Hand and Upper Extremity

General Considerations for Hand and Upper Extremity (UE) Intervention

I. Anatomy of the forearm and upper arm

A. Bones of the forearm and upper arm

1. Radius
2. Ulna
3. Humerus

B. Bones of the wrist

1. Distal radius
2. Ulna
3. Eight carpal bones
4. Associated joint capsule
5. Several ligaments

C. Muscles of the forearm and upper arm

1. Deltoid
2. Triceps
3. Anconeus
4. Biceps brachii
5. Brachialis
6. Brachioradialis

D. Blood supply to arms

1. Right arm
   a. Originates from the brachiocephalic artery
   b. Passes through the right subclavian artery
   c. Divides into the axillary, brachial, radial, and ulnar arteries.
2. Left arm
   a. Supplied by left subclavian artery
   b. Includes the left arm's axillary, brachial, radial, and ulnar arteries.

II. Anatomy of the hand (DeMott & Flinn, 2020, pp. 21–45)

A. Bones of the hand and wrist: two rows of carpal bones

1. *Distal row:* hamate, capitate, trapezoid, and trapezium.
2. *Proximal row:* pisiform, lunate, triquetrum, and scaphoid.

B. Muscles that originate from the lateral epicondyle

1. Anconeus
2. Supinator
3. Extensor carpi radialis longus (ECRL)

4. Extensor carpi radialis brevis (ECRB)
5. Extensor carpi ulnaris (ECU)
6. Extensor digitorum (ED)
7 Extensor digiti minimi (EDM).

C. Muscles that originate from the medial epicondyle

1. Pronator teres
2. Flexor carpi radialis (FCR)
3. Flexor carpi ulnaris (FCU)
4. Palmaris longus (PL)
5. Flexor digitorum superficialis (FDS).

D. The main arteries supplying blood to the hand and wrist are the *radial* and *ulnar arteries.*

E. Sensory receptors of the hand

1. Pacinian corpuscles, responsible for vibration
2. Ruffini end organs, responsible for tension
3. Merkel cells, responsible for pressure.

F. *Intrinsic muscles* are the small muscles in the hand (Cooper, 2020, p. 2).

G. *Extrinsic muscles* are longer musculotendinous units that originate proximal to the hand (Cooper, 2020, p. 2).

III. Evaluation of the hand and UE (Klein, 2020a, pp. 46–65)

A. Client history, including of the current injury or symptoms, prior medical intervention, and pertinent medical history.

B. Complete occupational profile and establish rapport (AOTA, 2020, 2021). Assess psychosocial and coping status.

C. Assess cognition, including ability to adhere to home program.

D. Observation

1. Nonverbal communication
2. Position of the injured extremity
3. Posture and trunk
4. Spontaneous use of UE and hand
5. Guarding
6. Scar
7. Wounds
8. Skin.

E. *Pain assessment:* Note when pain occurs during other parts of the evaluation, including during active range of motion (AROM) or passive range of motion (PROM), strength testing, and palpation.

F. Wound assessment

G. Scar assessment

H. Specific testing and assessments

1. *Pain scales:* Numeric and visual analog scales, verbal rating scale, graphic representation, pain questionnaire
2. *Wound assessment:* Size, depth, granulation tissue, drainage, odor, temperature
3. *Scar assessment:* Color, size, flat/raised, adhesions
4. *Vascular:* Observation of color and trophic changes, palpation (pulse, capillary refill assessment, modified Allen's test), and temperature assessment
5. *Range of motion (ROM) of the forearm, wrist, fingers, and thumb:* Active and passive goniometric measurements
6. *Edema:* circumferential (tape measure) and volumetric measurements (volumeter)
7. *Sensation:* Semmes–Weinstein monofilament and two-point discrimination. Monofilament is used for nerve compression, and two-point discrimination is typically used for nerve laceration and recovery.
8. *Strength:* grip strength, pinch strength, and manual muscle testing. These tests are not to be performed unless resistance has been approved by the referring physician, and testing is contraindicated before full healing of a fracture, ligament repair, tendon laceration, or tendon transfer, or as determined by the referring physician.
    a. *Grip strength test:* Jamar dynamometer
    b. *Pinch strength test:* Use pinch gauge device. Client is seated, elbow flexed at 90° with arm adducted at side, forearm in neutral position. Each test is repeated 3 times, and an average is calculated.
        i. *Lateral pinch (key pinch):* pinch meter is placed between the radial side of index finger and thumb.
        ii. *Three-point pinch (three-jaw-chuck pinch):* pinch meter is placed between the pulp of the thumb and pulp of the index and middle fingers.
        iii. *Two-point pinch (tip-to-tip pinch):* pinch meter is placed between the tip of the thumb and tip of the index finger.
    c. *Manual muscle testing:* strength is graded according to normal (5), good (4), fair (3), poor (2), and trace (1).
9. *Coordination:* ability to manipulate items in the environment, ranging from gross coordination to fine coordination tasks. Standardized assessments include O'Conner Dexterity Test, Nine-Hole Peg Test, Jebsen–Taylor Hand Function Test, Minnesota Rate of Manipulation Test, and Purdue Pegboard Test.

I. Use of orthoses and the amount of time and activities during which these are worn

J. Functional ability, including within context of daily activities.

Common Shoulder Diagnoses (Butler, 2020, pp. 167–202)

I. Thoracic outlet syndrome/brachial plexopathy

A. *Thoracic outlet syndrome* consists of an array of clinical entities involving the shoulder region.

B. Thoracic outlet can be divided into four regions.

1. Sternocostovertebral space
2. Scalene triangle
3. Costoclavicular space
4. Pectoralis minor (coracopectoral) space.

C. Brachial plexus allows for individual neurons from spinal nerves to reach their respective peripheral nerve.

1. Upper trunk supplies the scapula.
2. Lower trunk supplies the hand intrinsic muscles.
3. The anterior division of the lower trunk supplies the medial cord.
4. The anterior divisions of the upper and middle trunk supply the lateral cord.
5. The anterior divisions supply the elbow and wrist flexors with the exception of the brachioradialis.
6. The posterior divisions of all trunks supply the posterior cord (which also supplies the brachioradialis).
7. The posterior cord supplies the elbow and wrist extensors.

D. Level of restriction for brachial plexus injuries is related to severity, neural sensitization, and amount of intraneural and/or perineural scarring.

E. Treatment

1. Nonoperative
   a. Education on safe boundaries of motion to minimize irritation
   b. Diaphragmatic breathing to minimize use of scalene
   c. Education on safe sleeping positions
   d. Education on proper posture to minimize stress on brachial plexus
   e. Guided exercises to strengthen scapular stabilizers and elevators
   f. Visual feedback exercises to facilitate scapular proprioception.
2. *Operative:* Main goal is decompression of neurovascular contents, or neurolysis.

