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REVIEW

Current concepts: mallet finger

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Abstract Loss of the extensor mechanism at the distal interphalangeal (DIP) joint leads to mallet finger also known as baseball finger or drop finger. This can be secondary to tendon substance disruption or to a bony avulsion. Soft tissue mallet finger is the result of a rupture of the extensor tendon in Zone 1, and a bony mallet finger is the result of an avulsion of the extensor tendon from the distal phalanx with a small fragment of bone attached to the avulsed tendon. Mallet finger leads to an imbalance in the distribution of the extensor force between the proximal interphalangeal (PIP) and DIP joints. If left untreated, mallet finger leads to a swan neck deformity from PIP joint hyper extension and DIP joint flexion. Most mallet finger injuries can be managed non-surgically, but occasionally surgery is recommended for either an acute or a chronic mallet finger or for salvage of failed prior treatment.

Keywords Mallet finger · Bony mallet finger · Soft tissue mallet finger

Injury to the extensor mechanism at the distal interphalangeal (DIP) joint can lead to mallet finger also known as “baseball finger” or “drop finger.” This can be secondary to tendon substance disruption or to a bony avulsion. Soft tissue mallet finger is the result of rupture of the extensor tendon in Zone 1, and a bony mallet finger is the result of an avulsion of the extensor tendon from the distal phalanx with a small fragment of bone attached to the avulsed tendon (Fig. 1). Mallet finger leads to an imbalance in the distribution of the extensor force between proximal interphalangeal (PIP) and DIP joints. If left untreated, mallet finger can lead to a swan neck deformity from PIP joint hyper extension and DIP joint flexion. Most mallet finger injuries can be managed non-surgically, but occasionally surgery is recommended for either an acute or a chronic mallet finger or for salvage of failed prior treatment. This paper will review the current treatment guidelines for the surgical and non-surgical management of mallet finger.

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Incidence

The incidence of bony mallet finger is well reported in the literature [7], but there is no published data regarding the incidence of soft tissue mallet finger. Mallet finger injuries are most commonly seen in young and middle aged male patients. The mean age for males is 34 compared with 41 in females. Seventy-four percent of bony mallet finger injuries involves the dominant hand, and more than 90 % of injuries was found in the ulnar 3 digits [51]. Schweitzer and Rayan determined in a kinematic study of the terminal extensor mechanism that the long finger is at greatest risk for mallet deformity; this was based on its significant increased flexion deformity of the DIP joint with each one millimeter increase in length of the terminal tendon. As little as 1 mm of terminal tendon lengthening resulted in −25° of DIP joint extension lag. This means adjusting exact tension during surgical intervention is crucial for preventing mallet deformities.[40]. Jones et al. did an epidemiological study of 24 members of a family over three generations and proposed a familial predisposition to develop the mallet finger deformity [20].

Fig. 1 Lateral of small finger bony mallet with minimally displaced small osseous fragment

Mechanism of Injury

The most common mechanism of injury in mallet finger is a sudden flexion of the DIP joint with the resistance force directed along the long axis of the finger [43]. This leads to terminal extensor tendon tear or tendon avulsion with a bony fragment. In athletes, it is commonly seen with a forceful blow to the tip of the finger causing sudden flexion. Baseball players typically present to their provider with the diagnosis of a “jammed” finger [6, 51]. Open injuries are caused by a laceration, crush, or deep abrasion. DIP joint hyperextension can cause mallet finger secondary to a dorsal lip fracture as the hyperextended distal phalanx impacts on the head of the middle phalanx [26].

Classification

Patel and Gerberman defined acute mallet fingers as those presenting within 4 weeks of injury and chronic mallet fingers as those presenting after 4 weeks of injury. Several classification systems have been described for mallet fingers [13, 37].

The most widely recognized classification system for bony mallet finger is the Wehbe and Schneider classification system [51]. They divided the mallet fractures into three types and each type is subdivided into three subtypes depending on the degree of articular involvement. Wehbe and Schneider recommend operative treatment for type II subtypes B and C given its degree of articular involvement. However, except for irreducible injuries, results from Wehbe and Schneider demonstrated that surgical versus non-surgical treatment did not influence final results (Table 1).

