EXTENSOR TENDON INJURIES

ZONE BY ZONE MANAGEMENT

HAND THERAPY
RUH - BATH

ZONES I & II - MALLET INJURY

Interruption of the extensor tendon in zones I and II results in loss of active DIP joint extension - a mallet injury (Figure 1). The injury can be open or closed and caused by rupture or laceration of the tendon or avulsion fracture.

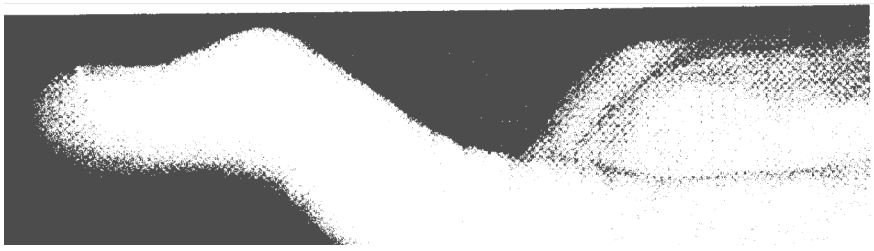

Figure 1: Mallet Deformity

Patterns of closed injuries depend on the position of the DIP joint at the time of injury and the direction of injuring force.

Tendon rupture occurs with the DIP at 45° or less extension. Direct trauma to the partially flexed DIP ruptures the central fibres of the terminal tendon (Figure 2).

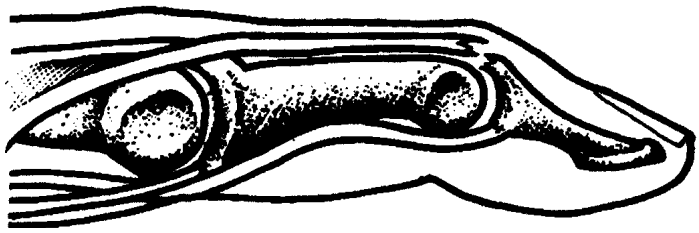

Figure 2: Tendon Rupture

Passive flexion of the DIP in a position of 45° or more produces a dorsal avulsion fracture.

(insert figure)

Figure 3: Avulsion Fracture

Closed Injuries

Whether the mechanism of injury is through tendon rupture or avulsion fracture (assuming less than 50% of the articular surface is avulsed) the treatment is the same. The DIP joint must be splinted in extension for a period of 6 to 8 weeks. The position of the DIP joint is critical to minimise development of an extensor lag. If extension cannot be achieved immediately due to oedema or fixed posture the patient must be regularly reviewed for splint adjustment and extension should be achieved over the first few days.

Correct position is better achieved by taping (e.g. leukoplast, strappal) rather than strapping. A layer of paper tape applied under this taping will prevent skin maceration and soreness.

Splints made on oedematous digits will need adjustments as the swelling subsides. Coban can be used under the splint.

Full PIP joint mobility must be maintained during the splinting period. PIP joint motion reduces tension at the site of injury.

Digits with more hypermobile joints can be splinted in slight hyperextension. Hyperextension can produce skin blanching with cutaneous and tendon ischaemia and therefore the dorsal skin should not blanch in the splinted position. Hypermobile joints can require longer splinting periods (an additional 3 to 4 weeks).

Various splint designs are available but variations in digital contour, joint flexibility and swelling after injury support the use of custom-made splints for the individual. The splint may be volar or dorsal depending on therapist and patient preference although dorsal splinting (Figure 4) does not encroach on the tactile palmar surface of the digit and avoids localised pressure over the site of tendon injury (which could be caused by taping over the dorsum).

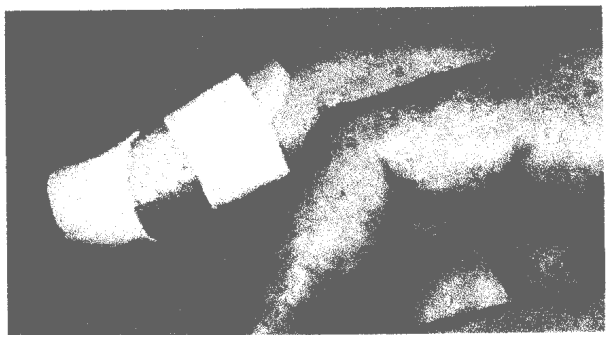

Figure 4: Dorsal Splint

The splint should be removed periodically to 'air" the finger, change the tape and check skin condition and pressure areas. During this time the patient must ensure that the DIP joint is fully supported in extension. During removal of the splint the skin can be gently tapped and massaged to stimulate circulation.

