Basic Principles of Splinting the Hand
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Basic Principles of Splinting the Hand

This article presents the basic principles needed in the fabrication of static and dynamic splints. The principles are defined, and examples are used as illustrations. The biomechanics of dynamic splinting are described, with special attention given to low-profile dynamic splinting. Several low-profile dynamic splints are described, with current indications presented in case studies with supporting documentation for appropriate splinting protocols. [Duncan RM: Basic principles of splinting the hand. Phys Ther 69:1104–1116, 1989]

Key Words: Hand; Hand injuries; Kinesiology/biomechanics, upper extremity; Orthotics/splints/casts, upper extremity; Rehabilitation.

Splinting is a commonly used therapeutic procedure in the management of hand injuries. Splints can provide the essential therapeutic means of maintaining a position and holding it both statically and dynamically. The splint design follows specific principles with respect to the soft tissue trauma. Splinting is a combination of art and science and the creativeness of the therapist whose in-depth knowledge of anatomy and kinesiology is applied in the design and construction of custom-fabricated splints. The purposes of this article are to review splinting principles and to illustrate their application with clinical patient examples.

Splints are usually referred to as being either static or dynamic. The static splint is designed to support the hand, and the dynamic splint is designed to mobilize the hand. The splinting illustrations in this article are based on splints fabricated at Duncan Therapy Centers, Inc (Lynchburg, Va). These illustrations should be used as points of reference. The reader should be aware that there is a shortage of published data pertaining to the efficacy of splinting. The therapist, therefore, must utilize the principles of biomechanics, combined with a thorough knowledge of hand anatomy, when fabricating splints for patients with hand injuries.

The carefully designed custom-molded splint supports weak muscles and counteracts the pull of stronger muscles. The goal of any splint is to maintain the balance of the hand. The splint serves as the external force to counteract the imbalances of the internal forces.

**Lever Balance**

Generally, splints function as first-class lever systems with three points of pressure acting upon the extremity. As shown in Figure 1, a simple cock-up wrist splint positioning the wrist in a neutral position locates the three points of pressure. The first point of pressure in the splint occurs at the wrist, the axis of the joint. The other two points of pressure occur at the forearm trough (proximal end) and the palmar aspect (distal end) of the splint. The forearm trough serves as the force arm, and the palmar aspect acts as the resistance arm to the weight of the hand. These proximal and distal components of the splint act as the counterforce against the opposing middle force supplied by the dorsally placed wrist strap. In each splint, the three points of pressure must always be defined.

Fess et al have described a formula for computing the amount of force placed upon the proximal end of a wrist splint. By measuring the length of the completed forearm trough and the length of the palmar aspect and using the average hand weight of 0.9 lb,* they demonstrated the importance of force displacement to the forearm trough. The length of the palmar bar and weight of the hand are multiplied and divided by the length of the forearm trough (Fig. 2). The weight of the hand is transferred to the forearm trough, thereby adding to the patient's comfort level. A splint that traverses the forearm proximally should encompass two thirds of the forearm with equal heights on the ulnar and radial sides.

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*1 lb = 0.4536 kg.
Splinting Principles

Static Splints

Splints are often classified as either static or dynamic. The static splint has no movable parts and is designed to support or limit joint activity. The rationale for static splints can be outlined as follows:

1. Protects joint integrity by immobilization of the joint. To immobilize the joint would decrease the mechanical irritation on the painful joint associated with pathological conditions such as rheumatoid arthritis and carpal tunnel syndrome. Immobilization is also needed for fracture healing and healing of nerve and soft tissue repairs.

2. Maintains correct joint alignment. A deformity often seen in the patient with longstanding rheumatoid arthritis is ulnar deviation of the fingers attributable to the translational of the extensor tendons ulnarily into the valleys of the metacarpal heads. An ulnar deviation splint volarly supports the transverse arch and places the metacarpophalangeal (MCP) joints in semiflexion. At the distal end, four finger separators are cut and then molded between the fingers at the level of the proximal phalanx, gently positioning the fingers in neutral and maintaining alignment. The claw hand is seen in the patient with a low ulnar nerve lesion. The unopposed action of the extensor digitorum communis tendon by the ulnarly innervated lumbricales contributes to MCP joint hyperextension of the ring and little fingers. An anticlaw splint blocks MCP joint hyperextension and allows the extensor digitorum communis tendon to extend the proximal interphalangeal (PIP) joints. The loss of active thumb abduction often associated with a median nerve injury could contribute to a contracture of the thumb web space. Static splinting in a functional position would serve to maintain correct alignment and increase the patient’s functional hand use until active controlled movement is regained.

