CHAPTER 111

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HISTORY

For centuries physicians have used bandages and homemade devices to immobilize and support injured limbs. Before modern health specialization, the physician or surgeon built the devices or enlisted the help of the local blacksmith or carpenter. It is only in recent years that hand splinting has become part of a trained discipline.

The many injuries from the first and second world wars and the large number of polio patients stimulated the development of orthotics and prosthetics in the early 20th century. The large number of patients needing splinting must have influenced Bunnell's statement: "Splints should be standardized as much as possible to facilitate the large volume of work done by many people."[1] Polio was a significant catalyst for developing standard orthotic designs.

Hand Surgery

Bunnell and the other pioneers of hand surgery clearly recognized that static splints were needed for correct positioning of the hand postoperatively. Dynamic (or spring) splints were recommended to mobilize stiff joints.[2–4] The former was important because of the long transportation time for injured soldiers who were initially treated in field hospitals and then transferred stateside for definitive surgical care. Many of these hands were debilitated owing to incorrect initial splint immobilization.[3]

Although Adams,[5] Koch,[6] Koch and Mason,[4] Neviaser,[7] Marble,[8] Oppenheimer,[9] and others[10–17] from the 1920s to the 1940s published descriptive articles about specific splints, it was Bunnell in his *Surgery of the Hand*[2] in 1944 who provided the first extensive review of hand splinting for the surgical patient. Most other publications from that time were anecdotal descriptions of favored designs with few or no references.[9,18–21]

In the fall of 1944, just as Bunnell's book was published, he was asked by the U.S. Surgeon General to be the civilian consultant to the eight general hospitals in the Interior Zone.* In the following 2½ years when he traveled to these first hand centers, his teaching about the need for initial splinting to immobilize and dynamic splinting to remobilize the hand, became the standard of care.

* The Interior Zone refers to the stateside hospitals which received wounded soldiers from all war theaters.

Manufactured Splints

Many manufactured splints have been used (such as Bunnell's knuckle bender splint,[2] Oppenheimer's splint,[9] and the Thomas suspension splint[22]). When manufactured splints were not available, dynamic splints were built using plaster of paris with wire outriggers incorporated into the plaster base as described later by Peacock[23] (Fig. 111-1). Many of these classic designs continue to be referred to frequently. Numerous splints of this period were constructed by orthotists or orthopaedic technicians whose materials were limited to plaster, metal, wire, felt, and leather.[18,24–26] A few high temperature plastics were reserved for permanent disabilities (polio, spinal cord injuries, and extensive peripheral nerve loss).

Moberg observed that each U.S. hand surgeon had to have a splint workshop.[27] Bunnell also had several ready-made splints from a surgical instrument supplier for rehabilitation of his patients.[28]

Hand Therapy and Low Temperature Plastics

In the 1960s and '70s two concurrent events brought splinting into the mainstream of hand surgery practice. Hand therapy developed as a specialty, and low temperature thermoplastic splinting materials became readily available.

As physical and occupational therapists began working closely with hand surgeons, they developed and shared effective techniques of rehabilitation and splinting. Splinting was now ian integral part of immediate postoperative care, in contrast to the days of polio when the orthotist, removed from the hands-on care of the patient, would independently construct a device.

Therapists developed an increasingly important role as the low temperature thermoplastics allowed splints to be molded directly on the patient, and easily modified as function progressed. The roles of the orthotist and therapist became better defined: the orthotist made braces for permanent loss, while the therapist was an active participant in the rehabilitation process. Early hand rehabilitation texts included chapters on splints.[29–32] Commercially produced metal, felt, and wire splints fell out of favor because they were not as well tolerated as custom-designed and individually molded ones.

Not all surgeons work closely with experienced and trained therapists who can make splints. Many surgeons writing about

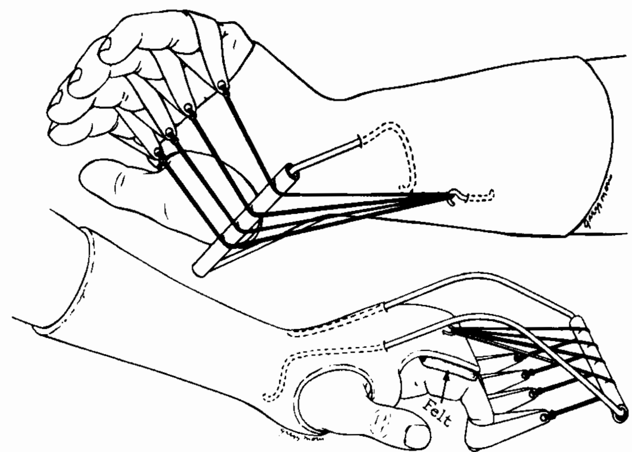


FIG. 111-1. Bunnell and others made dynamic splints of plaster of paris into which wire outriggers were incorporated. (*From:* Bunnell's Surgery of the Hand, *4th ed. Philadelphia, JB Lippincott, 1964, with permission.)*

splinting illustrate the early wire and felt designs.[33,34] Therapists must prove whether the custom-molded splints provide improved tolerance and better clinical results. There are no published clinical studies proving the advantage of custom splints.

Splinting Terminology

The art and craft of hand splinting are the responsibility of hand therapists. The absence of standardized training in splint making and the use of colloquial descriptive terms have prevented the recognition of hand splinting as a science.

What one person calls a "wrist cock-up splint," another calls a "wrist control splint," and yet another calls a "wrist support splint." This inconsistent terminology prevents easy communication and lacks a common language for comparative results.

Moberg identified the need for better prescription and regulation of splinting.[27] Fess recognized that splinting "encompasses a profusion of devices and terminology, and because similar splints may be used for dissimilar purposes, description and classification of various splints are often fraught with confusion, redundancy, and omission."[35]

In 1986, because of a member survey,[36] the American Society of Hand Therapists (ASHT) identified the need for standardized terminology. In 1992 it published the *ASHT Splint Classification System.*[37] Descriptions were *based on the function* of the splint rather than its form. This system uses a logical progression of descriptions so any splint for any joint can be accurately described (Fig. 111-2). It identifies which joints are included in the splint for primary mobilization, immobilization, or restriction and then further describes the secondary joints included. With this system colloquial terms or regional descriptors are no longer useful, but the purpose of the splint is the prime descriptor. The *problem* with this system is that one splint design may have many different functions (Fig. 111-3).

Transition to this new nomenclature will require new generations to learn and use this system. This is a major challenge, since we all have the habit of envisioning a three-dimensional device when we describe a splint. The idea is for the surgeon to know the skills of the hand therapist. A referral regarding the function of the splint is transmitted, but the actual design is left to the therapist.

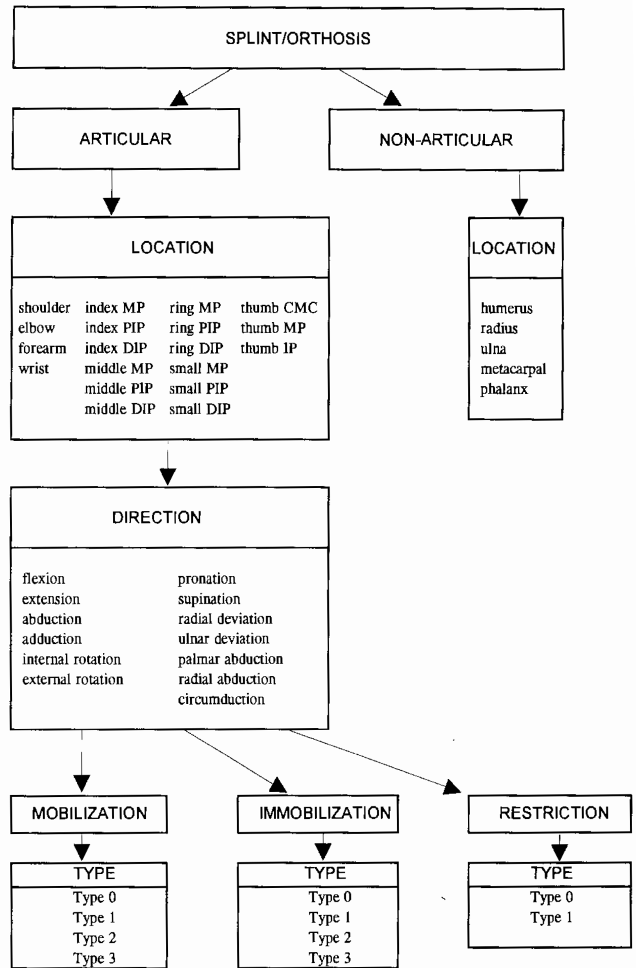


FIG. 111-2. Any splint can be described using the ASHT Splint Classification System flowchart. *Location* describes the primary joint/s affected by the splint and *type* refers to the number of secondary joints included in the splint. *(From:* Splint Classification System. *American Society of Hand Therapists, 401 N. Michigan Avenue, Chicago, 1992, with permission.)*

PRINCIPLES AND GOALS OF SPLINTING

Hand splinting can have one of two purposes: immobilization or mobilization.[2] Both splinting functions have a useful role in helping gain maximum function following trauma or surgery. The challenge for therapists and surgeons is to decide when each type of splint is most useful. Strickland described the dilemma well: "A strong appreciation for the biologic state of the involved tissues will aid in making decisions as to whether the injured part should be managed by rest or stress and the best timing for the use of each type of splint."[38]

Immobilization Splints

First, and most commonly, splints are used to immobilize and rest healing tissue.

Reduction of Inflammation from Trauma

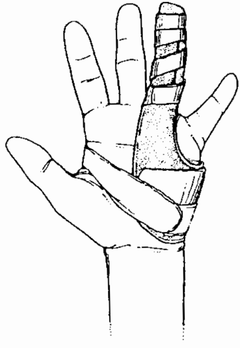
Resting hand tissues reduces inflammation to encourage orderly healing without disruptive external influences and is the initial choice for the acutely injured part. The normal inflammatory response to trauma, infection, and pain will respond positively to rest. Bunnell was emphatic that such splinting should cease when possible because of the atrophy and stiffening which rapidly occurs in the immobilized hand.[39] Immobilization periods have become shorter to minimize the negative effects of prolonged stiffness.

Reduction of Inflammation from Arthritis

Inflammatory arthritis responds to rest, but this rest may be short-lived, providing daily symptomatic relief. Splinting to provide rest, used with other treatments, has long been recognized as a standard protocol in this patient population.

Control of Pain

Without infection, rest of the acutely injured hand can decrease pain. In the healing hand, a delicate balance between rest to reduce painful inflammation, and exercise to maintain tissue glide can be accomplished by a *removable* splint.



SCS Classification	Secondary Joints	Possible Indication for Splint
RF PIP & DIP extension immobilization; type 1[3]	MP joint	Interarticular Fracture of PIP & DIP joints
RF DIP extension immobilization; type 2[3]	MP and PIP joints	Pedriatric Fracture of distal phalanx
RF PIP extension immobilization; type 2[3]	MP and DIP joints	Interarticular Fracture of PIP joint
RF MP extension immobilization; type 2[3]	PIP and MIP joints	Dupuytren's Contracture
RF MP & PIP extension immobilization; type 1[3]	DIP joint	Fractures of proximal and middle phalanges
RF MP, PIP, DIP extension immobilization; type 0[3]	All joints are primary	Dupuytren's Contracture
RF PIP lateral deviation immobilization; type 2[3]	MP and DIP	PIP collateral ligament repair
RF PIP & DIP extension mobilization; type 2[3]	MP joint	PIP & DIP contractures
RF DIP extension mobilization; type 2[3]	MP and PIP joints	DIP contracture
RF PIP extension mobilization; type 2[3]	MP and DIP joints	PIP joint contracture
RF MP extension mobilization; type 2[3]	PIP and DIP joints	MP joint contracture
RF MP & PIP extension mobilization; type 1[3]	DIP joint	MP & PIP joint contractures
RF MP, PIP, PIP extension mobilization; type 0[3]	All joints are primary	Flexor tendon scar/adherent in palm

FIG. 111-3. An example of the many possible descriptions of one splint design. The bracketed number defines total number of joints effected by the splint. *(From:* Splint Classification System. *American Society of Hand Therapists, 401 N. Michigan Avenue, Chicago, Illinois, 1992, with permission.)*

Provision of External Support

Splints may be used during any stage of healing to provide external support to internal structures. Unstable joints resulting from trauma or arthritis can benefit from such splinting for symptom relief and functional assistance (temporarily or as a substitute for surgery).