II. Frozen shoulder/adhesive capsulitis

A. Terms are used interchangeably.

B. Progressive loss of glenohumeral range of motion (usually begins with external rotation being most limited, followed by abduction, and internal rotation)

C. Phases of frozen shoulder

1. *Freezing phase:* characterized by shoulder pain interrupting sleep, pain with ADLs, and often pain at rest; ROM usually close to full however with pain often experienced before the end of motion
2. *Frozen phase:* movement patterns demonstrated as individuals attempt to compensate for lack of glenohumeral mobility; pain typically occurs with stretching at end of motion

3. *Thawing phase:* gradual return of motion and lasts up to 26 months

D. Treatment

1. Nonoperative
   a. Overstretching and pushing the joint to the point that reinitiates the inflammatory process should be avoided.
   b. Role of OT is to assist individuals in ADL modifications or adaptive equipment for ADLs; workstation modifications may also be considered.
2. *Operative:* manipulation (under anesthesia) and arthroscopic release of the glenohumeral capsule ligaments.

III. Rotator cuff disease

A. Up to 70% of shoulder disorders are related to rotator cuff disease.

B. Structures involved include muscles of the rotator cuff, the long head of the biceps tendon, the subdeltoid–subacromial bursa, and the coracoacromial (CA) arch.

C. Treatment

1. Nonoperative
   a. Initially, focus is on rest and anti-inflammatory modalities
   b. Early ROM exercises (pendulum and wand-assisted elevation in scapular plane)
   c. Strengthening the healthy part of the rotator cuff and scapular stabilizer muscles; isometrics and resistance band exercises may be considered
2. Operative
   a. Indications for surgery include full or partial tears that have not responded to conservative care and that continue to interfere with participation in ADLs.
   b. After surgery
      i. Typically 2 to 4 weeks of immobilization
      ii. Therapy then begins to regain ROM, progressing from passive to active motion exercise for the next 2 to 3 weeks.
      iii. At 8 to 10 weeks following surgery, strengthening exercises are initiated.

Fractures

I. Fractures of the hand (Hirth et al., 2020, pp. 291–310)

A. Types of fracture

1. Finger metacarpal fractures: half of all hand fractures
   a. Base shaft
   b. Neck
   c. Head, such as a boxer's (4th and 5th finger) fracture.
2. Thumb fractures
   a. *Bennett's fracture:* base fracture
   b. Shaft and neck fractures
   c. *Skier's thumb:* torn ligament.

3. Avulsion injuries occur when the tendon separates from the bone and insertion and removes bone material with the tendon (Solomon, 2020).
    a. *Mallet finger:* avulsion of the terminal tendon; splinted in full extension for 6 weeks.
    b. *Boutonniere deformity:* disruption of the central slip of the extensor tendon characterized by proximal interphalangeal (PIP) flexion and distal interphalangeal (DIP) hyperextension; the PIP is splinted in extension, and isolated DIP flexion exercises are performed.
    c. *Swan neck deformity:* injury to the metacarpophalangeal (MCP), PIP, or DIP joints characterized by PIP hyperextension and DIP flexion; the PIP is splinted in slight flexion.

B. Medical management and fracture healing (Seeley et al., 2020 pp. 254–269; Wietlisbach, 2020, p. 154)

1. Desired outcome is regeneration of bone and restoration of bone strength.
2. Three common phases of healing
    a. *Inflammatory* provides the cellular activity needed for healing.
    b. *Repair* forms the callus for stabilization.
    c. *Remodeling* deposits bone.
3. Complications of healing
    a. Misaligned fracture, wounds, pain, decreased nutrition to the area, decreased healing potential
    b. Age and bone disease affect healing.
4. *Medical intervention:* Closed reduction (CR) or open reduction, internal fixation (ORIF)
5. The safe time frame for movement versus protection depends on the fracture type, stage of healing, and physician orders.

C. Rehabilitation of hand fractures (Hirth et al., 2020, pp. 291–310)

1. Orthotic fabrications
    a. Use as prescribed by the physician or referring provider for safe splinting and functional splinting.
    b. Materials should be chosen to fit the client and the condition.
    c. Thermoplastic and casting orthoses are commonly used to provide support for healing structures.
2. Modalities for pain relief and tissue healing include heat, ultrasound, cryotherapy, paraffin, and transcutaneous electrical nerve stimulation (TENS).
3. Early controlled mobilization through therapeutic exercises
4. Consider intrinsic tightness versus extrinsic tightness, joint capsule tightness, and tendon adhesion (3–8 weeks post fracture or surgery).
5. Unusual numbness and tingling of the fingers and/or pain with active motion may indicate that the client is doing too much, too soon.
6. Home programs enable the client to continue safe exercises and functional activity at home between therapy sessions to ensure continued progress toward goals.
7. The most severe complication of hand fractures is complex regional pain syndrome (CRPS; see "Considerations of Pain and Trauma With Hand and UE Injuries" section).

II. Fractures of the wrist (Seeley et al., 2020, pp. 254–269)

A. Types of fracture

1. Distal radius fractures
   a. The most common UE fracture. It usually results from a *f*all *o*n *o*utstretched *h*and (FOOSH).
   b. *Colles fracture*
      i. Complete fracture of the distal radius with dorsal displacement
      ii. Most common type of wrist fracture
      ii. Often used as a blanket term to refer to all fractures of the distal radius.
   c. *Smith's fracture*
      i. Complete fracture of the distal radius with palmar displacement
      ii. Results from a fall on flexed wrist.
2. Distal ulna fractures
   a. Usually occur in conjunction with distal radius fractures; uncommon to see them in isolation.
   b. Include injuries to the ulnar styloid, ulnar head, or ulnar metaphysis.
3. Carpal fractures (fractures to individual carpal bones)
   a. The most common fracture seen and missed in injuries to the wrist is the scaphoid, accounting for 90% of all carpal fractures.
   b. Lunate fractures are associated with Kienbock's disease, a pathological process where blood flow to the lunate is compromised.

B. Nerve injuries associated with wrist fractures

1. Median nerve injury
   a. Produces carpal tunnel–like symptoms, such as palmar numbness and numbness of the first digit to half of the fourth digit
   b. Produces generalized weakness and pain.
2. Ulnar nerve injury
   a. Results in ulnar claw deformity (see the "Nerve Injuries and Syndromes" section)
   b. Produces numbness of the ulnar side of the hand and the fifth and half of the fourth digits
   c. Produces generalized weakness of the ulnar side of the hand and pain.

