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Acute tendon injuries in the hand and their management

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Introduction

Acute tendon injuries to the hand are common. In the UK, there are approximately 12 000 inpatient admissions annually for injuries to the tendons and muscles of the hand and wrist (Dew, 2009). Hand injuries involving the dominant hand can cause long-term disability if not appropriately managed. Diagnosis of tendon injuries in the hand relies on careful clinical assessment, particularly if flexor and extensor tendon injuries are not to be missed. This article describes the tendon structure, explains the causes of tendon injury and discusses their assessment and management for a foundation level doctor who will face these injuries regularly whether in primary care or the emergency department.

Tendon structure and physiology

The basic function of a tendon is to carry tensile force from muscle to bone. Tendons contain mainly collagen type I fibrils, fibroblast and proteoglycan matrix, making them strong and flexible. Tendons also have a well-ordered blood supply, which originates from three main sources – vessels in the perimysium, periosteal insertion and the surrounding tissues. In addition, they receive nutrition via diffusion from synovial fluid, produced by the synovial sheath. In the hand, the thumb has one main flexor tendon – the flexor pollicis longus – while each of the other four digits have both a flexor digitorum superficialis and flexor digitorum profundus tendon, although the flexor digitorum superficialis may be congenitally absent in the little finger in approximately 10% of individuals (Townley et al, 2010). After injury, tendons heal by a combination of extrinsic and intrinsic healing. The extrinsic healing response is thought to cause formation of adhesions, which can adversely affect surgical outcome.

Functional biomechanics

The functional biomechanics of the tendon depend on a number of factors that include:

1. An intact pulley system
2. Synovial fluid
3. Flexible joints
4. Tendon movement.

The intact pulley system in the hand is required to allow tendons to glide juxtaposed to the phalanges. Failure of the pulley system could result in bowstringing. Clinically, this may manifest itself as a weakened grip, incomplete flexion and secondary stiffness of the joint.

Studies have shown that the two most important flexor tendon sheath pulleys, arising from the periosteum of the proximal half of the proximal phalanx (A2) and the mid-portion of the middle phalanx (A4), need to be intact to maintain biomechanical efficiency. However, in practice it is not uncommon to vent these pullies (lateral release) to facilitate tendon repair and gliding (Kwai and Elliott, 1998). The synovial fluid provides nutrition and a constant source of lubrication to the tendon. Finally, stiff joints can limit motion and function despite a normal tendon system. When an intact pulley system operates with a flexible and well-lubricated joint, only then can effective tendon movement occur.

Zones

The hand is divided into zones both on the flexor and extensor side. It is important to know the zones of the hand as this

will allow effective communication of the site of injury, especially on referral to the hand surgeon.

Extensor zones

The extensor zones outlined below are illustrated in *Figure 1*.

- Zone I: distal interphalangeal joint
- Zone II: middle phalanx
- Zone III: proximal interphalangeal joint
- Zone IV: proximal phalanx
- Zone V: metacarpophalangeal joint
- Zone VI: dorsum of hand
- Zone VII: wrist
- Zone VIII: dorsal aspect of forearm.

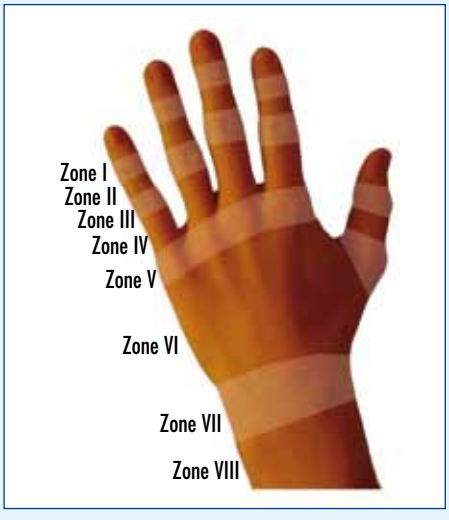
An easy way to remember these is that the odd numbers lie over the joints and the even numbers lie in between.

