The Unstable Metacarpophalangeal Joint in Rheumatoid Arthritis: Anatomy, Pathomechanics, and Physical Rehabilitation Considerations

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The metacarpophalangeal (MCP) joints bestow important strength to the longitudinal and transverse arch systems of the hand. In addition, these joints guide active movements of the fingers in 2 degrees of freedom, while allowing sufficient laxity for passive accessory motions. Both stability and mobility functions are attained in the healthy hand by a complex interaction among the muscles and the joints’ periarticular connective tissues. Rheumatoid arthritis (RA) often causes destruction of the MCP joints’ connective tissues, which leads to weakness of the tissues and an imbalance of active and passive forces, and subsequently, instability, pain, and deformity. The 2 most common deformities of the MCP joints associated with RA and instability are palmar subluxation and ulnar “drift.” Therapists and physicians often collaborate to treat these conditions through a combination of surgical and nonsurgical interventions. Two of the more conservative nonsurgical interventions typically involve a combination of splinting and education on joint protection. Additional nonsurgical treatment may include the judicious use of exercise and methods for relieving pain and reducing inflammation. Surgical intervention is often indicated when the more conservative treatments fail to arrest the progression of the pain or deformity. Regardless of the specific approach, effective intervention for instability of the MCP joint requires that the clinician possess a sound knowledge of the anatomy and the pathomechanical influences that predispose or cause the instability. This clinical commentary is intended to provide this information, as well as offer treatment guidelines based on our clinical experience. Whenever possible, research will be cited to support clinical interventions. This paper is especially geared to the therapist who may not currently specialize in the treatment of instability of the MCP joint but may require basic information on this important topic.

Key Words: fingers, hand deformity, patient education, splinting

The first sections of this paper describe the anatomic and biomechanical factors underlying both stability and instability at the metacarpophalangeal (MCP) joint. Although several types of instability exist, this paper focuses on palmar subluxation and an associated ulnar drift of the MCP joints—a common pair of impairments typical in rheumatoid arthritis (RA). Treatment typically includes improving alignment and function through splinting, educating on strategies to protect the joints, and, in cases of surgery, supervising postoperative management—topics to be discussed in the final section of this paper.

Information in this paper is intended to increase the understanding of the traditional medical treatment of instability of the MCP joint. The information may be particularly helpful to the generalist clinician who may not regularly work with this clientele.

STABILITY

A stable MCP joint is defined as a joint that exhibits normal mechanical alignment and kinematics. An unstable joint, in contrast, exhibits gross abnormal alignment and abnormal kinematics often associated with pain and limited function. Over time, instability at this important joint may progress to a fixed deformity. If untreated, the instability can significantly reduce the functional potential of the entire hand.

General Anatomical Features

Each MCP joint of the fingers is formed through the articulation of a relatively large, convex metacarpal head, with a smaller con-

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cave base of a corresponding proximal phalanx (Figure 1A). The prominent structure of these joints is evident by observing the dorsal side of the hand while closing and opening a fist. Flexion and extension expose and then conceal the large heads of the metacarpal bones. From the anatomic position, flexion and extension occur as the proximal phalanges rotate within the sagittal plane about a medial-lateral axis of rotation. Abduction and adduction, the joint’s second degree of freedom, occur as the proximal phalanges rotate within the frontal plane about an anterior-posterior axis of rotation. The rather extensive biplanar motion at the MCP joints allows the hand to open widely to manipulate large objects, such as a ball, or to close and firmly grasp objects of many different sizes.

The structure of the MCP joint and associated musculature limits the extent of active movement about the joint’s longitudinal axis. The MCP joint does, however, have relatively large amounts of passive axial rotation. This passive “play” within the joint is greater in the more ulnar-positioned digits \(^3\) and evident in the posture made during a “pistol grip.”

The MCP joint has a design much like a shallow ball-and-socket. Much of its stability is achieved through an extensive set of periarticular connective tissues, including the joint capsule, extensor mechanism, collateral ligaments, and palmar plate. These tissues provide greater depth to the otherwise shallow socket of the joint, thereby ensuring secure containment of the prominent head of the metacarpal. Articular cartilage covers and protects the concavity of the proximal surface of the proximal phalanx, as well as the entire head of the metacarpal, from its rounded apex to its more flat palmar surface (Figure 1A).

The extensive periarticular connective tissue that supports each MCP joint also supports the distal transverse and the longitudinal arch systems of the hand.\(^3\) These arches are flexible and change shape to alter the palmar concavity of the hand. The ability to actively and passively modify this concavity allows the hand to spatially conform around a nearly infinite number of shaped objects. In the healthy hand, stability throughout the MCP joints provides strength and resilience to the arch systems. A hand with severe instability of the MCP joints secondary to RA often flattens due to a partial collapse of these arches.

**Periarticular Connective Tissues**

The MCP joint is surrounded and enclosed by a capsule of fibrous connective tissue and, as all synovial joints, is lined internally with a synovial membrane. Tension within the capsule helps guide the natural joint arthrokinematics. As depicted in Figure 2A, during flexion, for example, tension in the stretched dorsal capsule prevents the joint from unnaturally “hinging” outward on its dorsal side. The tension helps maintain joint contact as the articular surface of the proximal phalanx slides-and-rolls in a palmar direction.\(^4\)

![Figure 1](image-url)

**FIGURE 1.** Lateral view of (A) the bones within the ray of the third digit, and (B) the connective tissues supporting the metacarpophalangeal and interphalangeal joints. Modified slightly and reprinted from Neumann\(^4\) with permission from Elsevier.
The dorsal surface of the capsule is reinforced by the dorsal hood of the extensor mechanism and the embedded tendon of the extrinsic extensor muscles (Figure 3). The oblique fibers of the dorsal hood serve as a distal attachment for the lumbricals and interossei muscles. The transverse fibers of the dorsal hood help centralize the tendon of the extensor digitorum communis (EDC) over the dorsal side of the MCP joint.

