Chapter 98

SPRING-WIRE EXTENSION SPLINTING OF THE PROXIMAL INTERPHALANGEAL JOINT

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HISTORY

The proximal interphalangeal (PIP) joint is vulnerable to injury, because it lies midway between the long lever arms of the proximal and middle phalanges. Its tight anatomic construction and intricate anatomy are unforgiving of forces crossing it in any plane but the normal flexion or extension. Residual flexion contracture of the PIP joint is a frequent complication after phalangeal fractures, PIP joint dislocation, volar plate injury, flexor tendon repairs, chronic boutonnière deformity, partial or complete tear of a collateral ligament, or major hand trauma resulting in edema and immobilization.[2-4,13,16] The powerful flexor tendon system with its efficient pulley system is far more effective in gaining flexion of the PIP joint than the primarily intrinsically powered dorsal hood mechanism is in gaining extension. The last range of full PIP joint extension can be gained most effectively by a gentle prolonged stretch to the tissues toward full extension to reestablish the balance of motion.

Splint design

PIP joint splinting is effectively achieved by a low-profile spring-wire splint incorporating only the finger, as first described by Capener.[9,10] This is a splint of a three-point design with spring coils lying at the axis of the PIP joint laterally (Fig. 98-1). This design is frequently referred to as the Capener splint,[14,17-20] and many commercially available splints using the lateral coil are sold as "Capener" splints.

Bunnell illustrates the use of both clock-spring splints and spring-wire splints to extend PIP joint flexion contractures.[7] Wynn Parry illustrates in detail the construction of spring-wire finger splints after Capener but describes the spring as being used primarily for resistance for finger flexion after flexor tendon repair or for full-time wear for immobilization in extension, as with a boutonnière deformity.[19] The gauge of wire, the increasing diameter of the coils, and the number of coils described by Wynn Parry provide a lower tension than the technique described below.

Commercially available Capener splints follow Capener's original design of increasing diameters of the coils. Fess studied the forces generated by these splints and found the forces to be variable within the same design and, as one would expect, variable based on the degree of the flexion contracture of the finger, because the splint is constructed to rest with the extension arms at 0 degrees.[11] Some forces were alarmingly high. Callahan and McEntee also observe that commercial splints provide varying amounts of tension. They express concern about the difficulty of commercial splints fitting accurately and about the force being distributed over a smaller surface area than that of a custom splint.[8]

The design described in this chapter has two coils of identical diameter and is routinely constructed from the same grade of spring steel piano wire. Force generated by this splint can be altered in many ways: the addition of more coils decreases the force applied, the extension arms can be bent to partially accommodate the flexion contracture (thus decreasing force and increasing long-wear tolerance), a lighter gauge wire can be used to alter tension, and the design of the Velcro loop allows the patient some

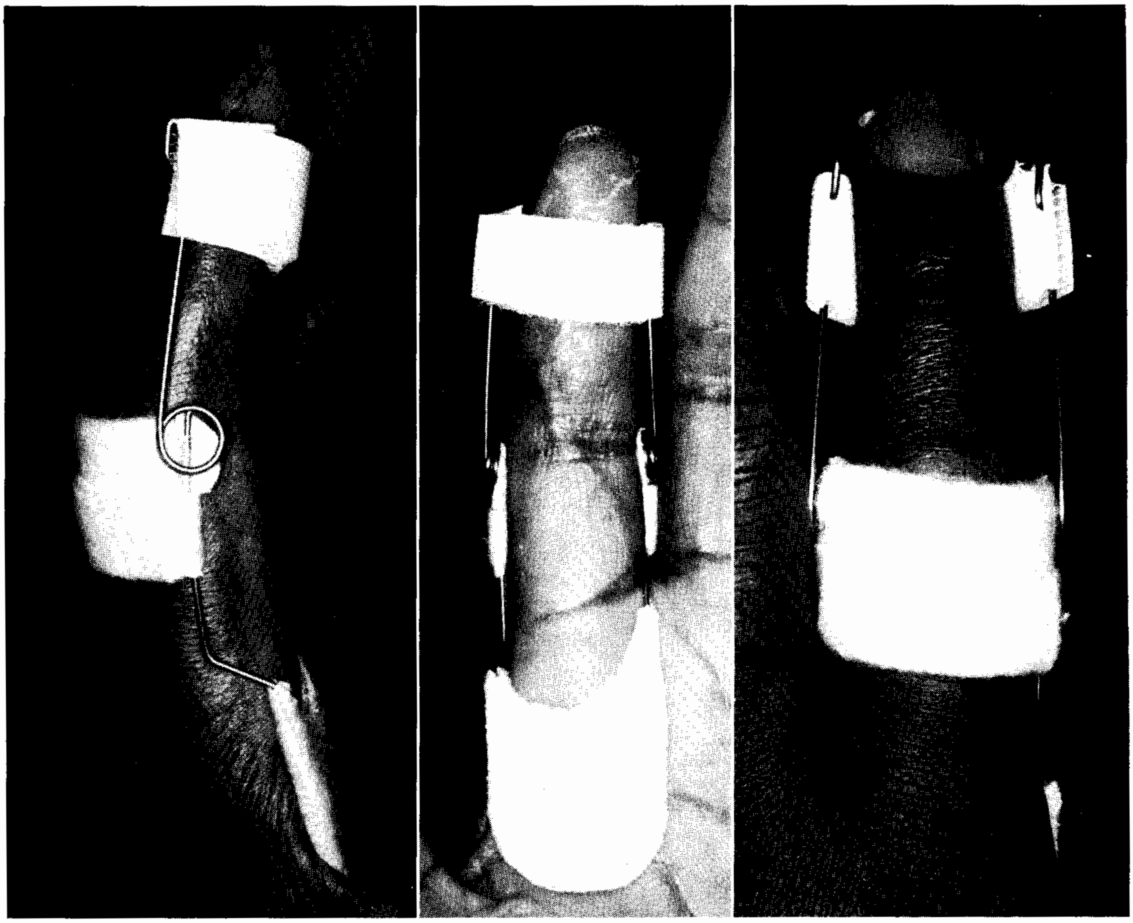

Fig. 98-1. Multiple views of low-profile spring wire splint for PIP joint extension.

adjustability in force applied. Although many clinicians have empirically suggested force levels for splinting, no clinical study validates these force recommendations.[5,6,11,12,15] Patient comfort and objective measurements demonstrating joint improvement in the absence of any complications have proven the splint design in this chapter to be an effective tool for correction of the PIP flexion contracture based on our 23 years of clinical experience with it. This design is most effective with PIP joint contractures of 45 degrees or less that have a "springy" feel in response to manual stretch.