Doyle proposed a classification for soft tissue and bony mallet fingers based on the mechanism of injury [11]. Type I is a closed trauma resulting in a tendon avulsion with or without a small fracture fragment, Type II is an open laceration with tendon discontinuity, Type III is a deep abrasion with loss of tendon continuity, and Type IV mallet finger includes three subtypes: A—trans epiphyseal fracture, B—hyper flexion injury with 20–50 % articular involvement, and C—hyper extension injury with more than 50 % articular involvement.

Treatment

There are several treatment options for mallet finger. Many splint configurations and surgical techniques have been described over the past several decades. However, the optimal treatment of each type of mallet finger injury remains controversial. Splinting is the most common initial treatment method for soft tissue or bony mallet finger. Regardless of the treatment option, common sequelae include a slight extensor lag and a prominent bump on the dorsum of the finger [6].

A mallet finger treatment outcome assessment classification was proposed by Crawford [8]. It is the most commonly used classification for outcome assessment after mallet finger. An excellent outcome is no pain with full range of motion at the DIP joint, less than 10-degree extension deficit is a good outcome, 10–25 degrees of extension deficit with no pain is a fair outcome, and more than 25 degrees of extension deficit or persistent pain is considered a poor outcome.

Most surgeons believe closed/non-operative treatment using splints produces satisfactory results for tendon avulsions without fracture and minimally displaced or small fractures [19, 34]. Makhlouf and Deek have considered surgery when splinting cannot correct acute deformities; however, we will review the present literature for acute open and chronic deformities.[31].

Table 1 Wehbe and Schneider classification

Types	
1.	No DIP joint subluxation
2.	DIP joint subluxation
3.	Epiphyseal and physeal injuries
Subtypes	
1.	Less than 1/3 of articular surface involvement
2.	1/3 to 2/3 of articular surface involvement
3.	More than 2/3 of articular surface involvement

Acute Mallet Finger

The authors feel non-operative management of mallet finger is indicated in cases of all soft tissue mallets and bony mallets which are well reduced in a splint without DIP joint subluxation. Immobilization of both the PIP and DIP joints was previously thought to be necessary to relax the extensor hood and intrinsic musculature during terminal extensor tendon healing. Katzman et al performed a cadaveric study to determine whether PIP joint motion would cause a tendon gap at the immobilized DIP joint. They demonstrated that gapping of a disrupted terminal extensor tendon occurred as a result of excursion of the distal tendon stump during DIP joint flexion, not because of retraction of the proximal portion of the tendon with simulated PIP joint extension. They concluded that only the DIP joint need be immobilized in extension to allow healing of the mallet injury. Most authors currently advocate immobilization of the DIP joint alone [23].

Splinting

There are many variations in the design of splints, but the principle is the same (Fig. 2). All mallet finger splints are designed to maintain full extension or slight hyperextension at the DIP joint. Commonly used splints are plastic stack splints, thermoplastic, and aluminum form splints. The authors recommend full time splinting for 6 weeks, followed by 2–6 weeks of splinting at night (Fig. 3). The splint should be used continuously and the DIP joint should be maintained in full extension even during skin hygiene care [13, 14]. Patients should be instructed on how to change the splint for periodic cleaning and examination of the skin without allowing the DIP joint to flex. Neglecting a mallet injury or incorrect treatment can lead to DIP joint dysfunction. 1 mm lengthening of the terminal extensor tendon results in 25 degrees of extension lag, and a shortening of 1 mm will seriously restrict DIP joint flexion [40].

Okafor et al reported on 31 patients treated conservatively using splints with 5-year mean follow-up and found high patient satisfaction despite an average 8-degree extension lag [36]. Gerberman et al showed that even delayed splinting of a mallet finger at an average of 53 days from injury resulted in a successful outcome with or without the presence of a small fracture defined as <30 % of articular surface. O'Farrell et al. described a sterile intra-operative splint system for surgeons to maintain and perform surgeries [35].

