ANATOMIC CONSIDERATIONS FOR SPLINTING THE THUMB

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In 1833, Sir Charles Bell wrote: "On the lengths, strength, free lateral motion, and perfect mobility of the thumb, depends the power of the human hand." With such a significant portion of hand function being attributed to the thumb, it is evident that so little is found in the literature regarding the biomechanics of splinting the thumb. Whether thumb motion is affected by an isolated injury or is the result of severe hand trauma or stiffness, an in-depth understanding of its complex biomechanics is required to enable precise splinting.

MOTIONS OF THE THUMB JOINTS

Individual thumb joint motions, as well as the complex composite motions, are reviewed in the following sections. Before one is able to comprehend the complex motions of the thumb, a clear understanding of the individual joint biomechanics is necessary.

The interphalangeal joint

Flexion and extension describe the motions of the stable boney joints of the thumb interphalangeal (IP) joint. The inherent stability of the IP joint allows force to be efficiently transmitted to the thumb tip. Flexion of the IP joint is in a plane perpendicular to the sagittal plane of the thumb. Extension of the thumb IP joint is in the opposite direction, but identical plane. Some describe limited pronation of the IP joint as it flexes due to the greater radial condyle height.

The thumb IP joint may readily hyperextend as much as 15 to 20 degrees more and flex as much as 80 degrees. Individuals with normal thumb IP hyperextension often incorporate the hyperextension during pinching because this allows the thumb pulp and the index finger pulp to have full contact (Fig. 116-2). Normal hyperextension of the uninjured thumb should be measured, and if present, requiring hyperextension should be a goal of mobilization splinting.

Although slight flexion is considered the ideal position for thumb IP joint fusion, the loss of full IP joint flexion greatly limits the ability of the thumb to participate in fine motor skills. In a patient's dominant hand, preserving full IP joint motion is vital for activities such as sewing, model building, and other precision work.

The metacarpophalangeal joint

The thumb metacarpophalangeal (MP) joint combines characteristics of both a condyloid and a gliding joint19 and has been described as having "no exact mechanical equivalent." Flexion and extension, ulnar deviation (adduction) and radial deviation (abduction), and rotation are all present at this joint. Flexion and extension are primary motions, with radial and ulnar deviation and rotation being accessory motions.20 The accessory motions of the MP joint are a reflection of the related motion occurring at the carpometacarpal (CMC) joint. For example, during thumb opposition, the thumb MP joint radially deviates approximately 20 degrees and rotates slightly to aid the thumb pulp meeting the index finger pulp.21,22 The combined mobility of the thumb MP joint and CMC joint range of motion (ROM) allows a greater functional ROM because abduction occurs simultaneously at both joints.22 It is important to note that one cannot fully flex the MP and IP joints of the thumb while holding the CMC joint in an abducted or extended position, a relevant point when splinting.

The shape of the head of the first metacarpal determines the ROM for flexion and extension of the MP joint, and the degree of fulgaris lasty determines the amount of adju-
Fig. 116-1. Flexion of the thumb metacarpophalangeal and interphalangeal joints.

Fig. 116-2. Normal interphalangeal hyperextension is used in many daily tasks.

Fig. 116-3. Metacarpophalangeal joint ligament configuration shows the adductor aponeurosis, the collateral ligament, the adductor tendon, and the extensor pollicis longus. (From Palmer A, Leun D: J Hand Surg 3:544, 1978.)

tor, abduction, and rotation available at the joint.20 The configuration of the collateral ligaments of the MP joint of the thumb allows stability of the MP joint in both flexion and extension (Fig. 116-3).

The normal ROM at the thumb MP joint is more variable among individuals than either the thumb IP joint or the CMC joint10,36 and is said to have the greatest variation of any joint in the body.16,20 The MP joint may flex only a few degrees in some individuals and bend to 90 degrees in others.4,10 Those with naturally limited MP joint flexion often tend to have a greater range of IP joint flexion, and those with a larger range of MP joint flexion may have more limited IP joint motion.