3. Prevents developing contractures. In the burned hand, for example, a flexion contracture of the PIP joint of the little finger must be prevented. The little finger assumes a relaxed position of flexion during rest as compared with other digits on the same hand, which contributes to the formation of a contracture. The suggested course of treatment includes fabrication of a static trough-like splint. The splint serves as the opposing force against the volar contracture by providing a sustained stretch. To prevent unnecessary pressure against the fingertips, these splints are revised every day or two to accommodate for the improvement in range of motion.

Fig. 1. Simple wrist cock-up splint illustrating three points of pressure.

Fig. 2. Force displaced to forearm trough. (1 in = 2.54 cm; 1 lbf = 4.448 N.)
demonstrated in his study of postoperative tendon transfers that static splinting was more effective than dynamic splinting. The dynamic splints all lead to much more movement. The tendency for the corrected contractures to recur postoperatively is of concern. The opposing forces supplied by the postoperative splint will prevent a recurrence of the contracture.

4. Provides support for joint laxity or for a ligament injury. Splinting is generally accepted as the most effective nonsurgical tool for maintaining passive ROM as tissues heal. A splint designed to stabilize and prevent subluxation of the carpal-metacarpal joint places the first metacarpal in abduction. It extends the site of force along the first metacarpal, distally beyond the metacarpal joint. The distal aspect of the first metacarpal should be stabilized, and the interphalangeal (IP) joint should be allowed unrestricted motion (Fig. 3).

5. Maintains passive ROM gained with dynamic splinting or other therapeutic passive stretching techniques. Static splinting is a therapeutic means of controlling contractures between treatment sessions.

6. Positions one joint to improve the function of another joint. Statistically positioning the dropped wrist of a patient with radial nerve palsy in extension would place the fingers at a better functional advantage for work.

Dynamic Splints

Dynamic splinting is the application of a moving force compartment that remains approximately constant as the part moves. The use of carefully placed outriggers provides a direction of force for traction obtained by the pull of rubber bands and individual slings. More specifically, the outrigger serves as the fulcrum for the dynamic splint. These splints are applied when the inflammatory response is under control and when assistance is needed in gaining passive ROM if the patient's ROM has started to plateau. The considerations for the design of a dynamic splint are as follows:

1. Provides resistance. A dorsally placed outrigger with rubber-band traction, for example, can provide controlled resistance to the finger flexors, thus maintaining tendon gliding and decreasing the problems associated with adhesions. The pumping action produced by the contraction and relaxation of the finger flexors against the rubber-band resistance can help to improve fluid dynamics, thus decreasing edema. Its use can also aid in muscle strengthening.

2. Prolongs stretching. The dynamic splint design will help to mobilize stiff joints and stretch shortened musculotendinous units. It provides passive traction (a controlled, sustained gentle stretch) to the tissue over an extended period of time. The dynamic splint has to move what the individual cannot. The patient should feel the stretch and the tension, but the pull should not be painful. How long the patient can wear the splint and the amount of tension acting on the joint are equally important for prolonged stretching. Brand suggests that a force of 200 to 250 g be applied for gentle prolonged stretching.

3. Substitution. A dorsally placed outrigger can assist or serve as a substitute for the weak or absent finger extensors of patients with radial nerve palsy and those with Silastic implants following MCP joint arthroplasty whose extensor tendons have been malaligned over a period of time.

†Dow Corning Corp, Midland, MI 48640.
motion; therefore, the custom-molded splint must allow for the functional movement of the arch if the normal hand function is to be maintained or increased.

The longitudinal arch is the third structural arch and allows flexion of the distal interphalangeal (DIP), PIP, and MCP joints. It is composed of the five metacarpals. The first, fourth, and fifth metacarpals move in relationship to the shape and size of an object placed into the palm. Grasp is accomplished when the object is held against the rigid portion provided by the second and third rays. This flattening and cupping component of the palm allows the hand to pick up objects of varying sizes. Because of the functional significance of these arches, care must be taken to maintain them within the splint fabricated.

**Flexion Creases**

Flexion creases are located over three areas of the volar surfaces of the hand: 1) digital, 2) palmar, and 3) wrist (Fig. 6). It is at these areas that the hand is allowed to move. The creases are in close proximity to the bony joints but not always directly over them. Therefore, when splinting to immobilize a particular joint, the corresponding flexion crease must be included within the splint. Conversely, when mobilizing a specific joint, the corresponding flexion crease must not be splinted.

Three digital flexion creases are located along the volar aspect of each finger. The distal and middle digital creases correspond with the underlying joint. The proximal digital crease is located distal to the MCP joint (base of the proximal phalanx). The interphalangeal and metacarpophalangeal creases of the thumb are located at their corresponding joint levels.