A pair of collateral ligaments reinforces the ulnar and radial sides of the capsule of the MCP joint. Figure 4 shows an intact radial collateral ligament of...
the index finger and cut radial and ulnar collateral ligaments of the middle finger. The thicker cord part of the ligament attaches to the palmar side of the proximal end of the phalanx; the accessory part attaches to the sides of the palmar plate (Figure 1B). The radial and ulnar collateral ligaments provide stability to the joint, becoming taut in the extremes of ulnar or radial deviation, respectively. The collateral ligaments also become more taut with flexion, the joint’s close-packed position (Figure 2A). In contrast, the collateral ligaments assume a more slackened state towards extension (Figure 2B). Data are lacking on the specific stress-strain relationship of the collateral ligaments as a function of sagittal plane position.

The palmar capsule of each MCP joint is reinforced by a thickened region of fibrocartilage known as the palmar (or volar) plate (Figures 1B and 4). The thicker and stiffer distal end of the plate attaches to the base of the proximal phalanx. The more elastic and thinner proximal end attaches to the corresponding metacarpal bone. The palmar plate of the 4 MCP joints is further reinforced by the deep transverse metacarpal ligaments (Figure 4). The palmar plates strengthen the MCP joint, resist the end ranges of extension, and provide an attachment site for the fibrous digital sheaths (Figures 1B and 4). The digital sheaths are anchored directly to the palmar plates and serve as tunnels, or fibro-osseous pulleys, for the tendons of the flexor digitorum profundus (FDP) and flexor digitorum superficialis (FDS). The pulley located on the palmar side of the MCP joint is often referred to as the first annular pulley, or A1 pulley (Figure 1B), 1 of several pulleys throughout the digit. Additional information on the structure and function of the pulleys is included in other sources.

Muscular Components

Both intrinsic (originating within the hand) and extrinsic (originating outside the hand) muscles cross the MCP joint of the fingers. These muscles provide fine and gross motor control to the fingers as a whole, serve as a source of proprioception, and furnish dynamic stability to the MCP joints.

Intrinsic Muscles

Three sets of intrinsic muscles cross the MCP joint of the fingers: 4 lumbricals, 7 interossei, and 2 members of the hypothenar muscle group. The anatomic and functional details of these muscles are listed in Table 1. Each lumbrical crosses the palmar side of the MCP joint and thereby assists with flexing this joint (see lumbrical associated with the index finger in Figure 3). Three palmar interossei and 4 dorsal interossei cross the MCP joints of the fingers. Each of these 7 muscles either abduct or adduct the MCP joint (Table 1). All interossei, however, cross palmar to the medial-lateral axis of rotation at the MCP joint, and therefore provide a flexion torque (see first dorsal interosseous in Figure 3).
### TABLE 1. Anatomic and functional information on the intrinsic muscles that cross the metacarpophalangeal joints.

<table>
<thead>
<tr>
<th>Innervation</th>
<th>Lumbricals</th>
<th>Dorsal Interossei</th>
<th>Palmar Interossei</th>
<th>Hypothenar Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Lateral: median nerve</td>
<td>• Ulnar nerve</td>
<td>• Ulnar nerve</td>
<td>• Ulnar nerve</td>
</tr>
<tr>
<td></td>
<td>• Medial: ulnar nerve</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximal attachments</td>
<td>• Tendons of the flexor digitorum profundus</td>
<td>• First: adjacent sides of first (thumb) and second metacarpals</td>
<td>• Second: adjacent sides of second and third metacarpals</td>
<td>• Abductor digiti minimi: pisohamate ligament, pisiform bone, and tendon of the flexor carpi ulnaris</td>
</tr>
</tbody>
</table>
|                              | • First: adjacent sides of third and fourth metacarpals | • Third: radial side of fourth metacarpal | • Fourth: radial side of fifth metacarpal | • Flexor digiti minimi: transverse carpal liga-
|                              | • Fourth: adjacent sides of fourth and fifth metacarpals |                   |                   | ment and hook of the hamate |
| Distal attachments           | • Oblique fibers of the dorsal hood (of the extensor mechanism) | • First: radial base of the proximal phalanx of the index finger and oblique fibers of the dorsal hood | • Second: radial base of the proximal phalanx of the middle finger and oblique fibers of the dorsal hood | • Both muscles: ulnar base of the proximal phalanx of the little finger |
|                              | • Second: adjacent sides of the middle finger and oblique fibers of the dorsal hood | • Third: ulnar base of the proximal phalanx of the middle finger and oblique fibers of the dorsal hood | • Fourth: ulnar base of the proximal phalanx of the ring finger and oblique fibers of the dorsal hood | |
|                              | • Third: adjacent sides of the fourth and fifth metacarpals | • Fourth: radial side of the little finger via the oblique fibers of the dorsal hood | | |
|                              | • Fourth: radial side of the middle finger and oblique fibers of the dorsal hood | | | |
| Actions                      | • MCP joint flexion and IP joint extension      | • Abduction of MCP joints; also MCP joint flexion and IP joint extension | • Adduction of the MCP joints; also MCP joint flexion and IP joint extension | • Abductor digiti minimi: MCP joint abduction and flexion |
|                              |                                                 |                   |                   | • Flexor digiti minimi: MCP joint flexion |

Abbreviations: IP, interphalangeal; MCP, metacarpophalangeal.

3). Like the lumbricals, the interossei also extend the interphalangeal joints owing to their distal attachments to the oblique fibers of the dorsal hood.

Two of the 3 hypothenar muscles cross the MCP joint of the little finger: the flexor digiti minimi and the abductor digiti minimi. When considering the abductor digiti minimi and the 7 interossei, each MCP joint is collateralized equipped with a primary abductor and a primary adductor muscle. These 8 intrinsic muscles—all innervated by the ulnar nerve—provide an important source of dynamic frontal plane stability and control to the base of the fingers.

**Extrinsic Muscles** The extrinsic flexors of the MCP joints are the FDP and the FDS. The tendon of the FDP attaches distally to the base of the distal phalanx; the more superficial tendon of the FDS attaches distally on either side of the shaft of the middle phalanx. Both tendons course distally through a series of synovial-lined fibro-osseous pulleys that stabilize their course throughout each finger. Figure 1B shows only the large A1 pulley, which maintains the position of the tendons relative to the MCP joint. Figure 4 shows a dorsal perspective of the flexor tendons entering the proximal side of the A1 pulley of the middle finger.

The FDP and FDS have the potential to flex every joint they cross, from the wrist to the distal interphalangeal joints. Both tendons are primary flexors of the MCP joint as they cross anterior to the joint’s axis of rotation (Figure 2A).

