terminal phalanx is disrupted. Typically the disruption is the result of sudden, forceful flexion while the digit is in extension — the closed "boink" injury. The deformity can also occur as the result of a laceration or deep abrasion involving the extensor tendon. If a mallet finger deformity is left untreated, the central "slip" often retracts and the lateral bands migrate dorsally, forcing the proximal interphalangeal joint into hyperextension while the DIP joint remains in flexion — a position known as the swan-neck deformity (Fig. 5).

All mallet finger deformities must be x-rayed. Referral for possible open reduction and internal fixation is indicated if

1. greater than 30% of bony surface of the distal phalanx is avulsed;
2. the articular fragment is comminuted;
3. the DIP joint has been subluxed or dislocated and cannot be reduced;
4. in children, if there is transepiphyseal fracture with significant displacement of the distal phalanx fragment — especially palmar displacement; or
5. the abrasion injury is so deep that immediate grafting is necessary.

If less than 30% is avulsed, treat closed mallet fingers by splinting the DIP joint at 0°–15° hyperextension for 8 weeks. After this, the patient is instructed to use the splint when doing heavy lifting or heavy jobs, and at night for another 2–8 weeks. When the splint is off the patient is instructed to do 10 active repetitions of DIP flexion and extension hourly.[3] Lacerations of the extensor tendon, at or proximal to the DIP joint, may be repaired, and then splinted as described above for closed injury.

In children, mallet finger deformities are often associated with transepiphyseal fracture of the distal phalanx. These are best managed by closed reduction to correct deformity and then splinting the DIP joint at 0°–15° hyperextension for 3–4 weeks. If the patient presents with a history of 6 or more weeks of a mallet finger deformity and the DIP joint is not subluxed or dislocated, splint the DIP at 0°–15° hyperextension for 12 weeks and then at night for a few weeks. The patient must be compliant and always keep the DIP joint in extension at all times. Whenever the splint is removed, the involved digit must be held in extension with the thumb; the joint must not be allowed to drop into flexion.

The patient is instructed to mobilize the MCP and proximal interphalangeal (PIP) joints. It is important not to splint the PIP or MCP joints in extension as the lateral bands will shorten, pulling the proximal end of the injured tendon away from its site of insertion.

Zone II — middle phalanx laceration

Most zone II extensor tendon injuries are the result of laceration or crush injuries.

While exploring the wound try to assess whether or not 50% of the tendon width has been cut. If so, suture the tendon and then splint the entire finger in extension for 3 weeks as described for zone I injury. If less than 50% of the tendon width has been cut simply splint for 2 weeks followed by gradually increasing the active range of motion. As with zone I injuries, the patient is instructed to mobilize the MCP and PIP joints.

Zone III — boutonniere deformity

Zone III extensor tendon injury manifests itself as a boutonniere deformity — flexion at the PIP joint and hyperextension at the DIP joint (Fig. 5). The basic mechanism underlying a boutonniere deformity is that insertion of the extensor tendon central slip to the base of the middle phalanx at the PIP joint is disrupted. The PIP joint can no longer be extended, but the DIP can be extended because the lateral bands of the extensor digitorum communis tendon remain intact and continue to insert into the base of the terminal phalanx. Over time, the lateral bands tend to migrate palmarly, which exaggerates the deformity. Once contracture sets in, the deformity is very difficult to correct.

The mechanism of injury can be closed or open and with or without avulsion or bony fragmentation. In closed injuries, the original injury may have occurred 1–2 weeks before development of the deformity.

All boutonniere finger deformities must be x-rayed. Referral for possible open reduction internal fixation is indicated if

1. there is a displaced avulsion fracture at the base of the middle phalanx;
2. there is marked instability of the PIP joint due to more extensive injury;
3. primary repair of the central slip is not possible; or
4. nonoperative treatment fails.

Uncomplicated open injuries are managed by

primarily repairing the injured tendon followed by splinting the PIP joint in extension for 3 weeks. Closed injuries are managed by splinting the PIP in extension for a minimum of 4–6 weeks. There seems to be controversy in the literature with respect to optimal time to immobilize these injuries. In older people, the period of immobilization is decreased to 2–4 weeks to minimize contracture formation. While the PIP is immobilized in neutral position (not hyperextension), all other joints are left free to move. The patient is encouraged to actively and passively flex the DIP joint hourly so as to prevent ligamentous tightness. The MCP and wrist joints are also left free and actively mobilized.

After the splint is removed an exercise program to gradually increase flexion and extension of the PIP joint should be prescribed. A physiotherapist can be consulted on how best to do this. It is recommended that night-time splinting continue for another 4–8 weeks after the continuous splint is removed.

Zone IV — proximal phalanx laceration

Most zone IV extensor tendon injuries are the result of laceration or crush injuries. While exploring the wound try to assess the width of tendon injury. If extension of DIP joints is intact and laceration of tendon appears to be partial, splinting of the interphalangeal joint as per closed zone III extensor injuries is recommended. If there is a complete uncomplicated laceration of the extensor tendon, primary repair with 4–0 nonabsorbable suture is recommended followed by splinting the PIP joint in extension for 3 weeks.

Zone V — metacarpophalangeal (MCP) joint

Zone V extensor tendon injuries are those localized around the MCP joint. They are usually open, and frequently human-bite related. Remember that if the injury occurred with the fist clenched (MCP joint in flexion) the tendon injury will often be proximal to the outer skin injury. If 50% of the tendon width has been cut, repair the tendon primarily. If less than 50% of the tendon width is cut, simply splint. Splinting is for 3 weeks followed by gradually increasing the active range of motion. The wrist and hand should be immobilized and splinted as follows: wrist extended 30°, MCP joint flexed 0°–30°, and both interphalangeal joints of the affected finger extended at 0°.

Zone VI — dorsal hand

Zone VI extensor tendon injuries are located over the dorsum of the hand between the wrist and MCP joint. Remember that significant tendon lacerations may still be associated with normal extension distal to the injury site because of juncturae tendinum extending from adjacent tendons of the extensor digitorum communis muscle. Careful inspection is therefore necessary to detect lacerations in this zone. Manage extensor tendon lacerations as per zone V extensor tendon injuries.

Wound care after repair

Wound care following extensor tendon injury involves closing the wound with sutures, applying topical antibiotic ointment and covering the wound with a simple dressing. The patient should be reminded about the risk of infection and told to return if signs of infection arise — erythema, discharge, pain and swelling. If the wound is the result of a human or animal bite, extensive irrigation and débridement of necrotic tissue is particularly important, and consideration should be given to leaving the wound open. The longer the treatment of a human bite injury is delayed the higher the probability the wound will become infected, and the more certain that one should leave the wound open to heal by secondary intention. Prophylactic antibiotics should be started on all patients with bite wounds and should be considered for all patients who have conditions that increase risk of developing infection (e.g., diabetes, peripheral vascular disease, long-term steroid use, collagen vascular disease, HIV, heavy smoker, alcoholism). A follow-up appointment is organized at 4 weeks — sooner if complications arise. It is important to remind the patient that the hand must be elevated to prevent swelling, which is associated with stiffness and loss of function.

Competing interests: None declared.

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