Flexor Tendon Injury

- Surgical repair of flexor tendon injury is a complex undertaking performed by specialists in the field. Like the surgery, hand therapy for these patients is a complicated and specialized area. Therapy can be time consuming, and it entails substantial education of the patient, with subtle but significant changes in splinting and exercise at every session to promote function while protecting fragile repaired structures. Multiple structures are often involved, and there are many precautions and contraindications that vary according to the details of the patient's surgery and the surgeon's specifications and preferences.

- **Five anatomical zones** describe flexor tendon injury to the index, long, ring, and small digits. Zone I is from the insertion of the FDS to the insertion of the FDP. Zone II is the area where the FDS and FDP both lie within the flexor sheath, from the A-1 pulley to the FDS insertion. This region has memorably been dubbed “no man’s land” to reflect the technical challenge and historically poor prognosis for repair in this area. Zone III describes the area from the distal edge of the carpal tunnel to the A-1 pulley of the flexor sheath, including the lumbrical muscles.

- It is essential to maintain close communication with the patient's surgeon. A therapist experienced in the treatment of these patients should closely supervise their care. Zone IV is where the flexor tendons lie under the transverse carpal ligament in the carpal tunnel. Injuries in this zone may include the median and ulnar nerves. Zone V is the area from the forearm flexor musculotendinous junction to the border of the transverse carpal ligament.