Substitute for Absent, Weak, or Imbalanced Muscles

Splints may also be useful when a major nerve injury deprives the hand of its normal muscle balance. Although a splint cannot simulate the dynamic balance of muscles, it can provide a blocking or stabilizing force to prevent overstretching of denervated muscles and joint contractures.

Evaluation of the Potential for Surgery

Finally, in selected cases, the temporary use of splints may help with surgical decisions. External splints applied to joints recommended for surgical fusion can assist the patient and surgeon in deciding the best position for arthrodesis. Surgical tenodesis can be mimicked by external splinting to learn the functional advantages, or disadvantages, of such a procedure.

Mobilizing Splints

The second purpose of hand splinting is to mobilize tissues using force applied by a splint to aid the way tissue heals. The appropriate use of mobilizing splints may eliminate the need for a surgical procedure.[40]

Many mobilization splints have a movable component, which applies force to the joint, or joints, of the hand and increases joint motion.

Protection of Healing Structures

Splints can provide defined limits to tissue glide or stress. "Controlled" motion has been shown to produce superior clinical results following flexor tendon repair[41] and is an effective technique for unstable dorsal proximal interphalangeal (PIP) joint dislocations.[42–45]

Increase or Maintainence of Joint Motion and Soft Tissue Glide

Immobilization to protect healing structures can limit joint motion, especially when edematous small joints are held in an imbalanced position. Tendons must glide through a scarred bed, and muscle must regain normal elasticity to effect movement.

Early use of dynamic splinting to help joints regain mobility is well recognized.[23,46–50] The advantages of early motion have encouraged early postoperative splinting to maintain joint motion while protecting healing structures, such as flexor tendons.

Influence on Skin Scar Formation

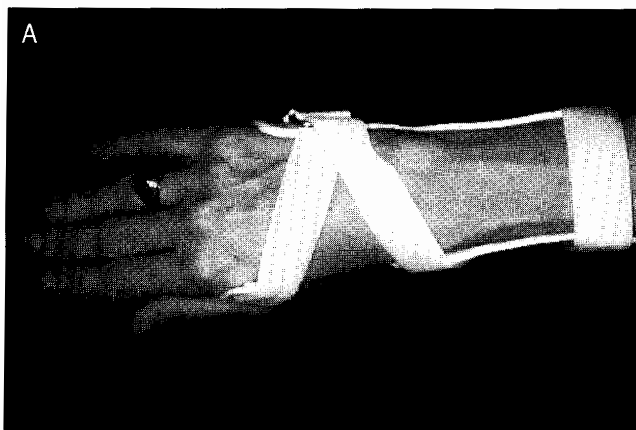
All scar contracts as it heals.[51] In the hand this is of particular functional concern if skin crossing joints becomes too short to allow normal motion. Prolonged positioning of the scar at maximum length combined with positive pressure[52] to minimize scar hypertrophy can often prevent the need for surgical release.

Categories of Splints Which Immobilize and Mobilize

There are four types of splints: *Static* splints immobilize and *dynamic* provide mobilization. *Serial static* and *static progressive* splints hold tissue at maximum length and are changed frequently to encourage tissue to lengthen. These two types combine positive characteristics of both immobilization and mobilization splints. A fifth device which mobilizes tissues is a *continuous passive motion* machine (CPM), which will also be discussed.

Static

A static splint is a device molded or applied directly to the hand that maintains the hand or joint/s in one position (Fig. 111-4). It may be worn continuously to support healing tissues or removed periodically to allow periods of specific protected exercises. Static splints are used most often to rest tissues, provide external support, and intermittently gain or maintain motion which has little resistance.



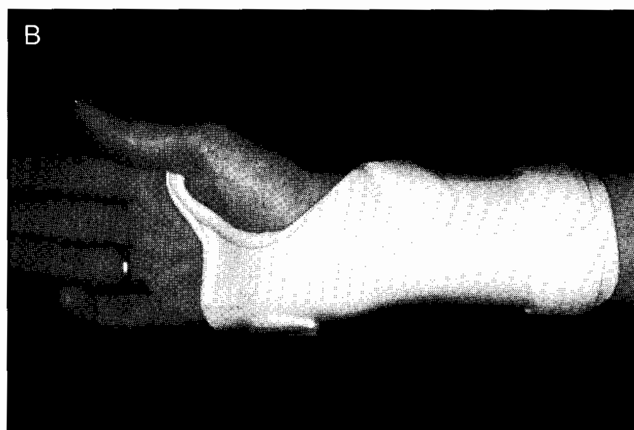


FIG. 111-4. A static wrist splint provides support and immobilization to the wrist. ASHT splint classification: wrist immobilization splint, type 0[1].

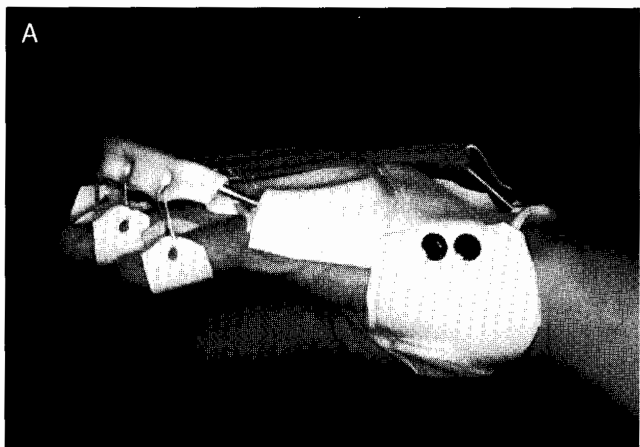
Dynamic

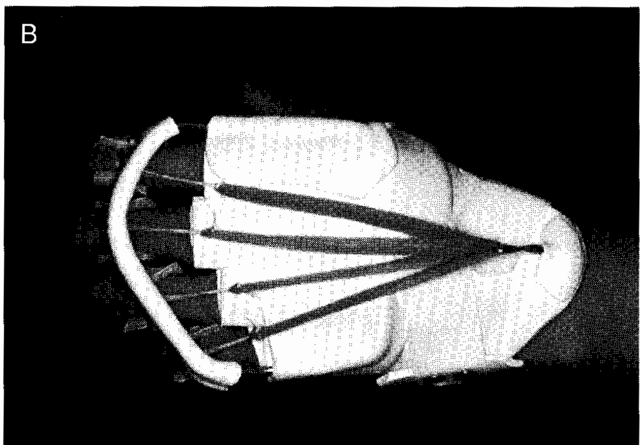
Dynamic splints provide a constant force to the joint/s. A dynamic splint has a base, usually made of molded plastic material, held securely to the hand and/or forearm. The force is generated either by a stretched rubber band or a wire spring coil via an outrigger attached to the base. The outrigger assures that the force is directed at or close to a 90-degree angle to the long axis of the bone (Fig. 111-5).

While the splint is worn by the patient, there is a constant force applied and, even as motion improves, the splint force continues. Dynamic splints are removable, and the force is intermittent because the splint is removed periodically.

Serial Static

Serial static splints are molded in a stationary position with the tissue at maximum length. They are changed frequently to accommodate the decreased resistance in the tissues. Such a splint may be a





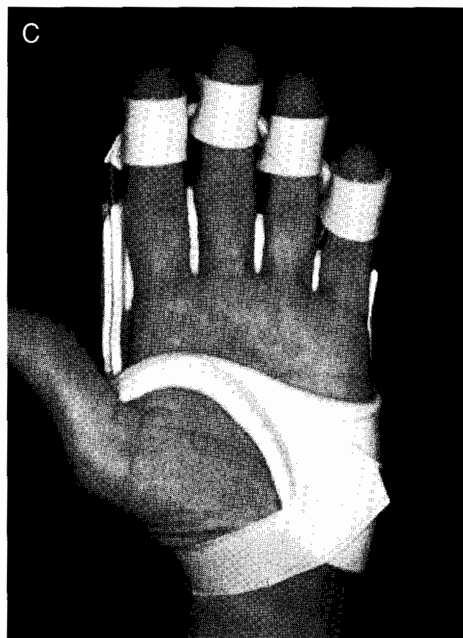


FIG. 111-5. A dynamic splint extends the proximal interphalangeal joints, while metacarpophalangeal joint extension is blocked by the dorsum of the splint. ASHT splint classification: IF-SF PIP extension mobilization splint, MP restriction, type 0[8].

plaster cast[53] worn continuously until removed by the therapist (Fig. 111-6) or a molded plastic splint applied and removed by the patient. The splint is worn for long periods so that the tissue adapts to this new position. Ideally the serial cast is changed every other day, or at least twice weekly, with brief periods of supervised exercise when out of the splint.[54] For patients who live some distance away from the clinic, the logistics of these frequent visits can be difficult.

Plaster of paris has long been recognized as an effective means of applying effective serial static splinting because of its conformity[2] and the belief that inelastic splints are more effective.[33,55] Many believe serial casting is indicated where use of dynamic splints has failed.[33,54] The author's experience supports the use of dynamic splints in joints responsive to manual stretch. For dynamic splinting to be effective, edema must be resolved and the injury must have been recent.

Often the question is whether to splint for prolonged periods in *one* direction when the joint lacks motion in *both* directions. Bell-Krotoski believes serial casting for proximal interphalangeal joint contractures is underutilized because of a fear of loss of flexion motion.[54] Although flexion is decreased temporarily, positioning the joint in extension by tissue elongation decreases the resistance to flexion.

Static Progressive

Static progressive splints may be identical with dynamic splints in construction of the splint base and outrigger, but the application of force is not dynamic. The force may be applied via the same outrigger and finger loop system or by another means. Instead of a rubber band or spring, tension is maintained once fitted (commonly with Velcro or mechanical components which can be adjusted in small increments) (Fig. 111-7).

The theory of static progressive splinting (holding the joint at easy maximum available length) is the same as that for serial static splinting. The primary difference is the way in which forces are applied. When serial static casting is used, force is evenly distributed over all surfaces. Static progressive splinting concentrates the force through the surface area of the splint part applying the pressure. Although the force application should be small, the amount of applied tension is variable, owing to the patient's ability to adjust it.

Static progressive splinting allows the patient to remove the splint and work on active glide and other stretching, or use another splint.

Continuous Passive Motion

Any discussion of splints that help to regain joint motion is not complete without consideration of CPM machines. Salter's work has shown the significant benefits of CPM for treatment of intraarticular fractures.[56–58] The advantages of increased wound tensile strength from CPM application[59] have led to its applications in a variety of conditions.

The therapist may need to add a custom splint to block motion in normal joints so that the motion of the CPM machine occurs at the involved joints (Fig. 111-8). CPM use is generally reserved for the early postoperative stage; it is of little value once the collagen fibers have developed cross-links and demonstrate resistance.

INFORMATION NECESSARY FOR HAND SPLINTING

The splint maker needs to understand the healing process and how splinting can affect it. A thorough knowledge of hand anatomy, kinesiology, pathology, and surgical procedures is also necessary.

Splint Position and Architecture of the Hand

Respect for the wrist as the keystone for hand positioning is the basis for all splinting, except isolated digital splinting (Fig. 111-9). The weight of the immobile hand, gravity, and resting muscle tension tend to pull the wrist into flexion, which increases tension in the extrinsic extensor tendons, pulling the metacarpophalangeal joints into extension. Concurrently, the tension of the extrinsic flexors is maintained, forcing the interphalangeal joints into flexion. The transverse arch of the hand, created by the descending arc of the metacarpal heads (by CMC flexion), is also lost when the metacarpophalangeal joints are extended. Both the longitudinal *and* transverse arches are thereby lost.