The extrinsic extensors of the MCP joints are the EDC and extensor indicis. When including an addi-
tional tendon to the fifth digit, 5 tendons emerge from the EDC muscle belly. The tendons of the EDC fuse into the extensor mechanisms of the fingers and, via this structure, attach to the dorsal side of the distal phalanx (see tendon to the index finger in Figure 3).

The extensor indicis originates proximally from the dorsal side of the ulna and adjacent interosseous membrane. The sole tendon courses parallel and ulnar to the index finger tendon of the EDC, and attaches distally in the extensor mechanism of the index finger.

Action of the EDC and extensor indicis produces extension of the wrist and hyperextension of the MCP joints. It is important to note that without concurrent activation of the intrinsic muscles to the fingers, the EDC cannot fully extend the proximal and distal interphalangeal joints.

**Mechanical Interaction Among the Muscles and Periarticular Connective Tissues**

The following sections will provide specific examples of synergistic relationships between muscles and periarticular connective tissues as they provide stability to the MCP joint. This information will provide the background for understanding the common pathomechanics at the MCP joint, which occur when diseased connective tissue fails to control and dissipate the forces produced by surrounding muscle.

**Sagittal Plane Activity** Active flexion of the MCP joints is driven by a combination of extrinsic and intrinsic muscles. As the MCP joint is driven into flexion, the collateral ligaments are pulled increasingly taut, which increases articular stability (Figure 2A). Part of the energy generated by the muscle action is temporarily stored in the healthy, partially elastic ligaments. Muscles and connective tissues, therefore, act synergistically in generating joint stability. Excessive laxity within the ligaments, either due to disease or trauma, may limit the ability of the connective tissues to store energy, ultimately shifting greater demand on the muscular system to provide joint stability. Although experimental data explicitly supporting this premise could not be found, in our opinion, this compensatory role of muscle is a very possible scenario. The increased muscular demand may or may not be well tolerated, depending on the existing pathology, health of the cartilage, and age of the person.

As the FDP and FDS flex the MCP joints, a component of their force exerts a traction directed palmarly on the A1 pulley. A healthy pulley is anchored to the posterior tubercle of the metacarpal bone via its connection to the palmar plate and collateral ligaments. Failure of the osseous ligament system to stabilize the pulley can contribute to palmar dislocation of the MCP joint.

The EDC and extensor indicis provide the force for extension of the MCP joints. As shown in Figure 2B, coactivation of the intrinsic muscles (lumbricals and interossei) produce a flexion torque that prevents the EDC from otherwise hyperextending the MCP joints. A primary clinical sign of paralysis of the intrinsic muscles is unwanted (and nonproductive) hyperextension of the MCP joints. Normally the intrinsic muscles oppose the extension torque produced by the EDC, thereby stabilizing the MCP joints at a time when the collateral ligaments are starting to slacken. As the MCP joints approach 0° of extension, forces that create articular stability at the MCP joints shift from the slackening collateral ligaments to the active intrinsic muscles and stretched palmar plates (Figure 2B).

**Frontal Plane Activity** During abduction and adduction of the fingers, the MCP joints are stabilized by a combination of active and passive forces. For example, abduction of the index finger is controlled by the action of the first dorsal interosseous muscle. This force stabilizes the radial side of the joint as the radial collateral ligament slackens. The ulnar side of the joint is stabilized by passive tension in the stretched ulnar collateral ligament, adjacent capsule, and palmar interosseous. The passive tension in these elongated structures resists abduction, thereby generating useful stabilizing tension across the joint. The generation of useful passive resistance by stretched and healthy connective tissue is an excellent example of “productive antagonism,” employed to varying degrees by all healthy joint systems of the body.

During abduction and adduction, the flexor and extensor extrinsic tendons that cross the MCP joint normally remain centralized across the joint due to their connections into either the extensor mechanism or the fibrous digital sheaths. This centralization negates these muscles from acting with a moment arm for frontal plane torque. Failure of the centralization results in an excessive and potentially damaging torque production in the frontal plane, a common cause of ulnar drift.

**INSTABILITY**

A dynamic, productive antagonism between forces generated in periarticular connective tissues and muscles provide stability to the MCP joints. Weakening of the connective tissue through trauma or chronic synovitis (a trademark of RA) reduces the ability of these tissues to control, share, and dissipate muscular-produced forces. When inadequately unopposed by healthy periarticular connective tissues, an active muscle becomes a primary destructive agent in the pathomechanics of MCP joint instability. This concept is elucidated through 2 of the most common presentations of instability at the MCP joint: palmar subluxation (or dislocation) and ulnar drift.
FIGURE 5. A hand of a person with severe rheumatoid arthritis. Note the ulnar drift of the metacarpophalangeal (MCP) joints of the fingers. The MCP joint of the index finger is also palmarly dislocated. Reprinted from Neumann40 with permission from Elsevier.

(Figure 5). These 2 presentations, often occurring concurrently, will be next described, assuming an underlying condition of chronic RA.

Palmar Subluxation of the MCP Joint

Activation of the 2 extrinsic finger flexors naturally creates a “bowstringing” force on the A1 pulley as the tendons pass palmar to the MCP joint (Figure 6A).40,52 The greater the MCP joint flexion angle and muscular activation level, the greater the bowstringing force. This force creates a palmarly directed pull through the A1 pulley, the palmar plate, and the collateral ligaments. In the healthy hand, this force is safely absorbed through the natural elasticity and strength of the tissues, from pulley to the ultimate attachment on the metacarpal bone.

Connective tissues weakened by severe and chronic RA may be unable to resist the palmarly directed force exerted by the flexor muscles. As depicted in Figure 6B, the collateral ligaments may become stretched to a point of rupture. As a consequence, the proximal phalanx may displace palmarly, creating a subluxed or completely dislocated MCP joint (see index finger in Figure 5). The resulting instability at the MCP joint weakens both the longitudinal and distal transverse arches of the hand, thereby reducing the hand’s natural palmar concavity.

