International Handbook of Occupational Therapy Interventions

Chapter 10
Splints: Mobilization, Corrective Splintage, and Pressure Therapy for the Acutely Injured Hand

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I can touch my palm with my finger pulp again after splints and mobilization. I'd made it.

—Client

Abstract Early active and passive mobilization helps reduce edema, encourages active tendon gliding, and prevents joint stiffness after injury and operative intervention of the hands. It also enhances tensile strength of the newly repaired tendons, soft tissues, or fractured site, minimizing scar adhesion. Corrective splintage and pressure garments contribute to an effective outcome.

Keywords Corrective splintage • Injured hand • Mobilization • Pressure therapy

Background

The phases of the wound healing process are as follows:

- The *inflammatory phase* is the immediate vascular and cellular response to wounding that clears the wound of devitalized tissue, debris, and foreign materials. Edema dominates subsequent to vascular dilation. The length of this phase depends on the severity of the structures damaged and the tissue-handling approaches that follow. It usually lasts for about 5 days if no complication exists.
- The *fibroplastic phase* of repair lasts from 2 to 6 weeks, starting 3 to 5 days after the wounds occurred. This phase includes tissue granulation, collagen accumulation, and epithelialization, that is, the wound begins to heal. Here, the tensile strength of the wound grows, an increase that may last for about 3 weeks before reaching a plateau and then linearly increasing for at least 3 months further.
- *The maturation phase* begins as fibroblastic activity decreases and may last for years when the amount of collagen decreases and the wound becomes stronger (Smith, 1995).

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To maximize treatment outcome, the choice of splintage should parallel the patient's tissue healing process.

Main Principles of Splintage

Splintage serves as a protective device to rest the injured finger(s) and hand in a functional and healing position. It helps relieve pain, prevents joint stiffening, and corrects joint contractures. It facilitates hand function in daily living by positioning the weakened or deformed fingers and hand optimally to facilitate occupational performance (Wong, 2002).

Main Principles of Movement Therapy Stress the Tissues of the Hand

Mobilization Through Active Motion

Mobilization through early active and passive motion aims at enhancing active tendon gliding, maintaining joint mobility, and preventing potential complications.

Early active mobilization of the hand should commence after the injured structures become stabilized. It encourages the pumping action of the muscles and the subsequent gliding of the soft tissue structures (Colditz, 1995). The aims are to decrease edematous fluid by mobilizing in an elevated position and facilitating finger-joint range of motion (Wong, 2002).

Mobilization Through Passive Motion

Passive motion is the mobilization of a joint by an external force intended to increase joint and soft tissue mobility (Maitland, 1977). It encourages tissues to reach a maximum available length within patients' pain tolerance, provided the resistance from the tissues is respected to prevent tissue damage from overstretching.

Purpose

The ultimate goal of hand therapy is to restore maximal hand function so that the client will be able to perform occupations independently.

Method

Candidates for the Interventions

People suffering from trauma that requires surgery of the hand(s) may benefit from hand therapy conducted by occupational therapists (OTs). According to the International

Classification of Functioning, Disability, and Health (ICF), the impairments relevant here concern structure of upper extremity and hand plus the function of the power of the muscles of a limb (World Health Organization, 2007).

Epidemiology

In Hong Kong, the risk of a hand injury at work occurs with odds ratios ranging from 10.5 to 26.0, as shown in a matched-pair interval analysis. The risk factors are (1) using malfunctioning tools/materials, (2) using a new work method, (3) doing an unusual work task, (4) working overtime, (5) feeling ill, and (6) being distracted and rushing (Chow et al., 2007). Another example, from the United States, of the extent of the need for hand therapy is that one fourth of workers (n = 232) who had used malfunctioning equipment or tools presented within 10 minutes with a hand injury (laceration, crush, or fracture) (Sorock et al., 2001). Hand trauma among children and in the home and during leisure time is not included in these figures.