Callahan and McEntee offer a modification of the spring coil splint, which they recommend for PIP joint contractures that have a "hard end feel"[7] (Fig. 98-2). They believe this combines the advantages of ease of application of the Capener splint with the constant force offered by serial casting. They suggest the use of brass welding rod as a

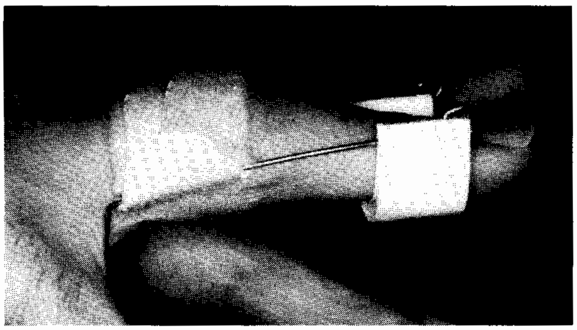

Fig. 98-2. Three-point extension splint without coils.

superstructure, which gives a static force to the joint, with the force being altered by the tightness of the Velcro strap. Spring steel piano wire also may be used; the memory in the wire provides a dynamic force without the coils.

Whatever the splint design choice, it must be based on a clear rationale of prolonged gentle stress to the joint with the force being applied using sound mechanical principles.

The technique described below is of greater ease and speed of construction than the soldering of tin as described by Wynn Parry. The splint described is designed with the goal of correcting only the mild flexion deformities (less than 45 degrees) of the PIP joint that respond to manual stretch with a "springy" feel.

CUSTOM SPLINTING

The advantage of the custom-made splint over the commercially available splint is obvious in that the length of the splint can be made to exactly match the length of the available lever arms and the coils can be located at the exact axis of the joint. Additionally, the dorsal piece lying over the proximal phalanx can be of maximum size, and it ends exactly at the axis of the PIP joint (Fig. 98-1), thus distributing pressure well on the dorsum of the finger, where there is little natural padding. The Velcro strap on the volar aspect of the distal end of the middle phalanx offers the patient adjustability of the tension so as to keep it within comfortable tolerance. Because the resting position of the splint force arms is at 0 degrees of extension, this design does not have the danger of hyperextending the PIP joint, as the Reverse Knuckle Bender can. The use of spring wire eliminates the fatigue factor one encounters with the rubber band outrigger systems; therefore the splint is effective for long-term use without adjustments.

The lateral coil system is effective only for flexion contractures of approximately 45 degrees or less, because a severely contracted finger will provide a counterforce that is at a right angle to the dorsal splint piece and thus the splint itself slips distally, being ineffective in gaining PIP joint extension. If clinical examination of a flexion contracture slightly greater than 45 degrees reveals a springy joint that responds to passive stretch, one can perhaps begin with the spring-wire design with realistic anticipation of early gains. The spring can be fitted initially so that the force arms of the splint rest in a somewhat flexed position, decreasing the tension being applied on the joint. At the next therapy visit it is often possible to bend the wire up to the 0-degree resting position, because the tolerance to the force has increased. In cases of severe (more than 45 degrees) longstanding flexion contractures of the PIP joints, one needs to devise a molded splint base with outrigger arms to provide effective extension force. Serial casting is often most effective with these severe deformities.

Not only does this three-point design provide an efficient extension force, but also by its low-profile design it is easily tolerated by the patient. It allows movement of the metacarpophalangeal (MP) joint of the splinted finger and does not impede motion of the other fingers. The size of the splint allows it to be carried in the pocket for easy and frequent application. Two splints may be worn on adjacent fingers (Fig. 98-3), but if three fingers are involved, a hand-based splint with outrigger system is recommended for ease of application and removal, and diminished bulk between the fingers.

Patients frequently state that the wearing of the splint offers a distinct relief to the tight feeling within the joint, and they demonstrate an eagerness to wear the splint. For these reasons this splint is considered to have a high rate of patient compliance. For the experienced therapist it requires no longer than 10 minutes to construct.

INSTRUCTIONS FOR WEAR

As with any dynamic splinting program the forces applied must be tolerable over an extended period of time to effect change in the collagen formation. It is important to instruct the patient that after use of the splint the flexion deformity will temporarily recur. Explain to the patient that this is a normal phenomenon and that a period of stretch may gain full extension but that it will not yet have permanently relieved the tightness of the tissues. Patients who have full flexion of the PIP joint are frequently instructed to wear the extension splint at night and are advised to observe how long after removal of the splint the deformity recurs. If it recurs during the waking hours, the patient is then instructed in additional periods of wear during the day, with the splint being removed for flexion exercises. Instruct the patient that the goal is to be able to maintain full extension for longer and longer periods when the hand is out of the splint. When only a slight lag develops after a full day out of the splint, it is appropriate to go to a routine of night splinting only. These instructions vary depending on the nature and extent of the injury and whether flexion range is also limited and flexion splinting and/or exercises need to balance off the extension force. Only an experienced hand therapist can evaluate the balance of motion and the amount of tightness and devise an appropriate splinting schedule.

CONSTRUCTION OF SPLINT

Materials

The materials used for the construction of the spring-wire splint are readily available (Fig. 98-4).

Spring-steel wire of 17.0 gauge (0.039 inch in diameter) is recommended and may be obtained from a local piano tuner or a piano supply company. One-pound coils (approximately 248 feet) are available and allow easy procurement of an appropriate length of wire. Spring steel has an inherent resistance to deforming forces and therefore must be overbent to obtain the desired shape. Avoidance of sharp bends will prevent the wire from snapping.

