PLASTIC SURGERY

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STAGES OF WOUND HEALING

- ❑ inflammatory phase - 0-2 days
  - debris and organisms cleared via inflammatory response e.g. macrophages, granulocytes
- ❑ re-epithelialization phase - 2-5 days
  - from edges of wound and from dermal appendages i.e. pilo-sebaceous adnexae
  - epithelial cells migrate better in a moist environment, i.e. wet dressing
- ❑ proliferative phase - 5-42 days
  - fibroblasts attracted to wound by macrophages
  - collagen synthesis by fibroblasts leads to increasing tensile strength
  - granulation tissue formed with neovascularization
- ❑ remodeling phase - 6 weeks-1 year
  - collagen cross-links, scar flattens
  - at 6 months, tissue strength plateaus at 80% of normal tissue strength

ABNORMAL HEALING

- ❑ occurs in areas where skin is under tension
- ❑ hypertrophic scars
  - hypertrophic tissue does not cross the boundaries of the scar
  - common sites include back, shoulder, sternum
  - red, raised, frequently pruritic
  - treatment is conservative
  - amenable to surgical revision
- ❑ keloid scars
  - tissue extends beyond the scar boundaries
  - common sites include sternum, deltoid, earlobe
  - collagen: whorls rather than bundles
  - increased frequency in darker skinned people
  - treatment: pressure, silicone sheets, topical steroids, intradermal steroid injection, intralesional excision and marginal steroid injection
  - may recur with surgical revision

FACTORS INFLUENCING WOUND HEALING

Local:
- ❑ trauma
- ❑ tension
- ❑ infection
- ❑ hematoma/seroma
- ❑ blood supply
- ❑ retained foreign body
- ❑ previously irradiated tissues

General:
- ❑ nutrition
- ❑ chronic illness
- ❑ steroids
- ❑ diabetes
- ❑ chemotherapy
- ❑ immunocompromise

WOUND CLOSURE

Primary Healing (First Intention)

- ❑ definition: wound closure by direct approximation within hours of wound creation (i.e. with sutures, flap, skin graft, etc...)
- ❑ indication: clean wounds

Secondary Healing (Second Intention)

- ❑ definition: wound left open to heal by granulation, epithelialization and contraction (myofibroblasts)
- ❑ indication: when primary closure is not possible or not indicated for any reason, including infection, delay in medical attention, loss of skin
- ❑ inferior cosmetic result, requires dressing changes, psychological impact of open wound

Tertiary Healing (Delayed Primary Closure)

- ❑ definition: intentionally interrupt healing process (i.e. with packing), then wound is usually closed at 4-10 days post-injury
- ❑ indication: contaminated wounds where initial primary closure is contraindicated
- ❑ prolongation of inflammatory phase lowers bacterial count and lessens chance of infection after closure

MANAGEMENT OF CONTAMINATED WOUNDS

- ❑ wound is considered contaminated when it contains more than 100 000 bacteria/gram
- ❑ acute contaminated wound (should be closed within 6-8 hours post injury depending on the state of the wound)
    - most can be closed with primary intention after adequate debridement (i.e. blade, irrigation)
    - cleanse and copiously irrigate open wound with physiologic solutions i.e. normal saline or Ringer's (no soap, alcohol, or other irritants)
    - contraindications to primary closure: animal and human bites, crush injuries
    - +/– systemic antibiotics (see Emergency Medicine Notes)
    - +/– tetanus (Tetanus toxoid 0.5 mL IM)
        - always check tetanus immunization status: reimmunize if patient has received less than three tetanus immunizations, if the last Td was more than 10 years ago, or if last Td unknown
        - if high risk wound (e.g. soil equipment, major trauma) then reimmunize if last Td was more than 5 years ago
    - wound closure with monofilament
    - follow up in 48 hours
- ❑ chronic contaminated wounds (e.g. lacerations > 24 hours, ulcers)
    - debridement: mechanical (e.g. "wet-to-dry" dressings), or surgical
    - frequent dressing changes
    - topical antibacterial creams (see Table 7)
    - systemic antibiotics are not useful - no penetration into the bed of granulation tissue
    - final closure via delayed wound closure or skin graft
    - successful closure depends on changing a chronic wound to an acute wound by decreasing bacteria count to 100 000/gram or less