However, there are no exact figures for how many people suffer from hand injury that may require rehabilitation, including occupational therapy, or for how many remain with a permanent disability. In the United Kingdom in 2006, the cost of hand surgery was more than £100 million (Dias and Garcia-Elias, 2006).

The Role of the Occupational Therapist

Occupational therapists (OTs) should have thorough knowledge of biologic and mechanical aspects of the injured hand, plus the clinical expertise to perform accurate clinical judgments leading to an effective splinting and movement program.

Results

Clinical Application: Mobilization of the Injured Hand

Mobilization of Repaired Tendons of the Hand

Controlled active and passive mobilization of the repaired tendons should commence within 1 week of surgery (Pettengill, 2005). Tendon excursion should be limited to a safe range but great enough to provide the stress necessary to stimulate biochemical changes that promote the healing process (Evans, 1995).

Table 10.1 presents an overview of the splintage common in rehabilitation of the injured hand.

Table 10.1 Overview of the splintage common in rehabilitation of the injured hand

Splint entitled	Splint figure	Functions of the splint
Repaired flexor tendons of the hand		
Controlled active flexor splint	Figure 10.1	A controlled active flexor tendon splint is used to allow early active mobilization of the fingers after flexor(s) repair. The active range of motion of the injured finger within the dorsal extension block splint is governed by the splint position. Passive flexion of the finger joints is allowed to maintain their suppleness.
Synergistic splint	Figure 10.2	A synergistic splint is a dynamic splint guided by wrist motion used to increase the excursion of the tendons within safe limits: from maximum wrist extension at 30 degrees to full flexion. The interphalangeal (IP) joints of fingers are passively flexed on the "place-and-hold" principle when the wrist extends to the 30-degree extension block.
Differential tendon gliding	Figure 10.3	Individual passive flexion of the IP joints enhances the isolated gliding of the flexor digitorum sublimis (FDS) and flexor digitorum profundus (FDP) in zone II.
Repaired extensor tendons of the hand		
Controlled passive extensor splint	Figure 10.4	A controlled passive extensor splint is used to allow early mobilization of the fingers after extensor repair. The injured finger is flexed actively and extended passively by the extensor assist within a controlled range. The volar flexion block is adjustable weekly.
Immediate controlled active motion splint	Figure 10.5	The immediate controlled active motion splint consists of two components. A finger extension-assist splint supports the injured finger in 20 degrees of relatively more extension than the adjacent fingers, and the finger actively extends supported by the adjacent fingers via the extension-assist splint. A wrist extension splint supports the wrist in 20 degrees of extension to relax the finger extensors.
Mobilization and passive motion of fractured fingers		
Splints for stable and nondisplaced fractures		
Buddy splint and proximal phalanx fracture resting splint	Figure 10.6	The buddy splint straps the injured finger and the adjacent finger together to facilitate the active motion of the injured finger. The night finger extension splint holds the finger and hand in a safe position to prevent potential flexion contracture developing in the IP joints and extension contracture in the metacarpophalangeal joint.

Corrective splintage		
Belly gutter splint	Figure 10.7	A belly gutter splint helps correct flexion contracture of interphalangeal joints by molding a hollow space underneath the contracted joint in order to reinforce the correcting force applied by the strapping from top of the joint.
Dynamic mobilizing splint	Figure 10.8	The dynamic mobilizing splint provides low-load tensile stress via its dynamic component, trying to realign the scarred tissue.
Serial static web spreader	Figure 10.9	The serial static web spreader gradually widens the tightening first web by serial adjustment or splint remolding.
Static progressive proximal interphalangeal joint splint	Figure 10.10	The static progressive proximal interphalangeal joint splint applies passive stretching to gradually restore the passive extension and flexion range of the joint. The inelastic component of the splint is adjusted without change to its main structures.
Clinical application: Edema control		
Edema control by elevation, active mobilization and pressure therapy		
Pitting edema	Figure 10.11	Edema retention around the injured site, or even the whole hand after the injury. Edematous fluid is movable and soft when direct fingertip pressure is applied in the early stage.
Pressure finger tube	Figure 10.12	A pressure finger-tube with gentle circumferential pressure will help reduce local swelling over a finger. The choice of materials used depends on the severity of the swelling.
Pressure glove	Figure 10.13	A pressure glove, providing gentle and circumferential pressure, helps control swelling if all the fingers and the whole hand become swollen after injury or surgery.