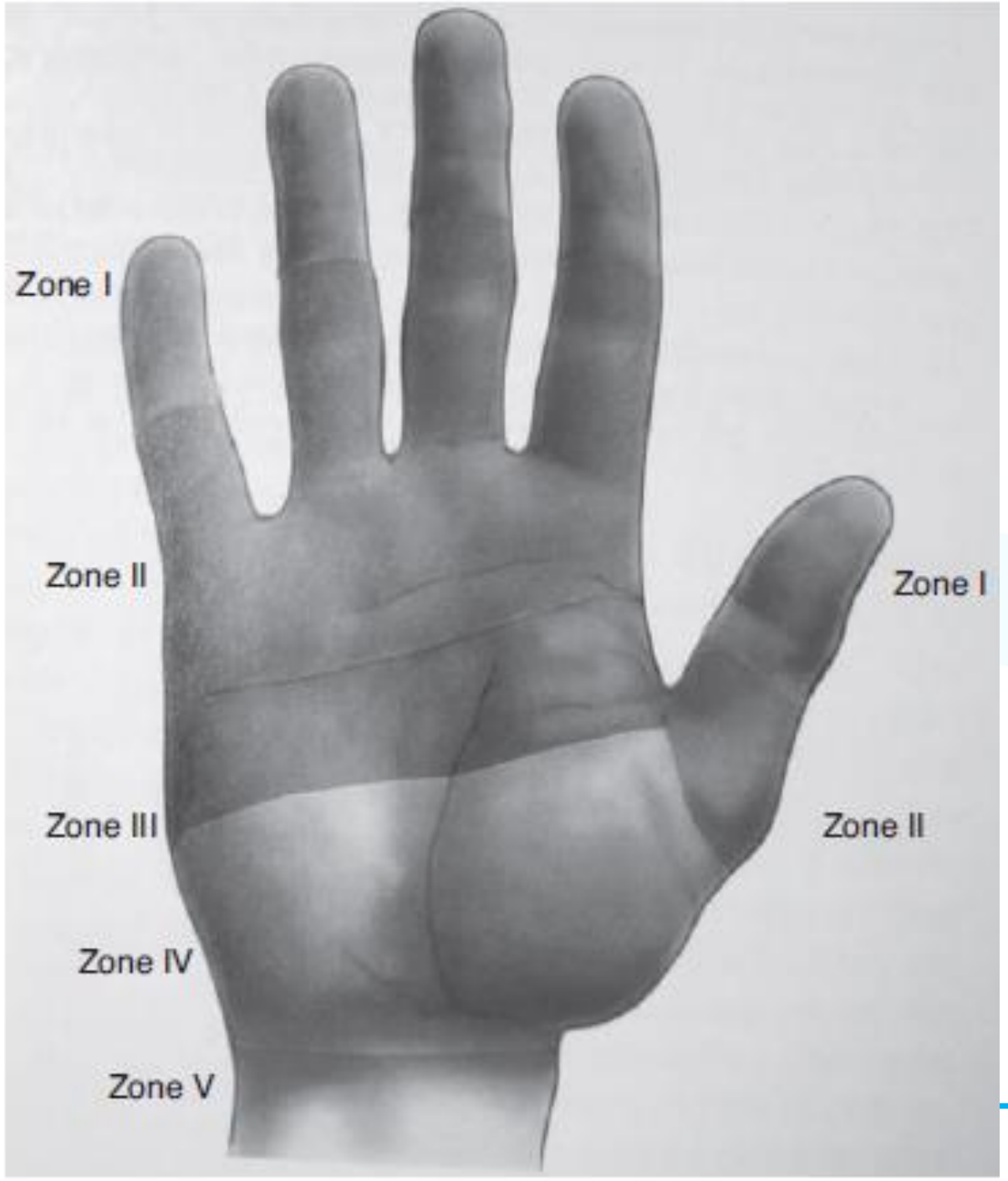

Figure 37-16 The five zones of the hand based on flexor tendon anatomy. Zone I contains flexor digitorum profundus tendon; zone II is the tendon sheath containing flexor digitorum superficialis and flexor digitorum profundus tendons; zone III is the lumbrical muscle zone; zone IV is the carpal tunnel region; and zone V is the forearm area. (From Rayan, G. M., & Akelman, E. [2012]. *The hand: Anatomy, examination, and diagnosis* [Kindle Locations 704–707]. Philadelphia: Lippincott [Wolters Kluwer Health]. Kindle Edition. Used with permission.)

- Physicians usually indicate specific postoperative positioning guidelines to protect repaired structures following flexor tendon repair. The goals are twofold and contradictory: to minimize adhesion formation and to prevent gap or attenuation of the repaired tendon. These dual goals highlight the complexity of therapy associated with this diagnosis. Various protocols exist for controlled mobilization, using a dorsal orthosis with the wrist in 10°–30° of flexion, MP joints in 40°–60° of flexion, and IP joints ideally in full extension (unless there has also been a digital nerve repair).

- The involved IP joints may have to be in some flexion if a digital nerve has been repaired. The Duran protocol entails passive digital flexion and extension within the protective orthosis to achieve 3–5 mm of differential digital tendon excursion. With this protocol, gentle active motion begins with medical clearance about 4 weeks after surgery.
- The passive flexion–active extension protocol, also called the Kleinert protocol, uses rubber band attachments to the fingernails to provide passive digital flexion within the protective dorsal orthosis.

- The patient performs gentle active digital extension, and the rubber band provides passive digital flexion within the confines of the protective orthosis. Exercises are gradually increased to 10 repetitions comfortably every waking hour. At night, the digits may be strapped carefully and comfortably to the dorsal hood of the orthosis to counteract the tendency to develop PIP or DIP flexion contractures.