This treatment allows the tendon to approximate and scar tissue to form, joining the two ends together.

DIP joint active range of motion is allowed at 6-8 weeks with continued night splintage for the next 2 - 4 weeks.

On removal of the splint the therapist should request unresisted active flexion of the IP joints followed by active extension. The therapist should carefully assess the extension range of the DIP joint. Loss of active extension - an extension lag-is a

complication of mallet injury and the full clinical result is not usually achieved until 6months after injury as the healing tendon scar contracts. On removal of the splint up to 10° extension lag is considered acceptable. A DIP joint with a greater extension lag should be splinted for at least 2 further weeks.

Patients who present with considerable flexion range immediately on splint removal are more prone to development of a significant extension lag over the next few weeks and therefore a night and intermittent day splinting regime should be used for the next 2 weeks. If the lag seems to be increasing at any time the splint should be reapplied continually for 2 weeks.

Resistive and passive flexion activities are avoided until week 10 post-injury.

Open Injuries

Tendon laceration and avulsion fracture including more than 50% of the articular surface should be surgically repaired and internally fixed with a K-wire for 2-3 weeks. An extension splint is then applied for a further 3 - 4 weeks. Management is then as for closed injuries.

Swan-neck Deformity (Figure 5a)

This deformity can result after a mallet injury and the therapist should be aware of this possibility and monitor carefully. Interruption of the terminal tendon insertion permits retraction of the extensor tendons proximally, transferring tension to the central slip and lateral bands which concentrate extension forces on the middle phalanx. If the volar plate is lax then hyperextension of the PIP joint can occur and flexor digitorum profundus flexes the DIP joint causing a mild swan-neck deformity (Figure 5b).

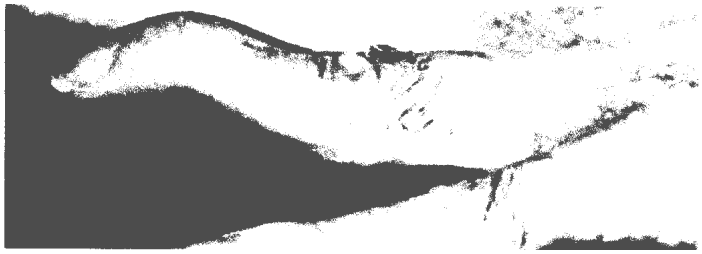

Figure 5a: Swan-necking

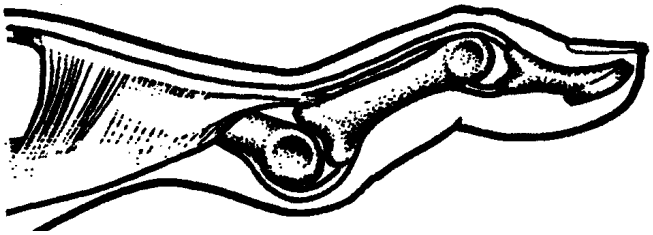

Figure 5b: Anatomy of swan-necking

If this deformity is observed then the PIP joint should also be placed in the splint blocking the final degrees of PIP joint extension.