Repaired Flexor Tendons of the Hand

Flexor tendon post-repair motion protocols include early-controlled forces, exerted through either passive or active motion (Strickland, 2005).

The traditional *passive way of splinting* (Kleinert et al., 1967; Lister et al., 1997) caused buckling of the repaired tendon within the synovial sheath (Horii, 1992). This way of splinting is no longer recommended.

Recent findings verify that flexor tendon rehabilitation should be based on controlled active digital motion (Lund, 2000). Here the *controlled active flexor splint* is used (Fig. 10.1).

The *synergistic splint* (Fig. 10.2), according to the Mayo Clinic protocol, is used to increase the differences (excursion) between the two digital flexors (Cooney et al., 1989; Savage, 1988). It functions at the optimal positions of the extended wrist and flexed metacarpophalanges of the hand joints to produce the least tension on a repaired flexor tendon during active digital flexion (Strickland, 2005).

Controlled *active and passive* motion should be integrated.

Passive flexion movements of the interphalangeal (IP) joints of the injured finger(s) contribute to maintaining joint mobility by influencing the edematous fluid,

Fig. 10.1 Controlled active flexor splint.

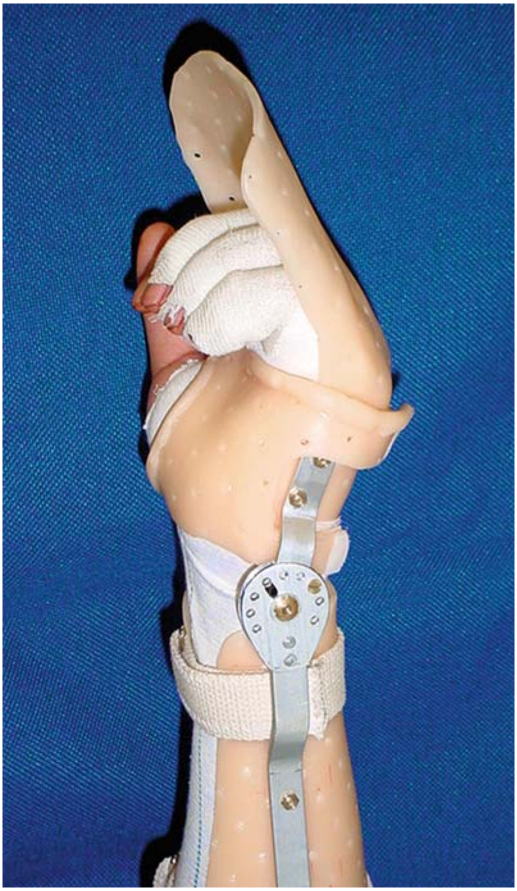

Fig. 10.2 Synergistic splint.

thus facilitating the active gliding of the tendons (Duran and Houser, 1995). Intervention in zone II flexor tendon injuries should include *differential tendon gliding exercise* to encourage isolated gliding of the two flexor tendons (Fig. 10.3).

Repaired Extensor Tendons of the Hand

The same principles are used for mobilization of the extensor tendons. *Controlled passive extension motion using a dynamic splint* seeks to prevent dense adhesions (Fig. 10.4) (Duran and Houser, 1995), and to stimulate intrinsic repair processes (Gelberman et al., 1981). The *Immediate Controlled Active Motion Extensor Tendon Program* (ICAM) gives the professional recommendations on how the pair of a wrist extension splint (wrist extended 20 to 25 degrees) and a *finger extension-assist* splint is designed to allow active digital flexion-extension. (Fig. 10.5) (Howell et al., 2005).