Flexor zones

The flexor zones of the hand and wrist, as outlined below, are illustrated in *Figure 2*.

- Zone I: bounded proximally by the insertion of the superficialis tendons and distally by the insertion of the flexor digitorum profundus tendon into the distal phalanx
- Zone II: proximal to zone II, the flexor digitorum superficialis tendons lie superficial to the flexor digitorum profundus tendons. Within zone II and at the level of the proximal third of the proximal phalanx, the flexor digitorum superficialis tendons split into two slips, known as Camper chiasma. These slips then divide around the flexor digitorum profundus tendon and reunite on the dorsal aspect of the flexor digitorum profundus, inserting into the distal end of the middle phalanx. The clinical significance of zone II injuries is that both tendons lie in the tight fibro-osseous canal (flexor sheath) making repair difficult and postoperative rehabilitation important in preventing adhesion formation
- Zone III: extends from the distal edge of the carpal ligament to the proximal edge of the A1 pulley (entrance of the tendon sheath). The distal palmar crease superficially marks the termination of zone III and the beginning of zone II
- Zone IV: includes the carpal tunnel and its contents (nine digital flexors and the median nerve)
- Zone V: extends from the origin of the flexor tendons at their respective muscle bellies to the proximal edge of the carpal tunnel.

Figure 1. Extensor zones of the hand, wrist and forearm. There are eight zones, which begin with the dorsal aspect of the distal interphalangeal joint and end with the dorsum of the distal end of the forearm.



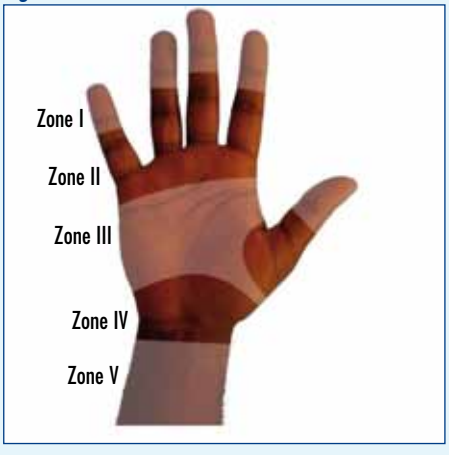
Aetiology and pathophysiology

Open injuries

Lacerations of the hand can result in the disruption of tendons leading to a complete or partial laceration of the tendon.

Clenched fist injuries to the mouth ('fight bite') are common presentations of open injuries. Treating these as minor injuries without recognizing the potential for oral bacterial contamination can result in significant morbidity. They should be considered to be an open wound and treated in line with the hospital's policy of antibiotics in open injuries (commonly co-amoxiclav orally or intravenously depending on the severity of injury) (Perron et al, 2002). In addition to the extensor tendon injuries commonly occurring with a human bite over the metacarpophalangeal joint (zone V), a patient may sustain injury to the joint itself, a fracture to the head or neck of the metacarpal (boxer's fracture), a chondral injury or even introduction of a foreign body, e.g. tooth.

Figure 2. Flexor zones of the hand and wrist.



In deep lacerations there may be tendon exposure and associated swelling where any neurovascular compromise must be identified. On examination, one may find that the digit involved will assume an abnormal posture while the wrist is in a neutral position.

Any suspicions of a breach of the joint capsule, such as deep wound or gas present on X-ray, mandates operative exploration and washout to prevent septic arthritis.

Closed injuries

The most common closed tendon injury to the finger is the mallet finger injury (*Figure 3*). It occurs from a sudden flexion of the distal interphalangeal joint of the finger, where the extensor tendon is either forcibly stretched (soft tissue) or avulsed from the tendon's insertion at the dorsal lip of the distal phalanx base (bony). This injury is common in sporting activities such as basketball, volleyball or rugby, when the ball hits the finger directly at the tip, causing a forced flexion.