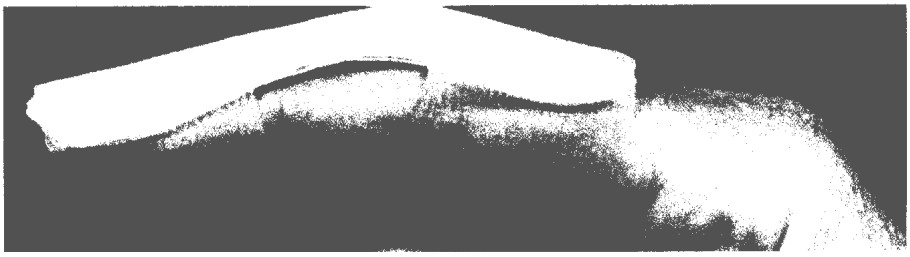

Figure 6: Swan-necking Splint

ZONES III & IV

Extensor tendon injuries in zones III and IV may result in a 'boutonniere deformity' (Figure 1a). Interruption of the extensor tendon at the PIP joint may result from lacerations, closed trauma, burns, and rheumatoid arthritis. Early deformities should be easily corrected whilst long-lasting ones have developed oblique retinacular ligament and tendon tightness.

The central slip alone is capable of initiating extension of the flexed PIP joint. Injury to the central slip results in the loss of this initiation. Interruption of the central slip allows the extensor tendon mechanism to slide proximally and the lateral bands fall below the axis of the PIP joint. The lateral bands become flexors of the PIP joint whilst concentrating their extensor force at the DIP joint (Figure 1b).

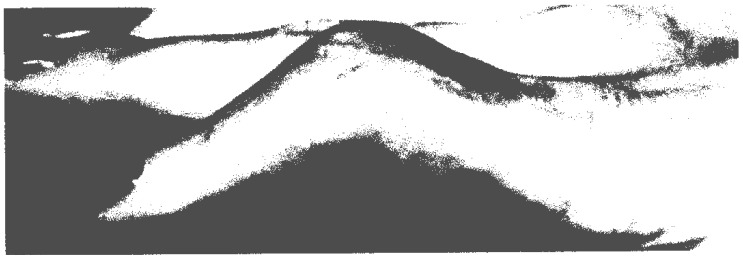

Figure 1a: Boutonniere deformity

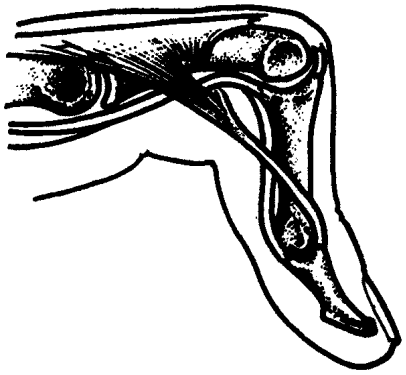

Figure 1b: Anatomy of Boutonniere deformity

Considerable oedema and dorsal tenderness of the PIP joint is associated with this injury / deformity.

This injury is complex and can require intensive and prolonged therapeutic intervention.

Closed Injuries

Suspected closed injuries of the central slip must be splinted with the PIP joint in full extension as soon as possible and reassessed in 1 week. During this time DIP joint motion is allowed. If normal extensor tendon function is evident after one week tendon rupture is not suspected and the splint can be discontinued unless there is still

significant oedema, tenderness or ecchymosis. In these cases the splint is continued for two more weeks.

Extensor tendon rupture should be splinted continually for 6 weeks. The PIP joint is splinted in neutral with free motion of the MCP and DIP joints. This active motion relaxes the intrinsic and extrinsic extensor tendon muscles, imparts a 3-4mm glide through the central slip and exercises the oblique retinacular ligaments to prevent shortening.
Again a variety of splints can be used e.g. capener, thermoplastic gutter or circumferential plaster cast (Figure 2). Given the oedema and tenderness associated with this injury, a plaster cast is the splint of choice to give gentle, even compression and should alleviate joint discomfort. The cast should be replaced at least every 10 days before it softens.

Figure 2: Splint Examples

Whichever splint is chosen, more regular refitting may be required until the oedema is resolved. The splint must not impede DIP joint flexion which should be carried out actively and passively on an hourly basis with 10-20 repetitions.

At six weeks carefully monitored gentle unresisted active flexion of the PIP joint is initiated with night splinting for a further 2-4 weeks. Continual splinting is reinstated if

extension lag or the boutonniere deformity recurs. Passive flexion of the PIP joint should be avoided as this may result in tendon attenuation and a recurrence of the deformity.