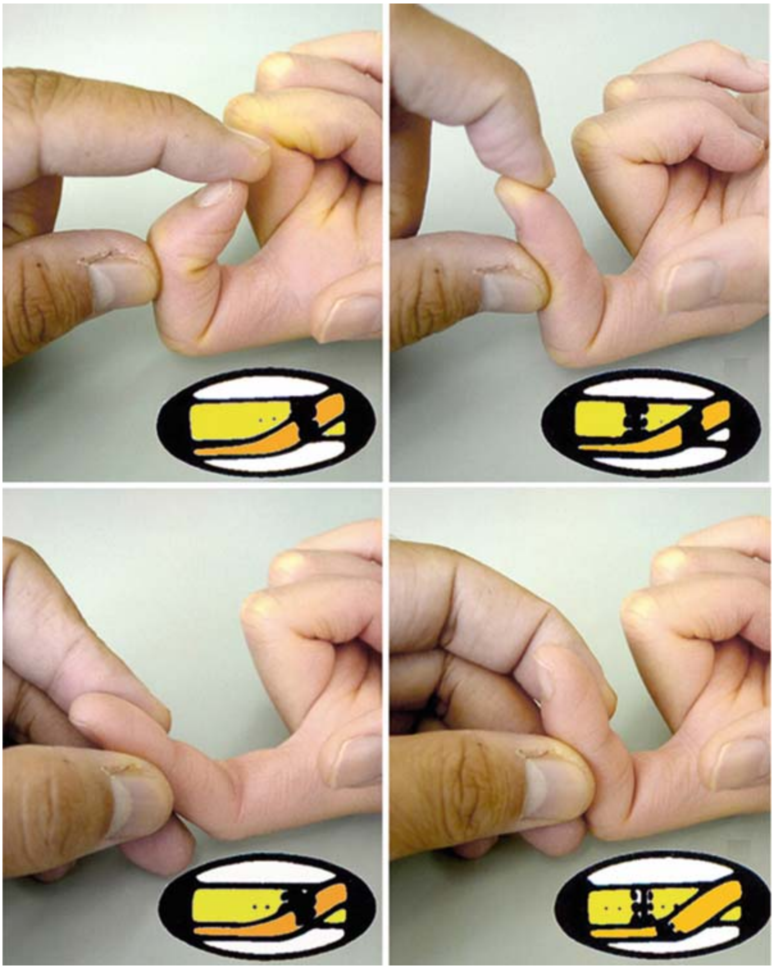

Fig. 10.3 Differential tendon-gliding splints.

Mobilization and Passive Motion of Fractured Fingers

The outcomes of managing finger fractures (especially proximal phalangeal fractures) depend on whether a stable anatomic position of the fracture is achieved and whether an *early active motion program* focusing on tendon gliding and joint mobility is conducted (Freeland et al., 2003).

Splints for Stable and Nondisplaced Fractures

Buddy taping or *splinting* (Fig. 10.6) to an adjacent uninvolved finger is sufficient to permit immediate active motion of the interphalangeal joints, enabling the extensor

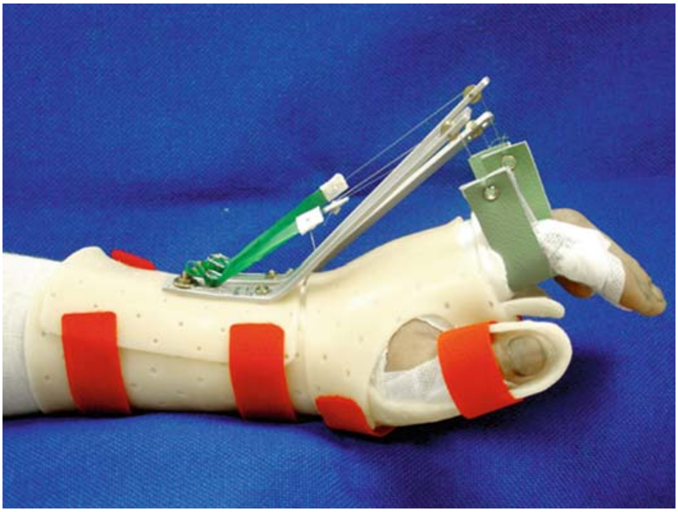

Fig. 10.4 Controlled passive extensor splint.