The distal palmar crease extends diagonally from a point just proximal to the MCP joint of the fifth digit to a...
point midway between the second and third MCP joints. It is used frequently as a landmark for the distal edge of a volar-based splint. By positioning the splint proximal to this crease, full finger motion is possible.

The wrist creases are noted for splinting landmarks. The distal wrist crease extends from the pisiform bone to the tubercle of the trapezium. It forms a line that separates the proximal and distal rows of carpal bones. The middle wrist crease corresponds to the radiocarpal joint and delineates the proximal border of the carpal bones.

**Skin**

The dorsal and volar skin creases have a direct relationship to underlying joint levels where hand motion occurs. These skin creases serve as splint boundaries for the joints that will be supported or mobilized (Fig. 7). In a cock-up wrist splint, which requires full MCP joint mobility, the transverse bar must not extend beyond the distal crease.

**Dual Obliquity**

An object held in the closed hand is neither parallel nor perpendicular to the long bones of the radius and ulna. The object forms an oblique angle to the radius and ulna. The different lengths of the metacarpals and the mobility of the first, fourth, and fifth metacarpals contribute to the two oblique angles of the hand. The first angle of obliquity demonstrates the progressive metacarpal head shortening (Fig. 8A). The second oblique angle demonstrates the radial-to-ulnar metacarpal head descent in a transverse plane (Fig. 8B). Splints that will support the second through fifth metacarpals must incorporate the dual-obliquity concept. As compared with the ulnar side of the splint, the radial side should be longer and higher (Fig. 9).

**Precautions**

The splint must be custom-fabricated with respect to soft tissue trauma. Principles of fit and design must be carefully considered to prevent additional soft tissue injury to the hand and subsequently decrease the wearing time of the splint.

**Friction**

Friction can be created by the resistance of the skin against the movement of the splinting material or by the skin rubbing against adjacent skin (ie, friction between the fingers). An improperly fitting volar splint will often migrate distally, creating friction against the volar metacarpal heads or transverse metacarpal arch.

**Pressure**

The splint creates force against the portion of the hand that is being corrected or moved. The soft tissue over bony prominences in the hand is thin, and excessive pressure over these areas can lead to pressure ischemia. The bony prominences of the hand
are the ulnar styloid process, the pisiform, the metacarpal heads, the radial styloid process, and the base of the first metacarpal (Fig. 10).

Padding can be used to create an empty space between the bony prominence and the splint. For example, to avoid ulnar styloid process pressure, padding is placed directly over the styloid process prior to applying the warm splinting material. The padding will be removed as soon as the splinting material hardens, creating an empty space over the ulnar styloid process as a means of eliminating direct pressure on the bone. Pressure must also be eliminated from the distal, proximal, and longitudinal edges of the splint. This pressure created by the splint edges can be decreased by gently rolling the splinting material outward away from the skin. A dorsally placed wrist strap and the forearm section of the splint can contribute to pressure over the ulnar styloid process. Finally, the metacarpal heads are susceptible to the pressure from dorsally based splints.

**Materials**

**Thermoplastics**

Many commercially available thermoplastics are used in splint fabrication. They each have their own characteristics regarding thickness, color, perforations, and self-bonding ability. They are commonly referred to as low-temperature plastics because they are softened in heated water. They become very moldable when heated and resume a rigid state after cooling. Each has a draping characteristic as it is shaped and easily conform to the contours of the hand. The most commonly used thermoplastics are Polyform®, Kay Splint, Aquaplast®, and Orthoplast. Polyform®, Kay Splint, and Aquaplast® are self-bonding and have a shelf life of three to six months. Aquaplast® is often used for circumferential splinting because it is more resilient when donning and doffing.

The larger pieces of thermoplastic material are heated and softened in a water temperature ranging from 140° to 180°F (60°–80°C). Heating guidelines for specific materials are often included with each case of sheeting material. A hand-held heat gun provides a second heat source, which aids in heating small areas that need to be softened or smoothed out. For example, the edges of the splint can be heated with the heat gun and rolled out.

**Strapping and Closures**

The most familiar splint strapping materials are Velcro®, cotton webbing, Betapile, and Neoplush. Velcro® tape is a nylon material that comes with an adhesive or nonadhesive back. One tape consists of tiny hooks that fit into a second tape of numerous loops. The adhesive backing adheres easily to the splint and serves for the attachment of the Velcro® strap that holds the hand down against the splint. The nonadhesive Velcro® is often sewn to cotton webbing straps for closure. Betapile is made of a form of polyethylene foam and covered with nylon. It attaches well to the Velcro® hook, but does not hold up as well as the Velcro®

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**Fig. 9.** Dual obliquity in splint design. Metacarpal bar is higher and more distal on radial side than on ulnar side.