Whenever splitting or mobilizing the MP joint of the thumb for flexion, one must examine and measure the contralateral thumb to establish realistic ROM goals.7,8

The carpometacarpal joint

The large ROM of the thumb CMC joint reflects the lack of bony stability of the joint13,42 and the accompanying ligamentous laxity. Because of this laxity, most problems associated with the thumb CMC joint are problems of decreased stability rather than stiffness. Often, one encoun-

ears the conflicting goals of achieving stability and maintaining mobility at this joint.33

The thumb CMC joint is a saddle joint with the primary contures allowing motion to occur at right angles. The convexity at the proximal end of the first metacarpal allows flexion and extension, and the convexity of the distal aspect of the trapezium allows abduction and adduction. The ligamentous laxity of the joint allows rotation (described by some as pronation)16,18,22 (Fig. 116-4). Enzor34 describes retropulsion, antepulsion, adduction, and abduction as the four directions of movement possible at the CMC saddle joint; others reserve the use of the terms retropulsion and antepulsion for combined joint motions. In any case, there is consensus regarding the description of specific static posi-
tions of individual thumb joints, although there may be controversy regarding the terminology to describe combined motions.

Retroposition describes the position of the first metacarpal rising above the plane of the other metacarpals (Fig. 116-5). This motion is full abduction and extension of the first metacarpal joint with full extension and adduction of the MP and IP joints of the thumb. This position may also correctly be described as full thumb extension and abduction. When less than full retroposition (extension and abduction) of the thumb is attained but full abduction of the first metacarpal is achieved in the same plane as the other metacarpals (as when the hand is flat on a surface), this may be described as radial abduction (Fig. 116-6).

When the thumb moves toward the fingertips and continues to move across the palm to the ulnar border, the terminology may be somewhat confusing. When the thumb rests against the radial aspect of the index finger, it is described as zero position or adduction (Fig. 116-7). Note that this describes only the motion of the CMC joint. Some clinicians refer to palmar adduction when the thumb is held against the hand on the palmar surface of the index finger. These two positions reflect a change in the position of the MP and IP joints, but the position of the CMC joint remains relatively unchanged.

When the IP, MP, and CMC joint motions are combined, the terms opposition and circumduction describe these composite motions. If the plane of the fingernail stays at a 90-degree angle to the plane of the palm and the thumb is pulled directly away from the index finger by a plate 90 degrees to the palm, this is termed palmar abduction (Fig. 116-8). As the thumb proceeds toward the tips of the index fingers, rotation at the CMC joint is accompanied by rotation and extension at the MP and IP joints. When full thumb rotation has occurred, the angle of the thumb becomes almost parallel to the plane of the palm, creating a position of opposition.22,23 (Fig. 116-9). When the thumb is touching the base of the ulnar digits and the fingernail is more parallel to the plane of the palm, the CMC joint is maximally rotated and flexed, describing the position of anteposition (Fig. 116-10).

The collective motion from the position of maximum radial abduction and extension (retroposition) to the ulnar border (anteposition) of the hand is termed circumduction. Circumduction describes the maximum arc of motion of the CMC joint22 accompanied by the associated MP and IP joint motion, whereas the previously defined terms describe a position of a joint or joints.

SPECIFIC JOINT PROBLEMS

The interphalangeal joint

The thumb IP joint, a stable hinge joint, is vulnerable to injury because it is involved in all manipulative tasks. Crush injuries or lacerations are usually the cause of IP joint injury, whereas sprain and dislocation injuries to the thumb IP joint

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**Fig. 116-4.** The saddle shape of the carpometacarpal joint allows multiple planes of motion. (From American Society for Surgery of the Hand: The Hand: Examination and diagnosis, ed 3, New York, 1990, Churchill Livingstone.)

**Fig. 116-5.** Retroposition (full extension and abduction) of the thumb.
Fig. 116-6. Radial abduction of the thumb.

Fig. 116-7. Adduction of the thumb.

Fig. 116-8. Palmar abduction of the thumb.

Fig. 116-9. Opposition of the thumb. Note the plane of the thumb nail.
are rare.\(^{19,21}\) This may be related to the greater stability of the IP joint because of the shorter lever arm of the distal phalanx.\(^{19}\) Because the stability of the IP joint is greater than either the MP or CMC joints, force is transferred to the looser proximal joints and they are more frequently injured.

**Capsular tightness.** When IP joint flexion is limited following a fracture, dislocation, or crush injury, the thumb MP and CMC joints must be stabilized by a splint so the flexion mobilization force can be directed specifically to the IP joint\(^{9,10,11}\) (Fig. 116-11). As the flexion range increases, the outrigger is shortened to maintain the line of pull at an angle of 90 degrees to the axis of the distal phalanx.\(^{8}\)

Splinting to regain full IP joint extension is often at the request of the patient to reestablish the normal hyperextended pinch pattern. This may be accomplished with serial splinting, either with a molded palmar thermoelastic shell or a small serial plaster cast. At times it may be better to provide a dynamic extension mobilization force to this joint if the other alternatives are unrealistic in relation to the patient’s lifestyle or if alternating flexion and extension are required.