DRESSINGS

- ❑ goals are absorption, protection, compression, acceptable cosmesis
- ❑ 1st layer (contact layer)
    - clean wounds: heal by re-epithelialization. First layer is nonadherent to protect new tissues (impregnated gauze such as Jelonet, Bactigras or Sofratulle)
    - chronic wounds: initial goal is debridement of nonviable tissue. First layer is Saline or Betadine soaked gauze —> dead tissue adheres to gauze and is removed with dressing change (known as "wet-to-dry" dressing)
- ❑ 2nd layer (absorbent layer)
    - saline soaked gauze, to encourage exudate into dressing by "wick" effect
- ❑ 3rd layer (protective layer)
    - dry gauze held in place with roller gauze or tape

SUTURES AND SUTURING TECHNIQUES

Anesthesia

- ❑ lidocaine +/– epinephrine
- ❑ never use epinephrine for fingers, toes, penis, nose and ears
- ❑ inject anesthetic into, not around, wound before debridement and irrigation
- ❑ toxic limit of lidocaine:
    - without epinephrine 5 mg/kg/hour
    - with epinephrine 7 mg/kg/hour (1 cc of 1% solution contains 10 mg lidocaine)
- ❑ early signs of toxicity are excitation followed by convulsive activity, then depression, arrest, or death

Table 1. Suture Materials

Site	Subcutaneous	Cutaneous
Material	usually absorbable organic: catgut - plain or chromic synthetic: polyglycolic acid (Dexon, Vicryl)	nonabsorbable: nylon (Dermalon) absorbable: fast-absorbing catgut
Advantages	decreased dead space (potential for abscess), decreased tension on more superficial sutures, hemostasis (less risk of hematoma/seroma)	good approximation of tissues, good eversion of wound edges, minimal tissue reaction to nylon, no need for removal if using catgut suture
Disadvantages	introduces foreign body (inflammation, source of infection), increased scar if used near skin surface	nylon sutures require removal, can leave marks if left in place too long, more time consuming than other methods (staples, glue)
Comments	organic sutures undergo enzymatic breakdown - causes more tissue reaction than synthetic sutures (hydrolytic breakdown); braided sutures offer more tensile strength but provide medium for infection	fast-absorbing catgut can be used for mucosal sutures, as well as in children provided there is minimal tension; surgical glue to be used only in wounds where there is very little tension; staples are very quick, but can move in place and irritate wound if not covered by proper dressing

Basic Suturing Techniques

❑ basic principles
- minimize tissue trauma: follow curve of needle, handle wound edges gently
- enough tension to approximate edges - do not strangulate
- use the finest needle and suture possible
- to avoid suture marks in skin
  - evert skin edges when closing
  - avoid tension on skin (close in layers)
  - follow lines of relaxed skin tension or skin crease lines if possible
  - keep sutures close to wound edges
  - remove sutures within 7-10 days; on face remove sutures in 5 days; over joints, remove sutures in 14 days
- to evert skin edges
  - enter the tissue with needle at right angles
  - take a bigger bite in the depth of the wound
  - take equal tissue on both sides of the wound
  - place knot to one side of the wound

❑ basic suture methods
- simple interrupted - face and when scarring is less important
- subcuticular - good cosmetic result, not as strong as interrupted
- vertical mattress - for areas difficult to evert (e.g. dorsum of the hand)
- horizontal mattress - everting, time saving
- continuous over and over - time saving