Wrist flexion with increased extensor tension inhibits the intrinsic-mediated metacarpophalangeal flexion and interphalangeal extension, resulting in the "intrinsic minus" position. The addition of edema sentences a hand immobilized in this position to months of

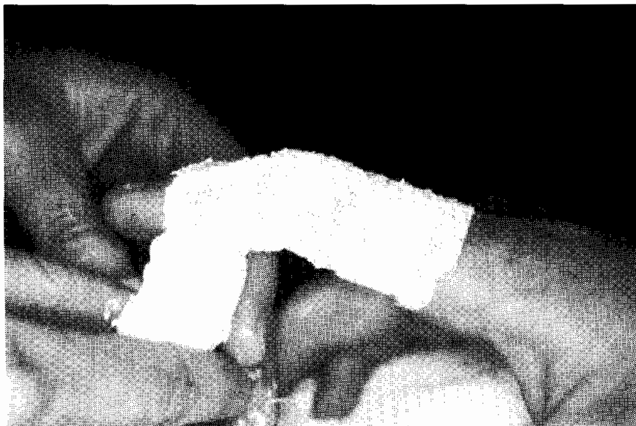


FIG. 111-6. A serial cast is applied to the finger to gain proximal interphalangeal joint extension. ASHT splint classification: PIP extension mobilization, type 1[2].

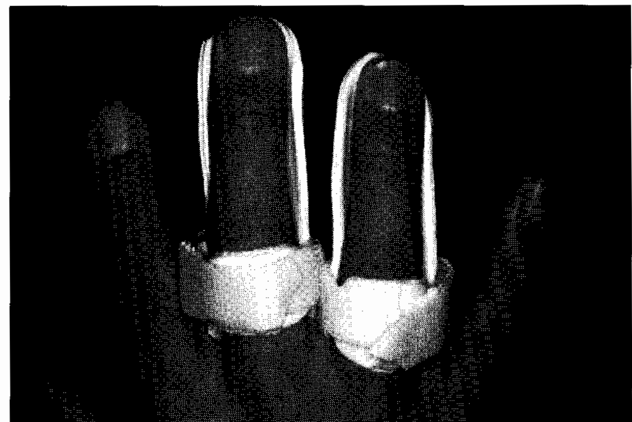


FIG. 111-7. A static progressive splint gains proximal interphalangeal joint extension by progressive tightening of the dorsal piece. ASHT splint classification: PIP extension mobilization, type 1[2].

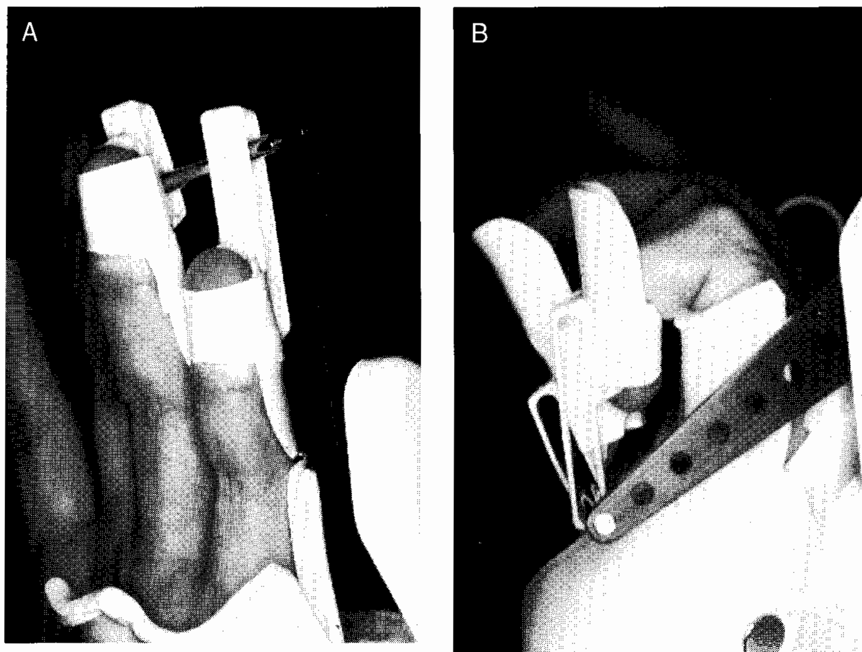


FIG. 111-8. Continuous passive motion of the ring and little finger interphalangeal joints is effective when a custom-made splint limits metacarpophalangeal joint flexion and also prevents distal interphalangeal joint hyperextension. ASHT splint classification: RF and SM PIP, DIP flexion mobilization, MP flexion restriction, MP PIP DIP extension mobilization, DIP hyperextension restriction, type 1[7] (wrist is included in splint).

intensive rehabilitation to regain the normal balance of motion. (See Chaps. 68 and 69.)

Equally important as wrist extension is the maintenance of the thumb in an opposable position of abduction and pronation. Wrist flexion also exerts tension on the thumb extensors, pulling the thumb into adduction, which makes it difficult to recruit the (balancing) intrinsic muscles. The thumb web develops an adduction contracture, limiting functional opposition.

Historically authors have advocated two different, but similar, positions to prevent these deformities: the "safe or functional" position[39,60] and the "intrinsic plus" ("clam digger") position[33,61] (Fig. 111-10). Before antibiotics and aseptic procedures, the likelihood of infection complicating any open injury or surgical procedure was significant. Therefore if the hand were to stiffen it was desirable for it to stiffen in such a position so as to still be useful. By positioning the wrist in slight (30 degrees) extension, the thumb in abduction, and all finger joints in slight flexion, the hand would likely retain some pinch ability even if stiffened by infection.

As surgical results improved, the intrinsic plus position was advocated because it favored the weaker intrinsic motions of metacarpophalangeal (MP) flexion and interphalangeal (IP) extension that are so difficult to obtain. The intrinsic plus position is not meant for

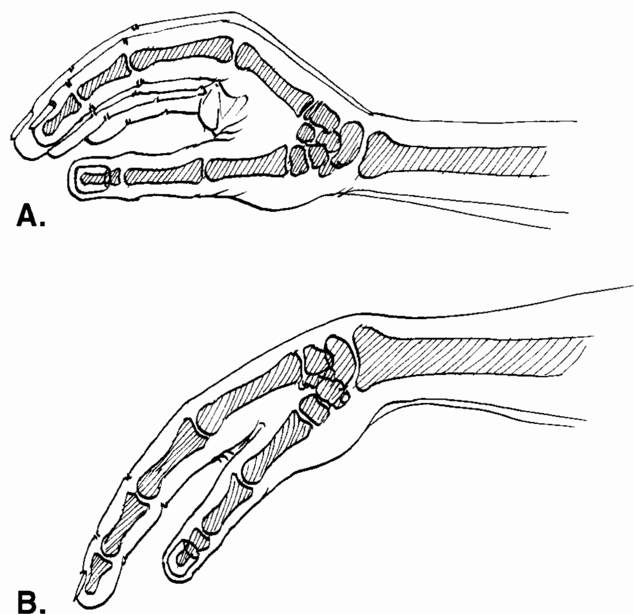


FIG. 111-9. *A.* Wrist extension positions the hand naturally into the normal transverse and longitudinal arches. *B.* As the wrist falls into flexion, the tension of the extrinsic extensors causes both arches to be lost.

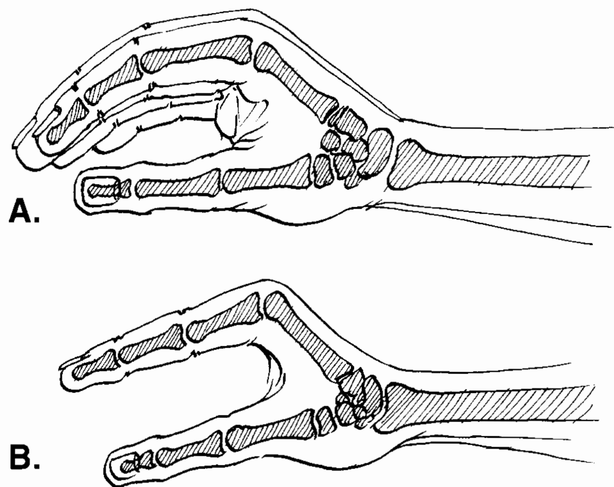


FIG. 111-10. *A.* The safe or functional splinting position places all joints in a midposition. *B.* The intrinsic plus position puts the metacarpophalangeal joints in maximum flexion and the interphalangeal joints in maximum extension with the thumb fully abducted.

prolonged immobilization and must be balanced with early motion and attention to intrinsic muscle stretching as healing allows.

Neither of these is a "position of choice" for all injuries or procedures. The individual tissues injured dictate the mechanical design of an immobilization splint to optimize the result.

Kinesiology of the Hand

The splint maker can no longer have only a vague idea about kinesiology. New information about tendon excursion, joint kinematics, and muscle fiber length must be applied to splinting. The therapist must recognize patterns of pathological movement readily and appreciate how external splinting can influence the balance of motion. This is gained from a cumulative clinical experience in which surgeon and therapist confer frequently.

Surgical Procedures

The splint maker must understand the details of any surgical procedure if its purpose is to be helped by external splinting. It is the mutual responsibility of therapist and surgeon to share information; therapists must diligently study anatomy and surgical procedures. Therapists who observe surgical procedures are more readily able to visualize the balance and movement of the internal structures when approaching the hand from the surface.

BASIC SCIENCE

Pathology of Stiffness

The general response of hand connective tissue to immobilization in the presence of edema is increased resistance to differential glide of the many tissue layers. The "one wound-one scar" theory explains that stiffness and limited glide can be distant from or local to the injury site.[62]

The mechanical properties of connective tissue are determined by the collagen fiber arrangement and the cross-links between adjacent collagen molecules.[63] Peacock uses the analogy of a nylon thread (as the collagen fiber), which is relatively inelastic. But a nylon stocking—in which the fibers are arranged so that cross-linking allows elasticity—is very elastic.[51] Scar production demonstrates a disorganized arrangement of collagen fibers, such that the "nylon stocking" loses it elasticity.

Human Tissue Response to Stress

Connective tissue responds to stress deprivation by progressively shortening and to constant tension by displaying plastic elongation,[64] described by some as a "growth response" of the tissues.[53,65] The need is for prolonged periods of splint application, as this growth-adaptation is not a quick response.

Until drugs are produced which can influence wound healing, stress is the best available means to influence collagen fiber orientation.[63] Scar, displaying a disorganized collagen fiber structure and decreased elasticity, will show increased organization of its fibers and increased elasticity as a response to the splint stress.[51] Splints can also control the extent of normal wound contraction. If the counterforce of the splint provides an equal or greater force than that of wound contraction, deformity is prevented.

CHOOSING SPLINTS BASED ON BIOLOGIC STAGES OF HEALING

The type and amount of stress needed to effect fiber realignment in the tissues is, to some extent, influenced by the stage of healing based on biochemical activity in the wound.[66] These stages in the healing may be prolonged or overlap. The clinical experience of the therapist ultimately focuses judgment on what splint type is most appropriate and when it should be applied. It would be ideal if the splint application were a science, but the practicality of trial and error is still a frequent determinant of the tissue tolerance to stress.

Stage I: Inflammation

The initial reaction to injury is a vascular and cellular response which removes devitalized tissue; this stage lasts about 5 days. Static splinting during this stage provides the desired rest. Only in minor injuries is intermittent active motion appropriate; the period of active motion must be short and be limited by the inflammatory pain and edema. Splinting should also include some means of gentle compression.

Stage II: Fibroplasia

After the initial inflammation subsides, injured tissues undergo rapid change. Immature collagen with disorganized fibers replaces normal tissue. It is this disorganized collagen that blends the tissue layers, creating one scar, and interferes with gliding planes between each tissue.[67]

At the beginning of the fibroblastic stage, the low tensile strength of the wound allows only gentle active motion and positional splinting. Static splints may support the joint in full extension, allowing the patient to concentrate on flexion during the day. Patients with a mild flexion contracture, who have little resistance to passive joint motion, can regain full motion with a simple gutter splint that holds the joint in its maximum degree of extension.[54,68] In the latter part of the fibroblastic stage, gentle dynamic splinting can encourage the collagen fiber direction and orientation.