Ulnar Drift

Even in the healthy hand, the MCP joints are frequently exposed to ulnar deviation forces, especially acting at the bases of the proximal phalanges.18,20,52,63 It is convenient to describe these naturally occurring forces as either internal or external, although they occur simultaneously. Three of the more commonly described mechanisms involving internal forces are: asymmetry in the slope of the heads of the metacarpals, a prevailing ulnar (medial) line-of-force of the extrinsic digital muscles and the interosseous muscles, and ulnar traction on the palmar plates via the connections between the hypothenar muscles and deep transverse metacarpal ligament. In addition to gravity acting on the fingers, the most likely external force stems from the ulnar-directed pinching force produced by the powerful thumb flexor muscles, including the adductor pollicis, against the radial fingers. If the index finger ulnarly deviates in response to the thumb’s forces, the overlying tendon of the EDC deflects ulnarly (medially) relative to the joint’s anterior-posterior axis of rotation (Figure 7A). This deflection generates a bowstringing force against the extensor tendon. In the healthy hand, the transverse fibers of the dorsal hood of the extensor mechanism and the radial collateral ligament centralize the tendon over the axis of rotation, thereby neutralizing the tendon’s leverage for a destabilizing ulnar deviation torque. Connective tissues weakened by chronic synovitis often fail to restrain the natural bowstringing force, thereby allowing the tendon to shift to the ulnar side of the joint’s axis of rotation (Figure 7B). As a consequence, the EDC produces an ulnar deviation torque whenever it is active. Over time, a vicious cycle is established: the greater the resulting ulnar deviation position, the greater the moment arm available to produce ulnar deviation torque. In time, the attenuated and stretched connective tissues that span the radial side of the joint may tear, allowing the proximal phalanx to rotate and slide ulnarily, leading to complete joint dislocation (Figure 7C). This dislocation and resultant posture of the fingers is defined as “ulnar drift.” Fueling these pathomechanics is the fact that increased intra-articular pressure within the MCP joints (such as with effusion) may contribute to an ulnar drift bias.28

Once in a position of ulnar drift, the ulnar deviated extensor tendons typically slip palmarly into the gullies formed between the prominent metacarpal heads. This palmar position may eliminate the tendon’s extensor moment arm at the MCP joints. If the tendons actually displace palmar to the axis of rotation, the force in the tendons would create a flexion torque at the joints. This situation
favors the palmar dislocation deformity described in the previous section. The deformity of “ulnar drift” typically describes not only excessive ulnar deviation and translation of the proximal phalanx, but also palmar migration or subluxation of the MCP joint.18

Ulnar drift that affects multiple joints can significantly reduce the function of the hand as a whole. Three-point pinch strength is reduced as the index and middle fingers drift away from the thumb pad. Severe ulnar drift of the fourth and fifth digits significantly interferes with power grip. Marked ulnar drift reduces the functional length of the digits, thereby reducing hand span.

Instability of the Wrist: Additional Pathomechanic Considerations

Structurally, the wrist-and-hand is formed by a series of intercalated articulations often referred to as a continuous kinematic chain. As a continuous link, deformity at a more proximal joint predisposes deformity and instability in the distal joints (the so-called “zigzag deformity”).40 In cases of severe RA, the classic zigzag deformity involves excessive radial deviation of the wrist and ulnar drift at the MCP joints.50 In the normal wrist, the tendons of the EDC are ideally aligned over the dorsum of the MCP joints (Figure 8A). This position reduces the natural ulnar deviation bowstringing force across the joints. Instability of the wrist, however, can alter the alignment between the extensor tendons and the MCP joints. Weakened ligaments of the wrist due to chronic synovitis can predispose generalized carpal instability, often leading to ulnar translocation of the carpus.18,40,58 Due to the frontal plane tilt of the distal end of the radius, compressive forces that cross the potentially unstable wrist tend to shift the carpus ulnarly (Figure 8B).40 This ulnar shift augments the moment arms of the radial deviator musculature of the wrist. Over time, the carpus—and firmly attached metacarpal bones—rotate radially in the frontal plane. As depicted in Figure 8C, the radially positioned metacarpals accentuate the ulnar bowstringing force across the MCP joints. If the extensor mechanism fails to centralize the tendons of the EDC, the tendons slide ulnarly, gaining moment arm length (as shown on the index finger), which contributes to the ulnar drift pathomechanics described above. These

FIGURE 6. One possible mechanism of palmar dislocation of the metacarpophalangeal joint. (A) “Bowstringing” force produced on the A1 pulley by the tendons of the extrinsic flexors passing palmar to the MCP joint. (B) At some critical point, the bowstringing force disrupts the palmar plate, collateral ligament, and proximal phalanx from the head of the metacarpal bone. Reprinted from Neumann40 with permission from Elsevier.
FIGURE 7. Ulnar drift pathomechanics. (A) The flexor force of the thumb can cause a natural bowstringing force across the metacarpophalangeal (MCP) joint of the index finger (EDC, extensor digitorum communis; RCL, radial collateral ligament). (B) Rupture of weakened transverse fibers of the dorsal hood allows the tendon of the EDC to migrate ulnarily. (C) Rupture of the overstretched and weakened radial collateral ligament allows further ulnar deviation and subluxation at the MCP joint. In A through C, the small circle over the head of the metacarpal depicts the axis of rotation. In B and C, the moment arm used by the displaced EDC is shown as a thick black line. Reprinted from Neumann40 with permission from Elsevier.

FIGURE 7. Ulnar drift pathomechanics. (A) The flexor force of the thumb can cause a natural bowstringing force across the metacarpophalangeal (MCP) joint of the index finger (EDC, extensor digitorum communis; RCL, radial collateral ligament). (B) Rupture of weakened transverse fibers of the dorsal hood allows the tendon of the EDC to migrate ulnarily. (C) Rupture of the overstretched and weakened radial collateral ligament allows further ulnar deviation and subluxation at the MCP joint. In A through C, the small circle over the head of the metacarpal depicts the axis of rotation. In B and C, the moment arm used by the displaced EDC is shown as a thick black line. Reprinted from Neumann40 with permission from Elsevier.

associated pathomechanics require that the wrist always be considered during conservative and surgical interventions for instability of the MCP joint.

THERAPEUTIC INTERVENTION

Goals for nonsurgical therapeutic intervention of the unstable MCP joint typically include reducing pain and inflammation, optimizing joint alignment, and minimizing, if possible, the underlying cause or causes of instability. This section focuses specifically on 2 forms of conservative treatment: splinting and advice on “joint protection.” Treatment of the classic symptoms of RA, such as control of pain and inflammation, and the judicious use of light exercise is published in other sources.31,41,45,57,61 This commentary closes with a brief description of the surgical techniques used to limit the progression of MCP joint instability, or reconstructing the joint following marked instability and subsequent mechanical failure.

