

Principles of tendon repair

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Abstract

Tendon injuries in the hand are common; they are usually open injuries requiring surgical intervention. In this article we discuss tendon injuries in terms of approach to repair beginning at the time of diagnosis through to the rehabilitation programmes and outcome measures commonly used in the UK. In general tendon injuries should be considered using Verdan's zones for both extensor and flexor injuries. Flexor tendons require a high strength repair and usually warrant a core suture with epitendinous reinforcement bearing in mind the importance of not disrupting glide with unnecessary suture bulk. Extensor tendons more proximally can be treated in the same way but distally require only a running suture in the flattened tendon ends. All tendon injuries require a period of protected mobilization with splinting aiming to protect the repair but reduce stiffness in other joints.

Keywords Core; extensor; flexor; hand; repair; tendon

Aetiology and epidemiology

In a Danish study reviewing 50,272 injured people, 28.6% of individuals had sustained a hand injury¹ and on average, between 14 and 30% of all treated patients in emergency care attend as a result of a hand injury. Tendon injuries account for 29% of all hand injuries and despite a change in society from an industry-based to a service-based economy, they have not decreased in frequency over recent years possibly as a result of an increase in sports activities and do-it-yourself (DIY) work.²

Injury pattern and diagnosis

Most injuries are open and require primary surgical treatment for exploration, lavage and repair of damaged tendons where indicated. Closed tendon injuries are also quite common and include specifically: mallet fingers, Boutonnière deformities and avulsions. In general a tendon injury to the hand is reported as open or closed, sharp or blunt, and traumatic or degenerative as well as defining whether the extensor or flexor tendons are involved.

Diagnosis

Open injuries warrant exploration to obtain diagnosis; closed injuries require more careful consideration. Clinical examination

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of the hand should include testing each individual extensor tendon including extensor digitorum communis (EDC) to each finger and consideration of extensor pollicis brevis and longus (EPB/EPL) and extensor indices and extensor digiti minimi (absent in 54–56% of hands). Flexor tendons for each digit should be tested isolating flexor digitorum superficialis and profundus (FDS/FDP) individually and testing flexor pollicis longus (FPL) in the thumb. [Figure 1](#) demonstrates the tendon zones as first described by Verdan.

When movement is present but painful this can indicate a partial tendon injury that warrants exploration.

In closed injuries, the level of injury can be difficult to locate and the position of the two tendon ends is not always obvious. In this setting, prior to surgery, ultrasound scanning is the most useful diagnostic tool. Ultrasound provides assessment of the tendon injury dynamically, measurement of the gap between the tendon ends and identification of pulley lesions and inflammatory processes.³ With open injuries, ultrasound scanning can be used to locate the proximal end of the tendon, this should only be done if it will not cause a delay to theatre.

Management of tendon injuries

Open injuries

All open injuries should be thoroughly lavaged and explored to identify tendons and other structures, that is, neurovascular bundles in the zone of injury which require repair.

For palmar injuries, a safe approach is to begin at the wound and expose further with a Bruner or mid-lateral based exposure of the zone of injury ([Figure 2](#)). In dorsal wounds, various extensions to assess the zone of injury are possible, however exposure must not compromise large skin flaps and distal compromise should be avoided.

Closed injuries

Conservative management: closed injuries should be considered on a case-by-case basis with the function of the hand and the demands of the patient of paramount importance. There are instances where an isolated tendon rupture in this setting causes minimal disruption for the patient and surgical intervention increases the risk of significant deficit. An example of this is the elderly patient with dementia in whom splinting will be distressing and adherence to a rehabilitation regime will be challenging.

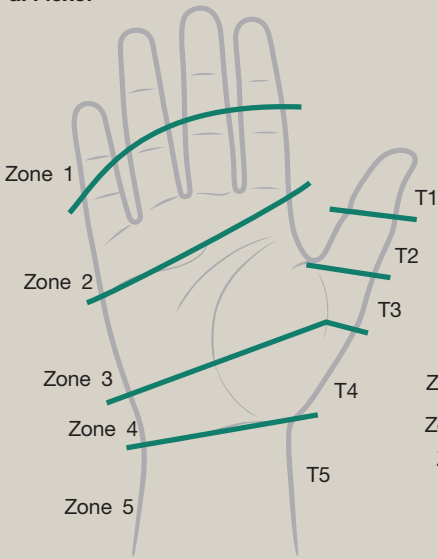
In particular; closed FDP ruptures with delayed presentation can, on occasion, be managed conservatively following a detailed discussion with the patient regarding the merits of extensive surgery and rehabilitation to gain flexion of the distal interphalangeal joint (DIPJ). Again, in this setting the patient's occupation and interests must be taken into account.