C. Medical management

1. Goal of medical management: regain normal anatomy of the wrist. May range from surgical intervention to conservative intervention with cast immobilization.
2. Medical provider will examine patient both clinically and radiographically (i.e. X-rays, computed tomography [CT] scanning, or magnetic resonance imaging [MRI]).
   a. *Nondisplaced fracture:* when a bone is fractured but overall anatomical alignment is maintained
   b. *Displaced fracture:* when a bone breaks and it is no longer aligned
   c. *Extraarticular fracture:* occurs outside of the joint and does not interrupt articular cartilage; often requires little intervention
   d. *Intraarticular fracture:* extends into the joint; can lead to osteoarthritis.

D. Rehabilitation of distal radius and carpal fractures

1. Goal: maximize functional recovery of the UE
2. *Acute phase (0–6 weeks):* immobilization is common, contributing to detrimental effects. Fewer than 10% of clients are referred to therapy in acute phase.
   a. *Edema management:* early management is critical. AROM, elevation, cold application, compression, and lymphatic drainage are commonly used to manage edema.
   b. *Pain management:* proper management can reduce risk for CRPS. Examples include pain medication, ice, heat (if edema resolving), contrast baths, graded motor imagery (GMI).
   c. *Functional use:* lifting and carrying is usually limited to 1–2 pounds, and no weight bearing is allowed
3. *Subacute phase (6 weeks and beyond)*
   a. *Cast/orthotic use:* primary goal is to support soft tissues and encourage the wrist to remain in extension to promote finger motion. Typically worn during participation in heavier tasks, at night, and when out in public. Dynamic or static-progressive orthotics can be used after the fracture is healed to increase ROM.
   b. *Edema management:* generally fibrotic if edema has persisted to this point (elevation no longer beneficial). Manual edema mobilization and compression may be helpful.
   c. *ROM:* exercises are used to facilitate movement and improve performance of the UE; examples include AROM with wrist extended and fingers flexed; blocking exercises; tendon and nerve gliding exercises; stretching exercises.
   d. *Pain management:* therapeutic strategies at this stage include ice, moist heat application, contrast baths, graded motor imagery, and electrical modalities such as transcutaneous electrical nerve stimulation (TENS).
   e. Scar management and desensitization
   f. *Orthoses to address adherence and tissue shortening:* often used when traditional methods of stretching do not improve ROM to functional level.
   g. *Functional use:* clients are encouraged to progress functional use, as tolerated with guidance to avoid overuse.
   h. *Strengthening:* usually started around 8–10 weeks, beginning with isometric exercises followed by open kinetic chain exercises, and lastly closed chain exercises. Grip strengthening is initiated with a sponge ball or theraputty.
   i. A home program is provided to increase progression of function and outcomes.
   j. *Modalities:* include heat, ultrasound, cryotherapy, paraffin, TENS; used to prepare tissues for work and assist with pain relief and tissue healing.

E. Complications

1. A wrist fracture that results in compression of the median nerve as it runs through the carpal tunnel may lead to carpal tunnel syndrome; see the "Nerve Injuries and Syndromes" section for more information.
2. The primary and most severe complication of distal radius fracture is CRPS (see "Considerations of Pain and Trauma With Hand and UE Injuries" section). Significant pain can lead to stiffness, loss of function, and disability.

III. Fractures of the forearm (Page, 2020, pp. 203–218)

A. Radial head fractures

1. Most common type of elbow fracture
2. Usually caused by a FOOSH
3. Most common complication is elbow flexion contracture, the loss of full elbow extension.

B. Olecranon fractures

1. Result from a fall onto a bent elbow or a direct blow
2. Ulnar nerve is susceptible to injury due to its location in relation to the olecranon.

C. Distal humeral fractures

1. Relatively uncommon
2. Falling is the most common cause.

D. Medical management

1. Nondisplaced fractures can be treated with a long arm sling, typically for the first week. Elbow extension is emphasized.
2. Displaced or unstable fractures are treated operatively to restore bony alignment and stability, as needed.
3. Open fractures must be treated operatively to clean the wounds and minimize risk of infection, to ensure alignment and stability, and to facilitate early mobilization.
4. Elbow fractures that are stable and aligned do not require operative treatment. 95% of radial head fractures can be managed nonoperatively.
5. Comminuted fractures are treated with radial head excision or replacement.
6. Most olecranon fractures require ORIF.
7. Almost all distal humeral fractures require operative intervention.

E. Rehabilitation of elbow fractures

1. Fracture stability is the prerequisite to any type of early motion.
2. Orthotics are used for immobilization as needed. The orthosis is typically removed within the first week. Gentle active and active-assisted elbow and forearm motion are initiated.
3. ROM begins early, within the 1st week if medically cleared.
4. Elevation, cold packs, light compression wraps, and light massage can be used for pain control and edema.
5. Be mindful of stiff elbow, a frequent complication of elbow dislocation and elbow fracture.
6. Once physician determines that there is evidence of fracture union and sufficient stability, gentle passive motion, joint mobilization, and soft-tissue mobilization may be initiated with eventual return to use of UE for light and gentle functional activities.
7. Once fracture consolidation is achieved (8–12 weeks following injury or surgery), resistive exercises may be introduced to facilitate strengthening of the involved UE with the goal of returning to the previous level of function without pain.

IV. Fractures of the upper arm (Butler, 2020, pp. 183–186)

A. Proximal humeral fractures

1. Most common fracture of the upper arm
2. May involve the articular surface, greater or lesser tuberosity, or surgical neck
3. May be located on the anatomical head, anatomical neck, or anatomical shaft.

B. Medical management

1. One-part fractures are initially treated by immobilization with use of a sling for 1 to 3 weeks. Passive movements when the humeral shaft and head move as a unit can be as early as a couple of days.
2. Two- to-four-part fractures require 4 to 6 weeks of immobilization. The one exception to this is clients with hemiarthroplasties, who begin PROM exercises on postoperative Day 1. Operative treatment most commonly includes ORIF.

C. Rehabilitation of upper arm fractures

1. Treatment may begin while still in the immobilizer. Gripping exercises and AROM of the elbow and wrist to prevent edema and stiffness may be introduced.
2. Orthotics (e.g., humeral fracture brace) can be worn for support of the fracture ends.
3. ROM may begin as early as 2 weeks after a nonoperative fracture as medically prescribed.
4. A sling is used to immobilize the fracture in nonoperative treatments.
5. A ROM protocol consists of aggressive stretching and can begin 4–6 weeks after the fracture as prescribed by the physician. Emphasis should be on proper glenohumeral and scapulothoracic movement.
6. Strength training is initiated at 8 to 12 weeks postinjury/repair. The emphasis during this phase is on the rotator cuff muscles and scapular stabilizer/force couple muscles. Open and closed chain exercises are included.
7. At 12 weeks, if functional ROM and normal movement patterns are achieved, plyometrics may be integrated.
8. Management continues at home, including a home exercise program.