Stage III: Scar Maturation

After about 6 weeks the fibroblastic stage is complete; correctly applied stress can prevent long-term stiffness. Excessive stress can destroy or prolong the progression of healing.

Since the new tissue is in the early stages of reorganization, brief periods of dynamic splinting are often effective to mobilize stiffened joints.[1,29,40,49,50,69–71] Intermittent stress application provides adequate force to produce plastic deformation because tissue resistance during the early part of this stage is small. A joint that responds to gentle sustained manual traction and shows a gentle slope on torque angle measurements responds to a short period of splinting (Fig. 111-11).[72–74] Some recommend a short period of semirigid splinting to reduce contracture, and then dynamic splinting applied intermittently to maintain position.[33] The idea is to apply the dynamic splint at the beginning of this stage when tissue resistance is responsive to intermittent stress.

The therapist and surgeon must learn to "read" the response of the hand to the stress of the splint. If signs of inflammation continue, serial static splinting may allow rest for the tissues, while regaining motion by serial positioning. When the patient lives some distance from the clinic or can use the splint only when not working, a static progressive splint may be best. The patient can remove a static progressive splint for daily tasks and the splint can be adjusted to accommodate improved motion.

During the final phase of scar maturation the amount of collagen decreases and the wound becomes stronger.[75] The cells have new interlinking bonds that provide resistance to motion. These

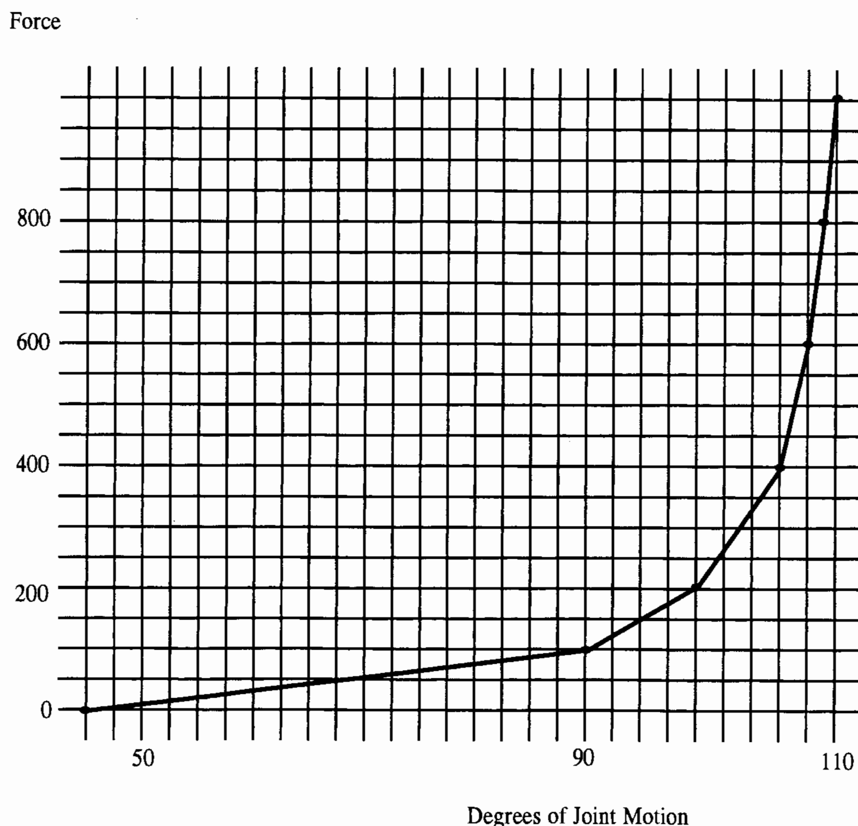


FIG. 111-11. The torque angle curve of a normal PIP joint demonstrates how resistance to joint motion at various angles is plotted. *(From: Flowers KR, Pheasant SD: The use of torque angle curves in the assessment of digital joint stiffness.* J Hand Ther *1:69, 1988, with permission.)*

hands truly feel stiff. As a joint is passively stretched, there is a distinct resistance at the end of the range of passive motion. This resistance can be objectively documented by a steep angle on a graph plotting torque angle curves.[73] Joints displaying significant resistance need the longest periods of stress application for motion to be regained. Intermittent splinting will take longer than continuous splinting to regain the same amount of motion.

The stress from dynamic splints is too intermittent for these cases. Serial static and static progressive splinting are the most effective means of regaining joint motion when the joint has significant resistance.[72,74] It is the author's experience that even chronic, exceedingly resistive, contracted joints respond to serial casting. Within three to four visits it can be seen whether a nonsurgical approach can be successful in gaining joint motion. (Accurate goniometric recordings are needed at each visit.) Monitoring torque angle curves helps the therapist and surgeon decide when surgical intervention is appropriate.[33]

Therapists must measure active *and* passive joint motion at each visit. The difference dictates whether splinting should be the priority or whether the patient needs to focus on an active exercise to translate the passive motion gained by the splint into active function.

BIOMECHANICS OF SPLINTING

Although basic mechanical principles dictate splint design, Barr is correct in stating that: "It must be emphasized that the design of any sort of splint stems from the patient's own problems and has no other valid identity."[31] It is not appropriate for the therapist to know how to make a limited repertoire of splints; each must be individually applied.

First Class Levers

All splints are first class levers (Fig. 111-12) with axes of motion at the joints to which they are applied. The fulcrum (splint base, or outrigger with attached force application) affects joint motion. To pull joints into flexion or extension, splints must have three points of pressure distribution: one is at the level of the joint; the other two are as far away from the fulcrum as possible to maximize leverage.[65,76]

The length of the forearm piece is relevant for pressure distribution when the weight of the hand must be carried by the splint.[77] Finger loops should be placed as far from the joint axis as possible so that the torque is maximized.[50,78]

Mechanical Effectiveness

Understanding splint types and tissue responses to them is the basis for effective splinting. Splint efficacy is limited by design accuracy, fit, and force consistency.

Even Distribution of Pressure

The splint must fit accurately. This is accomplished by careful molding and well distributed pressure. Bunnell advocated the use of nonpadded plaster of paris because of its ability to precisely conform.[2]

For example, pressure is distributed evenly by the metacarpophalangeal blocks molded as a continuation of the splint base (Fig. 111-5). Instead of concentrating pressure over a small dorsal area of each finger, it is distributed over as much surface area as possible. The leading edge of the block ends at the joint so that all force is specifically directed to the joint axis.

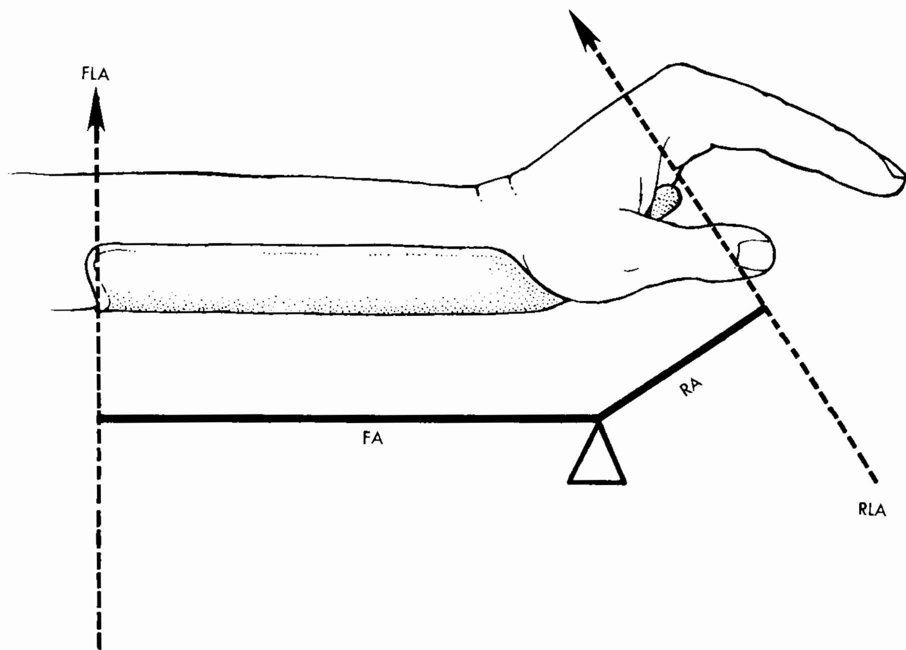


FIG. 111-12. Splints are first class levers. This wrist splint shows: FLA = force line of action; FA = force arm; RA = resistance arm; RLA = resistance line of action. *(From: Fess EE, Philips CA:* Hand Splinting Principles and Methods, *2d ed. St. Louis, CV Mosby, 1987, with permission.)*

Commercial dynamic splints frequently fail to offer the individual shape and pressure distribution needed, making wearing uncomfortable. Fitting of a commercial splint designed to apply joint pressure should be done by a knowledgeable person. If the commercial splint cannot be adjusted to distribute pressure evenly, it should be abandoned and a custom one constructed.

Prolonged Tension

Because tissue deformation occurs *most* effectively with a low load and long application,[50,64,78–80] it is always preferable to have a small force that the patient can tolerate for increasing time, rather than a large force that can only be tolerated for short periods. The tension needed to place tissues at (the end of) their elastic limits is all that is needed.[82] It is important to make patients aware of this splinting principle since the patient's goal should be increased wear time *before* force is increased. Similarly, if the patient cannot comfortably wear the splint beyond a few minutes and the splint fits well, the force should be decreased.

The consistency of force application in dynamic or static progressive splinting is most often related to the patient's tolerance to the level of force applied. There continues to be a debate about the optimal amount of force necessary to achieve maximal gains; 75 to 300 g has been recommended.[78,83] Ischemia of local tissues produced by application of the finger sling may be a more realistic limit.[84,85] Rubber bands[86,87] and springs[88] have been studied to find out the amount and consistency of force applied by each,[85] but the conclusive work has yet to be published. The pressure becomes increasingly relevant as application time increases. The intermittent application of force, which is the nature of most splinting, increases the amount of force that can be safely tolerated.[78,89] Flowers and LaStayo suggest that the splint prescription should indicate total end range time (TERT) for the force.[90]

The more mature the scar, the more likely experienced therapists are to choose a greater amount of force.[86] Until the question of "How much tension?" is answered, the patient's comfort re mains the best way of deciding maximum effective force ove time.[91]

Easy Adjustment

Any splint used to gain motion should be easy to remold, inexpen sive to replace, and quick to adjust; the splint must be adaptable t the anticipated joint change.

The low temperature plastics allow quick remolding and adjust ments to be made to adapt to new positions, to decreased edema, an to relieve unwanted pressure areas. Plaster allows quick construc tion of a new splint with small materials cost. The use of metal out riggers permits adjustments by simply bending the wire (Fig 111-13). As finger joint flexion increases, the line of pull of the fin ger loop needs to be redirected closer to the palm. Alternatively, a extension improves, the outrigger needs to be shortened and place more proximally.[50,78]

Perpendicular Force

The construction of a dynamic or static progressive splint require attention to additional biomechanical principles.

A force used to stretch a joint should pull at a 90-degree angl to the long axis of the bone.[50] The outrigger end is located close t the point of application of force. The outrigger redirects the line o pull and keeps it as close and as parallel as possible to the splin base.

This lever/force system is of value only if a secure splint bas has been applied that is intimately conformed, has pressure area well distributed, and accurately stabilizes the proximal joints. Th force efficiency of dynamic and static progressive traction alters i either the outrigger or its attachment to the base is unstable. If th outrigger is significantly unstable, it will deform before the tissue change.