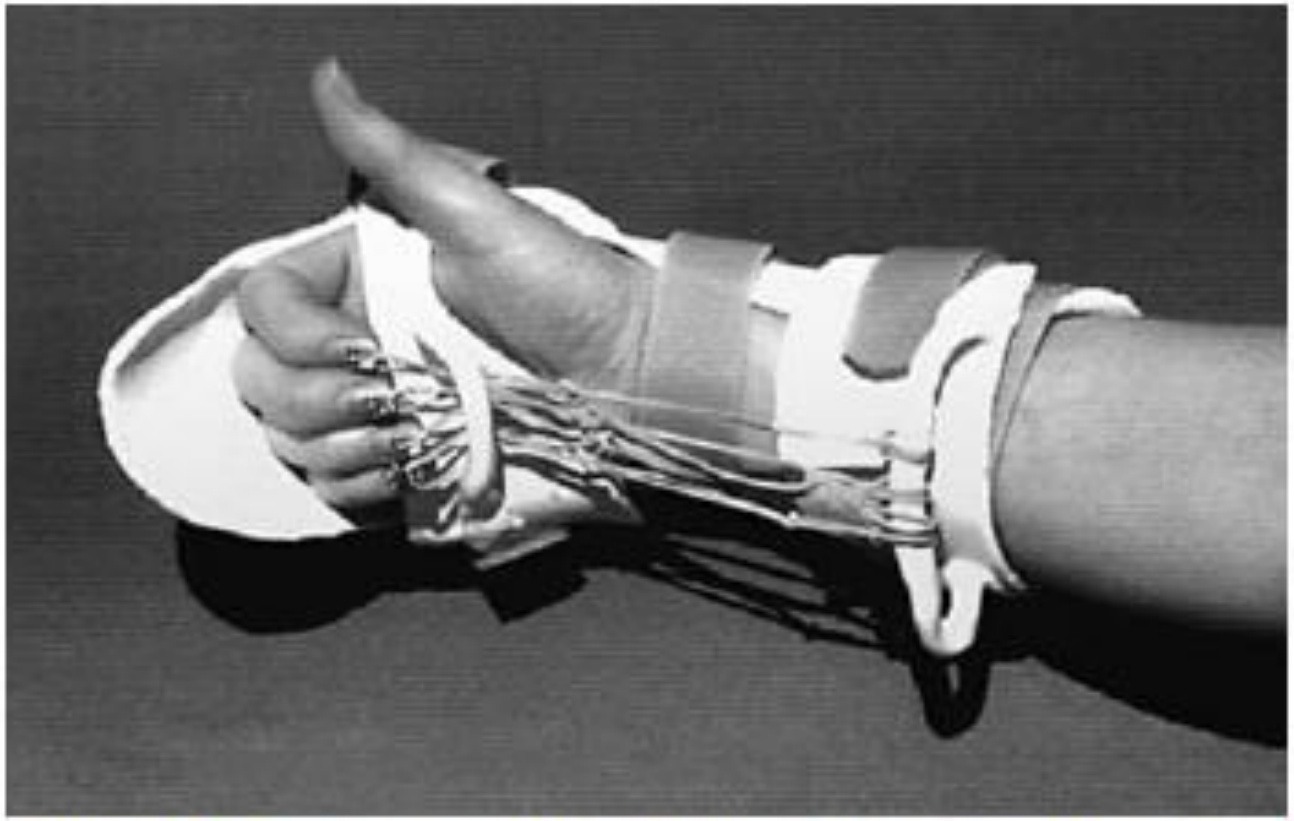

Figure 37-17 Modified Kleinert splint. Dorsal splint maintains the wrist in 30° of flexion, MPs in 70° of flexion, and IPs in extension. Rubber band attachments provide passive digital flexion.

- When the physician gives medical clearance to discontinue the dorsal protective orthosis, begin a graded program to promote functional movement. Oedema control and scar management remain high clinical priorities. Assess closely and determine tissue-specific limitations that guide the therapy program. Tendon gliding exercises and place-and-hold exercises are typical early techniques. Corrective splinting is useful, along with ADL, graded activity, and upgraded exercise as appropriate.

Extensor Tendon Injury

- Therapy of extensor tendon injuries is complicated and requires supervision by experienced hand therapists. Various protocols are available for immobilization, controlled passive motion, or active short arc of motion following extensor tendon repair.
- Seven zones describe the digital extensors for the index, long, ring, and small fingers, and five zones describe the thumb extensors (Fig. 37-18). Injury in zones I and II leads to a mallet deformity, which follows disruption of the terminal extensor tendon and manifests itself as DIP extensor lag (Fig. 37-19).