Tendons

I. Extensor tendons (Klein, 2020b)

A. Anatomy

1. Extrinsic extensor tendons to the digits
   a. Extensor digitorum communis (EDC)
   b. Extensor indicis proprius (EIP)
   c. Extensor digiti minimi (EDM)
   d. Extensor pollicis longus (EPL)
   e. Extensor pollicis brevis (EPB)
   f. Abductor pollicis longus (APL)

2. Tendons cross the wrist dorsally under the extensor retinaculum, separating into eight compartments to prevent bowstringing.
3. Sagittal bands center the extensor tendons over the MCP joint.

B. Zones

1. Thumb
   a. *Zone I:* Falls over the interphalangeal (IP) joint
   b. *Zone II:* Falls over the proximal phalanx
   c. *Zone III:* Falls over the MCP joint
   d. *Zone IV:* Falls over the first metacarpal
   e. *Zone V:* Falls over the wrist
2. Extensor tendon zones, digits II–V
   a. *Zone I:* Distal interphalangeal joint
   b. *Zone II:* Middle phalanx
   c. *Zone III:* Proximal interphalangeal joint
   d. *Zone IV:* Proximal phalanx
   e. *Zone V:* Metacarpophalangeal joint
   f. *Zone VI:* Metacarpals
   g. *Zone VII:* Carpal bones and wrist

C. Rehabilitation of extensor tendons after surgical repair

1. Most clients who have had an extensor tendon repair are allowed to use their hand for light activities by 6 to 8 weeks following repair.
2. *Resistance to tendon motion:* appropriate to introduce when adhesions limit active motion more than passive motion.
   a. All programs must be individualized, especially to minimize risk of tendon rupture.
   b. Avoid gapping or potential rupture of a tendon until 12 weeks after repair.
   c. Initiate active motion gently with gradual increase in tension, as healing advances.
3. *Goal of tendon rehabilitation:* achieve tendon gliding while minimizing tension on the repair. Decreasing edema and stiffness, performing movements slowly and gently, and positioning of proximal joints during active motion can help in minimizing tension on the tendon while mobilizing.
4. *Rehabilitation of Zones I and II extensor tendon injuries:* similar to that for closed treatment—immobilization for a number of weeks determined by the surgeon, followed by gradual increase in flexion of the DIP joint.
5. *Rehabilitation of Zones III and IV extensor tendon injuries*
   a. Early phase (immediately upon repair to 3–4 weeks following repair)
      i. Orthosis: a postoperative splint, a finger-length cast, or a thermoplastic orthosis may be applied to hold the PIP joint in full extension.
      ii. The orthosis is worn full time until 3 to 4 weeks postoperatively.
      iii. In this phase, the client is to move only the joints that are not restricted within the orthosis.
   b. Intermediate phase (4–8 weeks following repair)
      i. Discontinue use of orthosis.
      ii. Begin active flexion with individual joint flexion.

iii. At 5 weeks, advance to gentle composite flexion.
iv. If edema is not present, heat may be used to warm the tissues prior to active exercises.

c. Late phase (8–12 weeks following repair)
i. Client usually is allowed full normal use of injured hand.
ii. Limited flexion should be treated with heat combined with stretch, passive and active flexion of individual joints, blocking exercises, composite flexion exercises, and grip stretching.
iii. Static progressive or dynamic flexion orthoses may be used.

6. *Rehabilitation of Zones V, VI, and VII extensor tendon injuries*
a. Early phase
i. Orthosis: requires a full-length resting cast or thermoplastic orthosis.
ii. Hand and wrist exercises begin in the intermediate phase at approximately 4 weeks after repair.

b. Intermediate phase
i. Orthosis is used only intermittently during work and heavy activities after 4 weeks following repair, and gradually discontinued. A night resting pan orthosis in full extension is indicated if extension is limited.
ii. At 4 weeks, gradual increase in active flexion for individual joints is allowed.
iii. Modalities, including heat to decrease stiffness, may be incorporated if not contraindicated.
iv. At 5 or 6 weeks, composite flexion of fingers is initiated.

c. Late phase
i. Add grip strengthening and progressive functional UE exercise at 6 weeks following repair.
ii. Static progressive or dynamic flexion orthoses may be used for flexion deficits.

II. Flexor tendons (Klein, 2020c)

A. Anatomy

1. *For each finger:* flexor digitorum superficialis (FDS) and flexor digitorum profundus (FDP)
2. *For thumb:* flexor pollicis longus (FPL)
3. Tendons are long and thin in the hand compared with other areas of the body; they glide and run under a tight pulley system.
4. Pulleys are found on the flexor side to prevent bowstringing and consist of A1, A2, A3, A4, and A5; and C1, C2, and C3.
5. Anatomical landmarks and structures
a. Blood supply is limited; nutrition is provided mainly by synovial diffusion.
b. Nerve supply is innervated by the medial, radial, and ulnar branches of the hand.
c. Zones
i. Zone I extends from the fingertip to the center portion of the middle phalanx.
ii. Zone II extends from the center portion of the middle phalanx to the distal palmar crease (known as no man's land, because of difficulty of tendon gliding without scarring to surrounding tissues).
iii. Zone III extends from the distal palmar crease to the transverse carpal ligament.

iv. Zone IV overlies the transverse carpal ligament.
v. Zone V extends beyond the level of the wrist.

B. Complications

1. Nerve involvement, usually laceration, is common because of the mechanisms by which tendons are injured.
2. Edema must be therapeutically controlled to maintain motion and reduce pain and joint stiffness.
3. Pain is common at the site of the injury, impacting occupational performance.
4. Muscle actions are affected by impairment in flexion and deviation of the wrist and digits.
5. A frequent complication following flexor tendon repair is PIP flexion contracture where the PIP joint is unable to be passively extended.

C. Rehabilitation of flexor tendon repairs

1. Immobilization approach
   a. Rarely applied.
   b. Children age 12 years and younger are most often placed in immobilization for first 3–4 weeks.
   c. When there is a concomitant fracture or significant loss of skin requiring a skin graft, a period of immobilization may be necessary.
   d. May be used with people who have cognitive limitations.
2. Immediate passive flexion approach
   a. An immediate passive flexion protocol is initiated within 3 to 4 days following a traditional two-strand flexor tendon repair.
   b. A dorsal blocking orthosis that holds the wrist and MP joints in flexion and IP joints in extension to prevent excessive tension on the repaired tendons is used. Clients are instructed to passively flex fingers using Duran and Houser's technique (1975) to improve tendon gliding and active IP extension within the dorsal blocking orthosis.
   c. Benefits of this approach include improved circulation for tendon healing, decreased joint stiffness, and partial distal gliding of the flexor tendon.
   d. Two categories of immediate passive flexion protocols
      i. Orthosis that holds IP joints statically between exercises during the early phase of tendon healing
      ii. Orthosis with elastic traction that holds the fingers in flexion dynamically between exercises.
3. Immediate active flexion approach
   a. Benefit of this approach following tendon repair is to achieve flexor tendon gliding prior to formation of adhesions.
   b. Protect client in a dorsal blocking orthosis at rest and during place and active hold exercise of the fingers in flexion.
   c. Exercises consists of slow gradual passive flexion to decrease edema and stiffness, followed by the same passive flexion and active IP extension exercises that are used for immediate passive flexion approaches (see above). Wrist tenodesis exercises and active hold finger flexion exercises are also included.

