The hand is a gateway to the vast majority of our physical experiences and interactions. However, the hand is a delicately balanced organ, and when one structure is injured, the system as a whole falters. Given the variety of tissues in the hand, including soft tissue, blood vessels, nerves and bone, plastic surgeons are intimately involved in the surgical care of the upper extremity. Plastic surgeons have been pioneers in the field of hand surgery since its earliest days, from traumatic reconstruction to hand transplantation. A basic understanding of hand anatomy and care is essential to not only plastic surgery, but also orthopedics, emergency and family medicine.

I. HAND ANATOMY

A. Nerves
   1. Sensory - median, ulnar, radial (Figure 1)
   2. Motor - intrinsic muscles of hand
      a. Median nerve - thenar muscles, radial lumbricals
      b. Ulnar nerve - interossei, ulnar lumbricals, hypothenar muscles

B. Muscles and tendons
   1. Flexor system (Figure 2)
      a. Extrinsic flexors - Flexor digitorum profundus attaches to distal phalanx and bends the DIP (distal interphalangeal) and PIP (proximal interphalangeal) joints. Flexor digitorum superficialis attaches to middle phalanx and bends PIP joint.
b. Intrinsic flexors - Lumbricals bend the MCP (metacarpal-phalangeal) joints

Figure 2. Flexor tendon system


2. Extensor system (Figure 3)
   a. Extrinsic extensors join the extensor hood at the proximal phalanx, and extend the proximal phalanx at the MCP joint.
   b. Intrinsics (interossei and lumbricals) pass volar to the axis of the MCP joint (where they act as flexors) and move dorsal to the axis of the PIP joint to
insert on the dorsal distal phalanx. They act as extensors to the PIP and DIP joints.

Figure 3. Extensor tendon system

C. Skeleton (Figure 4)

Figure 4. Bony skeleton
D. Wrist – a large number of tendons, nerves and vessels pass through a very small space, and are vulnerable to injury (Figure 5).

Figure 5. Extensor compartments of the hand: (1st) APL, EPB; (2nd) ECRL, ECRB; (3rd) EPL; (4th) EDC; (5th) EDQ; (6th) ECU


II. INITIAL EVALUATION OF THE INJURED HAND

A. Evaluation of ABC’s
   1. Hand injuries are frequently associated with multisystem trauma, the patient must be stable and cleared from a trauma standpoint before further evaluation

B. History
   1. Time and place of accident
   2. Mechanism of injury (position of hand while injured)
   3. First aid given
   4. Right or left-hand dominance
   5. Occupation
   6. Age

C. Examination
   1. Observation
      a. Position of fingers - normally slightly flexed. An abnormally straight finger might indicate a flexor tendon injury (the unopposed extensors hold the finger straight)
      b. Sweating patterns (lack of perspiration may indicate denervation)
      c. Anatomic structures beneath the injury
2. Sensory - must test prior to administering anesthesia
   a. Pin to measure sharp/dull sensitivity, paper clip to measure two point discrimination in millimeters
   b. Test all sensory territories (median, ulnar, radial)
   c. Test both sides of each finger to test radial and ulnar sided digital nerves
3. Motor
   a. Profundus - stabilize PIP joint in extension, ask patient to flex fingertip (Figure 6)
   b. Superficialis - stabilize other DIP joints in extension. This neutralizes profundus action.
      i. Ask patient to flex unstabilized finger (Figure 7)
   c. Motor branch of median nerve; test palmar abduction of thumb against resistance
   d. Motor branch of ulnar nerve; ask patient to fully extend fingers, then spread fingers or cross fingers
   e. Extensor tendons
      i. Ask patient to extend fingers at MCP joints (tests long extensors)
      ii. Ask patient to extend PIP, DIP joints with MPs flexed (tests intrinsic extensors)
Figure 7. Testing superficialis function

4. Vascular
   a. Color – nailbed should be pink, blanch with pressure, and show capillary refill around two seconds
   b. Temperature – finger or hand should be similar in temperature to uninjured parts
   c. Turgor – pulp space should be full without wrinkles
   d. Pulse oximetry/Doppler are useful adjuncts to physical exam findings

D. Early care
   1. Use pneumatic tourniquet or BP cuff inflated to 250mmHg to control bleeding for examination and treatment. An awake patient will tolerate a tourniquet only for a short period (<30 min)
   2. If there is significant blood loss, apply pressure, wrap with a pressure dressing to the affected area and slightly proximally
      a. Do not clamp vessels
      b. Lidocaine with epinephrine can aid in exploration but only after neuro examination is completed
      c. Tourniquet may be used as last resort, but must be released intermittently
   3. Splint in safe position if possible (Fig. 6-8)
      a. Position where collateral ligaments are at maximum stretch, so motion can be regained with least effort Fig. (6-6)
      b. Positioning - wrist extended (30 degrees), MCP joints flexed (60-70 degrees), IP joints straight, thumb abducted and rotated in opposing position
      c. Proper splinting prevents further injury, prevents vessel obstruction, prevents further tendon retraction
   4. All flexor tendon, nerve and vascular injuries, open fractures, and complex injuries are managed in the operating room
      a. Many injuries can be treated in the emergency department or clinic using field blocks, digital blocks or wrist blocks
   5. Tetanus prophylaxis and antibiotic coverage as indicated