Fig. 2 Assorted splints utilized for non-operative treatment of mallet finger

There are several studies comparing mallet finger splints. Perforated splints are better tolerated than solid stack splints [24]. Aluminum-alloy malleable splints are associated with more skin complications as compared with the stack splint, but final outcomes are similar [30]. Warren compared the use of the Abouna splint (rubber coated wire splint) versus the stack splint in a randomized study involving 116 patients. The Abouna splint had skin complications and poorer patient satisfaction but similar final outcomes as compared with the stack splint [50]. Pike et al. compared the clinical and radiographic extensor lag measurements for mallet fingers treated with volar, dorsal, and custom thermoplastic splinting. There was no extensor lag difference between splints at 12-week follow-up and increased extensor lag was noted with all three splints after discontinuation at 6 weeks of time [38].

Stern and Kastrup reported a 45 % complication rate with non-operative splint treatment. These complications were usually transient and in the form of skin ulcerations [44]. Some extensor lag is likely with splint treatment, but this does not appear to result in patient dissatisfaction or functional deficit [32, 36].

Operative Treatment

Surgery is controversial in closed acute mallet finger but is indicated in all open injuries and in injuries with a large bony mallet fragment with subluxation of the DIP joint [50]. Fractures involving 30–50 % of the joint surface have been described as unstable and require surgery [17, 51]. Surgery is also indicated in patients with intolerance to splints.

Several different surgical techniques have been described in the literature: Kirschner wiring, extension block wiring (Fig. 4), small screws, hook plate, pull-through wires, figure of eight wiring, tension band wiring, umbrella handle k-wire fixation, and external fixation [2, 3, 10, 12, 16, 21, 25, 27, 39, 45–48, 52]. Reduction and fixation of the avulsion fragment can be performed by closed or open means. Extension block k-wire pinning is usually performed by closed methods while screws, hook plate, tension band, and pull through sutures are usually performed using an open technique. Patients treated with k-wire fixation had an average flexion range of 55 degrees and extension lag ranging from 0 to 20 degrees [29]. Damron conducted a biomechanical study that compared four different fixation techniques—k-wires, figure of eight wiring, pull through wire, and pull through suture. Pull-through

Fig. 3 Non-operative treatment using a plastic stack splint of a bony mallet at day after injury (**a**) and 6 weeks (**b**)

sutures are bio-mechanically more stable with no loss of reduction when compared to other techniques [9].

Splint Versus Surgery

Stern and Kastrup retrospectively reviewed 123 mallet fingers: 45 intra-articular fractures, 37 avulsion fractures, and 39 tendon injuries. Seventy-eight patients were treated with splints and 39 were treated with surgery. Splinting was the preferred treatment in this study because there was a high complication rate (53 %), including infection, nail deformity, joint incongruity, and fixation failure in the surgically treated patients [44].

In uncomplicated acute cases of mallet finger, splinting appears to be as effective as surgical intervention. In a prospective randomized trial with 41 patients, no differences were found in outcome between external splinting and internal fixation [1]. Lubahn reported a prospective cohort study of 30 mallet fractures treated with either splinting or surgery. He suggested that open reduction and use of smaller kirschner wires provides a cosmetically and functionally superior result in select cases [29]. Even with a recent meta-analysis by Handoll and Voghela, there was insufficient evidence to determine when surgery is indicated [15]. He suggested that the splint must be strong enough to withstand everyday use but patient compliance is necessary for non-operative treatment.

Complications

Both non-operative and operative treatments are not without complications. The most frequent complications were dorsal skin complications (ulceration, maceration, nail deformity) and recurrent flexion deformity. Some extensor lag is likely with operative treatment and splinting, but it does not appear to result in patient dissatisfaction or functional deficit [32, 36]. Up to a 45 % complication rate with splints has been described by Stern. These complications were mostly skin related and were almost always transient. A 52 % complication rate (infection, nail deformity, joint incongruity, implant failure, and residual pain) has been reported with k-wire fixation [44]. Open reduction and pull-out wire fixation is associated with a 38 % complication rate including, nail deformity and implant failure [44]. In a study by Bischoff, 51 patients with bony mallet finger injuries fixed with tension band wiring were studied. At the 14-month follow-up, 24 patients had complications including dorsal skin breakdown, infections, displacement of fractures, and avascular necrosis and extensor tendon rupture [4].