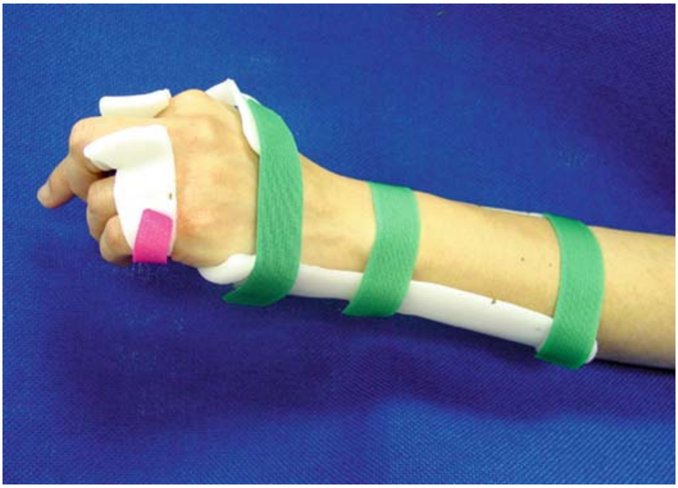

Fig. 10.5 Immediate controlled active motion splint.

mechanism to act as a tension band over the proximal phalanx. *Active motion* simultaneously compresses the fracture and stimulates periosteal callus formation, initiating the recovery of digital motion (Freeland et al., 2003). A *resting splint at night* is recommended to minimize the risk of contracture of the proximal interphalangeal (PIP) joint flexion. This splint is adapted to extend the IP joint and to keep the intrinsic tendons in a relaxed position by flexing the metacarpophalangeal (MP) joint.

Fig. 10.6 Buddy splint and proximal Phalangial fracture resting splint.

A *dorsal block splint* is used *for displaced or open fractures* repaired with surgical stabilization. This splint is intended to relax the tensions over the fracture and is used to facilitate movement (Freeland et al., 2003).

Passive motion of fractured fingers should generally not begin before fracture callus calcification has been confirmed radiologically. Normally this occurs 10 to 21 days after the injury. Gentle passive flexion and extension of the distal IP joint can be allowed with fracture site protected (Freeland et al., 2003).

Clinical Application: Splintage

Corrective Splintage

The OT examines the fingers and the hand through his or her "end feel," that is, slow and careful stretching and tightening of soft tissue or finger joint(s). The result indicates the types of splintage to be used.

Static Splint

A static splint holds the finger in one specific position that applies stress to the newly repaired tissue. Its purpose is to *prevent* joint contracture and correct the new onset of joint flexion tightness (Wong, 2002).

A *belly-gutter splint* (Fig. 10.7) is intended to correct flexion tightness of the PIP joint by holding the injured finger in a safe but corrective position. The splint is positioned over the metacarpophalangeal (MCP) joints at 60 to 70 degrees of flexion and with the IP joints in full extension.

Fig. 10.7 Belly gutter splint.

Dynamic Splint

A dynamic mobilization splint (Fig. 10.8) applies a passive pulling force to a specific joint in one direction while permitting active motion in the opposite direction, using energy-storing materials such as a "Theraband," rubber band, springs, and spring wire (Wong, 2002). It applies a low-load constant and gentle force to realign the soft tissue under stress, holding tension on the joint, tendon, scar, and adhesions at the maximum tolerable limit (Flowers and LaStayo, 1994).

Serial Static Splint

Through periodic readjustment of position, the *serial static splint* (Fig. 10.9) provides serial stretching of a contracting or deforming tissue. After the tissue being stretched

Fig. 10.8 Dynamic mobilizing splint.