Splinting

Although research on functional outcomes is limited,5,15,48,49 the use of splints remains the single most accepted form of conservative therapy to limit the progression of instability of the MCP joint. The ideally designed splint applies forces to the hand region as a means of optimizing joint alignment. Optimal or close to optimal alignment, even if unnaturally maintained by the splint, reduces stress on damaged and often overstretched connective tis-
sues. Equally important, optimizing alignment helps establish more normal leverage and line-of-force of the muscles, thereby reducing their deforming influence. Also, by providing varying amounts of immobilization, splinting encourages rest and protection, which is especially important when inflammation and pain are present.

Of utmost importance to the patient, splinting aims to reduce pain, improve the cosmetic appearance of the instability, and increase function. The extent to which splinting prevents the often relentless transition from mild to marked instability, and then to a fixed deformity, is difficult to determine with absolute certainty. Splinting nevertheless remains a rational biomechanical form of intervention that is often administered in conjunction with other forms of conservative treatment, such as medication, other modes of physical and occupational therapy, and patient education. The ultimate benefit of a splint depends not only on its design, but on how well it is accepted by the user.

There are many ways of classifying splints. One such classification utilized by the American Society of Hand Therapists is by location, type, and purpose. We choose to classify splints based only on their location. In a broad sense, splints used for treating instability of the MCP joint support either the wrist and the hand (Figures 9 and 10), or the hand only (Figures 11 and 12). The figures show a selection of splints typically available to clinicians. Several other splints that incorporate similar but varying features are available prefabricated or custom-made by the therapist. The reader is encouraged to consult other sources for more details on splinting of the MCP joint.\textsuperscript{1,16,27,37}

Splints designed for the unstable MCP joint are typically constructed of a combination of hard and soft materials, depending on the level of function of the patient, and the need for comfort, skin protection, adjustability, and durability. Consider, for example, the “resting pan” splint and the Comforter splint (Figures 9 and 10). These large and relatively bulky splints are designed more for protecting and resting multiple inflamed joints—MCPs and adjacent joints—and not necessarily to enhance function. For this reason, these splints are made of a hard thermoplastic material. The Comforter splint is lined with a soft cover to enhance comfort while wearing. Both splints are adjustable via a heat source and are very durable.

When designed and worn properly, each splint depicted in Figures 9 through 12 provides a different application of force against the proximal phalanges. The forces are designed to either direct the MCP joints toward radial deviation, or block from further ulnar deviation. For example, Figure 9B shows the ulnar side of the resting pan splint contoured to block ulnar deviation; adjustable Velcro straps over the digits provide additional radial deviation forces. The hand-based LMB splint, for example, uses 4 soft-core, wire foam separators between the fingers to centralize the MCP joints (Figure 11A). Each wrist-hand-based and hand-based splint is also designed to resist palmar migration of the proximal phalanges. The metacarpophalangeal ulnar drift (MUD) splint, originally designed in 1971,\textsuperscript{26} uses a set of padded aluminum finger separators that can be adjusted to resist palmar migration, in addition to resisting ulnar drift (Figure 12B). In contrast, the resting pan, Comforter, and LMB splints each have a palmar...
FIGURE 9. The resting pan splint immobilizes both the wrist and the hand, usually when maximum rest and immobilization are required. The rigid design securely immobilizes all the joints of the digits. (A) Lateral view. (B) Dorsal view showing straps used to reinforce radial deviation position of the metacarpophalangeal (MCP) joints. The padding placed just radial to the head of the metacarpal of the index finger helps maintain the wrist in a relatively neutral, frontal plane position.

“shelf” that supports the palmar side of the proximal phalanges (Figures 9-11). Ideally, the shelf component exerts a dorsally directed force to the proximal end of the proximal phalanges. A force applied too far distally can have the undesired effect of hinging or tilting the MCP joints back into extension, rather than providing the more pure dorsal slide arthrokinematics.

Although wrist-hand–based and hand-based splints have overlapping features, each has specific qualities that are more desirable in certain cases. Hand-based splints concentrate corrective forces almost exclusively at the MCP joints, leaving the more distal joints unconstrained. These splints are ideal for use during the day, especially for relatively active, high-functioning persons. The softer LMB splint significantly limits the biplanar movement at the MCP joints, in addition to blocking palmar migration of the proximal phalanges. The more rigid MUD splint, in contrast, immobilizes the MCP joints only within the frontal plane. As noted in Figure 12C, the hinged feature of the splint allows a moderate amount of flexion and extension. Technically, therefore, the MUD splint is classified as a dynamic splint. Rennie studied the impact of wearing the MUD splint on a group of 26 patients with RA and associated ulnar drift. Patients reported high acceptance of this splint: 79.2% claimed only minimal interference with activities of daily living, 87.5% stated they were satisfied with its comfort, and 95.7% reported continued use of the splint after 8 weeks. The frontal plane control imparted by the MUD splint reduced the ulnar drift an average of 10°. Wearing this splint, however, produced no statistical difference in scores on function, pain, grip, and pinch strength. This publication was the only outcome study that could be found that addressed the effectiveness of any of the 4 aforementioned splints for treating the unstable MCP joints. Wrist-hand–based splints have the therapeutic benefit of providing rigid support across multiple painful and inflamed joints throughout the entire wrist and hand (Figures 9-10). In addition, by blocking radial deviation of the wrist, wrist-hand–based splints can, in theory, limit the zigzag pathomechanics described in...
Figure 8. It is, however, a challenge to design a splint that simultaneously blocks radial deviation of the wrist while not compromising the effectiveness of blocking ulnar drift at the MCP joints, and vice versa. Additional sources should be consulted for further details.4,5,50

Wrist-hand–based splints are often used at night when maximum rest and immobilization are desired.7,39,47,51,56 The rigid design of the resting pan splint (Figure 9), for example, securely immobilizes all joints within the hand, in addition to providing at least some restraint against palmar and ulnar migration of the MCP joints. Although the large size limits its function, the resting pan splint has been shown to effectively decrease pain due to arthritis.7 The Comforter splint (Figure 10) is made of a hard shell, lined with a soft cover to increase wearing comfort, a desirable feature for use at night. The Comforter splint allows freedom of motion of the proximal and distal interphalangeal joints, and therefore is considered a more functional and less constraining device compared to the resting pan splint.