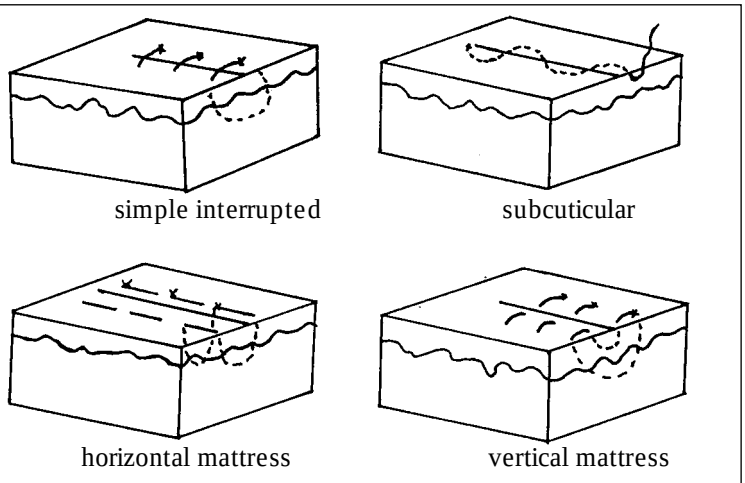

Figure 1. Basic Suture Methods

Drawing by Baseer Khan

SKIN GRAFTS

- ❑ definition: a segment of skin detached from its blood supply and transplanted to a recipient site (new blood supply)
- ❑ donor site selection
  - must consider size, colour, hair pattern, texture and thickness of skin required
  - usually taken from inconspicuous areas (e.g. buttocks, lateral thighs, etc...)
  - for facial grafts, preferable to take graft from above clavicle (e.g. post-auricular area)
- ❑ skin graft take occurs in 3 phases
  1. plasmatic imbibition - nourishment via diffusion (first 48 hours)
  2. inosculation - vessels in graft connect with those in recipient bed
  3. neovascular ingrowth - graft revascularized by ingrowth of new vessels into bed
- ❑ requirements for survival
  - bed: well vascularized (bone and tendon are unsuitable beds)
  - contact between graft and recipient bed : fully immobile
    - staples, sutures, splinting, and appropriate dressings (pressure) are used to prevent hematoma, seroma, and movement of graft
  - recipient site: clean (to prevent infection)
- ❑ types
  - autograft - from same individual
  - allograft - from same species, different individual
  - xenograft - from different species e.g. porcine

Table 2. Skin Grafts

	Split Thickness	Full Thickness
definition	epidermis and part of dermis	epidermis and all of dermis
donor site	more sites	limited donor sites
healing	re-epithelialization via dermal appendages	primary closure or split thickness skin graft
re-harvesting	~10 days (faster on scalp)	N/A
graft take	good; shorter nutrient diffusion distance	lower rate of survival
contraction	more	less
sensation	poor	good
aesthetic	poor	good
comments	can be meshed for greater area	use on face, fingers tips and over joints

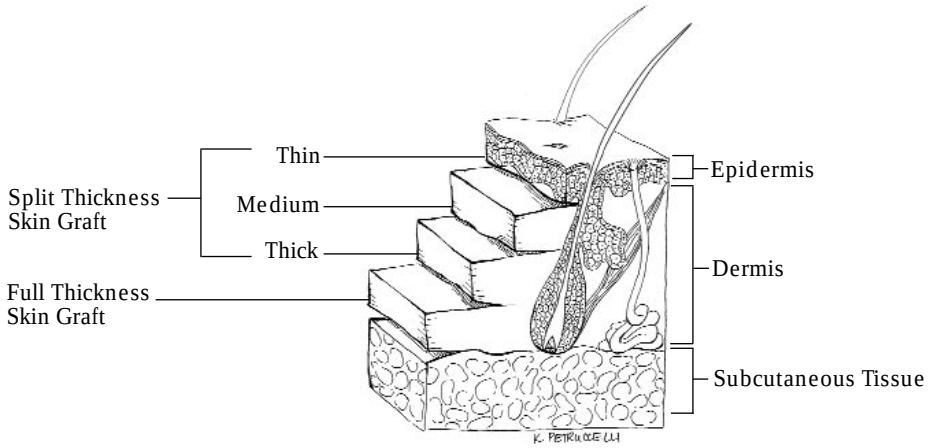

Figure 2. Split and Full (Whole) Thickness Skin Grafts

Drawing by Karen Petruccelli

OTHER GRAFTS

Table 3. Various Grafts

Graft Type	Use	Prefered Donor Site
Bone	repair rigid defects	cranial, rib, iliac, fibula
Cartilage	restore contour of ear and nose	ear, nasal septum, costal cartilage
Tendon	repair damaged tendon	palmaris longus, plantaris
Nerve	conduit for regeneration across nerve gap	sural, forearm, cutaneous arm
Vessel	bridge vascular gaps (i.e. free flaps)	forearm or foot vessels for small vessels, saphenous vein for larger vessels
Dermis	contour restoration (+/- fat for bulk)	thick skin of buttock or abdomen