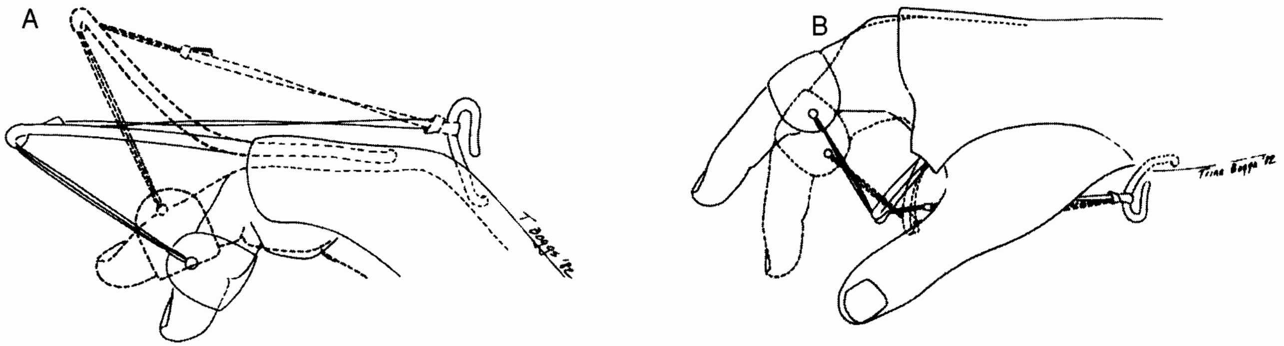


FIG. 111-13. The use of metal outriggers allows quick adjustment to assure the line of pull remains accurate. *(From: Colditz JC: Low profile dynamic splinting for the injured hand.* Am J Occup Ther *37(3):182, 1983, with permission.)*

SPLINTS FOR CLINICAL PROBLEMS

Splints for Joint Stability

Splints that support unstable joints are used to protect a healing ligament from external stress. Splinting can be as simple as a buddy tape to the adjacent digit or a sophisticated splint to reduce an unstable dorsally dislocated joint, permitting precise limits to motion (Fig. 111-14).

Splints can also provide an external substitute for loss of ligamentous restraint, such as for patients with rheumatoid and other connective tissue disorders. With multiple joint deformities, the splints may provide long-term functional assistance, or temporary assistance until surgical stabilization can be undertaken (Fig. 111-4).

Splints to Reduce Joint Tightness

Only a skilled manual examination can decide the character and amplitude of joint tightness. If passive joint motion does not change when the proximal and distal joint positions are changed, isolated joint tightness can be proved. If other soft tissue constrictions are present simultaneously, the extent of the joint limitations is obscured. Certain motion may need to be regained before the potential for other structures can be learned [e.g., passive PIP joint flexion must be gained to allow effective evaluation of intrinsic tightness (See Chaps. 68 and 69.)].

Many designs and types of splints are used to treat joint tightness. Common joint limitations and splinting approaches follow.

Proximal Interphalangeal Joint

The stage of healing and the amount of resistance from a PIP joint flexion contracture determine the design of the extension splint. Some surgeons and therapists advocate serial casting as the *first* choice[33] (Fig. 111-6); others recommend dynamic (Fig. 111-15) or static progressive splinting (Fig. 111-7).[92] The joint effusion common after PIP injuries can alone, in the absence of adherence, prevent full extension due to the internal pressure. For that reason, when the PIP joint is swollen, regardless of the stage of healing, a period of serial casting is recommended to gain motion while reducing edema. Often the gains can be maintained with intermittent use of a static or dynamic splint.

Regardless of the splint chosen, care must be given to avoid pressure over the dorsum of the proximal interphalangeal joint. Because full interphalangeal extension is rarely needed for daily function, proximal interphalangeal extension splinting must be applied for a long time to reestablish balanced motion at this joint.

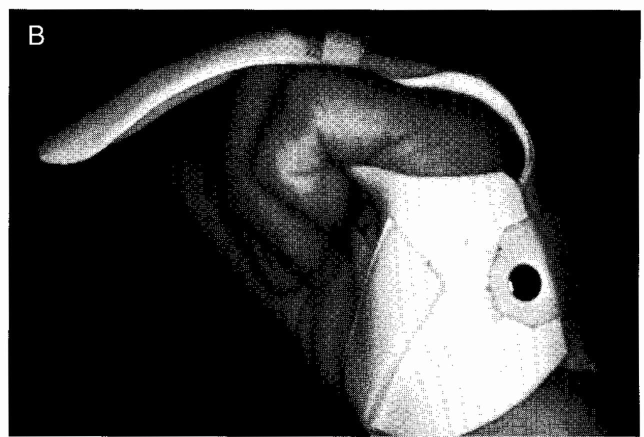


FIG. 111-14. A custom splint allows proximal interphalangeal joint flexion (*A*) but prevents full extension (*B*) following a dorsal fracture dislocation of the proximal interphalangeal joint. ASHT splint classification: RF PIP flexion mobilization, extension restriction, type 1[2]. (DIP joint is not included in classification since it has full range of motion within the splint.)

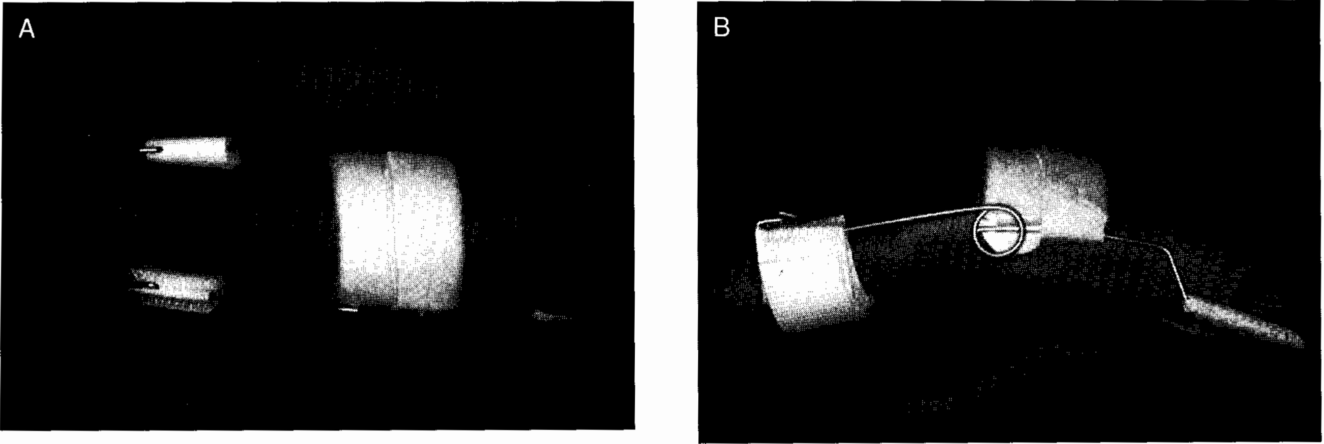


FIG. 111-15. A dynamic splint made of spring coils regains proximal interphalangeal joint extension. ASHT splint classification: SF PIP extension mobilization, type 1[2].

The intimate tendon and PIP joint anatomy means that the extensor frequently loses its ability to glide unimpeded across the joint capsule. Most often the frustration with splints used to reduce joint tightness of the proximal interphalangeal joint is not the inability of the splint to gain full passive interphalangeal joint extension, but it is the recurring active extensor lag. The intrinsic muscles responsible for interphalangeal extension have little power or mechanical advantage. Even after proximal interphalangeal joint passive extension is gained, there must often be intermittent day, and full-time night, splinting in extension. This must be balanced with intrinsic muscle exercises (IP joint extension with metacarpophalangeal joint flexion).

Metacarpophalangeal Joint

Metacarpophalangeal (MP) joints which lack passive flexion resist the best splinting efforts because of the anatomy of the collateral ligaments and metacarpal heads. The collateral ligaments must change in length more than 20 percent as 60 degrees of flexion is achieved.[93] Many versions of dynamic splints cause frustration because of the problem of the splint slipping distally instead of increasing the MP joint flexion.[80] Prevention of distal slippage is accomplished by intimate molding, use of a dorsal splint base plus a palmar bar, and, most importantly, an oblique strap at the thumb base. Construction details prevent slippage and improve splint tolerance (Fig. 111-16).

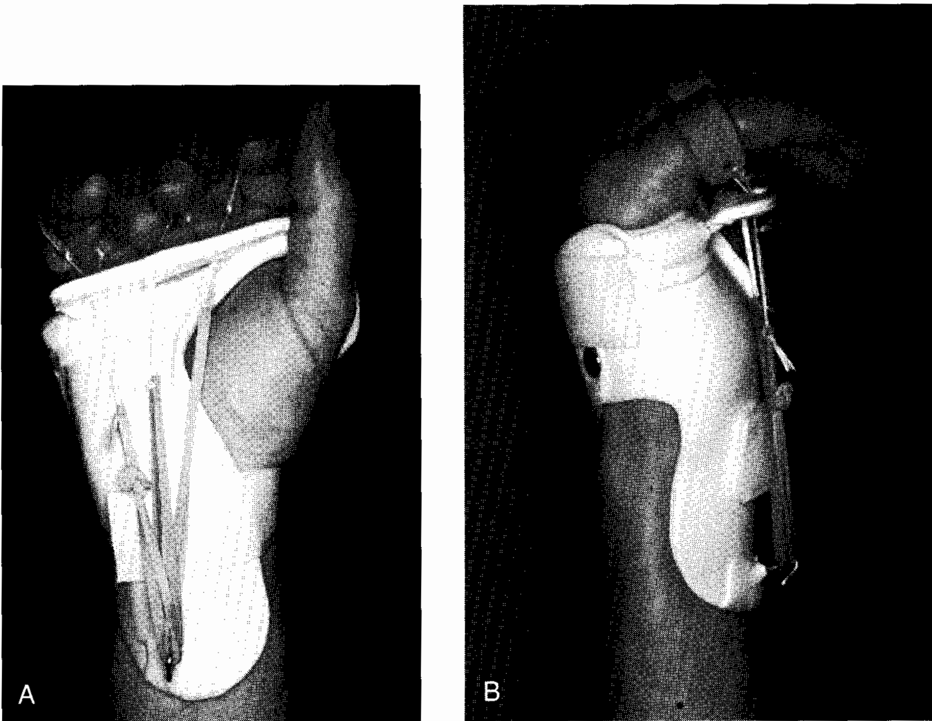


FIG. 111-16. A dynamic splint to regain metacarpophalangeal joint flexion is carefully contoured and assures room for full metacarpophalangeal flexion to occur. ASHT splint classification: IF-SM MP flexion mobilization splint, type 0[4]. (*Note:* Wrist can move through partial range while hand is in splint.)

More resistive metacarpophalangeal joints will respond to the prolonged positioning within a serial static plaster of paris splint, which is removed only for short periods for splint changes until the required motion is regained. Either a dorsal and palmar plaster slab can be applied, or a wrist cast can have a dorsal plaster extension added over the proximal phalanges to gain MP joint flexion.

Bunnell's splint of choice, and a splint still recommended by many, is the "knuckle bender," which is built to flex the MP joints effectively.[94] The lack of custom conformity and the splint's hard materials makes discomfort a major issue, as its application can create pressure areas and prolong edema.

Wrist Joint

Serial static splinting (casting),[33] dynamic extension splinting, and static progressive splinting may all be used to regain wrist extension necessary for function. The primary design element required for an effective dynamic wrist splint is a hinge, connecting the metacarpal and forearm components (Fig. 111-17). The wrist must be carried through its normal arc of extension *instead* of being compressed by the splint force.

Unlike splinting of the PIP and MP joints to regain motion, the wrist can be splinted to increase motion, and the patient still retains use of the hand. Serial static splints, adjusted as the patient gains wrist extension, can be worn during daily activities. A less resistant wrist joint may respond to intermittent use of a dynamic splint. As for other stiff joints, active wrist motion through the available passive range must be repeated often to maintain the gains made with the splint.

Splints to Reduce Muscle-Tendon Tightness and Adherence

Tightness of a muscle and adherence of a tendon along its path both cause limited motion. These may occur from direct trauma or when a muscle-tendon unit is immobilized to protect a more remote injury. An atrophied muscle shortens its resting length by 10 to 40 percent owing to the change in compliance of the elastin elements.[62] Adherence of the tendon along its path is most often associated with direct trauma to the tendon or tendon bed/sheath and is more likely where tendons are constrained by pulleys.