**Fig. 10.** Bony prominences of hand: (A) dorsal; (B) volar.
loop because nylon wears out after repetitive pulling away from the tiny hooks. It is a recommended strap for splints used in the management of edema. The soft Betapile foam supplies gentle compression to an edematous area, often aiding in fluid dynamics. Colditz and Malick suggest using two Velcro® straps and one Betapile strap for a better secured fist. Neoplush is a new elastic strapping material with nylon on one side and loop pile on the other. The Velcro® loop and hook closure is probably the most common closure. The use of a D-ring will reduce the load on a Velcro® closure by one half. To prevent distal migration of a dynamic splint, a D-ring setup at the wrist level can secure the wrist firmly into the splint.

**Design Considerations**

There are specific factors that must be considered in the design of the splint.

**Patient individuality.** A patient’s age, mental status, and living arrangements must be addressed. Splints designed for adult use are not necessarily recommended for a child. The therapist must obtain a good understanding of a patient’s comprehension skills, particularly if the patient must be able to put on and remove the splint without assistance. The therapist must consider whether the patient will have assistance donning and doffing the splint at home and how far the patient must travel for a particular splint to be reordered.

**Total treatment time.** The therapist must assess how long the particular splint will be needed and should be familiar with the shelf life of the splinting material. Low-temperature thermoplastics will begin to crack and discolor after prolonged use. If a patient will require splinting for an indefinite period of time, a high-temperature plastic (polyester resin group) or aluminum splint is recommended.

**Patient acceptance.** The splint should be simple, efficient, inexpensive, lightweight, nonoffensive, and easily adjustable. Patients often complain of problems with heat. To assist with heat accommodation, a stockinette can be worn over the hand, ventilation holes can be created in the splint, or a perforated plastic splinting material can be used.

**Sensation.** The design of the splint should allow as much sensation as possible. If the palmar tactile surface is hampered, there will be a decrease in the motor performance.

**Ease of application.** The patient should be able to easily don and doff the splint and to tighten and loosen the straps without difficulty. When this ease of application is not possible, the direct care provider assisting the patient must have a clear understanding of splint application, wearing time, and precautions.

**Biomechanics of Dynamic Splinting**

The goal of dynamic splinting is to provide a low-amplitude force over a prolonged period of time to influence the remodeling of new tissue. The force is supplied by rubber-band traction over carefully placed outriggers. The dynamic splint should overcome soft tissue and joint stiffness, but the stretch should not be painful.

The patient should bring the dynamic splint to each treatment session for reassessment and realignments. Measurable gains should be recorded within one or two treatment sessions. There are no specific formulas for wearing time because of numerous variables such as the tolerance of the soft tissue to stretch and patient compliance. The therapist must begin the splinting program conservatively. An example is a patient who sustained a complete extensor tendon laceration at the level of the MCP joint of the right index finger. He was referred to physical therapy at five weeks post-repair after four weeks of finger immobilization in complete extension. Within five days, he gained 60 degrees of active PIP joint flexion, but active and passive MCP joint flexion was restricted to 15 degrees. A volar splint was designed with dynamic rubber-band traction applied to the MCP joint in flexion. An initial wearing time of 30 minutes four times during the day was suggested. This splinting program was incorporated with home therapeutic procedures and blocking exercises. Two days following implementation of the splinting program, a 10-degree gain (35° overall gain) in passive MCP joint flexion was measured and the patient reported tolerating the splinting program well. At this time, the rubber-band tension was not changed and the wearing time was increased to 45 minutes six times during the day. Five days following implementation of the splinting program, the patient’s MCP joint flexion had increased to 40 degrees. Dynamic traction was modified to accommodate for the improvement in ROM. Adjustments were needed every three to five days. At 10 weeks postrepair, the patient’s active and passive MCP joint flexion had increased to 80 degrees.

The 90-degree line of pull must always be maintained. As the contracture changes or decreases, the placement of the outrigger must also change. The 90-degree line of pull is perpendicular to the axis of the long bone, which is the distal articulation to the limited joint. If a force greater than 90 degrees is applied, an unwanted pulling force is applied to the involved joint, whereas a force less than 90 degrees creates a pushing force on the articular surface.

Current literature supports the concept that the pull of traction is always toward the scaphoid. Fess recently demonstrated that the point of conveyance differs depending on the position of the wrist. Wrist extension will move the point of conveyance distally, whereas the point moves proximally with wrist flexion.