Closed injuries are also commonly related to forced extension during active flexion of the finger or vice versa. This can result in an avulsion injury. An example of a flexor tendon injury is an avulsion of the flexor digitorum profundus from its insertion at the distal phalanx, resulting in a loss of distal interphalangeal joint flexion: this is called 'jersey finger'. This most commonly affects the ring finger. Furthermore, a closed injury that should not be missed is a rupture of the central slip of the extensor tendon. Closed rupture of the central slip

Figure 3. Extensor tendon rupture (mallet finger).

of the extensor tendon hood of the finger, if missed at the initial examination, can later present as a buttonhole deformity (boutonniere deformity). The Elson test is performed to assess the integrity of the central slip. The finger being examined is flexed at 90° and the patient is asked to extend at the proximal interphalangeal joint against resistance (Elson, 1986). Any pressure felt by the clinician through extension of the middle phalanx can only be achieved by an intact central slip.

Assessment and diagnosis

As a junior doctor it is imperative that, before referral of the patient to the plastic or hand surgeon, a complete history and clinical examination is undertaken and clearly documented.

History

The most common presentation for tendon injuries of the hand is loss of function, which can be associated with stiffness and pain. In addition there are several other key aspects to the history of any tendon injury such as inquiring about hand dominance, profession and hobbies, which will enable the doctor to quantify the functional severity of the injury. This may also contribute to the decision making regarding the further management necessary for the patient.

Knowledge of the mechanism of injury may aid in the diagnosis, specifically in traumatic cases. In general, the force applied by trauma can be axial compression, torsion (twisting), crush (transverse compression), bending or a combination of forces. It is important to understand the position of the finger and hand at the time of injury. Structures within the hand slide with movement. The part of the tendon under a bruise or laceration during examination may not be the same part present during the injury. For example, an injury sustained where an object being gripped is forcefully removed from the holder may result in a flexor tendon injury. Alternatively, a violent crushing force, such as the impact of a punch, will likely involve an injury to the extensor compartment.

If faced with an open injury, it is crucial to ask about the patient's tetanus status, and if it is not up-to-date, then a risk assessment needs to be carried out to see if a tetanus booster is needed.

Other relevant aspects of the history include: past medical history (diabetes, vascular disease and although rare, connective tissue disease such as Marfan's syndrome may be significant), past surgical history (including previous hand trauma and surgical procedures), medication history (specifically patients on steroids or immunosuppressant medication), allergies and the patient's social history (including smoking, alcohol intake, job and independence of activities of daily living).

Examination

Inspection

Inspect the site of injury, noting bruising, swelling, erythema, foreign bodies and joint deformity. In addition, note other skin and nail changes, muscle wasting and other signs of chronic or systemic disease. Also inspect for any surgical or non-surgical scars. The examiner needs to look for any lacerations, and if present, the hand is best examined in the resting position as this will guide to the diagnosis as well as indicate which structure is likely to be involved in this injury. As with any joint or limb exam it is helpful to compare the affected with the non-affected side.

Palpate

Feel the skin, which may be warm or hot, indicating inflammation or infection, or cold, possibly indicating neurovascular compromise. Palpate along the joints and the flexor tendon sheath, feeling for deformities and tenderness. Synovial swelling can be detected using the Savill pinch test: in normal conditions when you pinch the skin at the palmar aspect of the proximal phalanx, it feels lax and can be pinched. However, in synovitis it is firm and tense.

Movement

Movement should be assessed at each joint involved with the injury, which may include each joint from the distal interphalangeal joint to the wrist. Assess active and passive movement at each joint, followed by a test of fine motor skills using a pinch test, and a grip test to assess strength.

Specific tendon assessment

Tendons should be tested in isolation, with awareness that partial division may weaken the tendon without complete loss of function. If flexion or extension against resistance is present but painful, a partial tendon injury should be suspected. Three common tendon injuries are highlighted in *Table 1*.