**Instability.** Instability of the thumb IP joint is rarely seen after injury but may be present as a result of osteoarthritis or rheumatoid arthritis of this joint (see rheumatoid arthritis discussion later in this chapter). Lateral instability, occasionally seen in osteoarthritis, allows excessive radial deviation at the thumb IP joint during pinch. Although fusion of the joint can eliminate pain and provide stability to increase pinch strength, a small splint can retain some mobility in the flexion/extension plane while stabilizing the joint in the radial and ulnar planes. A temporary splint may be made of thermoelastic material (Fig. 116-12), or the patient may choose a long-term Siris splint, custom made of sterling silver (available from Silver Ring Splint Company, Charlottesville, Virginia).

**The metacarpophalangeal joint**

Although capsular tightness may limit thumb MP joint motion following fracture, dislocation, tendon injury, or crush injury, the most common injury to the thumb MP joint is injury to the ulnar collateral ligament (UCL),\(^{16,17}\) followed by injury to the radial collateral ligament.

**Collateral ligament injury.** A fall on the outstretched hand forces the thumb MP joint into radial deviation (abduction), injuring the UCL. The injury may be partial where stability of the joint is retained, or the injury can result in a complete tear causing the joint to no longer be stable. Ligamentous integrity is important at the MP joint to provide stability during pinching and grasping of large objects.

Many use the term gamekeeper’s thumb to describe a thumb MP joint UCL injury.\(^{5}\) Originally called gamekeeper’s thumb because of the chronic UCL strain seen as a result of the gamekeeper’s twisting the heads of wounded rabbits, it is recommended now that the term gamekeeper’s thumb be reserved only for chronic strains of the UCL. Acute injuries are best described as skier’s thumb because of the frequency of this injury when the skier falls on the open hand.\(^{18}\)
It is generally agreed that incomplete tears of either the UCL or the radial collateral ligament can be appropriately treated with immobilization splinting to prevent radial and ulnar deviation. Surgical repair is required for complete lacerations. 5,6,19,20,23

Immobilization can be accomplished with a casting material, or in compliant patients, a removable splint that immobilizes the MP joint is acceptable. 14 Although some authors illustrate a thumb MP and CMC joint immobilization splint that includes the wrist, shorter splints that do not impede the CMC joint or wrist are also recommended. 9,11,16,23,26 A well-fitting splint need not include the wrist to protect the thumb MP joint (Fig. 316-13).
Even patients with chronic MP joint instability may benefit from a period of immobilization splinting and antiinflammatory medication. If the instability is relatively mild, the patient may manage symptoms by intermittent use of the splint. The splint is ideally used for protection during resistive activities that create symptoms but also may be helpful to provide a period of immobilization to diminish symptoms following aggravating activity.

To completely immobilize the thumb MP joint, the splint must obtain adequate purchase on the thumb metacarpal and the proximal phalanx. A small extension can be added to a CMC joint immobilization splint to encircle the proximal phalanges, preventing motion at the MP joint (see Fig. 116-13). The patient retains the ability to pinch while in the splint because the IP joint is free. The advantage to this splint design is that it opens and closes around the proximal phalanx to allow more specific stabilization of the proximal phalanx. Splints designed to slip over the IP joint usually allow some MP joint motion because the IP joint is always larger than the proximal phalanx. An identical design may be used for a period of continued immobilization after surgical repair of a collateral ligament injury.

Capsular tightness. Ligamentous injuries to the MP joint or fractures at or near the MP joint often limit active and passive motion. If an MP joint flexion mobilization force is attached to a wrist cuff, the loose CMC joint will be more influenced by this force than the stiff MP joint. To mobilize the thumb MP joint into flexion, the CMC joint must be stabilized before adding a flexion mobilization force at a 90-degree angle to the axis of the proximal phalanx of the thumb (Fig. 116-14). As the thumb MP joint motion increases, this outrigger length is shortened to maintain the correct line of pull.