In most dynamic splints, the force is supplied by stretched rubber bands. A splint should provide the longest possible length over which to stretch the rubber band; a long rubber band stretched twice its resting length will provide more constant tension than a
shorter rubber band stretched twice its resting length.\textsuperscript{15,16}

**Low-Profile Splinting**

The low-profile splint is recommended for the stiff hand that has sustained direct trauma.\textsuperscript{12} The observable differences between the high-profile dynamic splint and the low-profile splint is the placement of the outrigger and its function. The low-profile splint's outrigger does not serve for the attachment of rubber bands, in contrast to the high-profile splint's outrigger, but redirects the line of pull keeping it close to the splint base and minimizes the probability of torque. Brass welding rods without flux are recommended for the outrigger base.\textsuperscript{7,12} The heavier-gauge ⅛-in\textsuperscript{11} diameter welding rod is used when all fingers are included within the traction unit. Single-finger, shorter-traction units can use ⅜-in-diameter welding rods. The third recommended size (¼-in) is best used for hooks and very short pulleys.\textsuperscript{12} The decreased height of the outrigger makes the splint less bulky and provides more available length to the rubber band for more constant tension. As stated previously, the 90-degree line of pull must always be maintained. A strong, stable splint base is necessary for the attachment of the low-profile splint’s outrigger. The thermoplastics that bond easily to themselves are highly recommended for splinting material.

Leather finger loops are preferred over plastic loops because the leather does not tend to stretch excessively. One hole placed at either end of a finger sling is recommended for even application of force, as compared with one hole formed when the two ends of the finger sling are pulled together for the central placement of a rubber band (Fig. 11). A nonstretchable nylon string is attached to each side of the finger loop. A standard-gauge rubber band will be attached to the string. Following completion of the dynamic setup, the string goes through the pulley system and the rubber band attaches to a metal hook.

To maintain the streamline appearance of the low-profile splint, the hook, to which the rubber band is attached, can be placed at a point not in the direct line of pull. The rubber band with string attachment will provide the longest distance to stretch a joint. By spreading the force over greater surface areas, the splint can be worn over longer periods of time.

The low-profile splint’s outrigger provides specific multijoint stretching capabilities (Fig. 12). The PIP and MCP joints of the patient with a stiff hand in the previous example were contracted, or “tight,” with the initial treatment protocol directed at gaining MCP joint flexion. The patient’s collateral ligaments initially were difficult to stretch and required mobilization. This type of outrigger assisted in providing the required mobilization.

The outrigger is secured to the splint by heating the ends of the welding rod with the heat gun, then placing the hot rod ends onto the splint base. The outrigger ends will easily sink into the splinting material and will stay in place until a small piece of splinting material is cut and softened. This smaller piece will laminate over the outrigger base to the splint base, providing additional strength at the point of attachment.

Splinting material placed along the outrigger bar can be softened at specific points for hole puncture (Fig. 13). The holes direct the line of pull and maintain alignment as the pulley system glides over the outrigger. The strings of the pulley system pass through these holes, which can be coated with clear fingernail polish, allowing for easier gliding.

A small hook will serve to anchor the rubber band as it is brought up and secured to the string coming through the pulley. The nylon string can be tied to the rubber band and the knot reinforced with Krazy Glue.\textsuperscript{‡‡}

As stated previously, the low-profile splint provides the extra length to

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\textsuperscript{11} 1 in = 2.54 cm.

\textsuperscript{‡‡} Krazy Glue, Inc, 53 W 23rd St, New York, NY 10010.
stretch a rubber band. This extra length is needed to provide the longest distance possible to stretch a joint. Tension to stretch a joint should be tolerable and not painful. Tension to assist movement should allow joint flexion and then return the joint to the preselected starting position.

**Application of Splinting**

**Case Study 1**

"GH," a 42-year-old man, was involved in a motorcycle accident. He sustained a spiral midshaft fracture to the left humerus and radial nerve neuropraxia. The patient underwent open-reduction internal fixation to the humerus two days postinjury.

The patient was seen five days postinjury for the resulting radial nerve palsy. At rest, the patient's wrist-drop was 65 degrees; therefore, the decision was made to statically splint the hand. An easily removable dorsal wrist splint was fabricated, placing the wrist in approximately 20 degrees of extension. The splint decreased overstretching of the wrist extensors and, by positioning the wrist in extension, placed the fingers at a better mechanical advantage to begin finger function. It was not necessary to dynamically splint the fingers in extension.