Filament tape used for packaging is used to cover the wire superstructure and may be obtained from any office

Fig. 98-3. Two spring-wire splints can easily be tolerated on adjacent fingers.

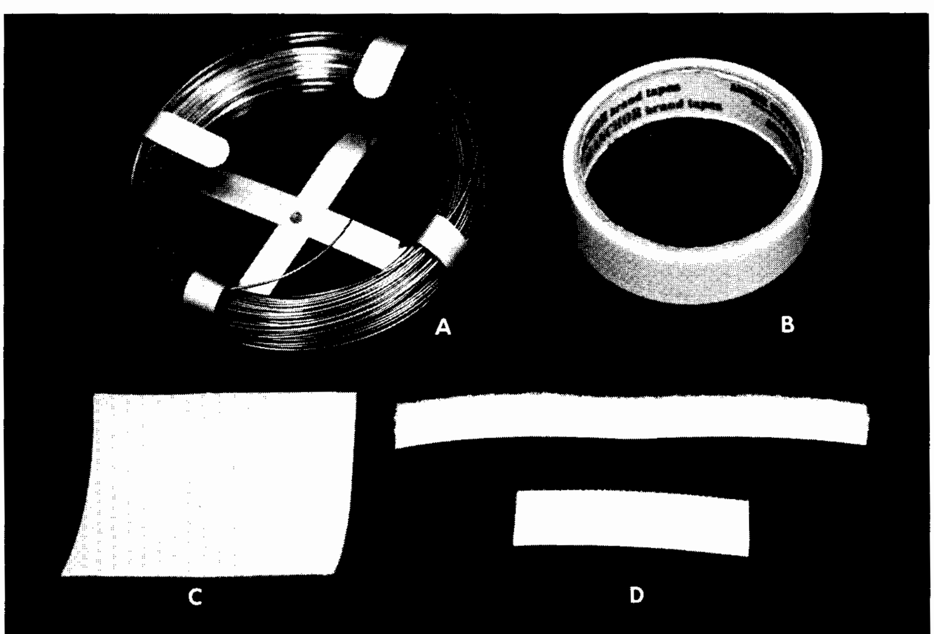

Fig. 98-4. Materials for spring-wire splint include: **A,** spring-steel piano wire; **B,** 1-inch filament tape; **C,** adhesive moleskin; and **D,** Velcro loop and pile.

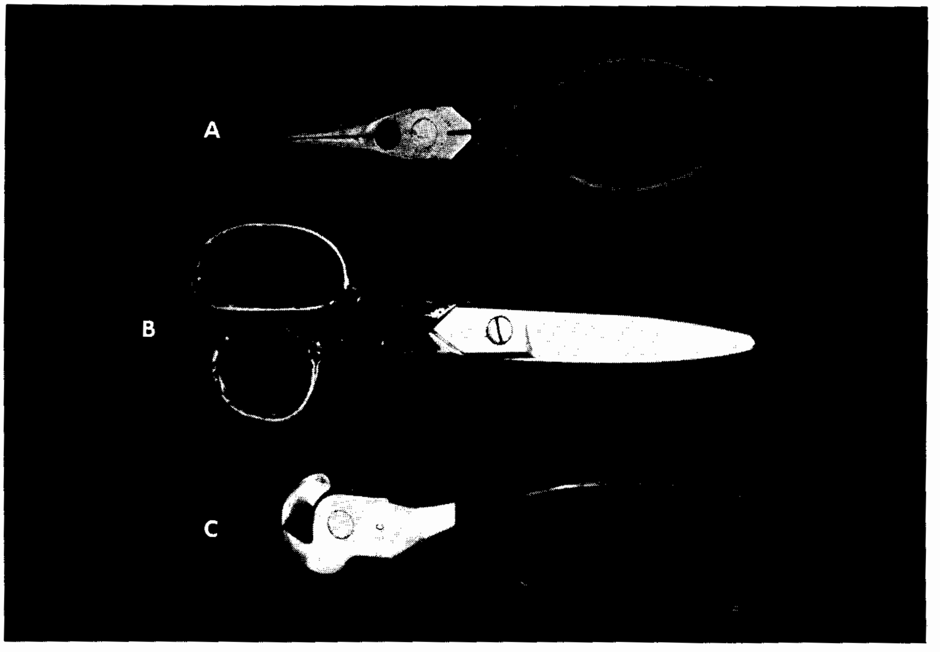

Fig. 98-5. Tools required for making spring-wire splint include: **A,** flat-jawed needle-nose pliers; **B,** leather scissors; and **C,** end-cutting nippers.

supply company. A 1-inch width is most workable for this technique, and it is important that no substitutions be made, because the filaments provide the necessary strength for long-term durability.

Adhesive-backed moleskin, available from splinting or surgical suppliers, is used to cover the filament tape for both its padding and cosmetic effect.

One-half inch Velcro fasteners are used for the distal strap, with the adhesive-backed hook providing easy attachment of the strap to the wire and the Velcro loop providing the strap itself.

Tools

As with any technique, it is the correct tool that creates ease and efficiency in the construction (Fig. 98-5).

Firmly constructed flat-jawed needlenose pliers are necessary to bend the resistant spring steel. Smooth or round jaws allow rotation of the wire. Six- or 8-inch flat-jawed needlenose pliers with teeth are recommended. Wirecutting pliers called "end-cutting nippers," which have a broad cutting area, are helpful, because the last step of construction requires cutting of the wire where it is inaccessible to the cutting jaws on the needlenose pliers.

Sharp scissors with short blades so as to be effective in cutting at the tip of the scissors are necessary for easy trimming and cutting in the small tight areas. Leather shears are excellent for this purpose.

The spring wire coil is effectively turned by the use of a special jig fashioned after the design illustrated by Wynn Parry.[19] Use of the commercially available jig illustrated* (Fig. 98-6) allows one to turn a tight and compact coil, which is difficult when attempted manually with pliers.