The carpometacarpal joint

As discussed previously, the configuration of the trapeziometacarpal ligaments and the saddle shape of the CMC joint allow rotation and the four other motions of flexion/extension and abduction/adduction (see Fig. 116-4). The trapeziun, on which the first metacarpal articulates, sits palmar of the other carpals, allowing the thumb to move in an arc around the fingers. Because of its large ROM and normal capsular laxity, the CMC joint most often requires immobilization splinting rather than mobilization splinting.
Osteoarthritis. The most common problem seen at the thumb CMC joint is increased laxity as a result of osteoarthritis (see Chapter 101).

As the laxity of the CMC joint increases with osteoarthritis, pain becomes present with resisted motion (pinch) (Fig. 116-15). Before arthroplasty is considered, corticosteroid injections, oral antiinflammatory drugs, and splinting may be used to control the symptoms.3,5,21

Most splints that immobilize the thumb CMC joint include one or both adjacent joints.6 The author advocates a smaller splint that immobilizes only the thumb CMC joint and can be more comfortably worn during activities7 (Fig. 116-16). When the thenar muscle bulk increases during pinch, the splint stabilizes the first metacarpal against the molded palmar portion of the splint.

Sprain/strain. Occasionally, a fall on the outstretched hand will transmit force to the thumb CMC joint, resulting in a sprain injury to the CMC ligaments. A splint restricting motion at the CMC joint as the ligaments heal will allow the patient to resume normal activities (see Fig. 116-16).

Posttraumatic adduction contracture. Adduction contractures can result from prolonged edema and immobilization, skin tightness, bone and joint pathology, abductor pollicis brevis weakness, ischemia or atrophy of the adductor muscle, nerve injury, Dupuytren's contracture, or a combination of these causes.3 The usual pathology of this deformity is a result of the thumb being allowed to remain in the adducted and flexed position as soft tissues heal. In this position, the first dorsal interosseous and the adductor muscles along with the skin and fascia are allowed to rest in a shortened position. Brown and McGrouther8 describe the first web as "a mechanism of great complexity which depends on the normal structure and function of many anatomical parts."

Most commonly, a thumb adduction contracture results from soft tissue contracture rather than bony restriction. It is uncommon for contracture of the first web space to result solely from injury to the CMC joint.

Functional abduction of the thumb is not simply an index of the angle between the first and second metacarpals. It is also the ability to fully extend all the joints of the index finger and thumb to obtain maximum distance between the two digits. Theoretically, one could have 90° of abduction of the first metacarpal in relation to the second metacarpal, but a severe flexion contracture of the thumb or index finger would prevent grasping of large objects in the first web space.

Traditional hand immobilization (resting) splint designs have advocated holding the finger MP joints in full flexion with full IP joint extension and the thumb palmarly abducted. The soft tissue, skin, and muscles between the first and second metacarpals are not held at a maximum length when the thumb is in palmar abduction. A hand immobilization splint should maintain the position of the fingers described previously, but the position of the thumb should be in a more abducted and extended position. This position maintains the length of the adductor and other intrinsic muscles, as well as the flexors and skin. Because the thumb is more powerful in flexion and abduction, one need not fear the loss of these positions.

*References 7, 16, 20, 27, 31, 32, 34, 39.
Splinting has an early and definitive role in preventing adduction contractures of the thumb, and a variety of mobilization splinting approaches may be helpful.

Mobilization splinting. A mild positional contracture secondary to immobilization and edema may be alleviated by using a large piece of foam placed in the first web space and gently tied in place with a figure-of-eight strap around the wrist (Fig. 116-17). Overnight wear will allow the expansion of the foam to position the thumb abducted.

![Foam splint](image)

Fig. 116-17. A foam splint gently maintains abduction of the first web space.

![Night splint](image)

Fig. 116-18. Dynamic thumb abduction mobilization splint with the pull at less than 90 degrees at the base of the proximal phalanx.

This is especially useful with insensitive areas or with an edematous hand. The force is gentle, is well distributed, and can do no harm.