FLAPS

- ❑ definition: tissue transferred from one site to another with vascular supply intact unlike a graft
- ❑ classified according to blood supply to skin: random and axial
- ❑ indications for flaps
  - soft tissue coverage i.e. padding bony prominences
  - reconstruction i.e. after facial, breast, or lower leg tissue loss
  - provide vascular recipient bed for skin graft
  - to improve blood supply to bed i.e. bone
  - improve sensation (nerves to skin flap intact)
- ❑ may require use of tissue expanders pre-operatively to increase available tissue (especially in scalp area)
  - consists of subcutaneous silicon reservoir into which saline is injected intermittently over several weeks

Random Pattern Flaps (see Figure 3)

- ❑ skin and subdermal tissue with random vascular supply
- ❑ limited length:width ratio to ensure adequate blood supply (on face 1.5:1, rest of body 1:1)
- ❑ rotation/transposition flaps
  - Z-plasty - used to gain or to change the line of direction of the central limb of Z (i.e. release of scar contractures)
  - Limberg
- ❑ advancement flaps (V-Y, Y-V, single/bipedicle)

Axial Pattern Flaps

- ❑ flap contains a well defined artery and vein
- ❑ allows greater length:width ratio (5-6:1)
  - a) peninsular flap - skin and vessel intact in pedicle
  - b) island flap - vessel intact
  - c) free flap - vascular supply anastomosed at recipient site by microsurgical techniques
- ❑ can be sub-classified according to tissue content of flap:
  - musculocutaneous/myocutaneous - vascular supply to skin from musculocutaneous perforating vessels
  - fasciocutaneous - vascular supply from plexus superficial to fascia