Examination of the flexor tendons should be performed with and without resistance. Examination of the specific flexor tendons is as follows:

- Flexor pollicis longus: instruct the patient to bend the tip of the thumb against resistance, with the proximal phalanx being held stable
- Flexor digitorum profundus: while fixing the proximal interphalangeal joint (e.g. dorsum of the fingers against a flat table) ask the patient to actively flex at

Table 1. Common tendon injuries in the finger

Injury	Examination	Deformity	Treatment
Central slip extensor tendon injury	Tender at dorsal aspect of the proximal interphalangeal joint (middle phalanx). Inability to actively extend the proximal interphalangeal joint	May cause a boutonniere deformity over time	Splint the proximal interphalangeal joint in full extension for 6 weeks
Extensor tendon injury at the distal interphalangeal joint	Tender at dorsal aspect of the distal interphalangeal joint. No active extension of the distal interphalangeal joint	Mallet finger	Splint the distal interphalangeal joint continuously for 12 weeks
Flexor digitorum profundus tendon injury	Tender at volar aspect of the distal interphalangeal joint. Inability to flex the distal interphalangeal joint. Distal interphalangeal joint should be isolated during the examination	Jersey finger	Splint finger and refer to orthopaedic or plastic hand surgeon

Modified from Leggit and Meko (2006)

the distal interphalangeal joint while pressing down onto the middle phalanx (*Figure 4*)

- Flexor digitorum superficialis: while holding the metacarpophalangeal and proximal interphalangeal joints of the other fingers in extension, instruct the patient to flex at the proximal interphalangeal joint of the injured finger
- Palpate the tendons of flexor carpi ulnaris, flexor carpi radialis and palmaris longus (which is not present in about 15% of individuals) while the patient holds the wrist and fingers in hyperflexion
- If pain or weakness is present on resisted proximal interphalangeal or distal interphalangeal joint flexion, the suspicion of a partial flexor tendon injury should be raised
- Extensor pollicis longus mainly extends the thumb. The tendon is intact if the patient is able to lift his/her thumb while his/her palm is flat on the table.

If a laceration of a tendon is present, one should be wary of muscle contraction that can pull the tendon away from the site of injury. Owing to the superficial nature of extensor tendons, any dorsal laceration of the hand should be assumed to involve partial or complete tendon laceration until proven otherwise.

All the above injuries should be referred to a specialist hand surgeon and will invariably need input from the hand therapy unit. They should not be treated by the emergency physician in accident and emergency.

Neurovascular examination

It is vital to exclude neurovascular compromise in any hand injury. This can be done by feeling the temperature of the skin and testing capillary refill, as well as simple sensory testing.

Figure 4. Assessment of flexor digitorum profundus.

Imaging studies

First-line imaging will consist of lateral, anteroposterior and oblique radiographs, with the aim of detecting fractures and the presence of foreign bodies. Ultrasound and magnetic resonance may be used during specialist investigation (Bodner et al, 1999).

Management

Conservative adjuncts

All patients should have wounds cleaned, betadine gauze and a non-adherent dressing applied with a simple resting splint in position of safe function, followed by a referral to the hand surgeon. Flexor digitorum profundus avulsions need surgical exploration and repair in nearly all cases.

Surgery and rehabilitation

Closed tendon injuries of the hand need to be assessed in a timely manner and should be reviewed by the specialist team within 24 hours of presentation. It is not uncommon for patients to present in a delayed manner which can complicate the treatment options and the success of the functional outcome. Delayed primary repair of a tendon should be performed within 3 weeks of injury, as further delay may prevent end-to-end repair because of degeneration of the tendon ends and myostatic contraction of the injured muscle. Tendon grafting or tendon transfers may need to be considered in late presentation of tendon injuries that require operative intervention.

Owing to risks of infection, open injuries should be reviewed and assessed by the hand specialist within 24 hours.

The surgical management of flexor tendon injuries is dependent on the nature of the injury and the zone where the injury has taken place. For example, a zone II injury involving the flexor tendon would include both the flexor digitorum superficialis and flexor digitorum profundus (as they are both in the same tendon sheath). These would be repaired directly with early protected mobilization to avoid adhesions. Injuries to zone III (palm) and zone V (wrist) are often associated with nerve injuries which affect prognosis. However, the tendon repairs in these zones tend to carry a good outcome. Zone IV (carpal tunnel) injuries may be complicated by postoperative adhesions.