Table 2 contrasts the major functional advantages and disadvantages of the wrist-hand– and hand-based splints.

Joint Protection

Joint protection programs for persons with unstable MCP joints are typically designed to limit the internal and external forces that promote the characteristic deformities of ulnar drift and palmar subluxation.4 As with splints, teaching patients how to modify the performance of activities to reduce stress on their unstable MCP joints remains a mainstay of conservative treatment.8,10,21,22,35,36 A component of joint protection education identifies and warns about performing those functional activities that likely promote
the deformity or instability. As examples, tightening a jar with the right hand places unnecessary ulnar deviation forces on the MCP joints. Also, vigorous flexion of the fingers to wring out a towel, for instance, places unnecessary flexion forces at the base of the proximal phalanges. Patients are taught to limit both the magnitude and duration of these potentially harmful activities, alter the fundamental way the activity is performed, or use assistive devices (Table 3).

Regardless of the affected joints, any program of joint protection requires a strong educational component that explains to the patient the basic deforming influence and underlying pathology. Even a basic understanding of these issues likely encourages the patient to learn more on the subject. Education should also include ways to rest the unstable joints, such as the use of splints. In theory, rest reduces the overall cumulative stress on the joints, which should reduce inflammation, pain, and the duration of action of the deforming or destabilizing forces. Patients also need to be educated on the importance of adhering to the joint protection program, including being compliant with wearing a splint.

Stamm et al. have shown that joint protection programs, combined with appropriate exercises, improve grip strength and global hand function in persons with generalized osteoarthritis of the hand. Outcome studies on the effectiveness of joint protection programs, specifically for the unstable MCP joints involved with RA, could not be found. The literature on joint protection for the hand is generally limited to implementation, assessment, and compliance, as well as behavioral and educational changes that occur in patients following a joint protection program. Joint protection programs have been shown to increase patients’ knowledge and management of their condition, and also to influence

| TABLE 2. Functional advantages and disadvantages of wrist-hand-based and hand-based splints. |
|---|---|---|
| **Wrist-hand based** | **Advantages** | **Disadvantages** |
| • Resting pan splint (Figure 9) | Protects and supports | Bulky |
| • Comforter splint (Figure 10) | Incorporates entire wrist and hand | Not cosmetically appealing |
| | Comfortable at night but may be tolerated during the day | Low functional capability |
| | Less skin pressure because of larger surface area for application | |
| **Hand based** | • Light weight | • Does not support the wrist |
| • LMB splint (Figure 11) | • Cosmetically appealing | • Greater skin pressure because of smaller surface area for application |
| • MUD splint (Figure 12) | • Functional | |
| • May be comfortable for day and night use | |

Abbreviation: MUD, metacarpophalangeal ulnar drift.

| TABLE 3. Examples of joint protection techniques to decrease ulnar deviation and palmar subluxation forces on the metacarpophalangeal joints. |
|---|---|---|
| **Functional Activities** | **Potential Deforming Consequence** | **Joint Protection Techniques** |
| Turning a key in a house or car door lock | Increased ulnar deviation force | Use a built-up key holder/turner |
| Lifting a coffee cup by the handle | Increased ulnar deviation force | Use both hands to hold cup |
| Writing using a three-jaw chuck pinch | Increased palmar subluxation force | Use larger gripped pen and practice using less force to hold writing utensil |
| Cutting food with a knife | Increased ulnar deviation force | Use a rocker knife or hold knife in a dagger like fashion |
| Carrying files, hand held purses or boxes using a lateral pinch | Increased ulnar deviation force | Use both hands by carrying objects with opened palms—not fingers; use backpack |
| Using the right hand to tighten a jar | Increased ulnar deviation force | Use both hands or the thenar eminence, or use a jar opener |
| Holding a newspaper or a book using a lateral pinch | Increased ulnar deviation force | Place newspaper on a table or use a book holder |
| Buttoning using a three-jaw chuck pinch | Increased palmar subluxation force | Use button hooks |
their behavior. Hammond and Lincoln have shown that joint protection education improved knowledge but not the actual use of the protection methods. Whether joint protection programs, even if adhered to, actually limit the progression of instability of the MCP joints is unknown. Justification for teaching joint protection principles to patients with instability of the MCP joints is based more on anecdotal, theoretical, or empirical evidence based on sound biomechanical and physiologic rationale.

SURGICAL INTERVENTION

This commentary closes with a brief description of the surgical techniques used to limit the progression of MCP joint instability, or reconstructing the joint following marked instability and subsequent mechanical failure.

Surgery on the MCP joint is typically considered only after more conservative approaches have failed to arrest the progression of pain or instability. The following section describes 4 relatively common procedures, each performed with goals of preventing or correcting the instability related to ulnar drift and palmar subluxation of the MCP joint.

Synovectomy

A common sequela of advanced RA of the MCP joints is marked proliferation of the inflamed synovial membrane. The presence of this tissue—known as pannus—causes a distension of the capsule and associated supportive ligaments. Over time, the distended connective tissues loose the ability to stabilize the joint against forces produced by muscle and external contact. In principle, a synovectomy limits the progressive distension of the connective tissue. This surgical procedure is usually indicated for those with persistent and often painful synovitis without significant erosion of the articular cartilage. However, a synovectomy is generally not advised for persons with marked instability or deformity, or for those who would likely respond favorably to more conservative measures, such as intra-articular steroid injections, systemic medications, such as nonsteroidal anti-inflammatory drugs or methotrexate, and splinting. Synovectomy is most often performed in conjunction with surgical reconstruction of the surrounding periarticular connective tissue and only rarely as an isolated procedure.

The synovectomy is performed by making an incision through the dorsal capsule of the involved MCP joint. The ulnar portion of the extensor mechanism is reflected radially to gain access to the bulging synovial tissue. Once the excess synovium has been excised, the extensor mechanism is restored to its central position over the joint, followed by closure of the cutaneous tissue.

Therapy is usually initiated 1 to 2 days postoperatively and consists of wound care, edema control, active range of motion exercises, and the use of a dynamic extension splint with a dorsal outrigger (Figure 13). The dorsal outrigger of the splint incorporates loops that are attached to the fingers by rubber bands or springs. The splint controls the alignment of the MCP joints and biases the joints toward extension and radial deviation. The patient can actively flex the fingers for functional activities against the resistance of the rubber bands (or springs). As the patient relaxes, the tension within the rubber bands returns the MCP joints to an extended position, helping to protect the healing dorsal capsule.