*Available from Smith & Nephew Roylan, Inc.

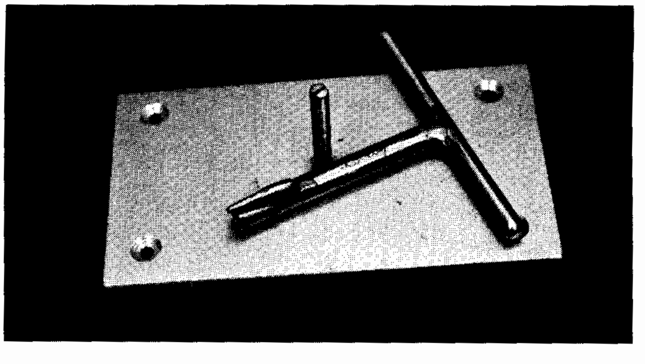

Fig. 98-6. Special jig for turning coils for spring-wire splint.

Fig. 98-7. Step 2. Bending initial curve.

The dimensions of the jig are specifically for the 17-gauge wire used for the PIP joint splint, although the jig may be used for other splint designs.

Procedure

1. Cut a length of 17-gauge piano wire approximately 14 inches in length.

2. Form a U-shape in the wire by holding the wire with the pliers and bending the wire gently with the fingers. Keep the wire and the pliers moving back and forth to create a smooth-curved shape (Fig. 98-7).

3. After the initial curve is made in the wire, it will retain the curved shape. With the fingertips apply a force to bend the wire in the direction opposite the resting curve. Slide the fingertips down the wire while applying force to straighten the wire (Fig. 98-8).

4. Working on the palmar aspect of the finger, adjust the wire shape so that it is slightly wider than the width of the finger (Fig. 98-9). It is important at this stage and throughout the splintmaking that the wire be parallel in all planes. At this stage it should lie flat on a smooth surface.

5. With the wire U-shape positioned on the palmar aspect of the finger and the curve resting at the distal palmar crease, mark the point of the wire just distal to the finger-web space (Fig. 98-9).

6. Bend the wire at a 60-degree angle so that it is between the fingers. Pay special attention to the finger webs, measuring carefully on both the radial and ulnar aspects, because they

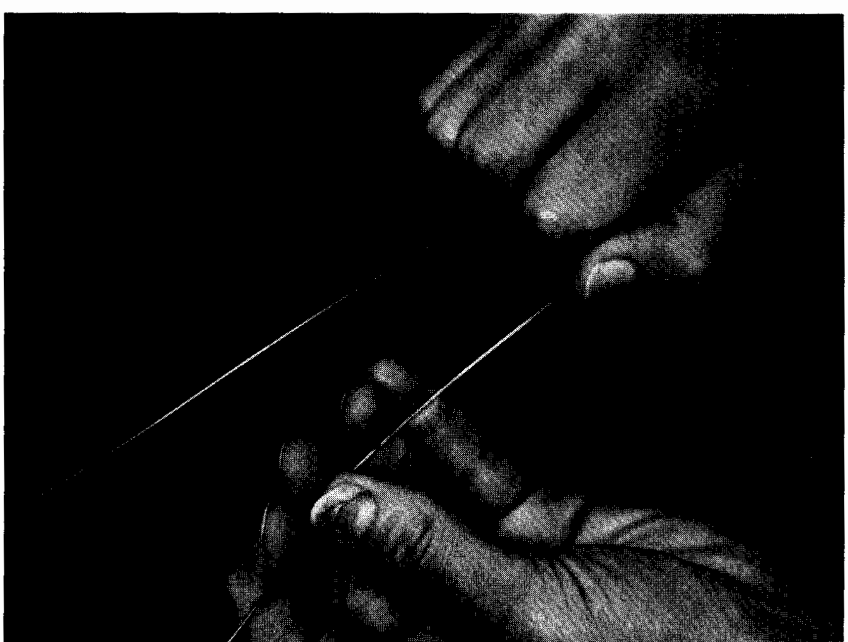

Fig. 98-8. Step 3. Straightening wire ends, making U shape of wire.

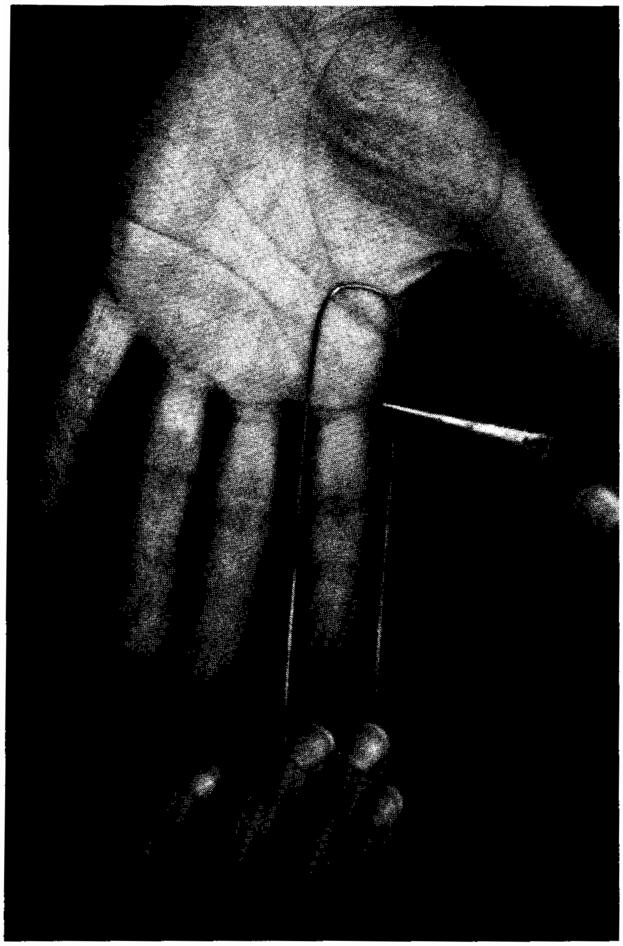

Fig. 98-9. Step 4. Measuring width of splint superstructure. Step 5. Marking location of the bend to carry wire to the lateral aspect of finger.

differ on each finger. Hold the wire with the wide part of the jaws of the pliers, and bend the wire sharply at the edge of the pliers by applying force with the fingers (Fig. 98-10).