When a deformity presents late with a persistent PIP joint flexion deformity the splinting is used to overcome the flexion deformity prior to the 6-week splinting period which cannot begin until neutral extension range has been achieved. Gentle dynamic flexion splinting of the DIP joint can be incorporated to overcome tightness of the oblique retinacular ligament (Figure 3).

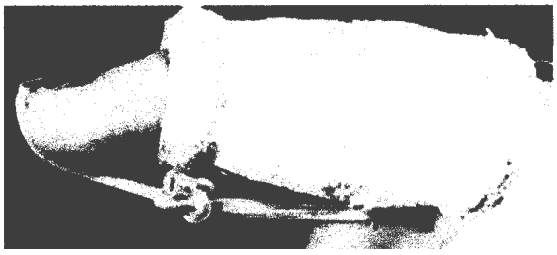

Figure 3: *Dynamic DIP joint traction*

Open Injuries

Open injuries and closed injuries, which do not heal with conservative methods, require surgical repair. Traditionally this consists of tendon repair and then immobilisation of the PIP joint for 6 weeks with or without K-wires. The PIP joint must be immobilised at absolute 0° to prevent tension on the repair site which may cause tendon gapping and healing in an elongated position.

Due to the significant tendon-to-bone interface (greater than any other part of the hand) and proximity to joint structures in zones III and IV, this area is particularly prone to adhesion formation causing restricted tendon excursion, extensor lag and joint stiffness. In light of this early mobilisation protocols have been developed.

Repaired injuries in these zones can be mobilised as early as 3-4 weeks with protective splinting between exercise sessions. This flexion should be graded with 30° in week 1, up to 50° by week 2 and then adding 20 to 30° per week. Development of extension lag should be counteracted with increased extension splinting and reduced degrees of flexion.

Evans (1994) found that repaired central slip injuries treated with immobilisation often resulted in problems with extensor tendon lag, insufficient extensor tendon excursion, joint stiffness and loss of flexion. She therefore has developed the 'active short arc motion protocol'. At 24 to 48 hours post-op a dorsal thermoplastic gutter splint is made holding the PIP and DIP joint in neutral (Figure 4a).

Figure 4a; Dorsal thermoplastic gutter

A volar template splint is also made which accommodates 30° active PIP joint flexion and 25° active DIP joint flexion (Figure 4b).

Figure 4b: Volar template splint

This splint is used every waking hour. With the wrist in 30° flexion and 0° MCP joint position, the template splint is held in place and the patient flexes to the limit of the splint and then actively extends the digit to neutral (Figure 4c). This position is then held for several seconds before flexing down to the splint again. This is repeated 20 times every hour.

Figure 4c: Extension within splint

The patient should also actively flex the DIP joint with full PIP joint extension 10 - 15 times every hour, by undoing the distal strap on the dorsal splint (Figure 4d). This maintains excursion of the lateral bands and the oblique retinacular ligaments.

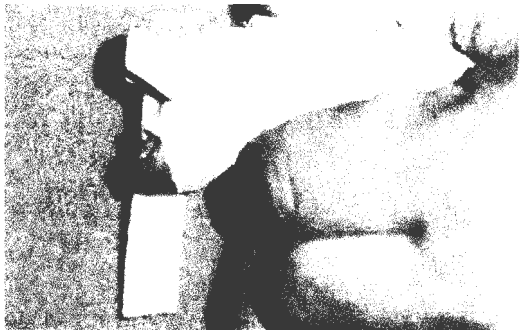

Figure 4d; Active DIP joint flexion within splint

If no extensor lag develops the template splint should be modified in 2 weeks to allow 40° active PIP joint flexion. This should be further increased to 50° in week 3 and to 70-80° by the end of week 4.

Static neutral extension splinting between these hourly exercises in maintained for 6 weeks. Composite active finger flexion can begin in week 6 but should be gradual to not jeopardise PIP joint extension. Resistive activity is avoided until week 10.

ZONES V& VII

The dorsum of the hand has greater soft tissue mobility and therefore tendon glide should be easily restored. However adhesion can occur in complex (involving multiple structures) injuries, particularly crush injuries and in the presence of significant oedema.