4. General considerations for all flexor tendon repairs
    a. Active flexion is initiated right after surgery in the immediate active flexion approach; however, clients with immobilization and immediate passive flexion approaches do not begin active flexion until 3 to 4 weeks following repair.
    b. Exercises should begin with those that result in the least force to the tendon repair.
    c. The force in exercises advances in this order, from least force to most force:
        i. Passive flexion and protected extension
        ii. Place and active hold in flexion
        iii. Active composite fist
        iv. Hook and straight fist
        v. Isolated joint motion (blocking)
        vi. Resisted composite fist
        vii. Resisted blocking.
    d. Modalities
        i. Heat to gradually prepare the tissue for motion
        ii. Neuromuscular electrical stimulation (NMES) to promote tendon excursion and activation
        iii. Use of modalities begins once cleared by the prescribing physician or provider.
    e. A clearly identified and planned home exercise program and integration within functional activity is important to ensure the client's safety and progress toward goals.

Nerve Injuries and Syndromes (Moscony, 2020, pp. 219–253)

I. Radial nerve injury

A. Most common injury of the UE peripheral nerves after humeral fractures

B. *Symptoms:* posture of hand is wrist drop with possible lack of finger and thumb extension

C. *Nonoperative treatment:* wrist cock-up splint with or without dynamic finger and thumb extension assist; passive and active ROM; and isotonic strengthening exercises upon muscle reinnervation.

D. *Operative treatment:* static wrist extension splint 30°; after 4 weeks, adjust splint to 10° to 20° extension.

II. Common sites of entrapment and injury with radial nerve injuries

A. Radial tunnel syndrome

1. Entrapment of the radial nerve in an area extending from the radial head to the supinator muscle
2. *Symptoms:* burning pain in lateral forearm
3. *Nonoperative treatment*
    a. Long arm splint, elbow flexed, forearm supinated, wrist neutral
    b. Massage or transcutaneous electrical nerve stimulation (TENS) for pain management
    c. Pain-free ROM

d. Nerve glides
e. No forceful wrist extension and supination.

4. *Operative treatment*
   a. Long arm splint, elbow flexed, forearm supinated, wrist neutral for 2 weeks
   b. Then wrist cock-up splint for 2 more weeks
   c. Passive and active pronation and supination
   d. Hand-strengthening exercise at 3 weeks
   e. Resistive exercise at 6 weeks.

B. Posterior interosseous nerve syndrome (PINS)

1. Rare nerve palsy involving some of the wrist extensors and all of the finger extensors
2. *Clinical presentation:* weakness or paralysis of ulnar wrist extension, digit extension, and extension and radial abduction of the thumb
3. *Symptoms:* pain, described as a "deep ache" with palpation over the proximal lateral forearm; more symptomatic at night and with activities that engage the extensor muscles of the wrist and fingers (e.g., typing on a computer)
4. Electromyography (EMG) is usually positive for nerve compression at the radial tunnel
5. *Nonoperative treatment:* Orthosis splint with combined positioning of elbow flexion, forearm supination, and wrist extension. If uncomfortable, using a wrist brace that positions the wrist in extension and avoiding prolonged positions of pronation with elbow extension may be recommended.

III. Median nerve injury

A. Causes ape hand deformity

B. *Symptoms*

1. Ape hand deformity
2. Sensory loss in index, middle, and radial side of ring finger
3. Loss of pinch, thumb opposition, index finger MCP and PIP flexion
4. Decreased pronation.

C. *Nonoperative treatment:* static thenar web spacer splint

D. *Operative treatment*

1. Dorsal wrist blocking splint worn for 4–6 weeks
2. AROM and PROM in splint for digits and thumb
3. Tendon gliding exercises
4. Scar massage
5. Discontinue splint at 6 weeks and begin strengthening exercises and light functional activities.

IV. Common sites of entrapment and injury with median nerve injuries

A. Anterior interosseous syndrome

1. Compression to the anterior interosseous nerve

2. *Symptoms:* nonspecific deep aching pain in the proximal forearm that increases with activity; usually no sensory symptoms; negative Tinel's sign (i.e., no tingling sensation when tapping the nerve over the skin)
3. Results in
   a. Motor loss involving the flexor pollicis longus to the thumb, flexor digitorum profundus to the index and long finger
   b. Collapsed distal IP joints when attempting to make the "okay" sign (called Ballentine's sign)
   c. Possible paresis of the pronator quadratus.
4. Orthotics involve stabilizing the IP joint of the thumb and, often, the index finger in a position of flexion to enhance function and tip pinch with activities.

B. Pronator syndrome

1. Entrapment of the proximal median nerve between the heads of the pronator muscles
2. *Symptoms:* deep pain in the proximal forearm with activity; sometimes sensory involvement
3. Symptoms may be provoked by resisted elbow flexion and are exacerbated with concurrent resisted forearm pronation; negative Tinel's sign.
4. *Nonoperative treatment:*
   a. Splint elbow 90° to 100° flexion, forearm neutral
   b. TENS for pain
   c. Gentle prolonged stretching supination and elbow, wrist, and finger extension
   d. Activity modification
   e. No repetitive forearm rotation with resistance and prolonged elbow flexion.
5. *Operative treatment*
   a. Half cast
   b. AROM all UE joints while wearing cast
   c. Muscle strengthening in 1 week
   d. Full AROM gained by 8 weeks.

C. Carpal tunnel syndrome

1. Carpal tunnel syndrome is caused by entrapment of the median nerve as it courses through the carpal tunnel. It is the most common nerve compression injury of the UE.
2. Causes include fluid retention leading to temporary swelling at the carpal tunnel of the wrist, compressing the median nerve (e.g., from pregnancy, trauma, infection, diabetes, hypothyroidism, gout, rheumatoid arthritis, etc.); occupations requiring repetitive motion, such as meat packing and automobile parts assembly; and prolonged positioning such as working on a computer keyboard).
3. *Symptoms:* paresis of the thenar muscles with weakness or loss of thumb opposition; sensory impairment generally involves numbness and tingling in the thumb and index and middle fingers, especially at night. Numbness or tingling and pain are typically worse at night.
4. Motor impairment presents as diminished fine motor coordination; in advanced cases, the abductor pollicis brevis and opponens pollicis muscles may be atrophied.