Although GH was employed as an electrical plant supervisor, he often performed sedentary substitute tasks such as testing dry-cell batteries for short periods of time during the day. This task required him to sit at a worktable, with his left forearm supported on the tabletop in the neutral position while holding and releasing the 2- to 3-in batteries in his left hand. The patient needed a grip span of 2.25 in to functionally use the left hand. The batteries were then checked with a meter held in his right hand.

The patient was anxious to resume his job, and at five weeks postinjury, his physician allowed him to return to work if a suitable left-hand working splint could be worn to substitute for the absence of wrist and finger extension. The patient was able to use the dorsally based splint described previously with a low-profile outrigger attached (Fig. 14). The tension supplied placed the patient's MCP joints in neutral, allowing 70 to 75 degrees of flexion and full PIP joint flexion.

The use of the outrigger increased the patient's extension ROM and allowed him to perform his substitute job testing batteries of various sizes. A thumb extension outrigger was not used because the patient had sufficient thumb abduction to perform this task and light activities of daily living. When GH returned to work at five weeks postinjury, his active thumb web-space expansion (palmar abduction) measured 60 degrees.

**Case Study 2**

Mrs “P,” a 65-year-old widow, had a 20-year history of rheumatoid arthritis. She was referred to physical therapy five days prior to surgery with severe MCP joint dislocations (2-5 digits) of the right (dominant) hand and moderate ulnar drifting with an intact extensor mechanism. Her initial treatment included a history (eg, age, job, medications, past and present medical status) and an evaluation of joint and muscle status and sensation. She had minimal wrist involvement, but no pain or active synovitis. Her PIP joint ROM was within normal limits, and her sensation was intact. Mrs P was placed in the category of simple hand involvement (MCP joint destruction and dislocation with no other significant complications noted).17

Preoperative measurements (Tab. 1) were taken for fabrication of the patient’s postoperative splint, a dorsal splint that would provide a stable base for the low-profile outrigger and support the patient’s weak wrist. Dynamic splinting is an essential part of the postoperative rehabilitation program because it maintains stability as mobility is gained.18

The dynamic splint was fabricated and adjusted for Mrs P’s right hand six days postsurgery. The slings were placed over the proximal phalanx of each digit, and the pull was in 5 degrees of radial deviation. The tension on the rubber bands was tight enough to support the digits in neutral (0°) of extension in the index and middle fingers and 10° of flexion in the ring and little fingers because of
### Table 1. Preoperative Measurements (in Degrees) for Right Hand of Mrs "P"

<table>
<thead>
<tr>
<th>Finger</th>
<th>AROM</th>
<th>PROM</th>
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<tbody>
<tr>
<td>Index</td>
<td>(-60-110)</td>
<td>(-45-110)</td>
</tr>
<tr>
<td>Middle</td>
<td>(-50-110)</td>
<td>(-35-110)</td>
</tr>
<tr>
<td>Ring</td>
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<tr>
<td>Little</td>
<td>(-50-115)</td>
<td>(-45-115)</td>
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<table>
<thead>
<tr>
<th>MCP</th>
<th>(-5-95)</th>
<th>(-5-98)</th>
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<tr>
<td>PIP</td>
<td>(-10-95)</td>
<td>(-8-100)</td>
</tr>
<tr>
<td>DIP</td>
<td>(-5-50)</td>
<td>(-5-60)</td>
</tr>
</tbody>
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| Ulnar drift | 25 | 35 | 45 | 50 |

AROM = active range of motion.  
MCP = metacarpophalangeal joint.  
PIP = proximal interphalangeal joint.  
PROM = passive range of motion.  
DIP = distal interphalangeal joint.

From the first day of dynamic splinting through the third and fourth weeks postsurgery, the patient performed active and passive ROM exercises on an hourly basis approximately 12 times a day while wearing the dynamic splint. Flexion exercises were performed in the intrinsic-plus position, directing more of the flexion force at the MCP joint. The goal was to achieve 0 to 60 degrees of active ROM in the MCP joint of the index finger, increasing to 0 to 70 degrees in the ulnar two digits. The limited flexor power in the ulnar two digits. From the first day of dynamic splinting through the third and fourth weeks postsurgery, the patient performed active and passive ROM exercises on an hourly basis approximately 12 times a day while wearing the dynamic splint. Flexion exercises were performed in the intrinsic-plus position, directing more of the flexion force at the MCP joint. The goal was to achieve 0 to 60 degrees of active ROM in the MCP joint of the index finger, increasing to 0 to 70 degrees in the ulnar two digits. After eight weeks postsurgery, the patient's active flexion had increased to 60 degrees. Adequate MCP joint alignment was being maintained at four weeks postsurgery (with a maximum extension lag of 20°), and the patient was allowed to remove her splint for two hours, four times a day. Her exercise program was revised to include radial finger abduction when not wearing the splint. Dynamic splinting continued at night.