Oedema control is a particular concern in these zones due to the susceptibility of the dorsum of the hand to fluid accumulation which can lead to tendon adhesion and/or joint tightness.

Repair in these zones can be treated by: -

- Static splint and immobilisation
- Static splint and mobilisation
- Dynamic splint

Immobilisation

Immobilisation is very rarely advocated for tendon repair due to the increasing body of research showing the benefits of controlled motion. Total immobilisation is used for Zones I & II and Tt & T2 and is used in other zones for very young or noncompliant patients and for simple (only involving tendon) injury for the first 3 weeks.
Simple laceration to extensor indicis or extensor digiti minimi only requires immobilisation of the repaired tendons. With extensor digitorum communis the therapist must consider the position of the repair in relation to the juncturae tendinum which limits independent function of the EDC tendons. Repair proximal to this structure requires immobilisation of all fingers. Repair distal to the structure requires immobilisation of the involved digits and splinting of the adjacent fingers MCP joints in 30° flexion (Figure 1). This posture advances the proximal end of the repaired tendon through the force of the juncturae tendinum thus reducing tension at the repair site (Figure 2).

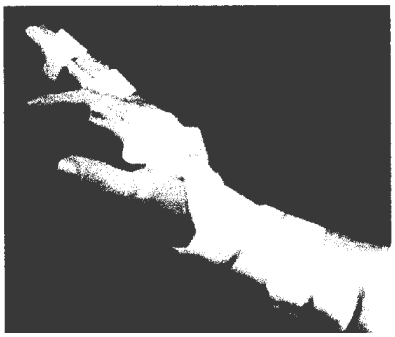

Figure 1: Immobilisation Splint

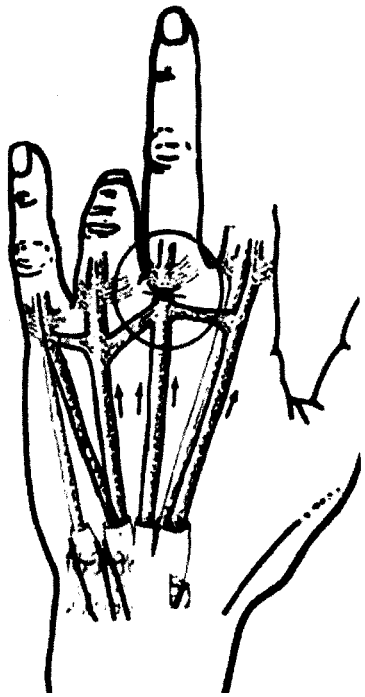

Figure 2; Juncturae Tendinum

On the *2nd* or 3rd postoperative day the surgical plaster should be replaced with a volar thermoplastic splint with the wrist at 40 - 45° extension, 0 - 20° MCP joint flexion and 0° IP joint flexion. Positioning the MCP joints in slight flexion is advocated to overcome collateral ligament shortening but has been found to lead to extension lag. With this protocol the therapists main concerns for the first 3 weeks are wound care, oedema management and maintaining the correct position to protect the repaired tendons from rupture or elongation.

Modification of this pure immobilisation programme has been advocated in recent years. IP joint motion only creates minimal tendon excursion in Zones V & VI and therefore a removable volar component can be made to the splint (Figure 3).

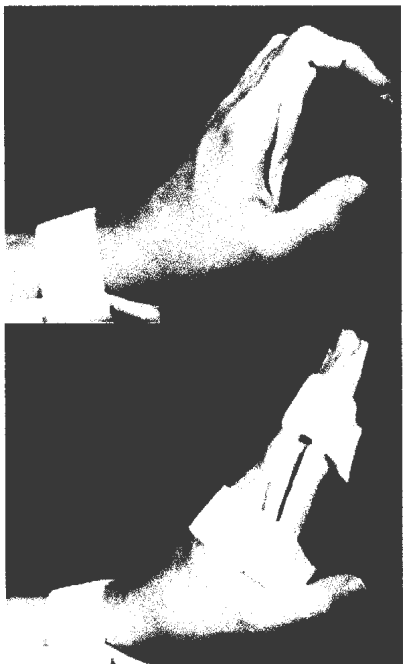

Figure 3: Removable volar component

Removal of this component every 2 hours for 10 repetitions of active IP joint flexion and passive IP joint extension maintains IP joint mobility. The wearing of this component between exercises should prevent development of extension lag and PIP joint flexion deformity.