General considerations: results are better when repairs are done within the first few days of injury. Delay to surgery potentially results in the need for secondary repair or tendon grafting which ultimately have poorer functional outcomes.

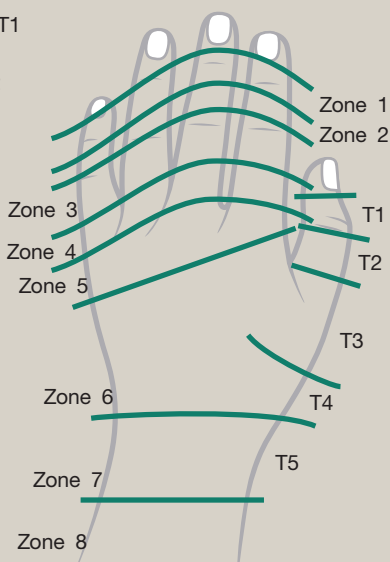
Minimal handling of tendon ends reduces the risk of vascular compromise from crushing longitudinal vessels that enter the tendon in the palm at the level of the proximal synovial fold, the

Flexor and extensor tendon zones

a. Flexor



b. Extensor



Flexor	
Zone	Description
1	Distal to FDS insertion
2	Between proximal flexor sheath and FDS insertion
3	Between distal flexor retinaculum and proximal flexor sheath
4	Under the flexor retinaculum
5	Proximal to the flexor retinaculum
T1	Distal to IPJ
T2	From A1 pulley to IPJ
T3	In the thenar eminence
T4/T5	As for fingers
Extensor	
Zone	Description
1	Over DIPJ
2	Between PIPJ and DIPJ
3	Over PIPJ
4	Between MCPJ and PIPJ
5	Over MCPJ
6	Between MCPJ and extensor retinaculum
7	Under the extensor retinaculum
8	Between the extensor retinaculum and musculotendinous junction
T1	Over IPJ
T2	Over proximal phalanx
T3	Over MCPJ
T4	Between MCPJ and extensor retinaculum
T5	Under the extensor retinaculum

DIPJ, distal interphalangeal joint; FDS, flexor digitorum superficialis; IPJ, interphalangeal joint; MCPJ, metacarpophalangeal joint; PIPJ, proximal interphalangeal joint.

Figure 1

segmental branches or from paired arteries entering the tendon sheaths via the long and short vincula at the osseous insertions.

Gauge of suture affects the strength of repair: the use of 3-0 Dacron sutures increased fatigue strength at least -2 fold when compared to 4-0;⁴ also increased repair strength has been shown progressively through 5-0 to 2-0 calibre sutures.⁵ The number of strands crossing the repair also affects strength; four strands crossing the repair are better than two. The use of an epitendinous suture (which will be discussed later in more depth) also increases repair strength. The use of a 'locking' configuration of suture repair, also increases strength of repair by minimizing suture pull out.

The principle of a 'locking' configuration suture is commonly misunderstood. It does not refer to a suture configuration which once placed cannot be adjusted. It indicates that when tension is applied to both ends of the suture crossing the injury (as would happen during flexion) a portion of the cross-section of the tendon is locked within the repair preventing cheese wiring. See [Figure 3](#) for clarification.

As well as strength of repair, the ease of the tendon glide should be considered. Excessive suture bulk and gapping in the repair should be avoided; a 2-mm gap increases resistance to glide and a 3-mm gap is unlikely to pass the A2 pulley without rupture.

Flexor tendon injuries

Zone 1: zone 1 (distal to FDS insertion) injuries are by definition FDP injuries. The FDP tendon can be avulsed from its bony attachment. This injury is sometimes referred to as a 'rugger jersey finger' as the injury is sustained during forced hyperextension when a player grabs the shirt of another. The ring finger FDP is most commonly affected as it is the longest flexed finger.

The Ledy and Packer classification is used for FDP injuries; in terms of clinical relevance it is useful for considering the type of repair required, as follows.

- Type I: tendon retracts into the palm: rupture of both vincula.
- Type II: tendon retracts to proximal interphalangeal joint (PIPJ): long vinculum intact.
- Type III: a large bony fragment avulsed with the tendon prevents retraction beyond the A4 pulley.

In types I and II the FDP tendon should be repaired if there is less than 50% of the cross section of the tendon intact. In injuries less than this, triggering can occur and the damaged tendon may need trimming to prevent this.

There are different approaches to tendon repairs in this zone; if disrupted, the 'back wall' can be repaired first with an epitendinous 5-0 non-absorbable suture. In general, a round-bodied suture needle is less likely to cut out in the process of

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