Dynamic or static progressive mobilization splinting to gain abduction of the thumb CMC joint and elongate the first web tissues is mechanically difficult. The anatomy of the web leaves little surface area on which to apply a force that is not distal to the MP joint. Care must be taken to apply the force at less than a 90-degree angle to pull on the first metacarpal head and not the proximal phalanx (Fig. 116-18). Force applied distally to the MP joint can result in increased deviation of the MP joint rather than CMC joint abduction. Conversely, it is important to be aware that extension and radial deviation of the thumb is needed to hold large objects. Therefore a splint that affects
<table>
<thead>
<tr>
<th>Nabuff classification?16,18</th>
<th>Primary site causing deformity</th>
<th>Deformity</th>
<th>Frequency of deformity</th>
<th>Splits for early stage of deformity</th>
<th>Splits for chronic stage of deformity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td>Thumb MP joint</td>
<td>Thumb MP flexion with IP extension (bonmot- niere of thumb)</td>
<td>Most common</td>
<td>Cuneiformal neoplastic split to provide &quot;external&quot; lightening</td>
<td>Custom-molded thumb MP joint extension immobilization splint</td>
</tr>
<tr>
<td>Type II</td>
<td>Thumb CMC joint</td>
<td>CMC adduction and dorsal subluxation; with accompanying MP joint flexion and IP joint extension</td>
<td>Most uncommon</td>
<td>CMC immobilization splint, if able to identify CMC joint problem early</td>
<td>CMC and MP joint extension immobi lization splint, if provided, symptomatic relief</td>
</tr>
<tr>
<td>Type III</td>
<td>Thumb CMC joint</td>
<td>CMC adduction and subluxation; MP joint extension; hyperextension of MP joint flexion (swan-neck deformity)</td>
<td>Common</td>
<td>CMC joint immobilization splint with block to prevent MP joint hyperextension</td>
<td>CMC joint immobilization splint with block to prevent MP joint hyperextension, if CMC joint subluxation is still possible</td>
</tr>
<tr>
<td>Type IV</td>
<td>Thumb MP joint</td>
<td>Thumb MP joint radiodensification due to laxity of the UCL (CMC adducted but not subluxed)</td>
<td>Less common</td>
<td>Thumb MP joint immobilization splint</td>
<td>None if first metacarpal is adducted, immobilization splinting of MP joint will not improve rather than enhance function</td>
</tr>
<tr>
<td>Type V</td>
<td>Thumb MP joint</td>
<td>MP joint hyperextension and IP joint flexion with normal CMC joint (pseudo&quot;swan-neck deformity)</td>
<td>Less common</td>
<td>Extension reduction splint</td>
<td>Extension reduction splint, if passably correctable</td>
</tr>
<tr>
<td>Type VI</td>
<td>General</td>
<td>Loss of bone stock and joint stability throughout thumb</td>
<td>Uncommon</td>
<td>CMC, MP, and IP joint immobilization splint as indicated</td>
<td>CMC, MP, and IP joint immobilization splint as indicated</td>
</tr>
</tbody>
</table>

CMC: Carpometacarpal; IP: interphalangeal; MP: metacarpophalangeal; UCL: ulnar collateral ligament.

Rheumatoid arthritis

The thumb is one of the most common sites of involvement in the hand with rheumatoid arthritis.16,18 Synovitis of the joint creates fibrous laxity as normal tensile forces crossing the ligament create patterns of collapse.19 Although information is lacking to validate the efficacy of splinting to slow or prevent thumb deformities, splinting is nevertheless recommended to provide symptomatic control, increase functional use of the thumb, and slow progression of deformity.20 In early stages, immobilization (resting) splints are often routinely recommended along with modification to control the effects of the disease.

Nabuff classified rheumatoid thumb patterns in the thumb in 196820 and updated the classification in 1984.21 Although the patterns of collapse are multiple deformities, Nabuff’s classification is organized by identifying the site of primary involvement that initiates the deformity (Table 116-1).
Interphalangeal joint. Not included in Nalebuff’s classification, perhaps because of the isolated joint involvement. In lateral instability of the thumb IP joint resulting from ligamentous laxity. Stability of the UCL at the IP joint is often diminished as a result of the radially directed force of the fingers toward the thumb during pinching.

Splints that completely immobilize the joint may offer increased stability but may be more bothersome than helpful. The same type of restriction splint may be used as discussed previously under thumb IP joint instability from osteoarthritis (see Fig. 116-12).