At 3 weeks gentle active motion of the MCP joints can begin as follows –

Active MCP joint extension wifh the wrist in 20-30° of flexion. This posture reduces resistance from the antagonistic flexor system. 'Place and hold' exercises are performed in this wrist position and the fingers supported in full extension. The supporting hand is then removed and the patient is asked to maintain active finger extension for several seconds. The patient is then requested to flex the MCP joints to 30° flexion, hold and the actively extend the MCP joints back to neutral. This exercise should be repeated 10-20 times per hour (monitoring for increasing signs of inflammation).

The wrist is then extended to 45° and the patient is requested to flex the MCP joints to 40 - 60° flexion whilst maintaining IP joint extension.

Some therapists also use these exercises immediately after tendon repair. This is called the Minimal Active Muscle-Tendon Tension (MAMTQ protocol and is only performed in the therapy setting until 3 weeks after surgery. If used this early full passive extension of all digital joints must be evident prior to starting the regime to minimise resistance from the flexor system. Resistance is also provided by dorsal oedema and therefore this is promptly treated with compressive bandage. MAMTT can be used alongside any extensor tendon regime in zones V & VI but is only performed with the therapist as it requires removal of the splint and therefore must be performed in a controlled situation.

At 4 weeks composite flexion can begin with the wrist at 45° extension. Protective splinting is continued between exercises and at night until 6 weeks post surgery.

At week 6 extrinsic extension exercises can start, with the patient extending their MCP joints whilst maintaining maximum IP joint flexion, the wrist should be at neutral. At this stage patients can also perform light functional activity.

Gently dynamic MCP joint flexion splinting can be added at week 8 as required.

Full resistive activity should be avoided until 12 weeks post surgery.

Static splint and mobilisation (Norwich Regime)

A static volar thermoplastic splint is made with wrist at 45° extension, metacarpals flexed to at least 50° and IP joints at neutral (Figure 4a).

Mobilisation is started on the first post operative day and the patients is instructed to complete the following exercise within the splint-

- Combined IP and MCP joint extension (Figure 4b)
- MCP joint extension with IP joint flexion (Figure 4c)

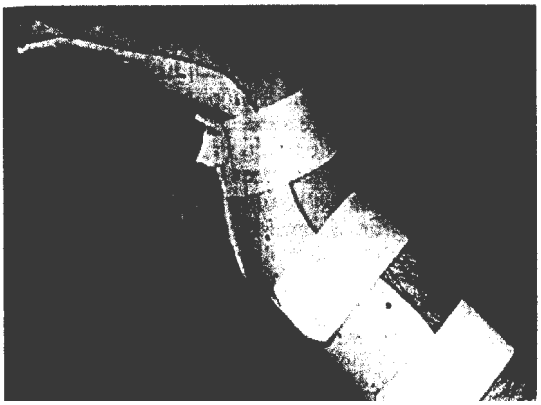

Figure 4a: Resting splint

Figure 4b: Combined extension exercise

Figure 4c: IP joint flexion exercise

Modifications of this regime also include -

- Passive extension of each finger
- Flexion of the MCP joints with extension of the IP joints
- Four complete exercise for 4 sessions per day for the first 4 weeks.

At week 5 the splint is only worn at night and composite finger flexion is commenced.

If an extension lag of over 30° is present at week 4 then the splint should be continued during the day for 2 more weeks with the original exercise regime but

with unlimited frequency. Composite flexion exercises are then delayed until 6 weeks post surgery.

Dynamic splinting

A dorsal forearm based dynamic extension splint is fitted by 3 days post surgery. The wrist is held at 40 to 45° extension and elastic traction holds the MCP and IP joints in full extension (Figure 5). The slings should be wide enough to support the PIP joints in extension and prevent PIP joint flexion whilst flexing at the MCP joints.

