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REVIEW

Zone 1 flexor tendon injuries: A review of the current treatment options for acute injuries



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Summary Zone 1 flexor tendon avulsion and laceration injuries are commonly managed by plastic surgeons. These injuries are traditionally repaired using the button pullout technique originally described by Bunnell in 1940. The morbidity related to this method is well documented and this has led to the development of alternative repair methods. These include modifications of the pullout button technique, internal suture techniques and more recently techniques using bone anchors. However, at present no one technique has been shown to be superior to the others either in terms of outcome or low complication rates. This review examines the published techniques for dealing with these injuries with a view to providing the reader with the available outcome data for each repair type.

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Anatomy and classification

Zone 1 flexor tendon injuries affect the flexor digitorum profundus tendon (FDP) distal to the insertion of the superficialis tendon. They are a relatively common condition and occur predominantly in young adults. The mechanisms of injury are usually lacerations or closed avulsions, with the latter occurring as a result of a forced extension to the distal phalanx of a finger that is actively flexing.¹ The

degree to which the proximal tendon retracts determines the classification and this in turn influences the management options. Other key factors include the presence of an associated distal phalanx fracture, the delay to treatment and the vascularity of the tendon.^{2,3} The avulsion injuries occur most commonly in the ring finger and a number of theories have been postulated to explain this. In a cadaveric study, Manske and Lester demonstrated the insertion of the ring FDP was significantly weaker than that of the middle finger.⁴ Bynum and Gilbert showed the ring finger was the most prominent digit during flexion and thus experienced the most force during pull-away testing.⁵

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The most widely used classification system for describing avulsion injuries is that of Leddy and Packer, which has been modified to incorporate specific injury subtypes.⁶ In type 1 injuries the proximal stump of the FDP retracts into the palm resulting in partial devascularisation of the tendon. The collapsed sheath fills with haematoma leading fibrosis and the muscle belly is prone to developing a myostatic contracture preventing tendon stump advancement¹ (Figure 1).

In type 2 avulsions the tendon retracts to the level of the proximal interphalangeal joint (PIPJ) with or without a small avulsion fracture. These are the most common type of avulsion injuries and repair can be attempted up to three months after the injury with good results.^{7–9}

Type 3 injuries are characterized by a large bony avulsion fragment that prevents the tendon retracting beyond the distal edge of the A4 pulley.¹⁰ In type 4 injuries there is a simultaneous avulsion fracture along with an associated avulsion of the tendon from the bony fragment.¹¹ Type 5 injuries are characterised by a distal phalanx fracture along with avulsion of the FDP.¹²

Moimen and Elliot have classified laceration injuries of zone 1 into 3 distinct subgroups. Group 1a represent lacerations distal to the A5 pulley where it is impossible to place a core suture. Zone 1b represent injuries between the distal edge of the A4 pulley and zone 1a. Lastly, those injuries beneath the A4 pulley are classes as zone 1c.¹³ Thus, zones 1b and c can be repaired using conventional tendon repair techniques, whereas zone 1a is treated in the same manner as the avulsion injuries.^{7,14} Furthermore as with the avulsion injuries the management of the lacerated FDP can be complicated by an associated distal phalangeal fracture.

Treatment options

The treatment of these injuries is challenging and the outcomes so far have not been as satisfactory as those of

other tendon injuries. In a recent paper by Moimen et al. only 50% of patients achieved good or excellent outcomes following repair.^{13,15} The decision on whether to operate needs to take into account the chronicity of the injury, the size of the bone fragment, the type of avulsion and associated injuries. Fortunately, in the majority of cases a direct repair can be attempted using a variety of techniques described in the literature. The ideal repair should be able to withstand the stresses encountered during the rehabilitation phase and leave the digit free from flexion contracture. At present, no one technique has been shown to be superior to the others in terms of outcome and complication rates. The aim of this review is to focus on the published techniques for dealing with Types 1 and 2 distal FDP injuries which form the majority of cases with a view to providing the reader with the available outcome data for each repair type.

In cases where the tendon cannot be retrieved or there is greater than 1 cm tendon loss there are a number of treatment options. The patient can be offered joint fusion as an immediate or delayed procedure if the distal interphalangeal joint (DIPJ) becomes unstable. If the pulley system is intact there is the option of primary tendon graft or in the case of pulley disruption a two-stage reconstruction addressing both the tendon and pulley system.^{1,8} These injuries are difficult to treat and a comprehensive discussion with the patient on rehabilitation and likely outcomes should precede any treatment.

Patients with zone 1 flexor tendon injuries can be treated using either internal or external fixation techniques. The external button pullout technique originally described by Bunnell in 1940 is still widely used.¹ However, there has been an increasing trend in the literature towards internal fixation in order to avoid some of the complications associated with the external button technique. The various repair techniques are illustrated in Figures 2–4 with the outcomes summarized in Table 1.

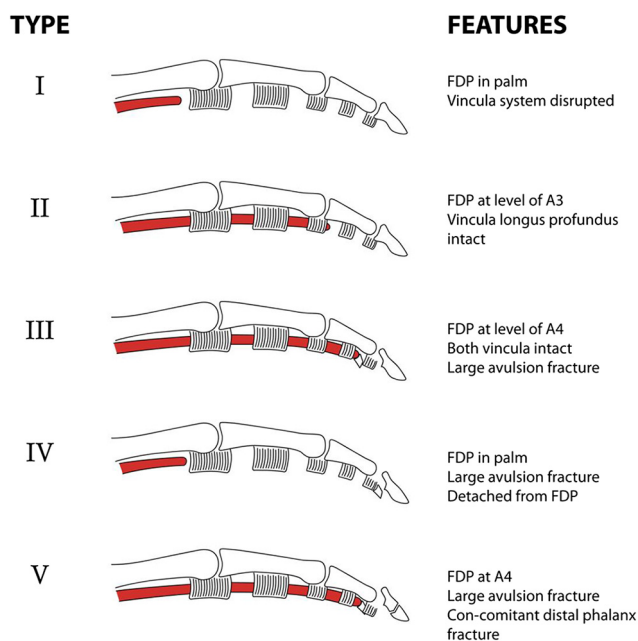


Figure 1 Classification of zone 1 flexor digitorum profundus avulsion injuries.

External fixation techniques

The original Bunnell technique used a stainless steel suture that was tied over a thicker piece of wire externally. This was modified by Littler where the steel suture was tied over a button placed over the nail plate. Further modifications include replacing the steel suture with monofilament sutures and using different suture configurations.^{1,16} Since the suture is externalized and must be removed, these techniques rely on non-locking suture techniques (e.g. Bunnell or Kessler) that are biomechanically weaker compared to locking sutures and this is one disadvantage of the pullout technique.^{17,18} The suture type also plays a role in the strength of the repair with ethibond being shown to have significantly greater pullout strength (44.9 N vs 37.6 N) and less gapping (1.7 mm vs 6.8 mm) compared to the monofilament prolene sutures.¹⁹ Furthermore, Silva et al. attributed some of the gapping seen with the pullout technique to the increased length of suture between the tendon stump and the point of fixation externally.²⁰ This phenomenon may in part explain why the outcomes in zone 1 repairs are often suboptimal, with some studies reporting good outcomes in only 50% of patients (Figure 2).¹³

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