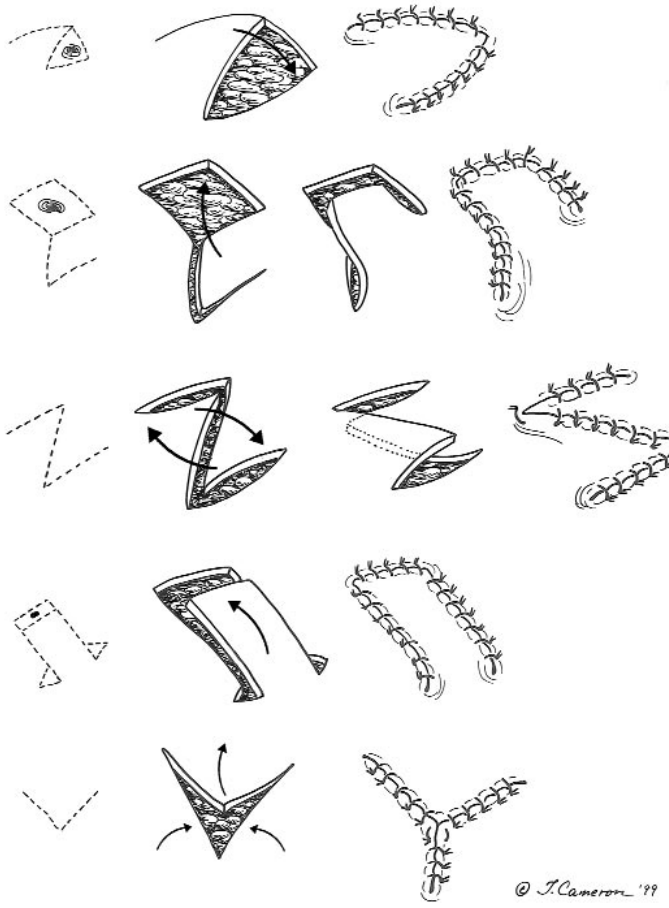

Figure 3. Wound Care Flaps

Drawing by Teddy Cameron

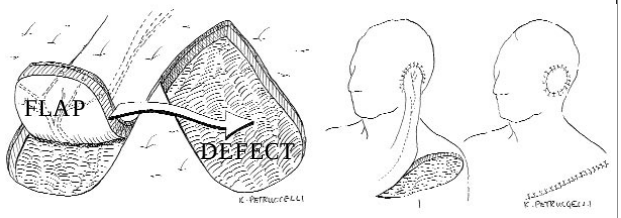

Figure 4a. Peninsular Axial Pattern Flap

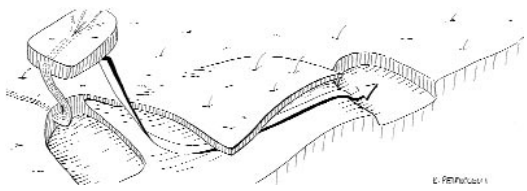

Figure 4b. Island Axial Pattern Flap

Drawings by Karen Petruccelli

THE HAND

HISTORY OF TRAUMA

- ❑ hand dominance, occupation, hobbies
- ❑ time, place (especially if at work), and mechanism of injury (position of hand, direction, duration and magnitude of force)
- ❑ visible arterial spurting at time of injury
- ❑ previous hand trauma/surgery
- ❑ tetanus status, meds, allergies, complicating conditions
- ❑ label digits thumb, index, middle, ring, little or D1-D5 respectively

GENERAL ASSESSMENT

- ❑ compare with unaffected region/hand
- ❑ neuromotor
  - hand (see Table 4)
  - fingers - assess digital nerves at distal tips with two-point discrimination on radial and ulnar aspects
- ❑ vascular
  - capillary refill (< 1 second), Allen's test, temperature, skin turgor, Doppler probe, colour
- ❑ tendons
  - each joint in the hand has a prime mover
  - palpate tendons
  - never test tendons against resistance if tendon laceration is suspected - let patient actively move joints themselves
- ❑ phalangeal fractures
  - look for a) rotation b) shortening c) overlap of fingers with flexion ("scissoring")

Table 4. Neuromotor Examination of the Hand

	Median	Ulnar	Radial
sensory	radial aspect of index finger pad	ulnar aspect of little finger pad	dorsal webspace of thumb
motor extrinsic	flex distal IP joint of index finger (flexor digitorum profundus)	flex distal IP joint of little finger (flexor digitorum profundus, extensor carpi radialis)	extend wrist and thumb (extensor pollicis longus)
motor intrinsic	thumb to ceiling with palm up (abductor pollicis brevis)	abduct index finger (first dorsal interosseous)	----------

Table 5. Tendon Examination of the Hand

	MCP	PIP	DIP
extensor tendons	Ext. dig. communis	Intrinsics (lateral bands)	Intrinsics (lateral bands)
flexor tendons	Intrinsics (lumbricals)	Flex. dig. superficialis	Flex. dig. profundus

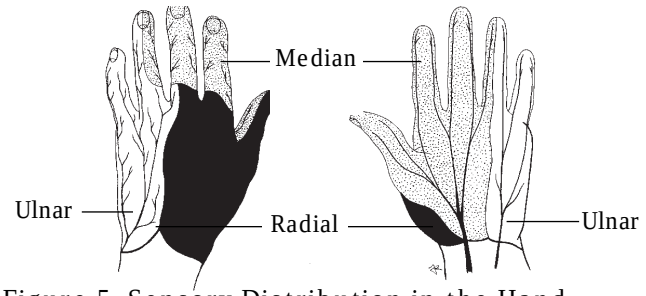

Figure 5. Sensory Distribution in the Hand

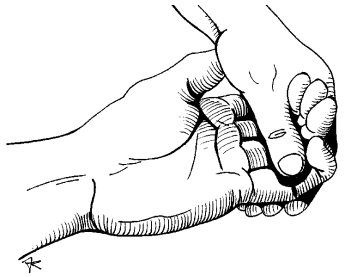

Figure 6. Testing Profundus

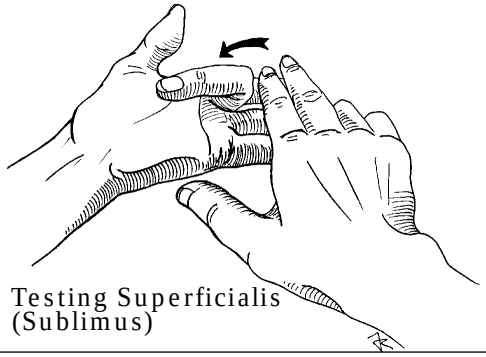

Figure 7. Testing Superficialis (Sublimus)