5. *Nonoperative treatment*
   a. A carpal tunnel syndrome splint or splint with wrist in neutral position to relieve pressure on the median nerve in the carpal tunnel and control edema; a prefabricated wrist cock-up splint can be used if wrist position is adjustable.
   b. Nerve and tendon gliding exercises.
   c. Activity modification that includes ergonomic handles, gel pads, or padding on handles.
   d. Avoid sustained pinch or gripping, when wrist is in a flexed posture. Avoid repetitive overuse of the wrist. Avoid positioning wrist in flexed posture when sleeping—use orthosis at night to keep wrist from bending.
   e. Postural retraining and proximal conditioning exercise.
   f. Ergonomic evaluation and modification of workstation
6. *Surgical treatment*
   a. Surgical treatment includes traditional open carpal tunnel release or endoscopic release.
   b. After surgery, some clients may not need therapy.
   c. For more complicated cases, wound care and scar mobilization are provided.
   d. Pain management may include use of gel pads on the scar. Pain on either side of the surgical release is called *pillar pain.*
   e. Splinting is provided only to clients who sleep with the wrist flexed or who will engage in too much activity too soon (e.g., immediate return to work).
   f. AROM of wrist, thumb, and fingers begins 1–2 days postsurgery.
   g. Nerve and tendon-gliding exercises are provided.
   h. Strengthening activities begin in 3 to 6 weeks.

V. Ulnar nerve injury

A. Ulnar nerve

1. Allows for simultaneous wrist flexion and ulnar deviation in addition to power grip via full flexion of the ulnar two digits (e.g., used for swinging a golf club or hammer).
2. Is necessary to allow for tip and lateral or key pinch.
3. Enables hypothenar and interrosei muscles to allow the hand to powerfully cup an object (e.g., doorknob).

B. Injury to ulnar nerve results in flattening of the normal arches of the hand.

C Low-level lesions (wrist) result in classic claw deformity of the digits with hyperextension of the MP joints and flexion of the IP joints.

D Paralysis of the thenar adductor causes loss of pinch strength.

E. Considerations for evaluation of ulnar nerve injuries

1. *Froment's sign:* flexion of the IP of the thumb when a lateral pinch is attempted
2. *Wartenberg's sign:* the fifth finger held abducted from the fourth finger.
3. *Jeanne's sign:* hyperextension of the thumb MCP.

VI. Common sites of entrapment and injury with ulnar nerve injuries

A. Ulnar tunnel syndrome, or Guyon's canal compression

1. Causes include ganglion, neuritis, arthritis, or carpal fractures at Guyon's canal.

2. Sensory loss occurs in the little finger, ulnar side of the ring finger, and the palmar ulnar hand; if sensory loss is on the dorsal side of the hand, the injury is proximal to Guyon's canal.
3. Loss of intrinsic ulnar innervated muscles (interossei and adductor pollicis, flexor and abductor digiti minimi) and subsequent motor loss result in *claw deformity,* in which the MCPs hyperextend and the IPs flex, hand arches are flattened, and pinch strength is lost.
4. Nonoperative treatment
    a. An ulnar nerve palsy or anticlaw splint is used, and dynamic PIP extension assist may be added if PIP flexion contractures are present.
    b. A padded antivibration glove can be used during activity to protect from further nerve irritation.
    c. Activity modification includes ergonomic handles, gel pads, and padding on handles of vibratory equipment (e.g., lawn mower).
    d. Client education includes avoiding postures and activities that aggravate the condition, such as ulnar deviation combined with wrist flexion.
5. Postoperative treatment
    a. Bulky dressing is applied for 3–10 days.
    b. Splints
        i. Dorsal blocking splint maintains the wrist at 20°–30° flexion; an MCP block maintains 45° flexion to protect nerve repair.
        ii. Splint is adjusted at 3–6 weeks to increase wrist position to neutral.
        iii. Discontinue the splint at 6 weeks.
        iv. Use of the splint continues until muscle function returns.
    c. Wound care and scar mobilization are performed.
    d. Sensory desensitization begins when the wound has healed and stitches are removed.
    e. AROM of the wrist and hand begins at 6 weeks; clients may resume ADLs and begin muscle strengthening and work conditioning, if needed.
    f. Sensory reeducation begins at 10–12 weeks post surgery, once protective sensation has returned.
    g. Tendon transfer is done if the nerve has not regenerated within 1 year. After surgery, the OT practitioner may provide EMG biofeedback, NMES, and instruction in avoiding substitution of movement patterns (Kasch & Walsh, 2013, p. 1053)

B. Cubital tunnel syndrome

1. Cubital tunnel syndrome is caused by proximal ulnar nerve compression at the elbow between the medial epicondyle and the olecranon process. It is the second most common nerve compression of the UE after carpal tunnel syndrome.
2. Causes include fracture or dislocation of the elbow, osteoarthritis, rheumatoid arthritis, diabetes, alcohol abuse, tourniquets, and assembly-line work.
3. Sensation is decreased in the little finger and ulnar half of the ring finger.
4. Motor problems may include decreased grip and pinch strength because of weak interossei, adductor pollicus, and flexor carpi ulnaris muscles.
5. Nonoperative treatment
    a. Edema control
    b. Pain management

c. Elbow splint or positioning at 30°–70° flexion for 3 weeks, forearm and wrist in neutral, and digits free
d. Ulnar nerve gliding
e. Proximal conditioning activities
f. Posture and ergonomic training

6. Postoperative treatment
   a. Therapy following cubital tunnel release in situ will focus on addressing pain or hypersensitivity; typically no ROM restrictions.
   b. If an endoscopic release is performed, postoperative splinting is usually not ordered and the client is encouraged to begin AROM and nerve gliding within the symptom-free range.
   c. If an ulnar nerve transportation was performed, the need for orthotics, activity restrictions, and a postoperative therapy program is based on the type of surgery, and the surgeon will dictate the course of rehabilitation.

VII. Double crush syndrome

A. Occurs when a peripheral nerve is entrapped in more than one location.

B. *Symptoms:* intermittent diffuse arm pain and paresthesia with specific postures

C. *Nonoperative treatment:* treat according to each nerve injury or syndrome. Avoid movements or postures that aggravate the symptoms. Nerve-gliding exercises and exercises for scapular stability, posture, and core trunk strengthening are recommended.