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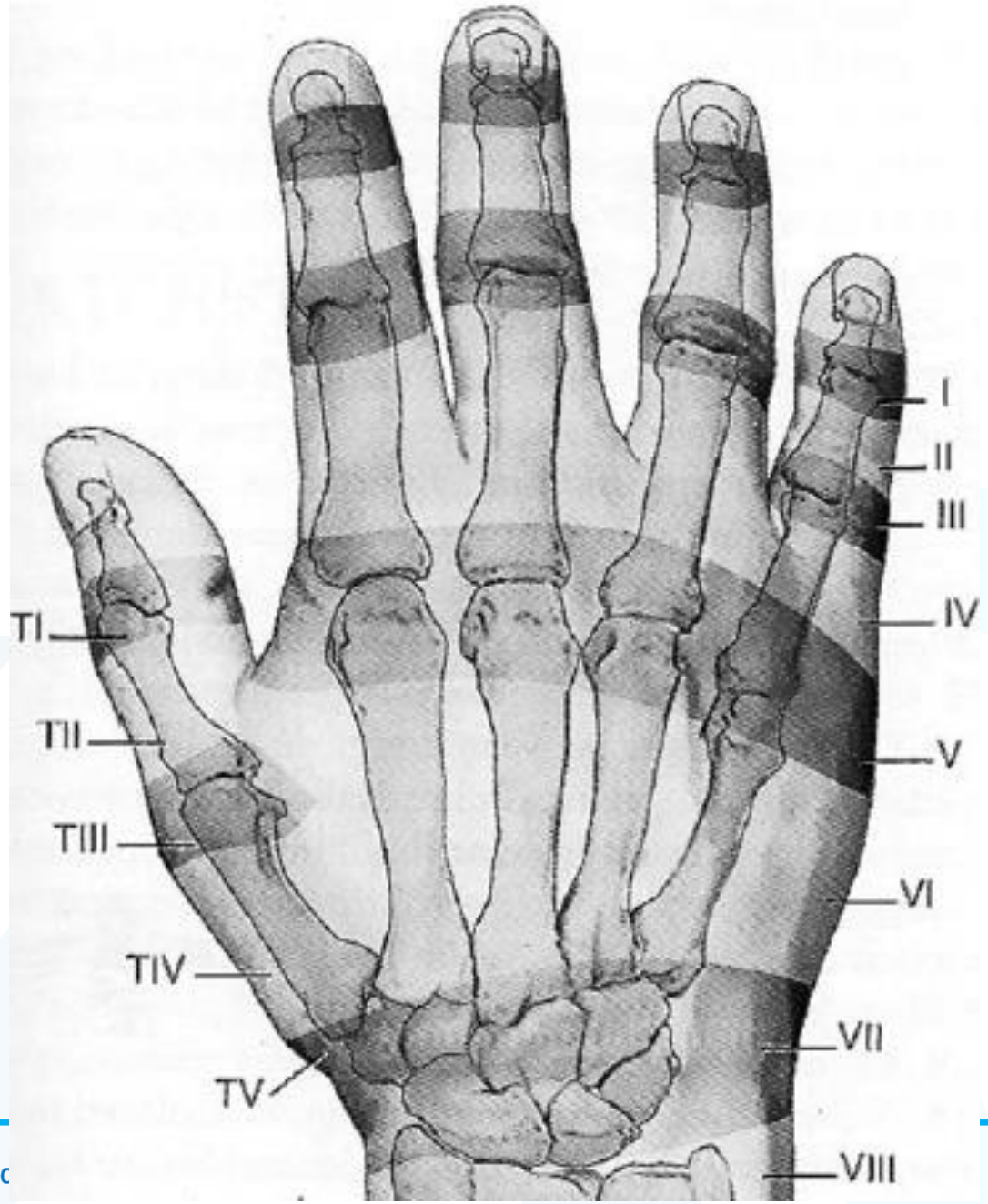