Fig. 98-10. Steps 6 and 7. Bending wire at 60-degree angles.

7. Bend the wire again at a 60-degree angle so that it now lies in a position midlaterally on the finger. Again check to be sure the wire is parallel (Fig. 98-11).

8. Replace the splint on the palmar aspect of the finger, and mark the location of the axis of the PIP joint. One easily determines the axis by locating the apex of the middle palmar finger crease.

9. Place this point of the wire in the middle of the slot in the jig base (Fig. 98-12). Place the jig handle over the jig base, and while maintaining a downward pressure on the wire, turn two complete revolutions (Fig. 98-13). It is important during this procedure to hold the splint superstructure with a bit of torque so that the coil is turned at exactly a 90-degree angle to the axis of the parallel wires. Because the wire superstructure cannot rest directly under the coil being turned, the coil will not be parallel unless this torque

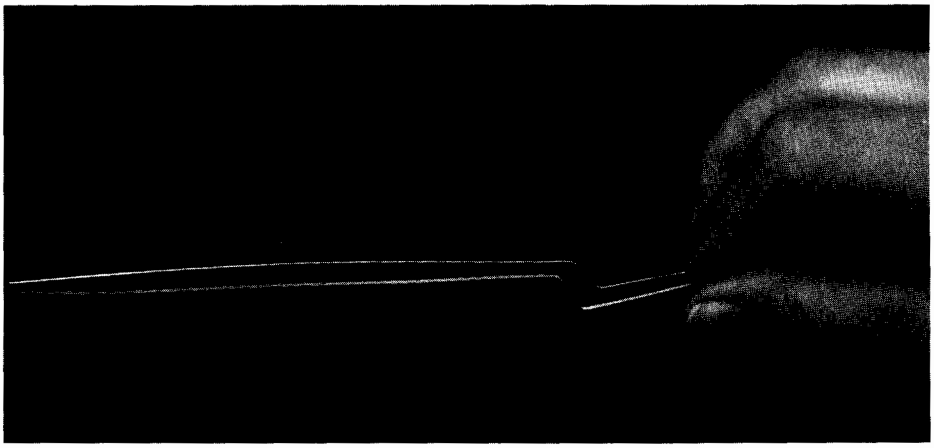

Fig. 98-11. Steps 6 and 7. Lateral view of parallel wire superstructure.

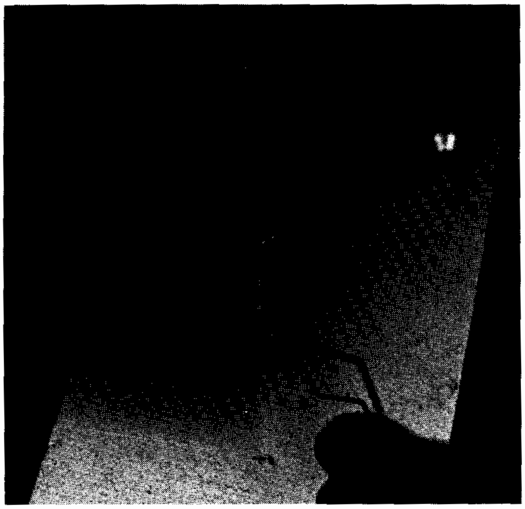

Fig. 98-12. Step 9. Placement of joint axis location in center of the jig slot.

is applied (see Fig. 98-13). It is important to remember that for extension splinting of the PIP joint the coil is always turned toward the palmar aspect of the finger.

10. Replace the splint (with one coil turned) on the volar aspect of the finger, and mark the remaining axis location (Fig. 98-14).

11. Repeat step 9 to turn the second coil (Fig. 98-15).

12. Pad the base of the splint by wrapping six to eight layers of filament tape around the curved area. Trim it with scissors to fit the shape of the wire curve, and cut out a curved shape at the bend of the wire that goes into the finger-web space (Fig.98-16). Thin thermoplastic material may be substituted and trimmed as described.

13. Slide a piece of filament tape under the coil, with the sticky side of the tape toward the splint (Fig. 98-17). Wrap tape around the opposite side, and once again ease it under the coil. The nonsticky side of the tape should lie against the skin of the finger. Fit the splint on the patient's finger and adjust the length of tape so that the coils lie exactly in the midlateral position of the finger, at the PIP

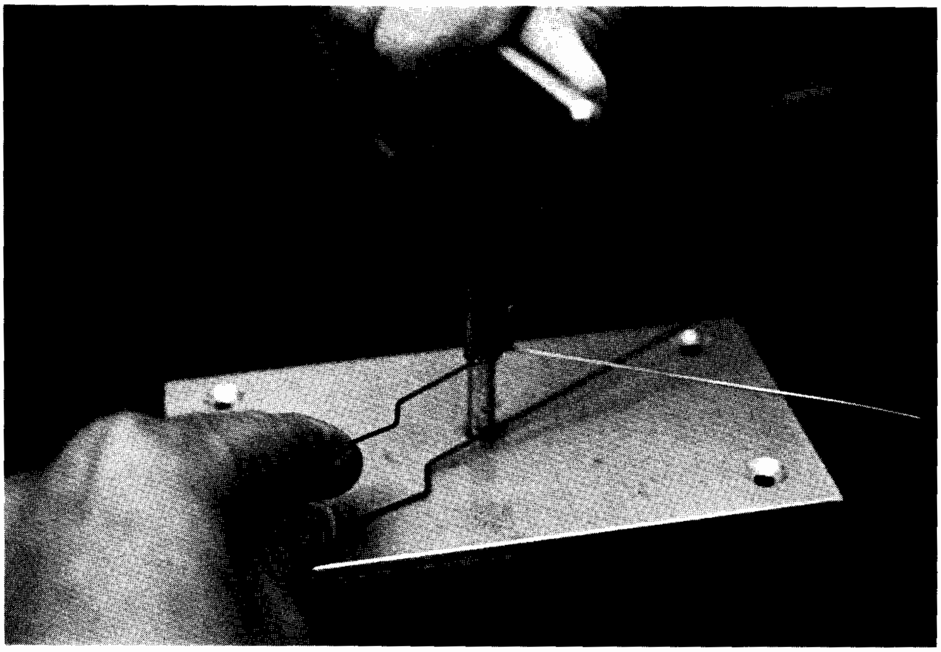

Fig. 98-13. Step 9. Turning initial coil.