VIII. Elbow, wrist, and hand tendinopathies (McQueen & Pemberton, 2020, pp. 311–319)

A. de Quervain syndrome

1. de Quervain syndrome is caused by cumulative microtrauma resulting in tenosynovitis of the thumb muscle tendon unit, the abductor pollicis longus and extensor pollicis brevis, and the tendons in the first dorsal compartment of the wrist.
2. Causes include forceful, repetitive thumb abduction with wrist ulnar deviation, carpometacarpal (CMC) osteoarthritis, scaphoid fracture, intersection syndrome, or radial nerve neuritis.
3. At highest risk are women ages 35–55; women in late pregnancy; mothers of young children; and people who engage extensively in keyboarding, piano playing, knitting, needlepoint, and racket sports.
4. Finkelstein's test: instruct the client to flex the thumb into the palm of the hand, then ulnar deviate the wrist; test is positive if symptoms are reproduced.
5. Nonoperative treatment
   a. Medical treatment includes corticosteroid injections.
   b. Forearm-based thumb spica splint with wrist in neutral and thumb in opposition; thumb IP should be left free. Orthosis should be worn during the day as much as possible and always worn at night for 4 to 6 weeks.
   c. Activity modification and avoidance of pinch are recommended.

d. Once pain and swelling are addressed after orthosis wear and activity modification, stretching and ROM are initiated. If stretching and ROM do not exacerbate symptoms, strengthening exercises commence, beginning with isometrics, advancing to light weight (1–2 lb), and progressing to full weight bearing.
e. Ergonomic education.

6. Operative treatment
   a. Surgical intervention is recommended if two corticosteroid injections combined with 6 months of conservative management do not relieve symptoms.
   b. Medical treatment includes surgical release of the first dorsal compartment.
   c. Postoperative therapy may be initiated 10 to 14 days after surgery.
   d. Active and active assisted ROM exercises may be introduced 2 weeks after surgery.
   e. Progressive strengthening program may be initiated 4 weeks after surgery.
   f. Scar management and desensitization techniques are used.

B. Digital stenosing tenosynovitis (trigger finger)

1. Trigger finger occurs with sheath inflammation or nodules near the A1 pulley.
2. Described as "snapping," "popping," or "catching" of the flexor tendon during finger movement.
3. Nonoperative treatment
   a. Splinting the MCP at 0°–15°
   b. Avoidance of activities that cause pain and triggering
   c. Home exercise program including passive PIP and DIP joint flexion, active composite full-finger flexion, both active and passive full-finger extension, and active hook fisting.
   d. Steroid injection into tendon sheath.
4. Operative treatment
   a. Surgically releasing the A1 pulley
   b. Clients will be able to return to normal activities 1 to 4 weeks following surgery.
   c. Most do not require therapy services after an A1 pulley release. If it is required, it is due to decreased motion from a PIP joint flexion contracture, scar tenderness, or generalized limited hand motion.

IX. Assessment of sensory function after nerve injury

A. Semmes-Weinstein monofilament testing

B. *Two-point discrimination testing:* assess client's ability to discriminate between one point and two points of pressure applied randomly to the fingertip

C. Localization of touch

D. *Moberg pickup test:* timed test involving picking up, holding, manipulating, and identifying small objects. It is used with children and adults with cognitive impairment to test median nerve function.

E. *Hoffman-Tinel's sign:* tap on the median nerve at the wrist to elicit symptoms; test distal to proximal for best accuracy.

X. Sensory reeducation after nerve injury

A. *Protective reeducation* teaches clients to visually compensate for sensory loss and to avoid working with machinery and temperatures below 60°.

B. *Discriminative reeducation* uses motivation and repetition in a visual–tactile matching process in which clients identify objects with and without vision.

C. *Sensory recovery* begins with pain perception and progresses to vibration of 30 cycles per second, moving touch, and constant touch.

D. *Desensitization* is a process of applying different textures and tactile stimulation to reeducate the nervous system so that clients can tolerate sensations during functional use of the UE.

Considerations of Pain and Trauma With Hand and UE Injuries

I. Complex regional pain syndrome (CRPS; Stralka, 2020, pp. 490–494)

A. Definition: pain disproportionate to an injury that is either sympathetically maintained or independent of the sympathetic nervous system (formerly called reflex sympathetic dystrophy).

B. Types of CRPS

1. *Type I*: No definitive evidence of a major nerve injury; can occur spontaneously
2. *Type II*: Develops after a nerve injury.

C. CRPS Symptoms

1. Neuropathic pain (spontaneous burning pain)
2. Allodynia (sensation misinterpreted as pain)
3. Hyperalgia (increased response to painful stimuli)
4. Hyperpathia (exaggerated, sometimes delayed response to sensory stimuli)
5. Edema
6. Contractures
7. Bluish or red, shiny skin
8. Abnormal sweating and hair growth
9. Muscle spasms
10. Decreased strength
11. Low tolerance for activity.

D. Medical treatment of CRPS

1. *Stellate or sympathetic block:* an injection of local anesthetic into the front of the neck or lumbar region of the back to block pain
2. *Intrathecal analgesia:* injection of pain medication into the spinal canal
3. *Removal of neuroma:* surgery to remove a thickened nerve
4. *Installation of spinal cord stimulator:* a small electrical pulse generator implanted in the back to control pain

5. *Installation of peripheral nerve stimulator:* electrodes placed on the peripheral nerves to send electrical impulses to control pain.

E. Rehabilitation of CRPS

1. Gentle, pain-free AROM for short periods; no PROM or painful treatment
2. *Stress loading:* for example, scrubbing the floor, carrying a weighted handbag
3. *Pain control techniques:* TENS, splinting (static, then dynamic as tolerated), continuous passive motion
4. *Edema control techniques:* elevation, massage, AROM, contrast baths, compression
5. Desensitization techniques, fluidotherapy
6. Mirror therapy with cortical audio-tactile interaction
7. Blocked exercises, tendon gliding
8. Joint protection, energy conservation
9. Consideration of mind–body connection, including cognitive–behavioral techniques, mindfulness, relaxation, and diaphragmatic techniques
10. Best managed with multidisciplinary approach that includes a physician who specializes in treating neuropathic pain and CRPS.

II. Cumulative trauma disorder (CTD; Kasch & Walsh, 2018, pp. 995–1000)

A. *Definition:* trauma to soft tissue caused by repeated force (also called *overuse syndrome* and *repetitive strain injury*). CTD indicates the mechanism of injury but is not a diagnosis.

B. *Diagnoses:* tendinitis (e.g., lateral epicondylyitis or de Quervain's tenosynovitis); nerve compression syndromes (e.g., carpal tunnel syndrome or cubital tunnel syndrome); myofascial pain

C. *Work-related risk factors:* repetition, high force, direct pressure, vibration, cold environment, poor posture, cis-female gender, and prolonged static position

D. *Symptoms:* muscle fatigue, pain, chronic inflammation, sensory impairment, and decreased ability to work

E. Five grades (I–V) according to severity

1. *Grade I:* Pain after activity, resolves quickly, no decrease in amount or speed of work
2. *Grade II:* Pain during activity, resolves when activity stopped
3. *Grade III:* Pain persists after activity and affects work productivity; objective weakness and sensory loss
4. *Grade IV:* Use of extremity results in pain up to 75% of time, work is limited
5. *Grade V:* Unrelenting pain, unable to work.