Although the synovectomy is performed as a means to slow the progression of connective tissue weakening and associated joint destruction, no study could be found that has unequivocally proved the effectiveness of this procedure. Because 30% to 50% of patients with RA experience periods of spontaneous...
remission of their synovitis, it is difficult to determine the effectiveness of any such preventative surgery. For this reason, many rheumatologists and surgeons are reluctant to recommend a synovectomy of the MCP joint.

Centralization of the EDC Tendon

As described earlier in this paper, each tendon of the EDC is centralized across the dorsal aspect of its associated MCP joint. This central location is maintained by healthy periarticular connective tissue. Tissues severely weakened by chronic synovitis may fail to prevent the tendon from migrating ulnarily and possibly palmarly to the joint’s axis of rotation. Surgical centralization of a displaced tendon is performed with goals of reducing instability, correcting the ulnar drift, restoring active extension of the MCP joint, and preventing recurrent displacement of the tendon. Although several surgical techniques are described to centralize a displaced tendon, most procedures excise the ulnar portion of the transverse fibers of the dorsal hood and the tendon of ulnarily located intrinsic muscle, while tightening the radial portion of the transverse fibers. Depending on the finger, the excised intrinsic muscle is either the palmar or dorsal interosseous, or abductor digiti minimi. Releasing these tissues reduces the ulnarily directed forces imposed on the extensor tendons. The extensor mechanism is then surgically aligned over the dorsum of the MCP joint by several methods, including attaching the extensor tendon to the radial side of the joint capsule or base of the proximal phalanx, or by reefing (ie, tightening by folding) a portion of the radial aspect of the extensor mechanism.

Therapy is usually initiated on the second through fifth postoperative day, under the direction of a hand therapist. The repaired joints are immobilized in a static wrist-hand extension splint during all times except exercise. This splint is similar to the resting-pan splint, depicted in Figure 9, except that it holds the MCP joints in extension. Careful, guided passive range of motion is performed making sure not to overstretch the centralized extensor tendons. Forces creating ulnar deviation are avoided. At week 1 postsurgery the patient is directed to wear the dynamic extension splint during the day and the static wrist-hand extension splint at night. Both splints should be worn for 4 to 6 weeks; continued use of the static splint with radial deviation straps at night may be recommended for those patients who still show signs of ulnar displacement of the joints. Gentle active (nonresistive) and passive exercises are continued in all directions except ulnar deviation to maintain flexibility and alignment of the digits.

Crossed Intrinsic Muscle Transfer

In 1960, Straub introduced a surgery of first releasing, and then redirecting and inserting, tendons of intrinsic muscles as a means to reduce the net ulnar deviation force in a hand with ulnar drift. This surgery was also designed to reinforce the radial side of the MCP joint. This surgical procedure—known as the crossed intrinsic transfer—is performed in conjunction with a synovectomy and reconstruction of periarticular soft tissue, or joint replacement arthroplasty. The intrinsic muscles are released from the ulnar sides of the index, long, and ring fingers, and transferred to the radial side of the adjacent fingers, either to the radial collateral ligament or extensor mechanism, or the proximal phalanx. In addition, the little finger frequently requires release of the abductor digiti minimi tendon, and the index finger requires shortening of the tendon of the first dorsal interosseous.

Therapy is initiated after 3 weeks of postoperative immobilization to allow the transferred tendon to form a strong anastomosis. At 3 weeks, hand therapy includes using the dynamic extension splint with dorsal outrigger for 3 weeks, soft tissue mobilization to limit scar formation, and active range of motion exercises in all directions except ulnar deviation.

MCP Joint Replacement Arthroplasty

MCP joint replacement (or resection implant) arthroplasty is typically considered for persons with a fused or palmarly subluxed or dislocated MCP joint, pain significantly interfering with activities of daily living or vocation, fixed ulnar drift deformity with associated overshortening of muscles or ligaments, and radiographic signs of joint destruction. Ultimately, a functionally successful operation requires that the interphalangeal joints, distally, and the wrist, proximally, be stable. Reconstructive surgery of these adjacent unstable joints can be performed simultaneously with the MCP joint arthroplasty.

MCP joint arthroplasty involves the replacement of the head of the metacarpal and base of the proximal phalanx with either a silicone rubber implant or a metal implant with or without a carbon polymer prosthesis. Reconstruction of the soft tissues that contribute to the MCP joint deformity is an essential element of the surgery. The implant consists of a central joint “spacer,” which is attached to the distal and proximal shafts (Figure 14). Bending of the implant occurs in both sagittal and frontal planes, primarily where the shafts meet the central spacer. During movement, the shafts of the implant “piston” slightly within the holes drilled within the intramedullary canal of the bones. The piston action increases the range of motion of the proximal phalanx. To allow the piston action, no cement or other rigid method of implant-to-bone fixation is used.
arthroplasty is stabilized by scarring and subsequent tightening of the fibrous capsule.

The surgical technique for the MCP joint arthroplasty varies slightly from surgeon to surgeon. In general, however, following a dorsal incision of the joint capsule, the collateral ligaments are released from their associated metacarpals. A portion of the metacarpal head is removed, followed by an excision of osteophytes from the articular surfaces of the proximal phalanx. Soft tissue releases must be adequate to correct the subluxation. After closure of the capsule, surgeons often take additional steps to help protect against the recurrence of ulnar drift, such as combining elements of the crossed intrinsic transfer, centralization of the extensor tendon, and reattaching and tightening of the radial collateral ligaments.

Particularly in the relatively active person, the MCP joint prosthesis is vulnerable to mechanical fatigue. Over time, therefore, a MCP joint implant can fracture or fail to limit the recurrence of the original joint deformity, or both. According to Trumble and Garner, approximately 90% of the MCP joint implants are still functional at 5 years after surgery. The actual longevity of the prosthesis varies based on the intensity of the mechanical wear placed on the implant.

At about 6 months after surgery, clinicians typically expect full active extension (to 0°) and 45° to 55° of flexion. Several weeks after surgery, however, flexion may increase to 70°, but typically reduces to 45° following the healing and stiffening of the dorsal capsule.