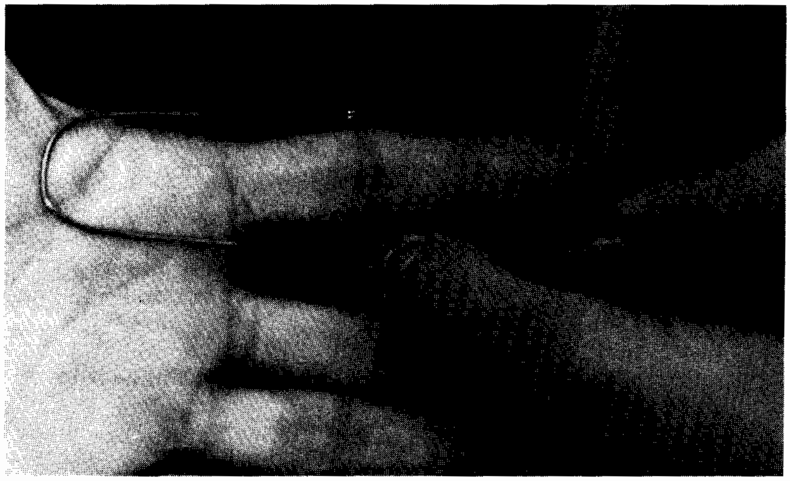

Fig. 98-14. Step 10. Marking second-joint axis location.

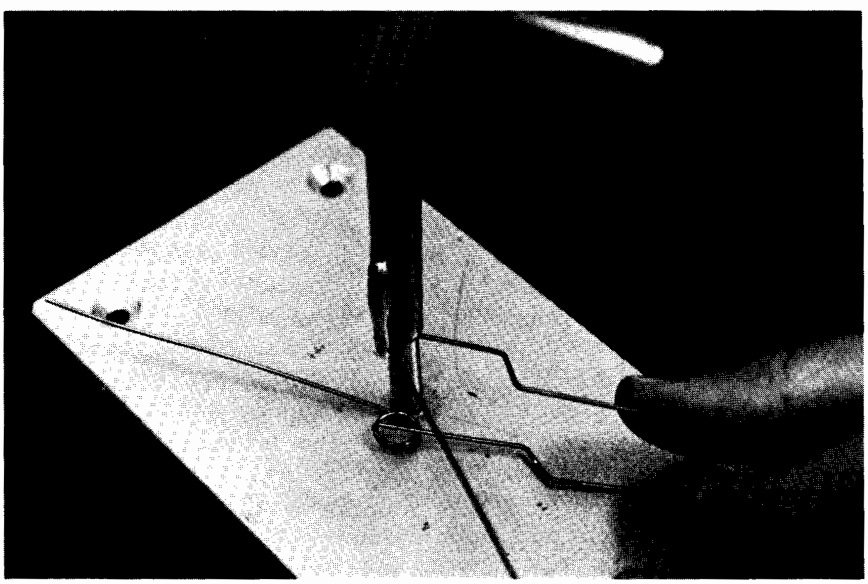

Fig. 98-15. Step 11. Turning second coil.

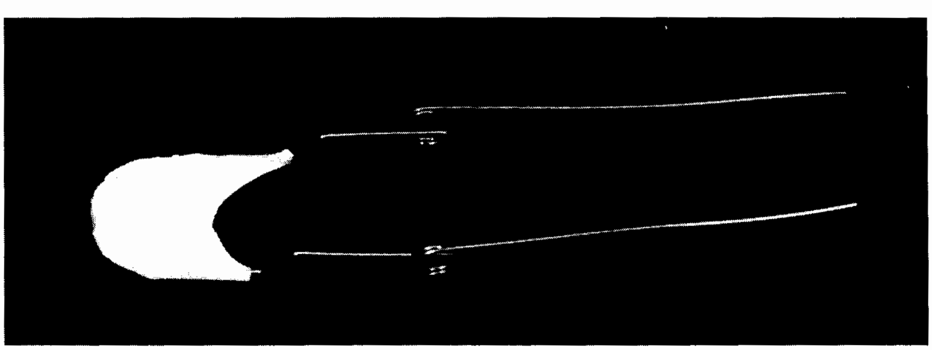

Fig. 98-16. Step 12. Covering proximal area with tape padding.

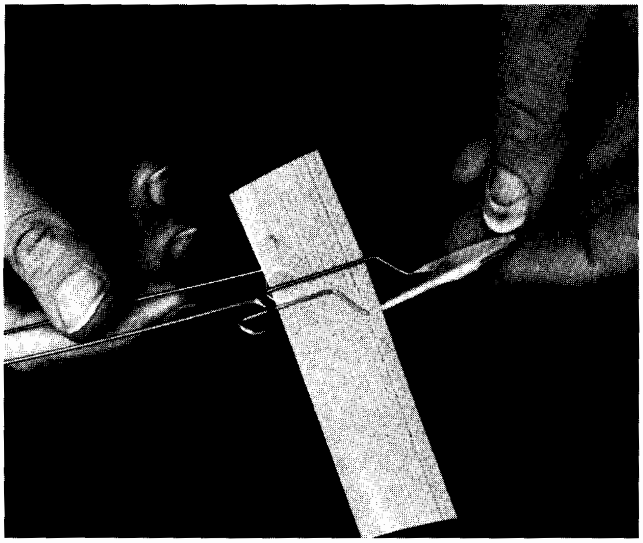

Fig. 98-17. Step 13. Applying filament tape to make dorsal hood piece.