Drawings by Jackie Robers

GENERAL MANAGEMENT

Nerves

- ❑ primary repair for a clean injury within 24 hours and without concurrent major injuries —> otherwise secondary repair
- ❑ epineural repair of digital nerves with minimal tension
- ❑ post-operative: dress wound, elevate hand and immobilize
- ❑ follow-up starting at 3 weeks post-operative and at 6 week intervals thereafter
- ❑ Tinel's sign (cutaneous percussion over the repaired nerve) produces paresthesias and defines level of nerve regeneration (a peripheral nerve regenerates at 1 mm/day or 1 inch/month, after the first 4 weeks as a result of Wallerian degeneration)
- ❑ physiotherapy to prevent joint contracture

Vessels

- ❑ often associated with nerve injury (anatomical proximity)
- ❑ control bleeding with direct pressure and hand elevation
- ❑ avoid probing, clamping, and tying off artery as incidence of nerve injury can be significant
- ❑ repair optimal if within 6 hours
- ❑ dress, immobilize, and splint hand with finger tips visible
- ❑ post-operatively monitor colour, capillary refill, skin turgor, fingertip temperature

Tendons

- ❑ most tendon lacerations require primary repair
- ❑ never test against resistance
- ❑ never immobilize joints > 3 weeks, will lead to stiffness and significantly increases rehabilitation time

AMPUTATIONS

Hand or Finger

- ❑ initial treatment: wrap amputated part in a saline soaked sterile gauze and place inside waterproof plastic bag on ice
- ❑ considerations for patient selection
    - patient: age, hand dominance, occupation, hobbies, motivation for rehabilitation
    - level of injury: functional results vary accordingly
    - nature of injury: guillotine better results than avulsion amputations
- ❑ indications for replantation:
    - child, thumb, clean hand, wrist, or multiple digits involved
- ❑ if replant contraindicated manage stump with thin split thickness skin graft, pedicle grafts, or allow to heal by secondary intention, especially in children

TENDONS

Common Extensor Tendon Deformities

- ❑ location described by zones (see Figure 11)
- ❑ mallet finger (zone 1): DIP in flexion with loss of active extension caused by extensor tendon rupture at DIP joint
- ❑ Boutonniere deformity (zone 3): PIP in flexion, DIP in hyperextension; associated with rheumatoid arthritis, trauma (laceration, volar dislocation, acute forceful flexion of PIP)
- ❑ Swan Neck deformity (zone 3): PIP hyperextension, DIP flexion
- ❑ de Quervain's tenosynovitis (zone 7): inflammation in 1st dorsal wrist compartment
    - +ve Finkelstein's test (pain induced by making fist, with thumb in palm, and ulnar deviation of wrist)