Figure 37-18 The seven zones of the hand based on extensor tendon anatomy. The odd zones I, III, V, and VII belong to distal interphalangeal, proximal interphalangeal, metacarpophalangeal, and wrist joints, respectively. The even zones II, IV, and VI belong to phalanx 2, phalanx 1, and metacarpal. (From Rayan, G. M., & Akelman, E. [2012]. *The hand: Anatomy, examination, and diagnosis* [Kindle Locations 742–744]. Philadelphia: Lippincott [Wolters Kluwer Health]. Kindle Edition. Used with permission.)

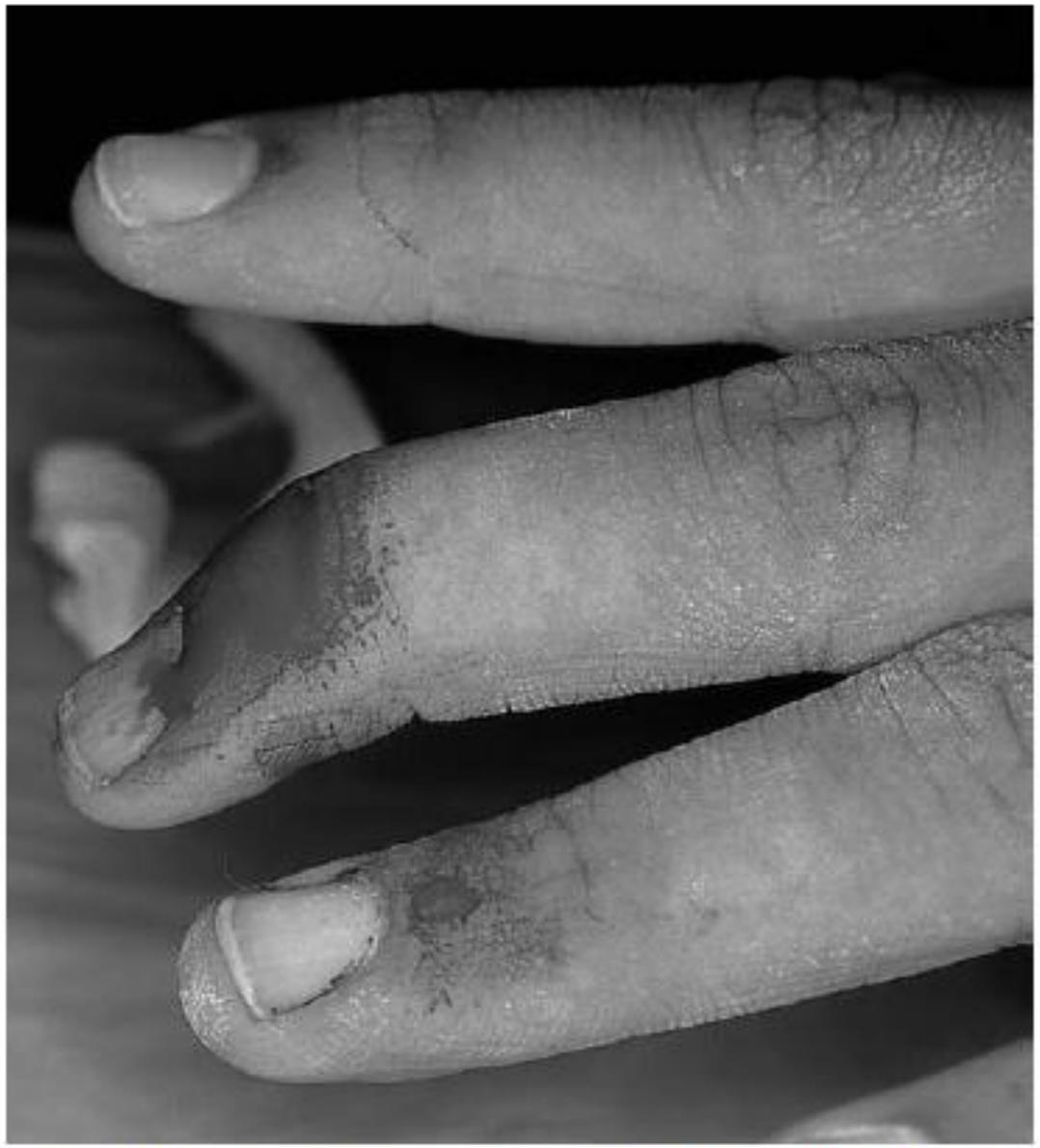

Figure 37-19 Mallet finger. (From Anderson, M. K., Parr, G. P., & Hall, S. J. [2009]. *Foundations of athletic training: Prevention, assessment and management* [4th ed.]. Philadelphia: Lippincott Williams & Wilkins. Used with permission).

- Depending on the nature of the problem, in nonoperative cases, therapy may include continuous splinting of the DIP in extension for 6–8 weeks as determined by the physician while the tendon heals. It is essential to maintain normal PIP ROM during immobilization at the DIP. When initiating ROM of the DIP after the terminal tendon has healed, watch closely for recurrence of DIP extensor lag and resume splinting as needed to recover DIP extension. Some physicians recommend continuation of night splinting when DIP AROM is begun.

- Extensor injuries in zones III and IV lead to a boutonniere deformity, an imbalanced digital position of PIP flexion and DIP hyperextension (Fig. 37-20). The deformity is due to volar displacement of the lateral bands secondary to involvement of the central slip. In nonoperative cases, splint the PIP in full extension for 6 weeks, and promote DIP active and passive flexion to prevent stiffness of the oblique retinacular ligament. In operative cases, follow the physician's guidelines, which may vary in timing and technique of mobilization and splinting. When the patient is medically cleared to begin PIP active exercises, watch closely for PIP extensor lag, and modify therapy and splinting accordingly.