Figure 8. Position of safety

E. Definitive treatment
1. Thorough cleaning of entire hand and forearm, with wound protected
2. Apply sterile drapes
3. Inspect wound - use tourniquet or BP cuff for hemostasis
4. Wound irrigation with normal saline
5. May need to extend wound to inspect all vital structures
6. Assure hemostasis with fine clamps and cautery
7. Nerve injuries should be repaired with magnification
8. Tendons are repaired primarily.
   a. Flexor tendon injuries in Zone II, "no man's land" (Figure 9), should be repaired by a trained hand surgeon
   b. If a hand surgeon is not available, clean and suture the skin wound, splint the hand, and refer as soon as possible for delayed primary repair. Repair should be done within 10 days
9. Reduce fractures and dislocations, apply internal or external fixation if needed
10. Postoperative dressings
    a. Splinting should be in safe position when possible, but alternative positioning may be required to protect tendon or nerve. Splint extensor tendon repairs in extension, and dorsal blocking splint for flexor tendon repairs
    b. Dressings should not be tight

Figure 9. Flexor zones of the hand
III. SPECIAL INJURIES

A. Fingertip - most common injury
   1. Tip amputations
      a. Basic principles - maintain length, bulk and sensibility
      b. Treatment options include secondary healing, skin graft, flap
   2. Nailbed injury
      a. Nailbed typically repaired with fine chromic gut suture
      b. Nail can be cleaned and replaced as a splint, or silastic sheet used as splint to prevent adhesion of the eponychial fold to the nailbed

B. Amputation
   1. Indications for replantation – thumb, multiple fingers, and children. Single finger replantations often not indicated. Must discuss with replant team.
   2. Care of amputated part
      a. Remove gross contamination and irrigate with saline
      b. Wrap part in gauze moistened in saline, place in clean plastic bag or specimen cup, seal
      c. Lay container on ice, or float on ice cubes in water. Don't immerse part directly in ice water or pack directly in ice – it may freeze
   3. Care of patient
      a. Do not clamp vessels
      b. Supportive care
      c. X-ray stump and amputated part

C. Burned hand
   1. Initial treatment
      a. Cleanse wound, debride broken blisters
      b. Evaluate blood supply - circumferential full thickness burns may require escharotomy
      c. Apply occlusive dressings to reduce pain
      d. Immobilize in safe position
      e. Refer to plastic surgeon if burn is extensive or may require grafting
   2. Hand therapy may be needed to maintain motion

IV. INFECTIONS

A. General principles
   1. Infection can be localized by finding:
      a. The point of maximum tenderness
      b. Signs of local heat
      c. Overlying skin edema
      d. Pain on movement
   2. A fever usually denotes lymphatic involvement
   3. Pressure from edema and purulent fluid in a closed space can produce necrosis of tendons, nerves, blood vessels, and joints in a few hours. Extreme cases can lead to amputation and even death.
4. Beware and alert for signs of necrotizing soft tissue infection!

B. Treatment principles
   1. Surgical drainage, cultures
   2. Immobilization in safe position, elevation
   3. Antibiotics

C. Special infections
   1. Paronychia - infection of the lateral nail fold Treatment: if early, elevation of skin over nail to drain. If late, with pus under nail, must remove portion of nail
   2. Felon
      a. Infection pulp space of fingertip - closed space without ability to expand - very painful
      b. Treatment is drainage over point of maximal tenderness laterally
         i. Septate of pulp must be divided to ensure drainage
   3. Subcutaneous abscess – incise and drain with care not to injure digital nerve. Be alert to possibility of foreign body
   4. Tenosynovitis – infection of tendon sheath. Should be treated as surgical emergency.
      a. Diagnostic signs (Kanavel’s signs)
         i. Fusiform swelling of finger
         ii. Finger held in slight flexion
         iii. Pain with passive extension
         iv. Tenderness over flexor tendon sheath (look for proximal swelling and pain along palm and forearm)
      b. Treatment is to open and irrigate tendon sheath. Untreated infection can destroy the tendon within hours
      c. Broad Spectrum Antibiotics

5. Human bite
   a. Have high index of suspicion – patients are often unwilling to admit being in a fight. Most common site over a knuckle
   b. Debride, cleanse thoroughly, culture
   c. Must rule out penetration of joint space – may need to explore in OR
   d. IV antibiotics for severe cases (Ampicillin-sulbactam most commonly used)
   e. Do not close wound