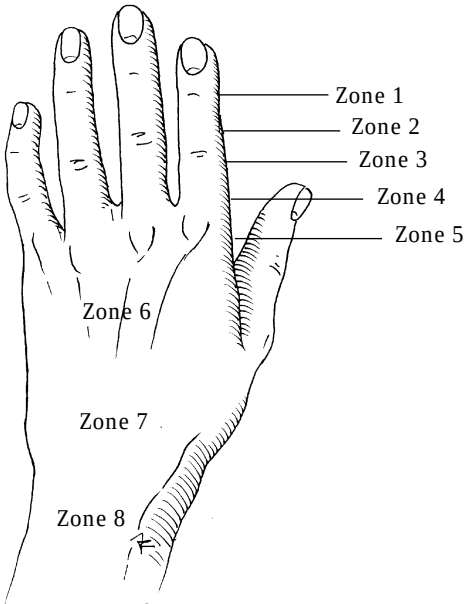

Figure 8. Zone of Extensor Tendon Injury

Figure 9. Mallet Finger Deformity

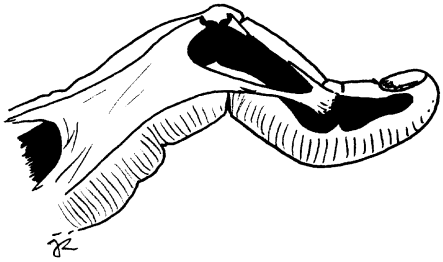

Figure 10. Boutonniere Deformity

Drawings by Jackie Robers

Flexor Tendon

- ❑ flexor tendon zones (importance for prognosis of tendon lacerations)
- ❑ "No Man's Land"
  - between distal palmar crease and mid-middle phalanx
  - zone where superficialis and profundus lie ensheathed together
  - recovery of glide very difficult after injury

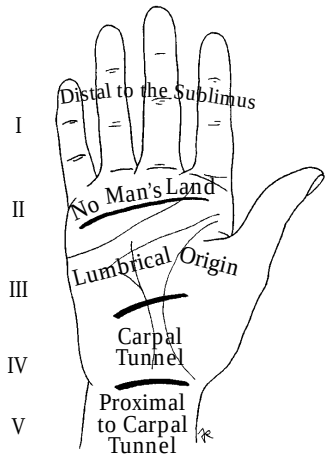

Figure 11. Zones of the Flexor Tendons

Drawing by Jackie Robers

Common Flexor Tendon Deformities

- ❑ stenosing tenosynovitis (trigger finger/thumb)
  - majority idiopathic
  - tendon/pulley size discrepancy causes locking flexion/extension
  - may palpate nodule at palmar aspect MCP
  - treatment: steroid injection into the sheath, surgical release is necessary if injection unsuccessful
  - surgical treatment includes release of A1 pulley, synovectomy, removal of tendon nodule

FRACTURES AND DISLOCATIONS

- ❑ about 90% of hand fractures are stable in flexion
- ❑ stiffness secondary to immobilization is the most important complication
- ❑ key: early motion
- ❑ preferred position of hand splinting is position of function and comfort (like a hand holding a pop can)
  - wrist extension 15º
  - MCP flexion 45º
  - IP flexion (slight)
  - thumb abduction/rotation
  - contraindications: post repair of flexor tendons, median/ulnar nerve (some wrist flexion to decrease the tension on the repair required)
- ❑ safe position - maximal flexion at the MCP joint to maximize ROM in case of extensor injury
  - wrist extension 45º
  - MCP flexion 60º
  - PIP and DIP in full extension
  - thumb abduction and opposition

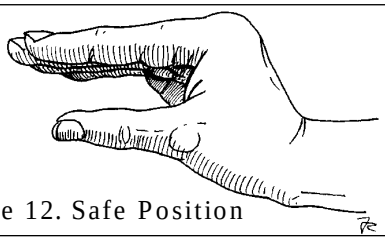

Figure 12. Safe Position

Drawing by Jackie Robers

Distal Phalanx Fractures

- ❑ require symptomatic protection
- ❑ soft tissue injuries more important than bone

Proximal and Middle Phalanx Fractures

- ❑ undisplaced or minimally displaced - buddy tape to neighbouring stable digit, elevate hand
- ❑ displaced - percutaneous pins (K-wires), splinting
  check for malrotation of finger ("scissoring") on making a fist

Metacarpal Fractures

- ❑ Boxer's fracture: head or neck of metacarpal of little finger
  - loss of prominence of metacarpal head, scissoring of fingers on making a fist
  - volar displacement of head
  - up to 30-40º angulation acceptable unless reduced range of motion or esthetic problem
  - if stable, splint with PIP and DIP joints free, otherwise surgery
- ❑ Bennett's fracture: intra-articular fracture/dislocation of base of thumb metacarpal
  - larger distoradial fragment displaced by abductor pollicis longus
  - treat with percutaneous pinning, thumb spica x 6 weeks
- ❑ Rolando's fracture: T-shaped intra-articular fracture of thumb metacarpal
  - difficult to treat, treat with open reduction