Acute Open Mallet Finger

Management of open mallet finger injuries is described in very few publications. Nakamura and Nanjyo hypothesized that the large DIP joint extension deficits in some open mallet finger injuries were caused by disruption of both the terminal extensor tendon and contiguous oblique retinacular ligaments. In these injuries, they found extension deficits ranging from 25 to 70 degrees. Allowing the extensor tendon to heal by bridging the scar with splinting was thought to predispose the digit to a DIP joint extensor lag and secondary swan neck deformity. Open surgical repair was recommended, using figure of eight stainless steel wiring and k-wire immobilization of the DIP joint for 3 weeks [32]. Doyle suggested a

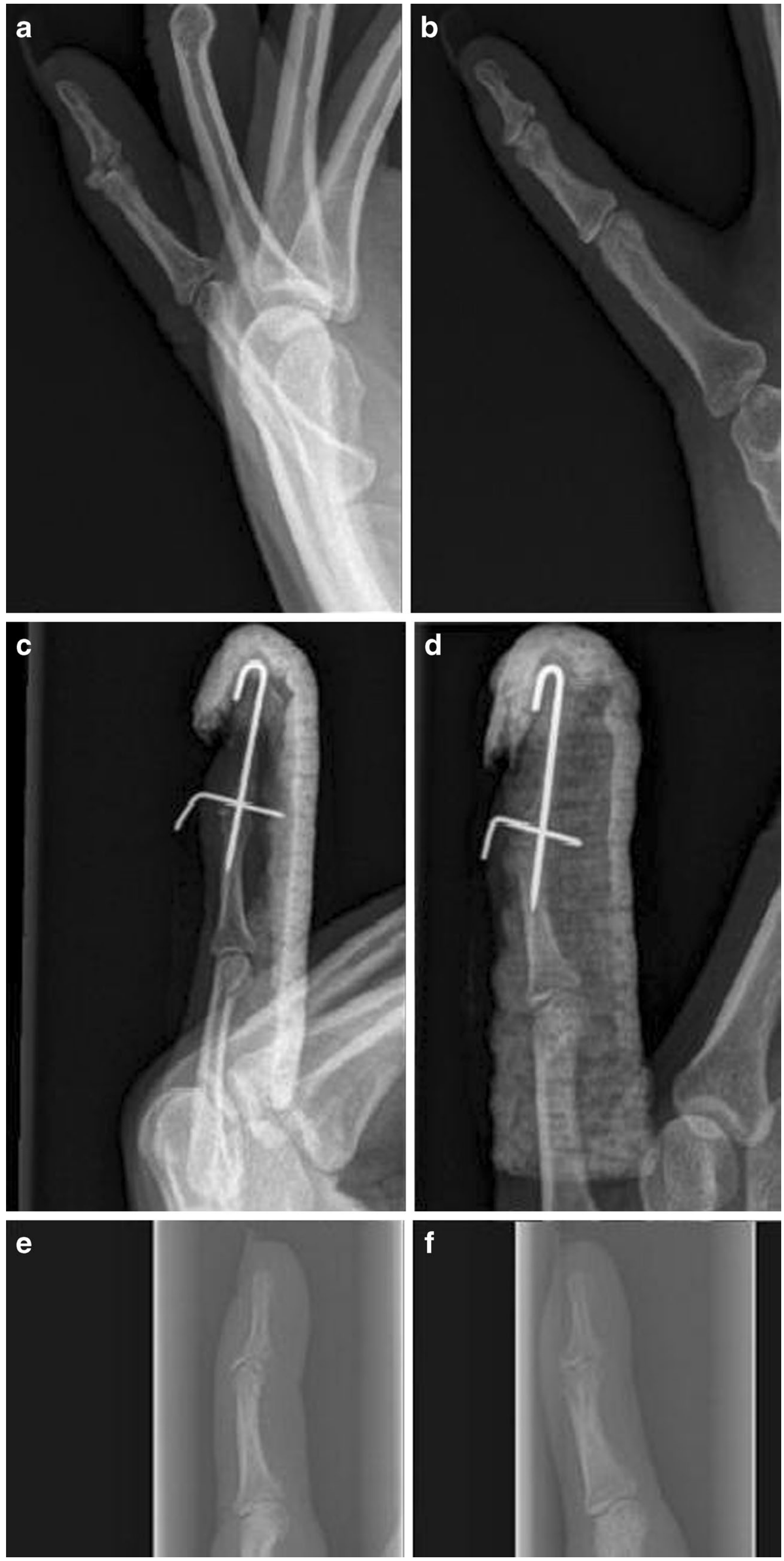

Fig. 4 Lateral and oblique radiographs of a small finger bony mallet pre-operatively (**a, b**), post-operatively (**c**, **d**), and approximately 8 weeks post-op demonstrating bony union. K-wires were removed at 5 weeks (**e**, **f**). The procedure was performed using the extension block technique with 0.45 mm k-wires

combination of surgical repair and splinting for acute tendon lacerations overlying the DIP joint. His technique involves a running suture to re-approximate both skin and tendon, followed by application of an extension splint. The suture is removed after 10 to 12 days, with splinting continued for 6 weeks [11]. Open mallet finger injuries require thorough irrigation and debridement before tendon repair. The lacerated tendon may be repaired separately or the tendon may be sutured incorporating the skin (tenodermodesis). Tendon reconstruction may be delayed if there is gross contamination. In these circumstances the DIP joint should be immobilized until definitive surgery. Open tendon injuries with a segmental tendon defect may require primary reconstruction or delayed reconstruction depending on the contamination.

Chronic Mallet Finger

A mallet deformity is considered chronic when splinting cannot correct the injury or more than 4 weeks has passed from the injury [13, 37]. Mallet injuries that present 4–8 weeks after injury without a fixed deformity should initially be treated with splints [13]. Surgery is usually considered in cases not receptive to splinting, if there is an extensor lag of 40 degrees, or if there is a functional deficit [22, 41]. Surgery is contraindicated if there is a fixed deformity of the DIP joint.