Metacarpophalangeal joint. Nalebuff’s type 1 deformity is commonly called a “passive-type” deformity of the MP joint of the thumb, although Nalebuff prefers the term extrinsic-minus deformity. Synovitis of the MP joint creates capsular distension and attenuation of the extensor mechanism. The decreased mechanical efficiency of the extensor at the MP joint diminishes the ability to balance the strong pull of the intrinsic thumb muscles during pinch. A flexion contracture of the MP joint results that usually progresses to volar subluxation and then dislocation of the proximal phalanx on the metacarpal head. As the deformity progresses, the imbalance of tendon pull across the joint brings the thumb IP joint into hyperextension (Fig. 116-20). In this deformity the CMC joint usually remains relatively uninvolved.

In the early stages of this deformity, when mild MP joint laxity is present, patients may receive considerable symptomatic relief and increased function from a small, snugly fitting neoprene splint (Fig. 116-21). This splint encircles the thumb MP joint with an elastic force that acts as an external ligament. Although commercial splints occasionally may be successful when used for this purpose, the splint must fit accurately to offer adequate support. Neoprene is the only material that stretches equally in all directions to allow support and mobility simultaneously.

As the deformity progresses and the proximal phalanx subluxates in relation to the metacarpal, a firmer splint is required to support the MP joint (Fig. 116-22). It must be molded in such a way to provide a force that stabilizes the proximal phalanx at the volar subluxation. To ensure comfort, the counterpressure over the dorsum of the MP joint requires a small pad to transfer the pressure away from the prominent dorsal bony contour. Various designs may be used for this purpose. The author prefers a small splint that covers minimal surface area on the hand and allows full CMC joint motion (see Fig. 116-22). Surgery is required to restore permanent stability to the joint, but even patients with grossly dislocated MP joints may appreciate symptomatic relief during hand use with a small supportive splint of the aforementioned design. However, it must be carefully fitted to provide adequate support without painful pressure over bony contours.

In type IV deformity, the UCL of the thumb MP joint becomes so attenuated that there is no radioulnar stability with pinch (Fig. 116-23). Taps—requiring abduction of the thumb—are accomplished with excessive radial deviation at the MP joint. The CMC joint secondarily becomes adducted but without associated joint subluxation. This adducted position is a result of the distance of the abductor muscle, which cannot effectively be used during pinch because the lax MP joint receives all of the force transmission.

If laxity of the MP joint is seen before the development of the adduction contracture of the CMC joint, a small thumb MP joint immobilization splint (see Fig. 116-22) can slow progression of this deformity. Surgical stabilization is required, however, for the patient to regain MP joint stability without external splinting. After the first metacarpal has become adducted, attempts at splinting will be met with futility because there is no way to provide stability to the lax radial MP ligament while maintaining functional grasp for the patient. In the absence of CMC joint abduction, the patient needs the extreme...
deviation of the MP joint for function. In longstanding deformities, fusion of the MP joint may require a soft-tissue release of the web to regain abduction.

Type V\textsuperscript{16} deformity results from hyperextension of the MP joint (rather than radial deviation) as a result of volar plate rupture (Fig. 116-24). The imbalance of the intrinsic and extrinsic muscle forces caused by this hyperextension creates secondary IP joint flexion. This may be compared with the swan-neck deformity seen in the fingers. However, in the fingers the dislocation of the finger MP joint is a principal cause of the muscle imbalance. In the type V thumb deformity, the CMC joint usually remains normal.\textsuperscript{16}

Hyperextension of the thumb MP joint can be restricted by a small three-point splint fitted to the joint of a design similar to splints recommended for swan-neck finger deformities (Fig. 116-25). If longer-term splinting is desired in home of surgery, a Sarv silver splint (Silver Ring Splint Company, Charlottesville, Virginia) can be used to provide the needed stability.

Carpometacarpal joint. In the rheumatoid hand, subluxation of the CMC joint results in abduction of the first metacarpal. The balance is then altered throughout the entire thumb. Nalebuff\textsuperscript{17} describes primary involvement of the CMC joint leading to deformity of type II and III and contributing to type IV (Fig. 116-26).

In the type II deformity, as the CMC joint subluxates and the first metacarpal becomes abducted, the balance of motion at the MP and IP joints is altered by the pull of the extrinsic and intrinsic muscles. This may be described as a complex secondary boutonnière deformity\textsuperscript{18} because hyperextension of the IP joint and flexion of the MP joint is seen. This is an uncommon deformity\textsuperscript{19} and is impossible to discriminate from type I deformity without x-ray examination.