Tendon adherence and muscle tightness are both demonstrated by a distinct difference between the ease of distal joint motion when the proximal joints are positioned first in flexion and then in extension.[91] Joint motion distal to the point of adherence is necessary to pull on the site of adherence. These positions of tightness demonstrate the positions needed for effective splinting. For example, to stretch the extrinsic extensor muscles, the wrist must be held in flexion while the fingers are concurrently flexed. To elongate the adherence of a repaired extensor tendon over the metacarpals, only joints *distal* to the repair (metacarpal) need to be included in the splint (Fig. 111-16). The type of splint chosen depends on the amount and character of the tissue resistance to stretch.

Intrinsic Muscle Tightness

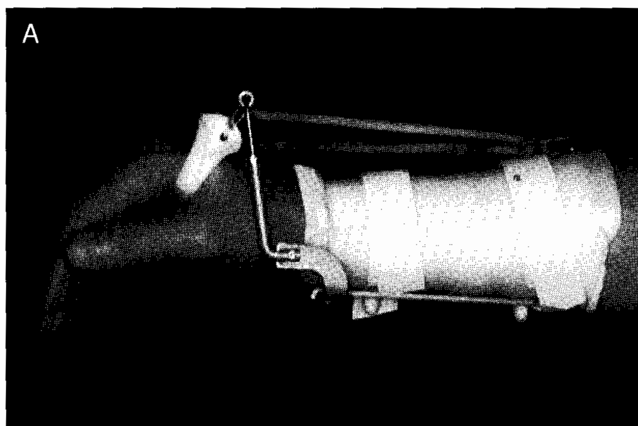
The intrinsic muscles are particularly prone to lose their elasticity in the presence of edema and limited hand motion, such as from a crush injury. The smaller intrinsic muscles with less excursion frequently require prolonged positioning in a stretched position to regain their elasticity. When manual stretching is not effective in reducing intrinsic tightness, use of intermittent splinting should be undertaken (Fig. 111-18). The importance of a position of MP hyperextension combined with interphalangeal flexion must be emphasized. The lack of a position of MP joint hyperextension and distal splint slippage prevents many splints from being effective.

Extrinsic Muscle Tightness

Because of their greater bulk and extension, extrinsic forearm muscles often regain their normal elasticity in response to manual stretching alone—especially if tightness results from immobilization instead of direct injury. Either serial static splinting of all joints concurrently or dynamic splinting of the distal joints while the proximal joints place the muscle on stretch are effective.

Splints for Nerve Injuries

Splints for tight joints apply force, but those used for the hand affected by nerve injury constrain motion to create a facsimile of the normal muscle balance. Bunnell stated, ". . . to substitute for the lost motion with just enough force so that when the opposing normal muscles are relaxed, the parts fall into the corrected position,



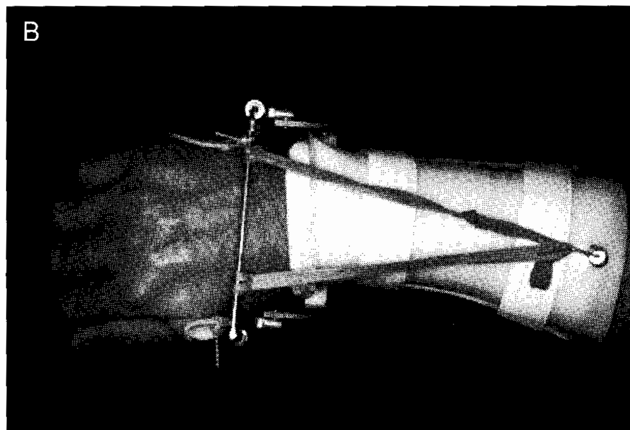


FIG. 111-17. A dynamic splint to regain wrist extension uses a commercially available wrist hinge component. ASHT splint classification: wrist extension mobilization, type 0[1].

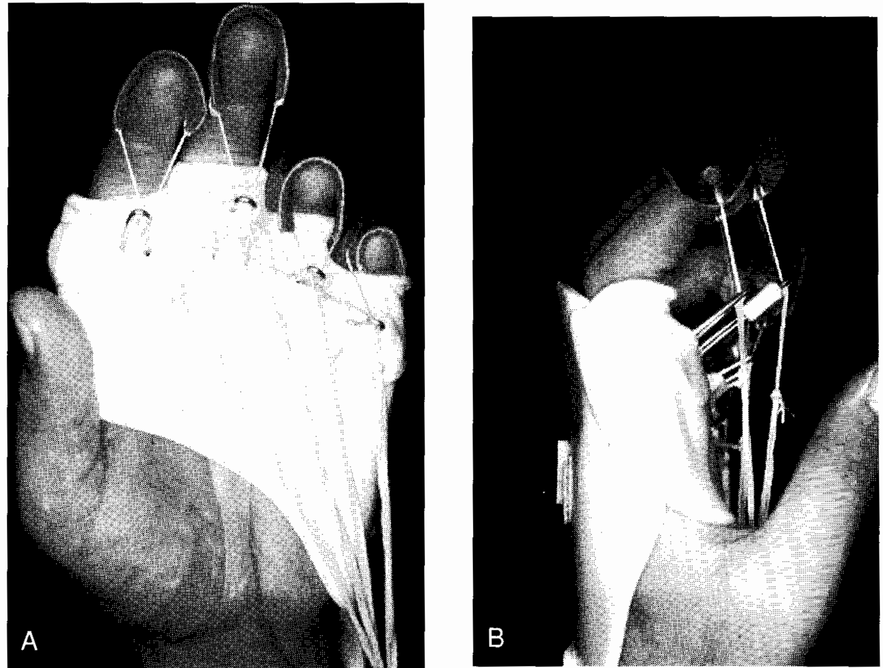


FIG. 111-18. A dynamic splint to stretch tight intrinsic muscles positions the metacarpophalangeal joints in full extension while the rubber band force is flexing the interphalangeal joints. ASHT splint classification: IF-SM PIP DIP flexion mobilization, MP restriction, type 1[13]. (Wrist is included in the splint.)

and yet allow the normal muscles, when activated, to carry out the full range of motion."[94]

Median Nerve Palsy

The primary functional motor loss with median nerve palsy is the inability of the thumb to abduct and oppose; the thumb adductor is unopposed. As muscle return is awaited, the abductor pollicis brevis and the opponens need to be placed in their shortest position and the first web space must also be passively maintained. A small splint to stabilize the thumb in a position where pinch can occur is the design of choice (Fig. 111-19). Night splinting is used to maintain the full span of the web space.[95] The traditional C-bar design of commercial splints neither adequately stabilizes the thumb for pinch nor maintains the maximum width of the first web.

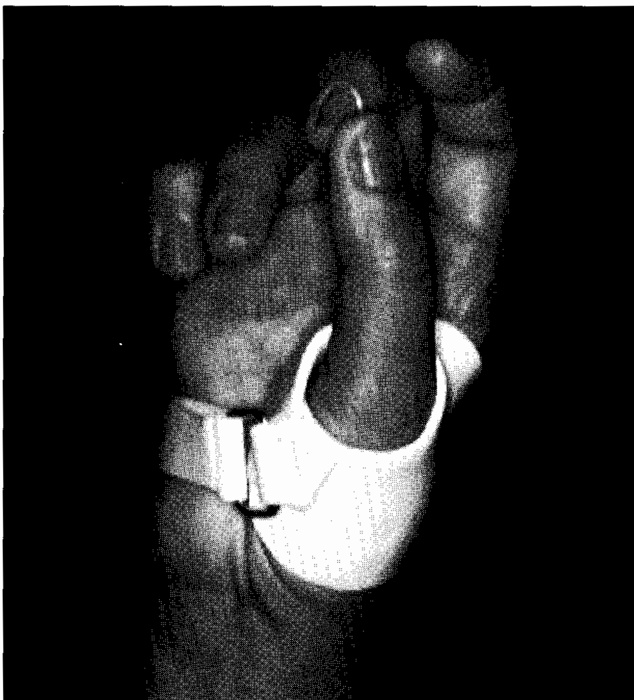


FIG. 111-19. A small splint stabilizes the thumb in median nerve palsy. ASHT splint classification: thumb CMC restriction, type 0[1].

Ulnar Nerve Palsy

In isolated ulnar nerve palsy, the use of a static dorsal MP joint blocking splint transfers the extrinsic extensor pull out to the dorsal mechanism of the proximal interphalangeal joint (Fig. 111-20), which activates full PIP extension and thwarts MP hyperextension.[95,96] This blocking splint prevents PIP joint contractures and overstretching the denervated intrinsic muscles. Additionally the

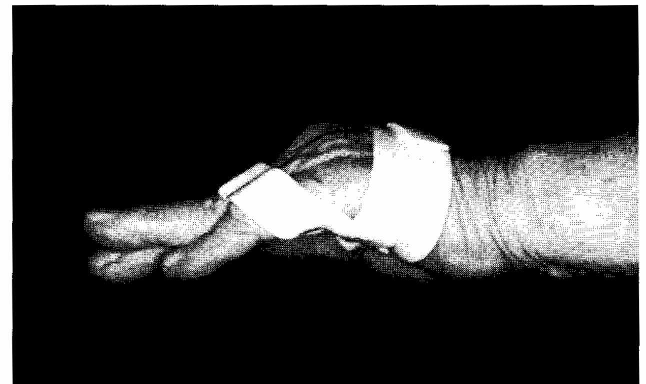


FIG. 111-20. This splint prevents metacarpophalangeal joint clawing in isolated ulnar palsy, but allows full finger flexion. ASHT splint classification: RF-SM MP extension restriction, type 0[2].

blocking action of the splint prevents the development of substitution patterns, thus allowing earlier isolation and strengthening of returning intrinsic muscle function.

Some authors have recommended spring coils to help MP flexion.[47] Correctly gauging the force necessary to assist with MP flexion and at the same time to resist metacarpophalangeal hyperextension is difficult. A static splint which blocks MP hyperextension is recommended by the author for its ease of fit and tolerance.[95]

Radial Nerve Palsy

The hand affected by radial nerve palsy has potential for normal function because of intact palmar sensibility, extrinsic flexors, and the intrinsic muscles. A splint should support the wrist and reestablish the normal tenodesis. Many authors have advocated dynamic splinting[23,60,97,98] or static wrist splinting[99–101] to simulate a more normal tenodesis. This author recommends a splint design with a static line that allows full finger flexion and functional wrist extension as the finger flexors tighten[102] (Fig. 111-21). Suspending proximal phalanges prevents the wrist from dropping into flexion and achieves MP joint extension. (Intrinsic IP extension is preserved.) The metacarpophalangeal joints develop extension contractures in this splint *only* if injury to the peripherial nerves has diminished the normal finger flexor power.

Splints for Tendon Injuries

Flexor Tendons

The results of flexor tendon surgery have been enhanced by postoperative protocols of constrained motion that follow the application of external splints (Fig. 111-22). This method has proved superior to postoperative immobilization.[41,103,104]

To accomplish greater tendon excursion within a safe range, modifications include a palmar pulley for full distal interphalangeal flexion.[105,106] Devices that provide consistent resistance to finger extension[107,108] have been designed to decrease the frequency of PIP flexion contractures.[109,111] Cooney et al. have advocated a tenodesis splint that allows greater excursion.[112]

The exact splint type, joint positions, and intricacies of the postoperative protocol vary among surgeons and therapists. (See Chaps. 47 and 48.) Individuality will continue until it is known exactly "how" to get the best results. The postoperative care of flexor tendons requires close and frequent communication between therapist and surgeon. To prevent tension on the healing tendon, MP joints are often put in maximum flexion. Although MP flexion may assist in preventing PIP flexion contractures by facilitating full interphalangeal extension, the motion available in the splint is via the intrinsic muscles which makes extrinsic flexor activity more difficult when active motion begins. For that reason, the author uses only 15 to 20 degrees of MP flexion in these splints.