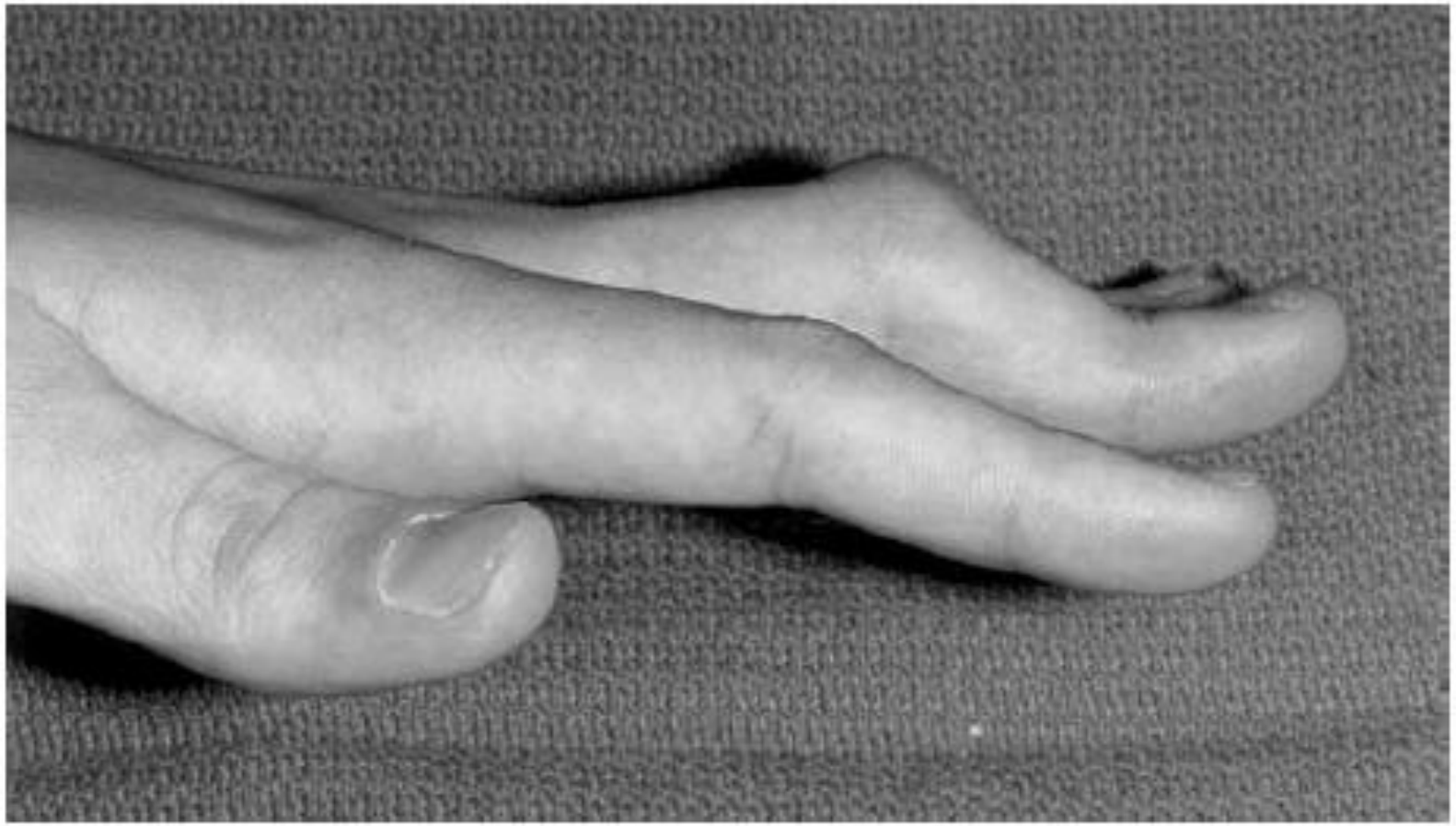

Figure 37-20 Boutonniere deformity. (From Anderson, M. K., Parr, G. P., & Hall, S. J. [2009]. *Foundations of athletic training: Prevention, assessment and management* [4th ed.]. Philadelphia: Lippincott Williams & Wilkins. Used with permission).

- Injury in zones V and VI may be treated by immobilization or by controlled early motion. Specific positioning and motion guidelines vary from surgeon to surgeon and are modified according to each patient's tissue responses. Multiple complex orthotics may be needed to achieve a program that balances rest and motion appropriately.
- Injury in zone VII is likely to result in restrictions because of development of adhesions. Communicate closely with the surgeon for specific positioning and motion guidelines.

Tenolysis

- Tenolysis is a surgical procedure to release tendon adhesions that restrict movement. Physicians do not usually perform this procedure until injured tissues have matured and PROM is maximized, as demonstrated by a plateau in progress during therapy. Therapy following tenolysis may begin as early as a few hours after surgery. The first few days following surgery are considered crucial. The physician's referral should include information on the integrity of the tendon and expected ROM goals based on intraoperative findings. First priorities are oedema control and ROM; observe and respect the tolerances of these fragile tissues.

Complex Regional Pain Syndrome

- Any upper extremity injury, whether as minor as a paper cut or as major as a complex crush injury, has the potential to result in devastating reflex sympathetic dystrophy (RSD), renamed complex regional pain syndrome (CRPS) by the International Association for the Study of Pain. CRPS type I follows a noxious event. Pain that is not limited to the territory of a single peripheral nerve occurs spontaneously and is disproportionate to the inciting noxious event. Oedema is present, with abnormality of skin colour or abnormal sudomotor activity in the painful area since the onset. The diagnosis of CRPS is excluded by other existing conditions that may cause the pain and dysfunction.