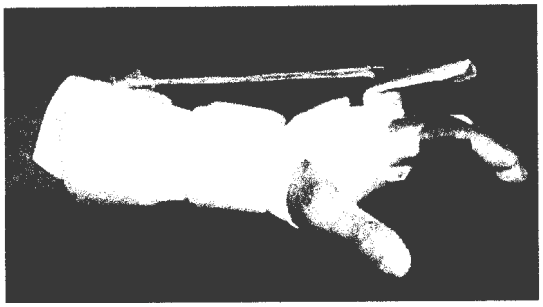

Figure 5: Dynamic splint

The patient is instructed to complete exercises in the splint on an hourly basis as follows -

Active flexion of the MCP joints to 30° and then allowing the elastic traction to return the joints to neutral (20 times each waking hour).

Some protocols use a volar phalangeal block (Figure 6) to limit this flexion to 30° whilst others rely on patient education.

Figure 6: Volar phalangeal block

After 2 weeks this active flexion is increased to 45° and to 60° after 4 weeks. The splint is removed at 6 weeks.

During this 6 week period the patient must also maintain full IP joint motion. The patient is instructed to remove the finger slings, support the MCP joints in full extension (easily achieved with a pen under the base of the proximal phalanges) and fully flex the PIP and DIP joints. The IP joints should then be passively extended.

If not using a volar phalangeal block the patient should use a static volar splint to maintain wrist and finger extension. In a dynamic splint with flexion block the patient should remove the finger stings and use a Velcro strap to immobilise the fingers against the block.

Active composite flexion and extension exercises are started at after 6 weeks and the patient is encouraged to complete light functional activity. Full resistive activity should be avoided until 12 weeks.

ZONE VII

The extensor tendons are synovial at the wrist as they pass under the extensor retinaculum through six compartments (Figure 1). Scarring is usually significant in this zone and adhesion is prevalent as in zone II flexor tendon injuries. In particular therefore a mobilisation regime is advocated to minimise these complications. Any of the discussed digital extensor regimes for zones V and VI can be used but patients should be encouraged to perform the mobilisation aspects of the chosen protocol on an individual digit basis to maintain differential glide and prevent tendons adhering to each other. MAMTT can be particularly useful as it includes wrist tenodesis exercises.

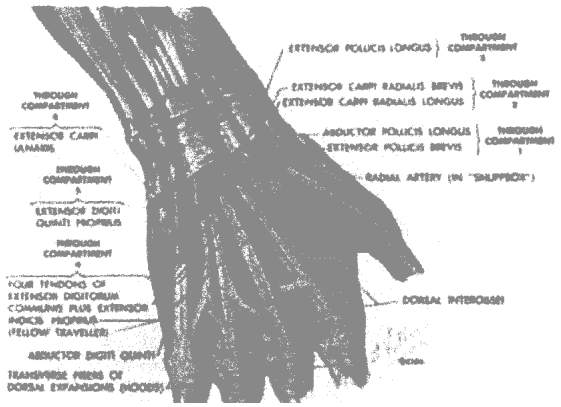

Figure 1: Extensor tendon compartments

If wrist extensors alone are involved the wrist can be splinted into 40-45° extension for 5 weeks with free digital range of motion (Figure 2). Active wrist extension is commenced after this time.

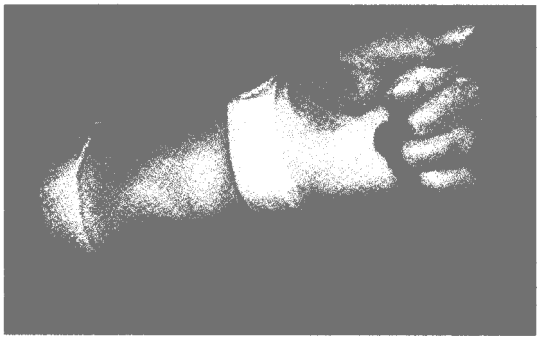

Figure 2: Wrist immobilisation splint

Alternatively MAMTT techniques are used until week 4 when active wrist extension from neutral can be included. Increments of active flexion are added slowly from weeks 5 to 8.