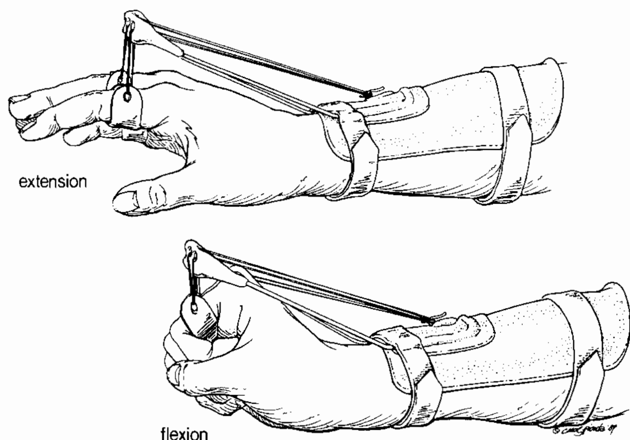


FIG. 111-21. This radial nerve palsy splint design recreates the normal tenodesis pattern of the hand. ASHT splint classification: wrist extension, MP flexion mobilization/MP flexion, wrist extension mobilization; type 0[5]. *(From: Colditz JC: Splinting for radial nerve palsy.* J Hand Ther *1(1):18, 1987, with permission.)*

Extensor Tendons

The rationale of early tendon gliding within a safe range is also applied to the postoperative management of extensor tendons (Fig. 111-23).[113,114] (see Chap. 49.) Some clinicians continue to use static splint immobilization for clean, uncomplicated, extensor tendon lacerations. These "simple" splints should hold the tendon at maximum *proximal* excursion since adherence with immobilization will occur. Many physicians are hesitant to hold MP joints fully extended because of the dread of losing normal MP flexion. In isolated clean tendon lacerations which are splinted for the *minimum* time necessary to protect the repair, it is the author's experience

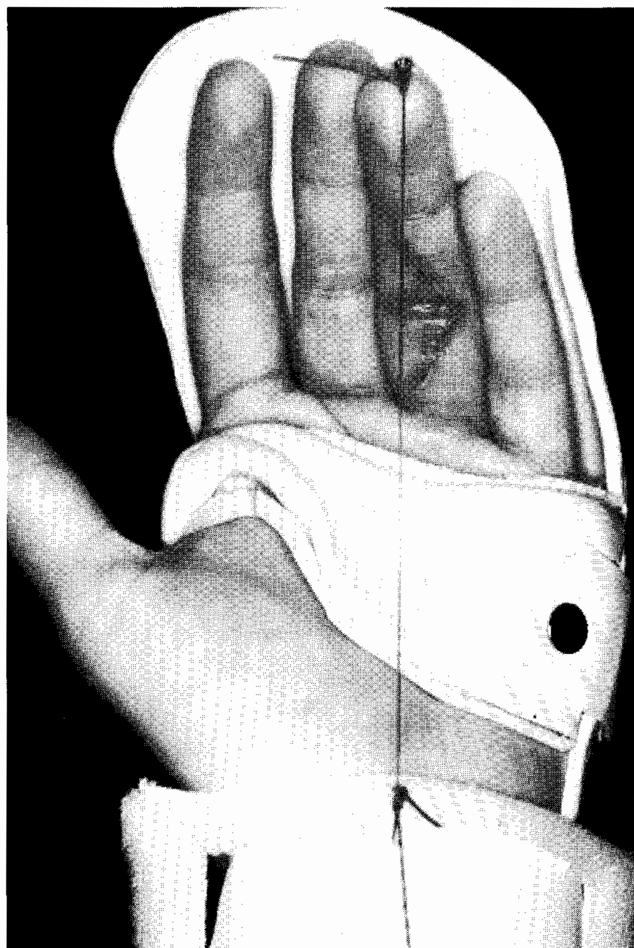


FIG. 111-22. A postoperative splint to limit excursion of digit with a repaired flexor tendon. ASHT splint classification: RF flexion mobilization, extension restriction type 4[7].

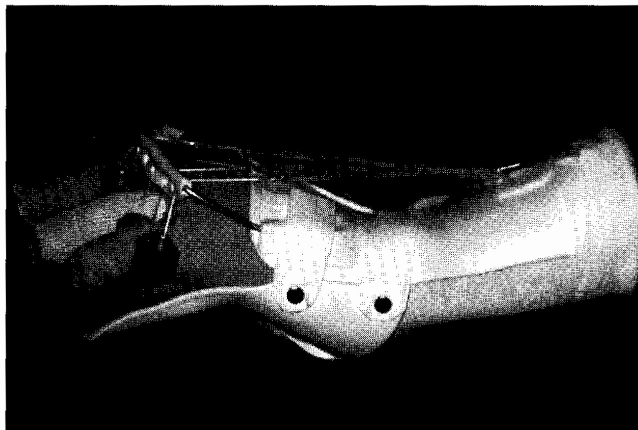


FIG. 111-23. A postoperative splint to limit excursion and stress on repaired extensor tendons on dorsum of hand; extension is assisted by the rubber band tension and flexion is limited by the palmar block. ASHT splint classification: IF-RF MP extension mobilization, flexion restriction type 1[5].

that loss of MP joint flexion is rare. Joints immobilized in midposition have a frequent problem of extensor lag. The weak extensors (even with the best patient efforts) have difficulty overcoming adherence. Conversely, such a tendon laceration held at maximum extension has only to gain glide distally (i.e., gain flexion), which is always easier because of the greater power of the flexors.

Although excellent results have been demonstrated with early active motion via dynamic splinting, many clinicians still reserve dynamic splinting for complicated wounds or extensor tendon lacerations near the dorsal retinaculum.

Splints for Scar Skin Tightness

Skin tightness is demonstrated by applying an elongation force to adherent skin or scar: Blanching, tension within a scar line, or immobility of skin graft or tissue bed is observed. Often when skin limits (joint) motion, placing the skin in a slack position allows increased motion at adjacent joints. Because splinting effectively elongates the scar through adaptation of the surrounding normal tissues, the joints proximal and distal to the scar should be included in any splint. The splint is applied directly to the scar, and an interfacing (silicone, etc.) mold between the splint and the scar assures total conformity. Pressure flattens the scar while the splint maintains scar length.

The problem of splinting to reduce skin tightness is the need for prolonged splint wear, which often interferes with hand use. To solve this dilemma one may apply a night splint to position the tight scar in the maximally stretched position. During the day elastic gloves or pressure molds (held in place with elastic wrap) provide consistent pressure and maintain as much length as possible while still allowing hand use.

Splints for Fractures and Joint Dislocations

Most splints made by therapists for fractures and dislocations are to help deal with joint tightness which results from these injuries. These splints have been discussed.

Therapists working closely with hand surgeons may frequently provide immediate splinting of stable hand fractures to facilitate early motion.[115] This approach has been developed based on Sarmiento's fracture bracing[116,117] and Burkhalter's functional casting for phalangeal fractures.[118] In selected, stable metacarpal and proximal phalangeal fractures the application of a molded splint prevents harmful forces crossing the fracture site. Mobility of all uninvolved joints and tendon glide across the fracture site are encouraged (Fig. 111-24).

Surgeons vary in their approach to treatment of PIP joint fracture-dislocations, but in many cases the therapist plays a central part in the treatment by applying a splint either to provide traction[45,119] or to constrain the reduced joint within a safe range of motion.[42–44] In this clinic the early use of a dorsal blocking splint (Fig. 111-14) in concert with the surgeon's frequent x-ray checks and therapy supervision have resulted in extremely gratifying clinical results.

Splints for Congenital Deformities

Only congenital anomalies due to failure of differentiation are affected by early external splinting. Camptodactyly in both the newborn and the teenager may well respond to splinting. The author's technique is serial static splinting in the newborn and dynamic splinting (Fig. 111-15) in the teenager who exhibits exacerbation of a PIP flexion contracture. Miura et al. have shown that with dynamic splinting only 5 of 62 teenage patients failed to improve and recommend that surgery be reserved for those in whom conservative treatment fails.[120]

Other selected congenital problems can be helped by splinting. A tight thumb-in-palm deformity (absent spasticity) can often be helped by a period of splinting. Radial club hands require external splinting to maintain the hand (wrist) in neutral until surgical stabilization. Soft tissue releases, such as with simple syndactyly, also benefit from postoperative splinting to maintain the new web space.

Splints for Dupuytren's Contracture Release

Following excision of Dupuytren's tissue, the greatest challenge for the therapist and surgeon is the prevention of stiffness of the small joints.[121] Most postoperative protocols use splints to maintain finger extension.[122,123] This author prefers a volar splint that provides direct pressure to the scar. The splint is part of the early postoperative care, initially removed only intermittently to allow active flexion. As the scar matures, an interface mold is made to

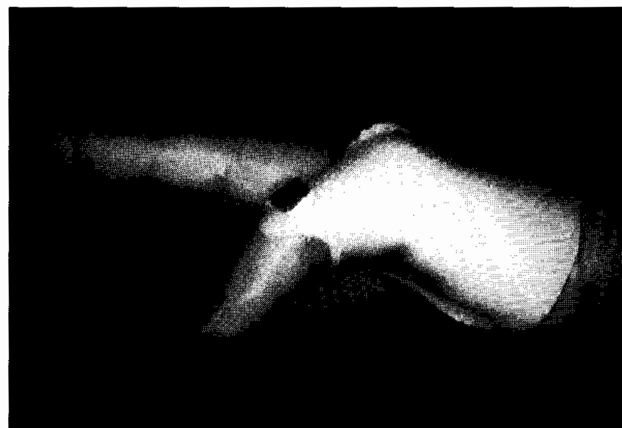


FIG. 111-24. A functional fracture brace for stable proximal phalanx fracture allows interphalangeal joint motion. ASHT splint classification: SM MP restriction, type 0[1].

provide direct pressure and the splint is worn only at night for an additional 2 months. The use of a soft dorsal leather strap helps provide comfortable long term dorsal counterpressure over the joint/s (Fig. 111-25).

Splints for Rheumatoid Arthritis

Nonoperative

Resting splints for the rheumatoid hand support joints, reduce inflammation of the synovium, encourage muscle relaxation, and eliminate pain with motion.[124,125] Splints that support unstable joints often allow increased function when worn either all the time or for specific activities.

Because of the multiple joint involvement frequently seen in rheumatoids, splinting is often required for one joint because another needs surgical treatment. The therapist and surgeon must not be tricked into splinting the most obvious deformity. It may be a more subtle deformity that is the greatest functional obstacle (e.g., instability of the thumb IP joint) (Fig. 111-26).

Postoperative

The role of postoperative splinting in directing new collagen fibers following MP joint arthroplasty is well documented.[126,127] Elastic traction to maintain alignment of the digits while allowing early motion is an integral requirement for success of the surgery. Several commercial splints and components are used to help the splintmaker easily adjust finger position (Fig. 111-27).

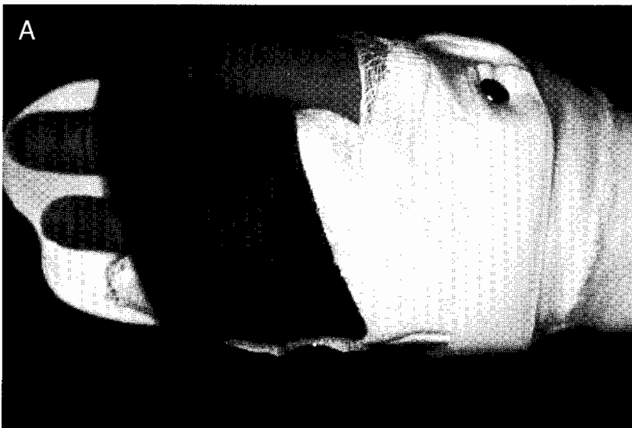
Many other surgical procedures for rheumatoid patients can be enhanced by splinting. These include dynamic splinting for repaired flexor or extensor tendons, positional or dynamic splinting to stretch postoperative tightness, or splints to protect a joint arthrodesis.

SPLINT PRESCRIPTION

Current Issues

Splint prescription today often reflects a "code" between a therapist and a surgeon that can be deciphered only by the parties involved. The terminology used most often reflects the terminology colloquial to the surgeon's training institution. Many surgeons are unaware of the vast number of custom and commercial designs available for various problems and may request the same splint for many different conditions.