The indications for extensor tendon repair includes a laceration greater than 50%, and tendon lacerations less than 50% with decreased strength and a tendon injury associated with significant skin loss or bony fracture. However, extensor tendon repair should not be attempted in the emergency department or acute care setting if no skilled surgeon is present, if the injury is contaminated (particularly in 'fight bite' injuries) or in the presence of bony injury.

Once the decision has been made to repair a lacerated tendon surgically, it is important for the surgeon performing the operation to fully explain the risks. Operative treatment carries risk of deep infection (1%), fistula (3%), skin necrosis (2%) and re-rupture (2%) (Kingsnorth and Majid, 2006).

Operative repair involves complete exposure of the ruptured tendon. A separate incision may be required to retrieve the more proximal tendon end. The most important aspects of repair are type and calibre of suture used, the number of strands of the core suture and the epitendinous suture. It is important to handle the injured tendon minimally and to perform a smooth repair to facilitate gliding.

Strength of a tendon repair is proportional to the number of core suture strands crossing the repair site. The types and techniques of suture placement are controversial and tend to depend on the surgeon's preference. The ideal suture material is one that is non-reactive, strong, easy to use, small in size and maintains a good knot. An epitendinous suture is used to add up to 50% to the strength of the repair. It also tidies the repair edges, thus decreasing adhesion formation, and reduces the gap at the tendon ends.

Rehabilitation can take up to 6 months, while the scar tissue matures and the tendon repair is thought to be solid. This timeline applies to both central slip injuries (where the proximal interphalangeal joint is placed in a splint in full extension for 6 weeks) and a mallet finger injury (where the distal interphalangeal joint is placed in a splint for 12 weeks). There are several rehabilitation protocols described: a common programme for flexor injuries involves immediate, controlled passive immobilization for 4 weeks followed by a combination of passive and active exercises for 2 weeks,

and active flexion and extension thereafter. Adhesions are greater in immobilized fingers post repair, and motion increases the tensile strength and gliding function of the tendon. It is important to note that the tendon repair is at its weakest at 10–12 days postoperatively.

In specific situations, a staged tendon reconstruction is indicated. This is most commonly following an avulsion or degloving injury to the hand or wrist, with associated tendon and soft tissue loss. Initial treatment consists of debridement of devitalized and contaminated tissues, followed by thorough irrigation. Stabilization of fractures, if present, also need to be considered. Given that primary repair of tendon injuries is often not possible, silicone rods attached to the tendon stumps can act as a temporary measure at the time of soft tissue coverage. Secondary grafting can be performed, typically 3 months later.

The patient is followed up regularly in the outpatient clinic after any tendon repair, to ensure that contracture of the digit does not occur. This process is a multidisciplinary one which involves not only the surgeon, but hand therapists, occupational therapists, GPs and occasionally psychologists for patients with severe disabling hand injuries.

Conclusions

It is essential to identify hand and tendon injuries accurately when the patient presents in order to provide the correct short- to medium-term management for these injuries. Failure to do this could lead to long-term detrimental effects on the patient's quality of life. This article has discussed the causes of tendon injury, the importance of a sound history and an examination that takes into account the various tendon injuries.

Management within the accident and emergency setting should include plain radiographs and conservative management using splints. Further specialist input should be sought for all but the most minor injuries as the consequences of misdiagnosis or mismanagement can be devastating to the patient. BJHM

KEY POINTS

- Tendon injuries to the hand and wrist are common and are important – they must not be missed by doctors at presentation.
- The keys to diagnosis are a good working knowledge of functional anatomy, a thorough history and examination including specific tendons, and appropriate referral for specialist input.
- The management of tendon injuries ranges from conservative adjuncts to specialized surgery and rehabilitation.
- Failure to expediently diagnose and manage such injuries, especially in the dominant hand, can lead to functional disability for the patient.

Table 1 *is modified from Leggit and Meko (2006) by kind permission of the American Academy of Family Physicians.*

Conflict of interest: none.

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