F. Occupational therapy intervention

1. *Acute phase:* reduction of inflammation and pain through static splinting, ice, contrast baths, ultrasound phonophoresis, iontophoresis, and high-voltage electric and interferential stimulation

2. *Subacute phase:* slow stretching, myofascial release, progressive resistive exercise as tolerated, proper body mechanics, education on identifying triggers and returning to acute phase treatment with flareups; static splint during activities that cause pain
3. Return to work
   a. Assessment of job site, tools used, and body positioning
   b. Therapy using a work simulator, weight well, elastic bands, putty, functional activities, and strengthening activities
4. Functional capacity evaluation
5. Work hardening
6. Consider psychosocial effects of hand injuries: evaluate and provide interventions as appropriate; facilitate referral to an appropriate mental health professional as indicated.

Splinting (Coppard & Lohman, 2020, pp. 2–12)

I. Overview of splinting

A. Definition

1. A *splint* is an orthopedic device designed, fabricated, or selected in conjunction with a client to temporarily support, protect, or immobilize a body part.
2. Splints and other orthoses can be classified as *articular* or *nonarticular* according to the location, direction, purpose, type, or number of joints included.
3. Splints should be comfortable and lightweight, aesthetically pleasing, and convenient to use; they should enable participation in valued occupations.

B. Evaluation

1. Splinting evaluations may include chart or medical report review, interview and observation of the client, palpation, occupational assessment (e.g., Canadian Occupational Performance Measure [Law et al., 2019]), and assessment of the following components: pain, edema, sensation, ROM, muscle strength, coordination, functional use, and psychosocial issues.
2. Other considerations are work status, motivation, social support, and reimbursement source.

II. Fabrication principles (Lashgari et al., 2018, pp. 744–754)

A. Material properties of low temperature thermoplastics include elasticity, memory, bonding, durability, rigidity, perforations, finish, color, and thickness.

B. Patterns are drawn by outlining the body part and then adding or subtracting from the outline to adjust for the position in which the body part will be held. Bony landmarks are indicated on the pattern.

C. Molding the splint to the client may involve adding closed-cell padding before conforming the splint to the body part and using gravity as an assist. For hand splints, the longitudinal, distal, and proximal transverse arches of the hand are maintained.

D. Finishing the splint requires applying reinforcement if necessary, rounding all corners, flaring the edges, applying appropriate rounded end straps, adding open-cell padding when appropriate, and making adjustments.

E. The practitioner instructs the client and caregiver in wear and care of the splint, gives contact information for consultation if problems occur, and monitors the client's responses to splint wear.

III. Types of splints (Cooper, 2020, pp. 1–14; Coppard & Lohman, 2020; Hock & DeMott, 2021, pp. 431–465; Lashgari et al., 2018, pp. 741–742; Schwartz, 2020, pp. 89–99)

A. Static splints, static-progressive splints, and serial casting have no moving parts.

B. Resting hand splints maintain the wrist in extension, thumb in abduction, MCP joints in flexion, and PIP and DIP joints in slight flexion.

C. Antideformity resting hand splints (burn intrinsic plus) maintain the wrist in neutral position or extension, the MPs in flexion, the IPs in extension, and the thumb in abduction with opposition.

D. Ball or cone antispasticity splints are ulnar or volar based and provide thumb palmar or radial abduction; a hard surface in contact with finger flexors; and serial casting for the wrist, elbow, knee, or ankle to decrease soft tissue contractures.

E. Wrist cock-up splints (dorsal or volar wrist immobilization) maintain hand arches, full thumb movement, and full MP flexion.

F. Thumb spica splints (volar thumb or radial gutter thumb immobilization) are used on the long or short opponens to provide CMC immobilization.

G. Finger splints include PIP extension (i.e., Boutonniere, Capener, prefabricated dynamic extension assist, and serial casting) splints, PIP flexion splints, PIP hyperextension block (swan neck) splints, DIP extension (mallet finger, serial casting) splints, DIP flexion splints, and silver ring splints.

H. Elbow splints include anterior and posterior elbow immobilization splints.

I. Knee extension splints provide posterior full knee extension to the extent possible.

J. Ankle splints include foot-drop splints to maintain 90° ankle dorsiflexion and ankle–foot orthoses.

K. Nerve injury splinting

1. *Carpal tunnel syndrome:* wrist in neutral to 10° extension
2. *Ulnar nerve at wrist:* block fourth and fifth MCPs to 30°–45° flexion to prevent hyperextension
3. *Radial nerve injury:* cock-up splint, with dynamic finger extension assist optional
4. *Pronator syndrome:* forearm and wrist neutral, elbow in 90° flexion
5. *Anterior interosseous:* forearm neutral, elbow in 90° flexion
6. *Radial tunnel syndrome:* wrist in 30° extension, forearm supinated, elbow in 90° flexion

IV. Special considerations for splinting

A. *Pediatric:* Consider age, frame of reference, and child's environment; make the splint appealing to the child by using colored materials or drawing animals on it; limit fit time by using a cold pack to set the splint more quickly; consider using a soft splint (Elias, 2020)

B. *Geriatric:* Consider age, frame of reference, client's environment, existing medical issues, any cognitive or perceptual deficits, low vision, hearing impairments, pain perception, thinning of skin and decreased adipose tissue, and any medication side effects; use stockinette under splint, pad splint well, soft straps, label splint (Riley & Lohman, 2020).

C. Dynamic splints have moving parts, and soft splints allow movement. Dynamic splints are designed to correct contractures, increase passive motion, protect recent surgery, or substitute for lost active motion.

1. *To correct contractures:* mechanical stretch of prolonged gentle pull over 8–12 hours to remodel soft tissue.
2. *To increase passive motion:* finger loop angle of pull of 90°; adjust splint as client improves to maintain 90° angle of pull.
3. *To protect recent hand flexor tendon repair surgery:* dorsal blocking splint can be used.
4. *To substitute for lost active motion:* radial nerve injury splint, with dynamic MCP extension assist if needed.

D. A soft, circumferential orthosis improves client compliance with wearing it.

1. Carpal tunnel wrist support
2. Antivibration gloves
3. Neoprene wrap thumb support for CMC osteoarthritis and de Quervain syndrome
4. Forearm bands for medial and lateral epicondylitis
5. MCP anti–ulnar deviation splints for rheumatoid arthritis
6. Buddy taping: Binding the injured finger to a healthy one to retain positioning for healing
7. Neoprene tube digit extension splint
8. Pediatric neoprene thumb abductor and supinator TheraTogs (TheraTogs, Inc., Telluride, CO; Elias, 2020)

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