Surgeons who work with well trained hand therapists may rely on the therapist to decide on the form of the splint—but only if the details of diagnosis, treatment, and splint purpose are accurately relayed.[128,129]



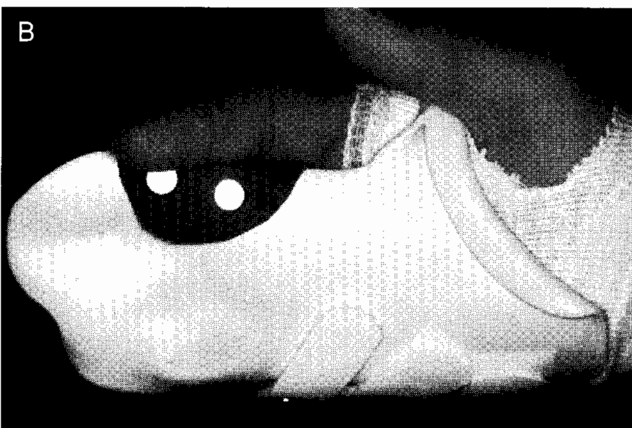
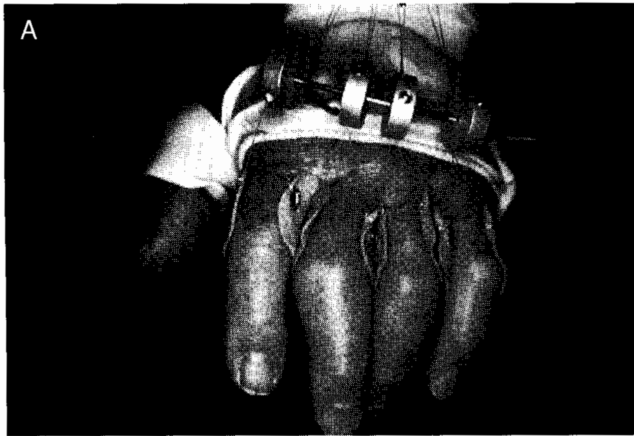


FIG. 111-25. A postoperative splint to gain full metacarpophalangeal and interphalangeal joint extension following release of Dupuytren's contracture. ASHT splint classification: MF-SM MP PIP DIP extension mobilization, type 0[9].

FIG. 111-26. *A*. An unstable thumb interphalangeal joint of a patient with rheumotoid arthritis is (*B*) stabilized by a small splint. ASHT splint classification: thumb IP RD restriction, type 0[1]. (RD = radial deviation.)



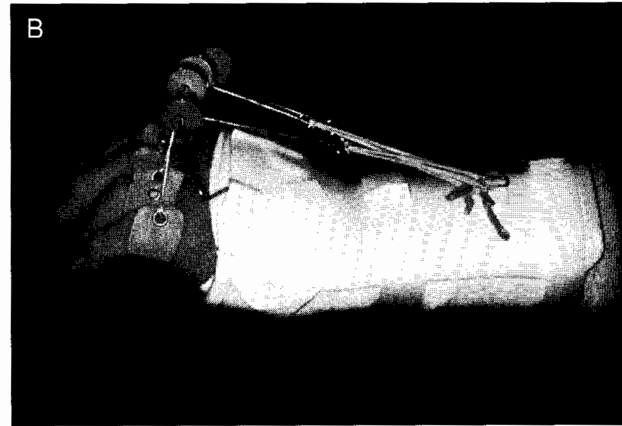


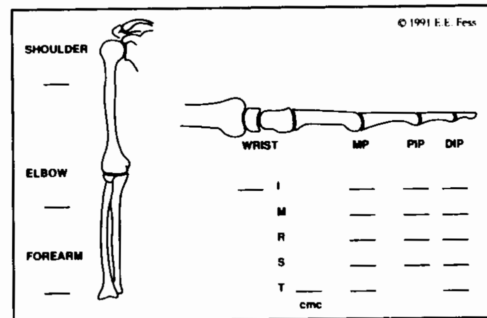
FIG. 111-27. A postoperative splint following metacarpophalangeal joint arthroplasty uses the Phoenix Outrigger for easy adjustment of finger position. ASHT splint classification: IF-SF MP extension mobilization, UD restriction, thumb CMC MP restriction, type 1[7]. (Patient also underwent arthrodesis of thumb MP joint.)

The ASHT *Splint Classification System* recommends that splint function is the primary information that must be communicated. The (splint) form or manner in which the function is achieved is secondary.[37] Only when therapists and surgeons alike receive similar training in naming and prescribing splints will standardization become a reality in clinics.

FIG. 111-28. Splint prescription form recommended by the American Society of Hand Therapists. Note recommended use of abbreviations. *(From:* Splint Classification System. *American Society of Hand Therapists, 401 N. Michigan Avenue, Chicago, 1992, with permission.)*

PHYSICIAN SPLINT ORDER FORM

Patient Name: ______________________ Date ____________



Indicate which joints you would like to have immobilized, mobilized or restricted using the following abbreviations:

Directional Abbreviations

Primary joints:	circled	Radial Deviation:	RD
Flexion:	↓ arrow	Ulnar Deviation:	UD
Extension:	↑ arrow	Lateral Deviation:	LD
Abduction:	<>	Palmar Abduction:	PA
Adduction:	><	Radial Abduction:	RA
Internal Rotation:	IR	Circumduction:	C
External Rotation:	ER	Mobilize:	
Pronation:	P	Immobilize:	X
Supination:	S	Restrict:	( )
		Specific Degrees:	write numerals where appropriate

Joint Abbreviations

Metacarpophalangeal:	MP
Proximal Interphalangeal:	PIP
Distal Interphalangeal:	DIP
Proximal & Distal Interphalangeal:	IP
MP, PIP, DIP, IP of a digit:	finger
All joints of fingers and thumb:	hand
Index Finger	I
Middle Finger	M
Ring Finger	R
Small Finger	S
Thumb	T

Indicate the purpose of the splint:

__ Block
__ Stop
__ Limit motion
__ Rest
__ Protect
__ Align
__ Balance muscle power
__ Prevent deformity
__ Correct deformity
__ Assist
__ Increase function
__ Substitute
__ Base for assistive devise
__ Increase range of motion
__ Minimize adhesions
__ Resist
__ Exercise
__ ____________

Physician signature____________________

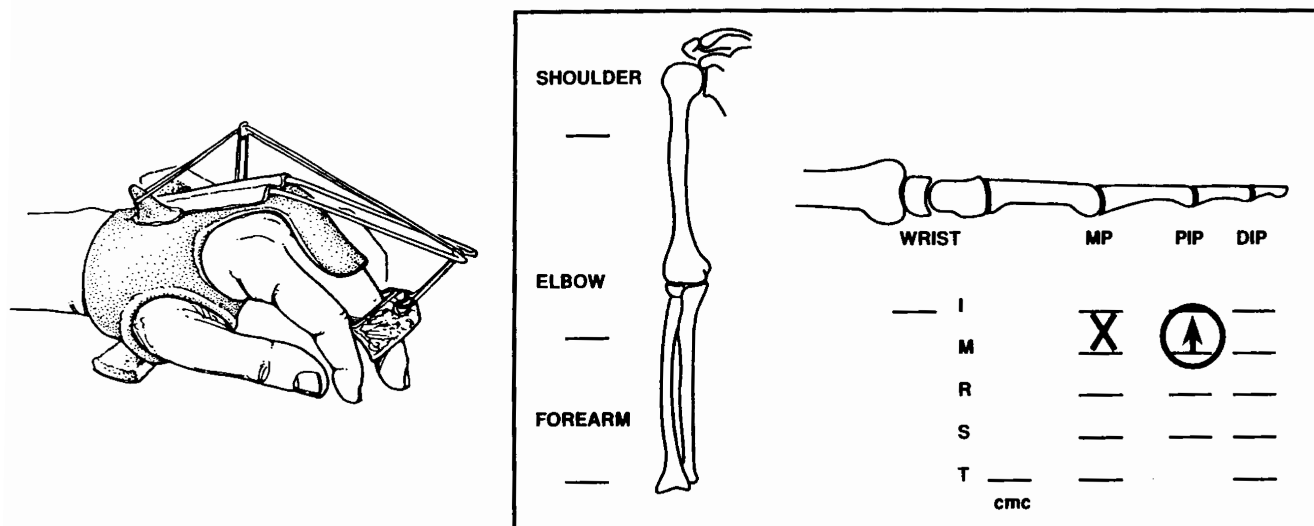


FIG. 111-29. Sample of prescription form used to prescribe splint illustrated. Note abbreviations and symbols in Fig. 111-28. *(From:* Splint Classification System. *American Society of Hand Therapists, 401 N. Michigan Avenue, Chicago, 1992, with permission.)*

ASHT Splint Prescription Recommendations

To ease communication between individual therapists and surgeons, as well as among hand therapy professions in general, standardization of splint prescriptions is needed. The ASHT recommends a splint prescription form to identify the desired splint function (Fig. 111-28), which communicates precise referral information (Fig. 111-29). Whether this form is used or the information is written out by the surgeon, a detailed diagnosis must accompany the splint prescription form.

COMPLICATIONS

Complications from the application of hand splints are absent from the literature, generally because these are infrequent, and the complications likely short-lived. Any splint applying a force or restricting motion can prove detrimental if applied incorrectly, used improperly, or worn too long or with excessive force.

Intolerance

Often the patient is limited in splint wearing time by discomfort created from splint application. This may be due to an isolated pressure point (e.g., over the ulnar styloid) or simply a rough edge producing local irritation. All splints applying force to the hand should be worn in the clinic for ≥15 min. The hand should then be checked for pressure before the patient leaves. It may be the smallest detail that limits effectiveness of the splint.

Other signs of intolerance to splinting are prolonged redness, swelling, and joint pain. The therapist and surgeon must then reduce or eliminate splinting time and pressure until the hand shows signs of greater equilibrium. Patients must understand the need for a *balance* between rest and motion. The immobility of the splint application must be offset by the right amount of active motion.

Ineffectiveness

Elaborate splints may be constructed and applied to the patient's hand, but sometimes the response to splinting is disappointing. Most often this results from poor splint mechanics, or the patient may assume that the splint is the *primary* means of regaining motion. There must be an active home therapy program to reinforce the gains made by the splint. Splinting is only a part of a comprehensive treatment approach which must always be used with a varied exercise program.[130]

UNSOLVED ISSUES

Hand splinting has become part of the routine care of many surgical and nonsurgical patients, but it has yet been proved that splinting is a necessary part of postoperative programs. A continuing responsibility remains to demonstrate efficacy. In this era where time and resources are scrutinized, therapists and surgeons will be required to demonstrate the best use of splints. These data will determine what type of splint, worn for what period of time, with what amount of force, provides the best results for each condition. Therapists and surgeons will be asked to show when and how custom splints are justified instead of less expensive commercial ones. Surgeons, therapists, patients, and now also patients' care managers need to be continuously educated.

The author appreciates the editorial and artistic assistance of Neil A. Watson.

ANNOTATED REFERENCES

Bunnell S: *Surgery of the Hand.* Philadelphia, JB Lippincott, 1944.

Not only a text of great historical interest, this is also an excellent review of principles of hand splinting which have endured.

Hunter JM, Schneider LM, Mackin EJ, Callahan AD (eds): *Rehabilitation of the Hand,* 4th ed. St. Louis, CV Mosby, 1995.

In this comprehensive text on hand rehabilitation, not only are there excellent chapters devoted to hand splinting, but various splinting techniques are also included in many other chapters.

Fess EE, Phillips C: *Hand Splinting Principles and Methods,* 2d ed. St. Louis, CV Mosby, 1987.

This text, which focuses primarily on effective mechanical principles of splinting, is the most comprehensive text available devoted to hand splinting.

Brand PW, Hollister A: *Clinical Mechanics of the Hand,* 2d ed. St. Louis, Mosby Year Book, 1993.

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Colditz JC: Low profile dynamic splinting for the injured hand. *Am J Occup Ther* 37(3):182, 1983.

A concise article describing the mechanics of dynamic splinting as first reported by Bunnell.

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