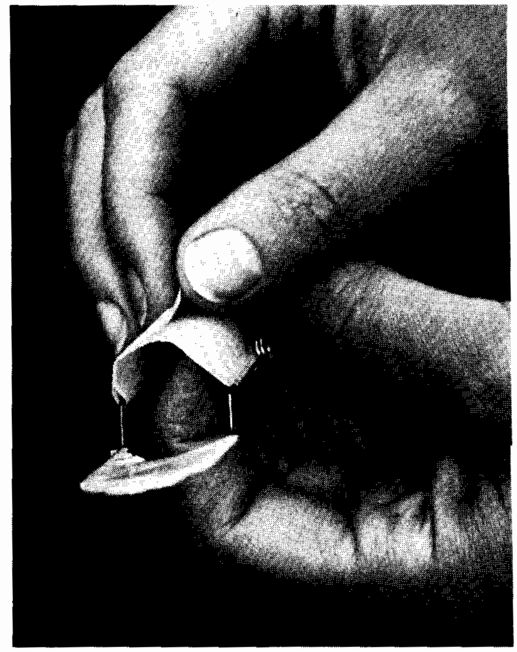

Fig. 98-18. Step 13. Applying filament tape to make dorsal hood piece.

joint axis. After adjusting the length of the tape, attach it to itself securely (Fig. 98-18). Thin thermoplastic material also may be used for the dorsal piece over the proximal phalanx, but the therapist must work quickly and accurately to ensure that the material is wrapped around the wire and under the coil while also being correctly molded to the dorsum of the proximal phalanx.

14. Place the splint on the finger, locating coils at the axis of the joint. Slide a piece of adhesive-backed Velcro hook (½ by 1½ inches) between one side of the finger and the lateral wire, with the sticky side toward the wire (Fig. 98-19). Fold the Velcro over the wire at the level of the distal interphalangeal (DIP) joint crease. Adhere the Velcro to itself, making sure that the unit is pointing palmarly.

15. Apply a ½-inch by 4- to 5-inch piece of Velcro loop to the Velcro hook on the side touching the palmar aspect of the finger. Take this piece of Velcro up dorsally between the finger and the wire, and loop the Velcro over the wire,

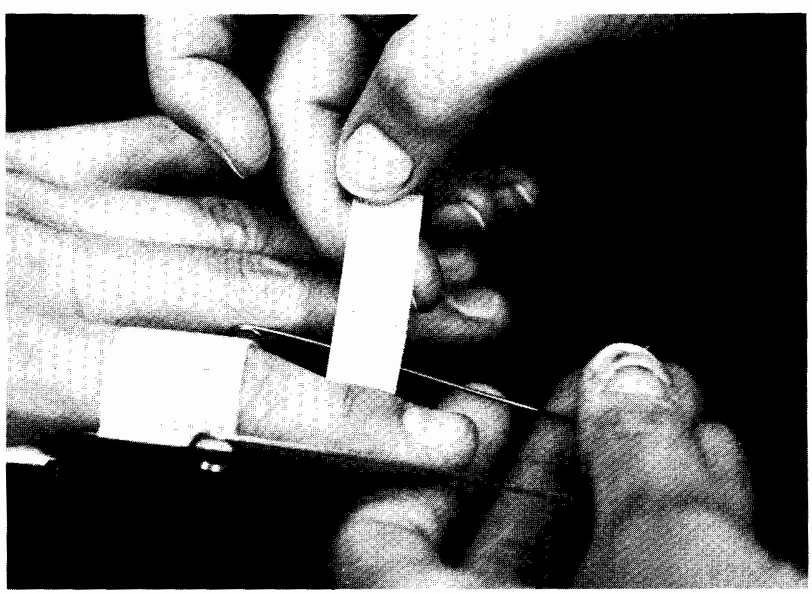

Fig. 98-19. Step 14. Applying Velcro hook.

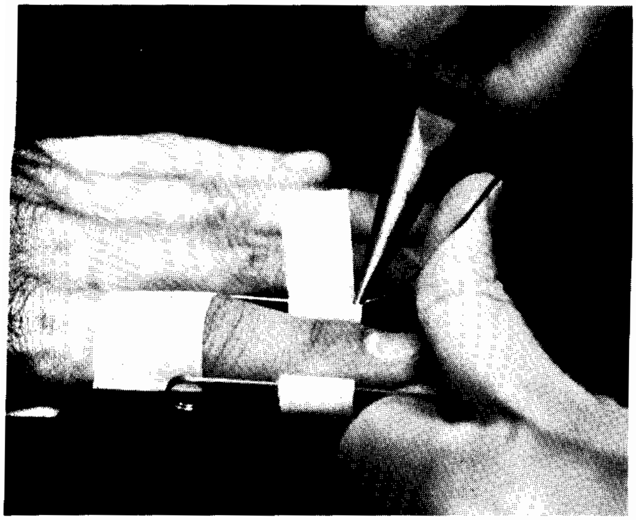

Fig. 98-20. Step 15. Applying Velcro loop to complete strap, and step 16, marking end of splint.

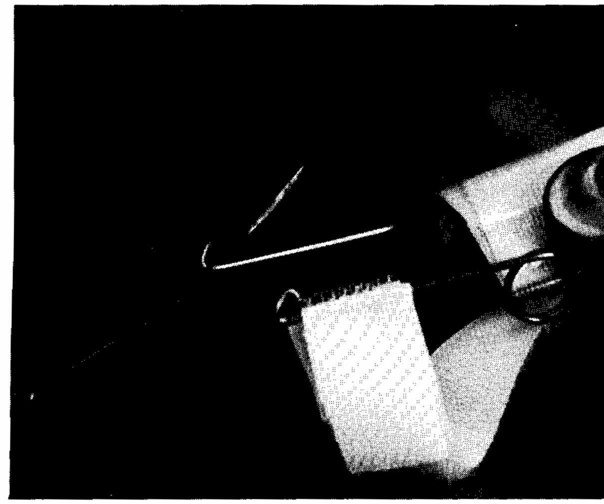

Fig. 98-22. Step 17. Cutting end coil.

carrying it palmarly again to adhere to the Velcro hook (Fig. 98-20). The Velcro thus forms a sling under the finger and allows adjustability, because the sling length can be determined by the amount of pull exerted on the Velcro loop.