Because the primary deforming force is located at the CMC joint, if seen early, the progression of the deformity may be slowed by stabilizing the CMC joint in an extended and abducted position (see Fig. 116-16). Realistically, it is difficult to predict the deformity progression, and usually
Fig. 116-26. Primary carpometacarpal pathology leads to deformities as described by Nalebuff. 50,51 A, Type II, flexion of the metacarpophalangeal joint with extension of the interphalangeal joint. B, Type III, hyperextension of the metacarpophalangeal joint with adduction/flexion deformity of the first metacarpal. C, Type IV, adduction/flexion deformity of the metacarpal with laxity of the ulnar collateral ligament. (From Colletz JC; Aetziitis. In Malick M, Kusy M, editors. Manual on management of specific hand problems. Philadelphia, 1984, Harmanville Rehabilitation Center.)

Fig. 116-27. A splint for carpometacarpal subluxation with metacarpophalangeal block to be used when metacarpophalangeal hyperextension is noted.

This uncommon deformity is only seen late when splinting may be of some symptomatic relief but cannot offer a definitive input to rebalance joint position.

In the type III deformity, 52 the primary site of involvement is also the CMC joint, with dorsal and radially subluxation of the joint allowing the first metacarpal to become adducted. MP joint hyperextension resulting from volar plate avulsion allows accommodation for the loss of abduction at the CMC joint. The MP joint develops a significant swan-neck deformity while the IP joint hyperflexes in an attempt to bring the pulp of the thumb into a better position. 53 It is difficult to appreciate this deformity in the early stages, although it would be appropriate to provide a CMC joint immobilization splint with a small block to prevent MP joint hyperextension (Fig. 116-27). However, patients who have begun to hyperextend the thumb MP joint in lieu of CMC extension and flex the CMC joint in lieu of MP joint flexion can be assisted with a CMC joint immobilization splint that demands MP joint flexion but prevents MP joint hyperextension.

If this deformity is seen late and the joints are dislocated, splinting may still provide symptomatic relief by stabilizing the joints during passive hand use. However, splinting at this stage cannot alleviate or prevent further deformity; surgery is indicated.

Although not associated with primary CMC joint involvement, type VI 54 deformity reflects a severe dysfunction of the thumb as the bone is resorbed in arthritis mutilans.
The joints of the thumb have no ligamentous integrity and move unrestrained when force is applied. Redundant skin resulting from bone resorption makes the fitting of a stabilizing splint a considerable challenge. If the splint is designed to carefully support each joint, it is possible to provide increased thumb stability either before, following failed, or in lieu of surgical stabilization (Fig. 116-29).

Narathtits's classification and the IP joint instability described previously are the most common deformities seen in the rheumatoid thumb. Any combination of instability and deformity may be seen in the presence of rheumatoid disease and the application of external force during normal hand use.

**PERIPHERAL NERVE LOSS**

**Median palsy**

The kinetic balance of the thumb is significantly altered in median-nerve palsy. Low median nerve-palsy demonstrates the pattern of flexion of the thumb as it lies in the adducted position across the plane of the hand (see Fig. 34-1). If left unsplinted, the shortened adductor pollicis and first dorsal interosseous muscles passively limit abduction of the first metacarpal.

Soon after a laceration of the median nerve, a static abduction splint is used to maintain the soft tissue length of the first web. A small palmar abduction immobilization splint (the traditional C-bar) does not maintain the full length of the soft tissues of the first web space. Such small splints may be useful during the day to stabilize the thumb, but a full abduction/extension splint at night best maintains full abduction of the web (see Fig. 116-19).

As sensibility returns, it is usually concurrent with some reinnervation of the intrinsic muscles of the thumb. To strengthen these muscles and reinforce normal use of the thumb, it is counterproductive to continue immobilization of the CMC joint. A splint should be used that allows active use of the returning short abductor and opponens while excluding the strong extrinsic power to the thumb. Either a small neoprene or leather splint will assist the patient in using the returning musculature (see Fig. 34-12).

**Ulnar palsy**

The thumb in ulnar-nerve palsy has a significant disability because part of the stabilizing force at the MP joint is lost. Froncist's sign (hyperflexion of the IP joint and hyperextension of the MP joint during forced pinch) is an indication of the weakness of the adductor pollicis and one half of the flexor pollicis brevis of the thumb. However, with normal sensibility in radial digits and otherwise unimpaired motion, it is difficult to provide a splint for the thumb that stabilizes in one direction without involving other functions. Thus a splint is not usually recommended. Tendon transfers may be useful.
Tendon lacerations

Postoperative care of flexor and extensor tendons is reviewed in depth in Chapters 27 and 31. A few suggestions are made here regarding commonly encountered problems with tendon injuries of the thumb.