Fig. 10.9 Serial static web spreader.

it adapts to its stretching force by achieving the maximum tolerable length, the old splint is remolded or renewed in order to sustain the tissue at its maximum length again (Wong, 2002). It also functions as night resting splint, maintaining the "maximum gain" from the mobilizing splints used during the daytime. The first web spreader as shown illustrates how it regains the width of the first web space by serial adjustment.

Static Progressive Splint

Static progressive splints (Fig. 10.10) are made up of inelastic components such as hook and loop tapes, adjustable hinges, screws, or turnbuckles to apply torque to a joint statically at a position as close to end range as possible. These components allow progressive changes in joint position without changes in the structure of the splint (Schultz-Johnson, 2002). The contracted joint or shortened tissue is positioned at its maximum tolerable length by adjusting the tension of the inelastic component to reposition the tissue at a new maximum tolerable length. This type of splint is effective over stiff joints especially during the mid-to-late scar maturation stage of healing.

Fig. 10.10 Static progressive proximal interphalangeal joint splint.

Risks with Using Splints

All splintage has to be made with precautions to avoid excessive force from overstretching that will cause a prolonged increase in swelling retention and temperature around the stretched joint. Aggressive stress that produces more tissue damage than remodeling introduces more scarring, triggering the vicious circle of joint stiffening.

Clinical Application: Scar-Remodeling

Corrective Splintage Through Low-Load Prolonged Stress to Induce Scar-Remodeling

Dynamic or static corrective splintage is used to correct *progressive or static hand deformity* during the fibroplasia phase of healing. *Mobilizing splints* are applied to provide stress for remodeling collagen tissues, keeping the involved tissues in a prolonged state of mild tension, maximizing articular gliding and tendon excursion (Brand, 1995).

Static, serial static, or static progressive splints are used with increasing mechanical force to move the joint and tissue into the position opposite contracture.

Clinical Application: Edema Control

Edema Control Through Elevation, Active Mobilization, and Pressure Therapy

Persistent edema has detrimental effects on the intimately fitting gliding structures of the hand, causing pain, joint stiffness, and connective tissue adherence. Movable pitting edema (Fig. 10.11) usually dominates during the acute stage after the injury. It gives way when one applies direct fingertip pressure over the edematous area, though a soft feel is still noted during the "end-feel" of passive joint stretching. Fibrotic edema is found in the chronic stage of injury because of prolonged retention of edema fluid over the fingers and hand. Movable edema is replaced by fibrotic adhesion, limiting the gliding of soft tissues and finger motion. The "end-feel" from the joint passively stretched is stiff and resistive (Colditz, 1995).

Edema control by elevation, mobilization, and pressure garment (Fig. 10.12) is essential. The involved hand should be raised to above heart level to facilitate the flow of the edematous fluid from distal to proximal. Patients are encouraged to mobilize, pumping away the edema fluid, although they may experience great resistance from the extra fluid. Gentle massage, distal to proximal, will facilitate

Fig. 10.11 Pitting edema.

Fig. 10.12 Pressure finger tube.

blood circulation and mobility of the tissue layers. Compression with elastic bandage or pressure garment (Fig. 10.13) works when it applies gentle and constant pressure circumferentially distributed over the swollen hand (Wong, 2002).

Fig. 10.13 Pressure glove.

Evidence-Based Practice

Kleinert and Duran protocols (Cetin et al., 2001) are the major guidelines for our routine flexor tendon programs for early mobilization, while programs encouraging active tendon gliding have been under investigation to enhance treatment effectiveness (Baktir et al., 1996; Brüner et al, 2003; Howell et al., 2005; Hung et al., 2005).

Discussion

Research on mobilization programs for tendon rehabilitation has been thorough and comprehensive. Further studies on the management of complications such as stiff fingers due to the splinting regime, the effectiveness of pressure therapy in swelling control, and the physical properties of materials used in treatment are needed to give us insight into the choice of evidence for hand therapy in the future.

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