Postoperative hand rehabilitation programs vary among surgeons and therapists. Regardless of the differences, however, most agree that a supervised program of postoperative therapy is essential for maximizing a patient’s functional outcome. Immediately postsurgery, the hand is immobilized in a bulky hand dressing for 5 to 7 days. After that time, guided and nonaggressive passive flexion and extension exercises are initiated, with care to avoid ulnar deviation and flexion beyond 70°. A dynamic extension splint with dorsal outrigger that radially deviates the MCP joints (Figure 13) is used during the day and a static resting pan splint (Figure 9) is worn at night. A closely supervised progressive exercise program is continued for a minimum of 3 months after the MCP joint replacement arthroplasty. Table 4 provides a more specific postoperative hand rehabilitation protocol, keeping in mind that this may vary depending on the collaborating hand surgeon.

CONCLUSION

An elaborate set of muscles and periconnective tissues interact in a precise fashion to provide both stability and mobility to the MCP joints of the fingers. A disease such as rheumatoid arthritis can alter the biomechanical properties of both muscle and connective tissues. Consequently, forces that normally constrain the joint become imbalanced, often leading to instability and deformity. The 2 most common deformities of the MCP joint involve palmar subluxation and ulnar drift. Conservative management of these deformities consists primarily of splinting and teaching methods to protect the joint from further destruction or deformation. Surgical intervention is often indicated if these treatments fail to arrest or slow the deforming process. Physical therapists often assume an important role in the rehabilitation and postoperative management of these patients. Treatments typically include continued patient education and fabrication of specialized splints, as well as providing guarded strengthening and flexibility exercises, wound care, and activities that limit scar formation, pain, and edema.

ACKNOWLEDGEMENTS

We would like to thank Dr James Sanger, Chief of Plastic Surgery at Zablocki Veterans Affairs Medical Center and Professor of Reconstructive and Plastic Surgery, Medical College of Wisconsin, Milwaukee, for his careful review of this manuscript. We also extend thanks to the Medical Media Department, Zablocki Veterans Affairs Medical Center, for all photographs.
TABLE 4. Sample of a postsurgical hand rehabilitation protocol for the metacarpophalangeal joint arthroplasty.

<table>
<thead>
<tr>
<th>Therapeutic Intervention</th>
<th>Time Postoperatively</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Techniques to control edema and pain</td>
<td>1 d-4 wk</td>
</tr>
<tr>
<td>• Wound care</td>
<td></td>
</tr>
<tr>
<td>• AROM and gentle PROM exercises in all movements of the hand and wrist, while avoiding MCP joint flexion beyond 70° and any ulnar deviation of the MCP joint</td>
<td></td>
</tr>
<tr>
<td>• Wear dynamic extension MCP joint splint with dorsal outrigger during the day to facilitate healing of the dorsal capsule (start day 5-7)</td>
<td></td>
</tr>
<tr>
<td>• Wear static resting pan splint at night to maintain the MCP joints in a neutral position (start day 5-7)</td>
<td></td>
</tr>
<tr>
<td>• Techniques to reduce or limit scar formation (start day 5-7)</td>
<td></td>
</tr>
<tr>
<td>• Home exercise program; AROM while wearing dynamic extension splint, edema control, joint protection; avoid use of operated hand for activities of daily living (start day 5-7)</td>
<td></td>
</tr>
<tr>
<td>• Continue edema control</td>
<td>4-8 wk</td>
</tr>
<tr>
<td>• Wear dynamic extension MCP joint splint with dorsal outrigger during the day</td>
<td></td>
</tr>
<tr>
<td>• Wear static resting pan splint at night to maintain MCP joints in a neutral position</td>
<td></td>
</tr>
<tr>
<td>• If functional MCP joint flexion is limited, consider a dynamic flexion MCP joint splint with volar (palmar) outrigger; alternate with dynamic extension MCP joint splint with dorsal outrigger during the day</td>
<td></td>
</tr>
<tr>
<td>• Continue AROM and gentle PROM exercises in all movements of the hand and wrist, while avoiding MCP joint flexion beyond 70° and any ulnar deviation of the MCP joint</td>
<td></td>
</tr>
<tr>
<td>• Isometric strengthening exercises for flexors and extensors of the MCP joint</td>
<td></td>
</tr>
<tr>
<td>• Begin light activities of daily living with the involved hand</td>
<td></td>
</tr>
<tr>
<td>• Pain control continued as needed</td>
<td></td>
</tr>
<tr>
<td>• Scar management continued as needed</td>
<td></td>
</tr>
<tr>
<td>• Home exercise program; AROM/PROM and isometric strengthening exercises (using precautions stated above), splinting, light activities of daily living</td>
<td></td>
</tr>
<tr>
<td>• Unrestricted PROM and AROM exercises; continue to avoid ulnar deviation of the MCP joints</td>
<td>8-12 wk</td>
</tr>
<tr>
<td>• Continue isometric strengthening exercises</td>
<td></td>
</tr>
<tr>
<td>• Initiate strengthening exercises using concentric and eccentric muscle activations of the hand and wrist within tolerance</td>
<td></td>
</tr>
<tr>
<td>• Wear static resting pan splint at night to maintain MCP joints in neutral position</td>
<td></td>
</tr>
<tr>
<td>• Discontinue dynamic extension MCP joint splint with dorsal outrigger during the day unless extension is limited</td>
<td></td>
</tr>
<tr>
<td>• If MCP joint flexion remains limited, wear the dynamic flexion MCP joint splint with volar (palmar) outrigger as needed during the day</td>
<td></td>
</tr>
<tr>
<td>• Unrestricted activities of daily living of the involved hand, avoid heavy labor activities</td>
<td></td>
</tr>
<tr>
<td>• Continue pain control and scar management as needed</td>
<td></td>
</tr>
<tr>
<td>• Home exercise program as indicated</td>
<td></td>
</tr>
<tr>
<td>• Wear static resting pan splint at night to maintain joint alignment and to encourage full extension of the MCP joints</td>
<td>3-6 mo</td>
</tr>
</tbody>
</table>

Abbreviations: AROM, active range of motion; MCP, metacarpophalangeal; PROM, passive range of motion.

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J Orthop Sports Phys Ther • Volume 35 • Number 8 • August 2005


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