V. FRACTURES

A. General principles
   1. Inspect, palpate, x-ray in multiple planes – AP, true lateral, oblique
   2. Reduce accurately
   3. Immobilize for healing – for appropriate time period
   4. Hand therapy to maintain motion – immobilization leads to stiffness

B. Specific fractures
   1. Metacarpal fractures
      a. Generally unstable fractures, can accept 10-40 degrees of angulation, if no malrotation present.
i. Malrotation/scissoring – have patient make a fist slowly, if involved finger overlaps another, there is rotation at the fracture site which must be reduced.
b. If angulation/malrotation are acceptable – treatment with splinting with buddy taping may be sufficient
c. If fracture is unstable and in poor alignment closed fixation with pins or open reduction with plates and screws may be performed
d. Special fracture - Boxer's fractures - 5th metacarpal neck.
   i. Misnomer as a boxer does lead their punch with their 5th MCP!
   ii. Frequently a striking injury (look for signs of bite injury)
2. Phalangeal fractures
   a. Unstable fractures require internal or percutaneous fixation
   b. Joint surfaces should be anatomically reduced
3. Tuft fractures (distal phalanx)
   a. If crushed, mold to shape
   b. Repair associated nailbed injury if needed
c. Splint for comfort (DIP only) for 1-2 wks

VI. JOINT INJURIES

A. Dislocation
   1. If already reduced, test for stability through arc of motion. Test collateral ligament stability with radial and ulnar stressing at affected joint. Test MPJ in flexion and IP joints in extension. Compare laxity to contralateral side to establish baseline.
   2. Most can be treated with closed reduction; open reduction can be necessary if supporting structures prevent the reduction (e.g. metacarpal head through extensor mechanism)
B. Ligamentous injury - usually lateral force
   1. Gamekeeper's thumb - rupture of ulnar collateral ligament of MCP joint
   2. Wrist injury - multiple ligaments can be involved. Diagnosis may require MRI arthrogram or arthroscopy. Clinical diagnosis by pattern of pain, x-rays, palpation for abnormal movement.
C. Treatment
   1. Immobilize 2-3 weeks for digital joint injury (MP or IP dislocation), then protected motion
   2. Thumb MPJ and wrist sprains require 6 weeks immobilization. (some, e.g. thumb ulnar collateral ligament, might need operative repair)

VII. CONGENITAL DEFECTS

A. Common defects
   1. Polydactyly - most common. Duplication of fingers, usually border digits. Duplication of 5th finger is common autosomal dominant trait in African-Americans. Thumb duplication often requires reconstructive surgery
2. Syndactyly - 2nd most common - May be simple, involving skin only, or complex, involving bone

B. Treatment - goal to decrease deformity and improve function
   1. Some problems are treated in infancy – e.g. splinting for club hand, thumb reconstruction
   2. Some treated by 12 months, before handedness develops – e.g. separation of syndactyly
   3. Some require multi-stage procedures – e.g. club hand

VIII. HAND TUMORS

A. Benign
   1. Ganglion cysts – most common tumor of upper extremity
      a. Synovial cyst of joint or tendon sheath
      b. Most common location scapholunate ligament
      c. Treatment is observation, aspiration or excision (aspiration with high recurrence –less so in children)
   2. Giant cell tumor – 2nd most common tumor, arises from proliferation from tendon sheath
   4. Bone tumors – enchondroma, Osteoid osteoma

B. Malignant
   1. Skin cancers (e.g. basal cell, squamous cell, melanoma)
   2. Malignant bone tumors are uncommon in hand

IX. MISCELLANEOUS

A. Rheumatoid arthritis
   1. Synovial hypertrophy can lead to nerve compressions (carpal tunnel syndrome), joint destruction.
   2. Hand surgeons can perform synovectomy, joint replacement, carpal tunnel release
      a. Disease modifying drugs have lessened the need for surgical intervention in these patients

B. Dupuytren’s contracture
   1. Fibrous contraction of palmar fascia causes flexion contractures of fingers
   2. Treatment is surgical excision, percutaneous release with a needle or Xiaflex (collagenase) for MCP contractures

C. Nerve compressions – compression of nerve by overlying muscle, ligament or fascia
   1. Common examples:
      a. carpal tunnel – compression of median nerve by transverse carpal ligament
      b. cubital tunnel – compression of ulnar nerve at elbow by Osborne’s ligament
2. Diagnosis by symptoms, exam, and EMG
   a. Tinel's sign - percussion of area leads to radiating pain through nerve distribution
   b. Muscle wasting of hands (intrinsiccs for ulnar nerve compression, thenar for median nerve)
3. Treatment options include splinting, NSAIDs, steroid injections, surgical release

REFERENCES