- CRPS type II is the same as type I except that it develops after a nerve injury, whereas type I does not involve a nerve injury. CRPS type III refers to a group not otherwise specified and includes patients who do not fulfil the criteria for types I or II.
- Pain that is disproportionate to the injury is the hallmark of CRPS. Constant attention to the patient's pain level and autonomic responses can lead to early medical management, if not prevention, of this challenging problem. The earlier this problem is diagnosed, the more successfully it may resolve.

- The four cardinal symptoms and signs of CRPS are pain, swelling, stiffness, and discoloration. Secondary symptoms and signs include osseous demineralization, sudomotor changes (sweating), temperature changes, trophic changes, vasomotor instability, palmar fasciitis (thickening of palmar fascia), and pilomotor activity (goose pimples or hair standing on end).

- Elegant animal studies have shown that self-protection through immobilization, intended to avoid pain, is itself a risk factor for the diagnosis of CRPS. People with CRPS must learn to use the extremity in ways that are pain free and biomechanically efficient. Normalizing sensory input also helps interrupt the vicious cycle of pain and stiffness.

Therapy for Complex Regional Pain Syndrome

- The most important therapy guideline is no PROM or painful intervention. The first thing is to control the pain. This includes management through medications, sympathetic blocks such as stellate ganglion blocks, and modalities such as TENS as appropriate. Close communication with medical experts specializing in pain management is ideal.

- Provide vasomotor challenge through stress loading (described later), temperature biofeedback, and posture changes during activity. It also helps to reset the sensory thresholds through contrast baths, vibration, and desensitization. Water aerobics and functional activities are excellent ways to provide active movement incorporating reciprocal motion. Use stress loading routinely with patients who are at risk for CRPS. Stress loading is proposed to change sympathetic efferent activity.
- Although the physiological mechanisms of stress loading are not known, it is popular among hand therapists for treating active CRPS, not the sequelae

- The two components of stress loading are “scrubbing the floor” (performed literally on all fours if possible), in brief sessions, three times per day initially, and carrying a weighted briefcase, done with the extremity in extension.
- The weight should be light and tolerable. Be sure it is not too heavy. Scrubbing and carrying achieve compressive loading and distraction of the upper extremity. If actual scrubbing cannot be tolerated, substitute comfortable weight-bearing exercises.

- The frequency and duration of scrub and carry are upgraded as tolerated. If wrist ROM limitations or injury precautions do not allow the patient to assume the scrub position, positions may be adapted to accomplish comfortable weight bearing.
- Also instruct the patient to perform frequent pain-free proximal AROM bilaterally.

- Avoid PROM or other therapy until the pain and swelling begin to subside, and then monitor responses closely. Incorporate traditional hand therapy, including orthotics and other non aggravating modalities, with oedema control, joint ROM, differential tendon gliding, restoration of musculotendinous lengths, strengthening, desensitization, physical agents including transcutaneous electrical nerve stimulation (TENS) and ultrasound as appropriate, and functional activity within tolerance. Manual oedema mobilization is effective with this diagnosis.

- Perhaps with CRPS more than other diagnoses, patient- directed therapy is essential. It is better to perform gentle, pain-free active exercises frequently for short periods than fewer and longer sessions. Light massage and active exercise help to interrupt the pain cycle. Make the exercise program bilateral and include reciprocal upper extremity motions. Allow the progress to be as slow as necessary to prevent worsening of symptoms. This diagnosis can be overwhelming and discouraging. Provide the patient with appropriate encouragement and reassurances that progress can be made over time.

- CRPS typifies the difficult clinical problems that hand therapists are trying to avert or avoid. Intervention programs that are progressing well can be suddenly and unexpectedly derailed by this disorder. For this reason, it is advisable to approach all hand therapy patients supportively and with a very careful eye, regardless of their diagnosis. Early identification of CRPS is a key to resolving it.