At six weeks postsurgery, Mrs P was allowed to begin light ADL involving hand use with the splint on. Joint protection was stressed (three-jaw chuck pinch rather than a lateral pinch). At eight weeks postsurgery, with adequate alignment being maintained, she progressed to performing light ADL without the splint. The splint was worn one hour four times a day as a means of resting the joints. By the 12th week postsurgery, daytime splinting was discontinued; Mrs P continued with her nighttime splinting for two additional months. The patient's digital measurements were again recorded 12 weeks postsurgery (Tab. 2).

### Case Study 3

"CK," a 48-year-old self-employed woodworker, sustained a tablesaw injury to the right (dominant) thumb involving an open comminuted fracture to the distal phalanx with numerous small fragments and a complete longitudinal division of the distal phalanx. The flexor pollicis longus tendon was still attached to the largest proximal fragment. The patient's treatment on the day of injury included debridement of small bone fragments, Kirschner-wire reduction of the larger bone fragments, and soft tissue repair.

CK was initially referred to physical therapy seven days postsurgery for evaluation; protective splinting; and the beginning of a regimen of slow,
Table 2. Digital Measurements (in Degrees) Recorded 12 Weeks Postoperatively for Right Hand of Mrs "P"

<table>
<thead>
<tr>
<th>Finger</th>
<th>Index</th>
<th>Middle</th>
<th>Ring</th>
<th>Little</th>
</tr>
</thead>
<tbody>
<tr>
<td>AROM(^a)</td>
<td>MCP(^b)</td>
<td>PIP(^c)</td>
<td>DIP(^d)</td>
<td>PROM(^e)</td>
</tr>
<tr>
<td>MCP(^b)</td>
<td>(-8-60)</td>
<td>(-8-60)</td>
<td>(-10-65)</td>
<td>(-10-68)</td>
</tr>
<tr>
<td>PIP(^c)</td>
<td>(-5-95)</td>
<td>(-8-95)</td>
<td>(-10-95)</td>
<td>(-8-98)</td>
</tr>
<tr>
<td>DIP(^d)</td>
<td>(-3-50)</td>
<td>(-5-54)</td>
<td>(-5-54)</td>
<td>(0-55)</td>
</tr>
<tr>
<td>PROM(^e)</td>
<td>MCP</td>
<td>(-5-62)</td>
<td>(-5-64)</td>
<td>(-8-65)</td>
</tr>
<tr>
<td>PIP</td>
<td>(-5-100)</td>
<td>(-5-100)</td>
<td>(-8-100)</td>
<td>(-3-100)</td>
</tr>
<tr>
<td>DIP</td>
<td>(0-58)</td>
<td>(0-60)</td>
<td>(-5-65)</td>
<td>(0-65)</td>
</tr>
</tbody>
</table>

\(^a\)AROM = active range of motion.  
\(^b\)MCP = metacarpophalangeal joint.  
\(^c\)PIP = proximal interphalangeal joint.  
\(^d\)DIP = distal interphalangeal joint.  
\(^e\)PROM = passive range of motion.

Table 3. Measurements (in Degrees) Recorded During Initial Evaluation for Right Hand of Patient "CK"

<table>
<thead>
<tr>
<th></th>
<th>Active</th>
<th>Passive</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thumb</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palmar abduction</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Radial extension</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>IP(^a)</td>
<td>. . . .</td>
<td>. . .</td>
</tr>
<tr>
<td>MCP(^b)</td>
<td>(0-10)</td>
<td>(0-15)</td>
</tr>
<tr>
<td>Opposition</td>
<td>to distal tip of long finger</td>
<td></td>
</tr>
<tr>
<td><strong>Wrist</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extension</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Flexion</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Radial deviation</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Ulnar deviation</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td><strong>Forearm</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supination</td>
<td>WNL(^c)</td>
<td></td>
</tr>
<tr>
<td>Pronation</td>
<td>WNL</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)IP = interphalangeal joint.  
\(^b\)MCP = metacarpophalangeal joint.  
\(^c\)WNL = within normal limits.