The two most commonly reported techniques for chronic mallet finger are tenodermodesis and central slip tenotomy as described by Fowler [22, 41]. Tenodermodesis consists of excising part of the tendon and skin over the DIP joint, then repairing the full thickness defect with non-absorbable sutures. The DIP joint is placed in extension and immobilized by internal fixation and/or splinting. Sorene and Goodwin reported a mean decrease of extension lag from 50 degrees to 9 degrees, with a mean follow-up of 36 months [42].

The aim of tenotomy of the central slip is to rebalance the extensor mechanism by transecting the insertion of the central slip, thereby transmitting increased extensor force and excursion to the terminal tendon. Bowers and Hurst utilized tenotomy of the central slip and demonstrated excellent results with full extension in 4 out of 5 patients. None of these patients had a bony component to their injury [5]. In a study by Houpt et al., 26 of 35 patients regained full extension after tenotomy whereas 8 patients had a residual deformity of 10–20 degrees and one patient with 30 degrees [18].

In a recent review article by Makhlouf, limiting surgery to the DIP joint is a reasonable option by converting the closed chronic mallet finger into an acute open mallet finger and suturing the tendon back using a suture anchor. It appears that creating an injury significant enough to stimulate healing potential is crucial to this technique [31]. This was demonstrated in a study by Ulker et al. where 22 patients with chronic mallet fingers underwent open fixation by suture anchor. Post-operatively, 15 of 22 patients had excellent results which included no pain, satisfactory cosmetic appearance, and active extension/flexion at the DIP joint that was equal to that of the uninvolved contralateral joint [31, 49].

Conclusions

All acute reducible bony or soft tissue mallet fingers are best initially treated with splints. Bony mallet fingers with more than 30 % articular involvement with joint subluxation are better managed surgically. Acute open mallet fingers and chronic mallet deformities, after failing a trial of splinting, are best managed surgically. There are a large number of comparative studies for splints versus surgery, but more comparative studies are needed to determine which cases respond best to surgical intervention. Some extensor lag is expected after treatment whether splint or surgery, but extensor lag does not correlate with patient satisfaction. Complications must be carefully considered when surgery is contemplated.

Conflict of Interest Sreenivasa R. Alla declares that he has no conflict of interest.

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Statement of Human and Animal Rights This article does not contain any studies with human or animal subjects.

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