THE THUMB

Zone T-I

Mallet thumb is rare but treated in a similar manner to zones I and II. Closed injuries are splinted for 8 weeks and surgical repair is splinted for 5-6 weeks. The splint should be continued after this initial time between active IP joint exercise and at night for a further 2 - 4 weeks to prevent extensor lag. Increments of flexion should be increased by 20° per week. Pinching and gripping objects can start between 6 and 8 weeks depending on initial periods of immobilisation.

Zone T-II

This zone includes the proximal phalanx and therefore injury to the tendon is usually related to a laceration or crush injury. The tendon is broad in this zone and therefore often sustains only partial laceration. If the injury is less than 50% the IP joint is immobilised for 10 days in extension and then gentle active mobilisation is started. Protective splinting between exercises is continued for 4-6 weeks.

Surgical repair is carried out for injury over 50% and the thumb is immobilised in extension for 6 weeks. The protocol then mirrors that for zones I and II.

Alternatively a short arc motion regime has been suggested which allows 25 to 30° flexion by week 3 and then incremental increases in flexion over the next 3 weeks. This has been found to reduce the likelihood of tendon-to-bone adherence in complex injuries.

Zones T-III, T-IV *&* T-V

Zone T-V is considered a complex area as it is the region of the extensor retinaculum and the tendon is synovial here. Dense adhesions can limit the excursion of extensor pollicis longus and as with zone VII, early mobilisation is often advocated. Injuries in these zones can be treated using a static splint and immobilisation or dynamic splinting and/or MAMTT.

Immobilisation

A static volar forearm based splint is made with the wrist at 40° extension and the thumb in radial abduction with the MCP and IP joints in neutral extension (Figure 1). If only extensor pollicis brevis is involved the IP joint can be left free, but with a distal component added to the splint at night to prevent an IP joint flexion contracture. The MCP must not be splinted in hyperextension. The fingers should be left free.

At 3-4 weeks the splint is removed every 2 hours for gently active thumb exercises. Active thumb flexion is completed with the wrist in maximum extension and MAMTT exercises are used to allow the wrist into 15-20° flexion.

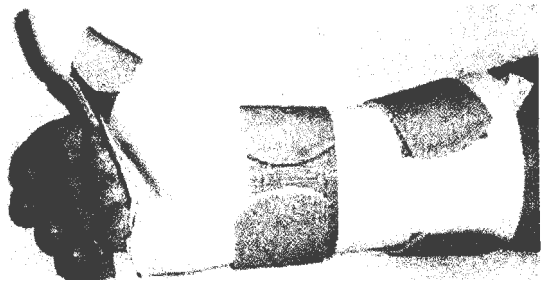

Figure 1: Immobilisation splint

The splint is removed at 6 weeks and dynamic flexion splinting can commence at 6 - 7 weeks as required.

Dynamic Splinting

A dorsal forearm dynamic splint is constructed with the wrist in 40° extension, CMC, MCP and IP joint in neutral extension (Figure 2). The elastic traction is applied to the distal phalanx. Active IP joint flexion to 60° is completed every waking hour with the traction returning the thumb into extension. A static splint can be used at night to maximise patient comfort. MAMTT can also be used from 24 hours post surgery (as for digital repair).

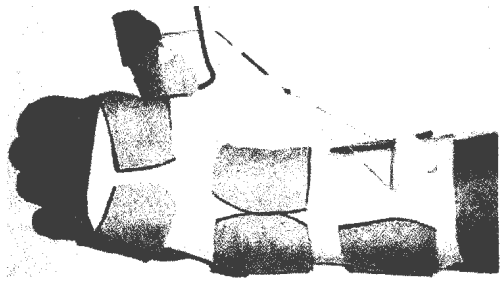

Figure 2: Dynamic splint

At week 3 gentle active MCP joint flexion is started outside the splint with the wrist in extension. In week 5 composite thumb flexion and opposition is commenced. At 6 weeks these movements can be performed with the wrist in any position. The splint is discarded at this time and fully resistive activity can be commenced at week 12.