At 2½ weeks postsurgery, the exercise program included guarded active IP joint motion of the thumb. A Polyform® trough was fabricated to protect the distal fracture during exercise. The Kirschner wire was removed five weeks postoperatively, and sufficient bone healing was reported. The patient continued with his active isolated motion by blocking the MCP joint, allowing active tendon excursion at the IP joint, and progressed to being treated with mobilization techniques. By 6½ weeks postsurgery, the patient's active and passive IP joint motions were equal (0°-20°). Dynamic splinting was incorporated into the patient's rehabilitation program. The low-profile splint fabricated blocked carpometacarpal and metacarpal joint motion as a means of isolating the traction at the IP joint level. The outrigger was made from a 1/16-gauge welding rod and was seated into the thermoplastic at approximately mid-palm. The volar-based splint extended proximally to 2 in below the wrist crease. The hook for rubber-band placement was attached on the ulnar side near this border (Fig. 15). The string and rubber band provided 2.5 in of length to passively stretch the joint. Wearing time was 30 minutes, five times a day, followed immediately by active isolated exercises. Over a period of seven days, the patient's evaluation revealed a moderately edematous thumb with dry, necrotic tissue over the thumb pulp and nail. The patient had active composite finger flexion to neutral extension and active composite finger flexion to within 2.5 cm of the proximal palmar crease. Additional hand measurements recorded during the initial evaluation are shown in Table 3.

![Fig. 15. Streamlined low-profile splint designed to increase passive interphalangeal joint flexion.](http://ptjournal.apta.org/)
Table 4. Measurements Recorded Three Months Postinjury for Right Hand of Patient "CK"

<table>
<thead>
<tr>
<th>Joint Motion Measurement</th>
<th>Active</th>
<th>Passive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thumb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palmar abduction</td>
<td>65</td>
<td>70</td>
</tr>
<tr>
<td>Radial extension</td>
<td>65</td>
<td>70</td>
</tr>
<tr>
<td>IP</td>
<td>(0-50)</td>
<td>(0-60)</td>
</tr>
<tr>
<td>MCP</td>
<td>(0-40)</td>
<td>(0-45)</td>
</tr>
<tr>
<td>Opposition-flexion</td>
<td>to PIP&lt;sup&gt;d&lt;/sup&gt; flexion crease of little finger</td>
<td></td>
</tr>
<tr>
<td>Wrist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extension</td>
<td>50</td>
<td>65</td>
</tr>
<tr>
<td>Flexion</td>
<td>65</td>
<td>75</td>
</tr>
<tr>
<td>Radial deviation</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>Ulnar deviation</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>Proximal joint</td>
<td>WNL&lt;sup&gt;e&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dynamometric Measurement</th>
<th>Grip Strength (psi)&lt;sup&gt;f&lt;/sup&gt;</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Grip span (in)&lt;sup&gt;g&lt;/sup&gt;</td>
<td>Right Hand</td>
<td>Left Hand</td>
</tr>
<tr>
<td>1.25</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>1.75</td>
<td>60</td>
<td>58</td>
</tr>
<tr>
<td>2.25</td>
<td>75</td>
<td>70</td>
</tr>
<tr>
<td>2.75</td>
<td>65</td>
<td>58</td>
</tr>
<tr>
<td>3.25</td>
<td>40</td>
<td>38</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pinch Strength (psi)&lt;sup&gt;f&lt;/sup&gt;</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Opposition</td>
<td>9</td>
</tr>
<tr>
<td>Three-point prehension</td>
<td>12</td>
</tr>
<tr>
<td>Lateral</td>
<td>25</td>
</tr>
</tbody>
</table>

<sup>a</sup>WNL = within normal limits; active composite finger extension to neutral; active composite finger flexion to distal palmar crease.

<sup>b</sup>IP = interphalangeal joint.

<sup>c</sup>MCP = metacarpophalangeal joint.

<sup>d</sup>PIP = proximal interphalangeal joint.

<sup>e</sup>Proximal joint range of motion within normal limits for forearm, elbow, and shoulder as well.

<sup>f</sup>psi = pounds per square inch.

<sup>g</sup>1 in = 2.54 cm.

The patient resumed his job as a woodworker two weeks prior to discharge and did not report any difficulty performing his job when treatment and splinting were discontinued at three months postinjury. Measurements obtained three months postinjury are shown in Table 4.

**Summary**

The basic principles of splinting have been discussed. The basic functions of static and dynamic splinting have been presented, using splinting examples to describe the various functions. The arch system, flexion creases, and the dual-obliquity concept and how they must be incorporated into splint fabrication were discussed. Splinting materials and closures were described. The basic principles of low-profile splinting were presented. Three case studies of patients who wore low-profile dynamic splints were presented, describing a low-profile splint designed to serve as a working splint for the absence of wrist and finger extension, to assist weak finger extension, and to passively stretch a joint.

**Acknowledgment**

I acknowledge Diane S Capobianco for preparing the illustrations.

**References**