16. With the splint still on the finger, mark the wire at the point where the splint should end (Fig. 98-20). The point should be just distal to the DIP joint crease, because the strap should lie directly under the DIP joint.

17. Remove the splint and turn a tight coil around the end of the needlenosed pliers at the point marked for the end of the splint (Fig. 98-21). Make sure to have a few inches of wire to work with, because it will make the turning much easier. Cut off the wire with the end-cutting nippers after the coil is turned (Fig. 98-22). To prevent the sharp ends of the wire at the end coil from snagging objects, the end coils may be covered with small pieces of thermoplastic material.

18. Cover the taped areas or thermoplastic materials with adhesive-backed moleskin, trimming it close and making sure no seams are on the inside of the splint (Fig. 98-23).

19. Apply the splint to the patient's finger, and check for proper fit, adequate circulation, and adequate distribution of pressure (Fig. 98-24).

20. Require the patient to apply and remove the splint independently. It is mandatory that the patient be able to demonstrate correct application of the splint.

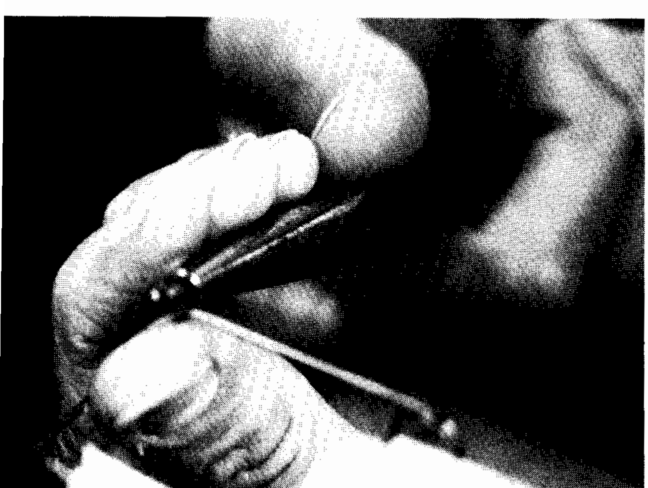

Fig. 98-21. Step 17. Making end coil.

Fig. 98-23. Step 18. Covering taped areas with moleskin.

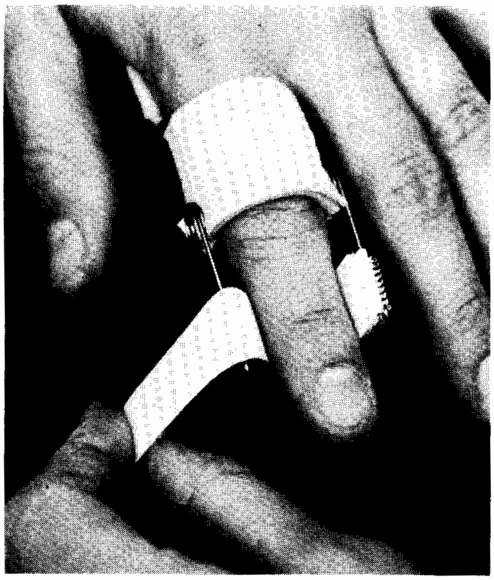

Fig. 98-24. Step 19. Applying splint to check for fit, circulation, and pressure.

Fig. 98-25. Use of a piece of thermoplastic splinting material to maintain width of splint and better distribute pressure over distal part of pulp.

Splint adjustments and modifications

As with any custom-made splint, minor adjustments and attention to detail ensure the long-term comfort of the splint on the patient. One of the most common problems is the bulbous, enlarged state of the PIP joint after injury. The enlarged PIP joint will receive pressure when the distal strap is tightened, because the tip of the finger is narrower than the joint. This situation can be particularly bothersome, because the collateral ligaments of the joint frequently have been injured and direct pressure over the area elicits exquisite tenderness. This problem can be alleviated by using the thermoplastic material alone or as reinforcement for the dorsal hood piece, making it function as a supporting arch. A small piece of splinting material molded under the distal strap so that it holds the ends of the splint apart can also alleviate this problem. It has the additional advantage of better distributing pressure at the tip. Frequently the leading edge of the Velcro strap will be constricting to the distal pulp, and this molded pad greatly increases comfort and prevents hyperextension of the DIP joint. (Fig. 98-25). An enlarged PIP joint also may be a problem when a spring-wire splint is fitted after a proximal phalanx fracture, because frequently the shape of the bone is deformed and one must adjust the dorsal hood piece so that it conforms to the bulbous shape of the proximal phalanx.

Although by far the most common use of a spring-wire splint is to correct a PIP joint flexion contracture, it can be modified to achieve other interphalangeal joint motions. It can easily be adapted to fit the interphalangeal joint of the thumb (Fig. 98-26). The direction of pull may be reversed for either thumb or finger interphalangeal joint flexion. It is important to note, however, that this design is effective to gain only the first ranges of flexion, because the line of pull will force the splint to slide off the finger in the latter ranges of flexion. Numerous other splint designs using spring wire are applicable to hand splinting, for which one should refer to other authors.[1,9]

Fig. 98-26. Use of spring wire in reverse direction to achieve the first ranges of flexion of the interphalangeal joint of thumb.

SUMMARY

The low-profile spring-wire splint first described by Capener is of significant clinical value because of its easy tolerance by the patient. A custom-made splint that exactly fits the length of the finger and applies force at the axis of the joint frequently offers advantages over a commercially available splint. The steps for construction are offered with the hope that this splint can become part of the armamentarium of the skilled hand therapist.

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