Flexor pollicis longus. The flexor pollicis longus (FPL) tendon may be managed by dorsal block splinting and rubber band traction after the Kleinert method. The wrist is held in flexion, and the first metacarpal is positioned in flexion to limit the FPL excursion.

After active motion is begun, a proximal block is needed to opsonize the mobile CMC joint. This allows transmission of FPL glide to the MP joint, the IP joint, or both. This can be done effectively with positional blocking splints that the patient uses when returning to normal activity. In distal FPL lacerations, the strong intrinsic muscles of the thumb flex the MP joint, leaving little available excursion for IP joint flexion. A longer splint blocking both MP and CMC joint motion may be necessary (Fig. 116-30).

Extensor pollicis longus. Extensor pollicis longus (EPL) lacerations are best managed by meticulous attention to splinting after the repair. If immobilization splinting is the procedure of choice, it is important for full excursion of this tendon that the thumb is held in full abstraction and extension with concurrent wrist extension (Fig. 116-31). It is advisable to position the IP joint in maximum extension so that the patient does not have a significant active lag in both extension and flexion.

Tightness or adherence

Any injury to the hand or thumb results in tightness or adherence of the extrinsic muscle-tendon units. Trauma to the thumb allows the extrinsic system to adhere at the level of injury, limiting glide. Movement of proximal and distal joints will alter other joint motion. To effectively splint muscle-tendon unit tightness, one must include all joints crossed by the unit and place the unit on maximum stretch. An example is tightness of the FPL, which would require splinting of the wrist in extension concurrently to all joints of the thumb being extended.

Mild tightness can easily be relieved by serial positional night plaster of Paris or thermoplastic splinting that positions all joints distal to the level of adherence in full extension. An example is adherence of the FPL tendon just proximal to the MP joint, which limits flexion of the MP and IP joints. A splint to enstage this adherence would flex the MP and IP joints concurrently, but the position of the CMC and wrist joints is irrelevant because they do not alter the excursion at the site of adherence (Fig. 116-32).
Congenital thumb deformities

Clasped thumb deformity. Newborn children may exhibit a clasped thumb deformity where the thumb is held adducted and flexed against the palm. If the thumb passively extends, the deformity is described as supple, representing an absence or weakness of the extensor mechanism. Complex clasped thumb deformities reflect an underdevelopment or absence of an extensor mechanism with associated joint contracture. A flexion and adduction deformity of the thumb may also represent arthrogryposis or windblown deformity, which have associated involvement of the fingers. The effectiveness of early splinting in the young child to gain extension and abduction of the clasped thumb has been demonstrated.

As one might expect, splinting offers the best results in the passively correctable thumb. With the majority of clasped thumbs responding to splinting, even though arthrogryposis and windblown deformities usually require surgical release, splinting may be valuable to prevent progression of the deformity.

Appropriate splinting to hold the soft tissues of the thumb lengthened is difficult in the pediatric population. The lack of bony prominences and the abundant soft tissues in a young child make purchase of the splint on the extremity difficult. I believe that inclusion of the wrist and the use of numerous wraps cause the fewest problems with splint slippage or removal of the splint by the child (Fig. 116-33). Wrapping Coban, a self-adhesive elastic wrap, over the splint can prevent even the most adamant child from removing the splint. Lin et al. report the use of a short thumb abduction and extension mobilization splint that does not cross the wrist, but they do not comment on problems with slippage or removal.

In children with these soft tissue thumb deformities, full-time use of thumb abduction splints is recommended as early as possible. Those splinted earlier respond better and require a shorter splinting period. The early application of the splint provides maximum soft tissue elongation and minimizes the splinting time needed. Early splinting also allows the child unrestricted use of the thumb when ready to explore the external world. Most surgeons consider operative release only after splinting is not successful.

Congenital trigger thumb. Congenital trigger thumb is far more common than congenital trigger finger. This may manifest as a snapping of the thumb or fixed flexion deformity of the thumb. Previously, operative release had been recommended as the treatment of choice. However, those recommending surgery as the treatment of choice report no attempt with presurgical splinting. Tsubuguchi et al. demonstrated that in most cases the triggering can be resolved by splinting the digit in full extension for a number of months.