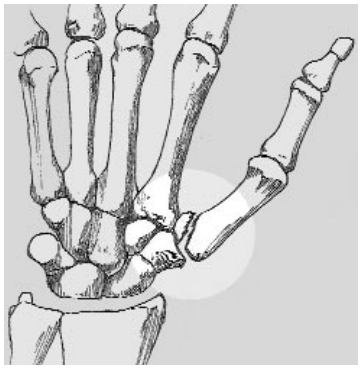

Figure 13. Bennett's Fracture

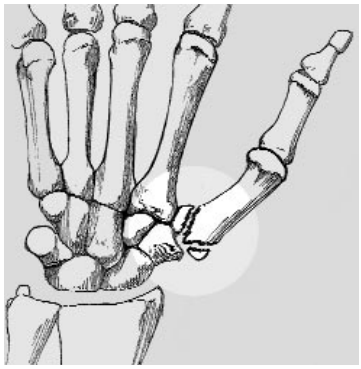

Figure 14. Rolandos's Fracture

Drawings by Meaghan Brierley

Digital Dislocations

- ❑ PIP and DIP dislocations (PIP more common than DIP)
  - usually dorsal dislocation
  - closed reduction and splinting (30º flexion for PIP and full extension for DIP)
- ❑ MCP dislocations relatively rare
  - most commonly thumb, index, little finger
  - dorsal dislocation of proximal phalanx on metacarpal head
  - neurovascular structures can be compromised
  - usually requires prompt open reduction
- ❑ gamekeeper's thumb: MCP ulnar collateral ligament rupture
  - mechanism: forced abduction of thumb (ski pole injury)
  - apply lateral stress with MCP at 0º and 45º flexion; if greater than 15º more than other thumb, may require surgery

DUPUYTREN'S CONTRACTURE

- ❑ contraction of longitudinal palmar fascia, forming nodules, cords and eventually joint contractures
- ❑ genetic disorder, repetitive trauma plays no role and connection with alcohol is controversial
- ❑ order of digit involvement: ring > little > long > index > thumb
- ❑ often bilateral
- ❑ stages
  1. palmar pit or nodule - no surgery
  2. palpable band/cord with no limitation of extension of either MCP or PIP - no surgery
  3. lack of extension at MCP or PIP - surgical fasciectomy indicated
  4. irreversible periarticular joint changes/scarring - surgical treatment possible but poorer prognosis compared to stage 3
- ❑ surgery is the only satisfactory treatment
- ❑ may recur, especially in Dupuytren's diathesis

CARPAL TUNNEL SYNDROME (see Neurosurgery Notes)

HAND INFECTIONS

Principles

- ❑ trauma is most common cause
- ❑ 5 cardinal signs: rubor (red), calor (hot), tumour (swollen), dolor (painful) and function laesa (loss of function)
- ❑ 90% of hand infections are caused by Gram positive organisms
- ❑ most common organisms (in order) - *S. aureus*, *Strep. viridans*, *Group A Strep.*, *S. epidermis*, and *Bacteroides melanin*
- ❑ infection vs. inflammation sometimes diagnostically challenging; look at history, physical (severe pain on axial compression of finger suggests infection), WBC count, XR, etc...

Types of Infections

- ❑ paronychia
  - infection of soft tissue around fingernail, often begins as "hangnail"
  - treated with antibiotics, and drainage if abscess present
- ❑ felon: deep infection of pulp space
  - treated with incision and drainage and antibiotics (oral cloxacillin)
- ❑ flexor tendon sheath infection (acute suppurative tenosynovitis)
  - Kanavel's 4 cardinal signs
    1. symmetrical swelling of digit
    2. tenderness along flexor tendon sheath
    3. flexed or semi-flexed attitude (posture) of finger
    4. severe pain on passive extension of DIP (most important)
  - treated promptly in the operating room with incision and drainage, irrigation, and antibiotics
- ❑ human bites
  - most common over dorsum of MCP (punch in mouth)
  - serious as mouth has 10^9 microorganisms/mL, (get trapped in joint space when MCP's extended and can cause septic arthritis)
  - treatment: Clavulin (see Emergency Medicine Notes)
- ❑ dog and cat bites (pathogens: *Pasteurella multocida*, *S. aureus*, *S. viridans*)
  - treatment: Clavulin (see Emergency Medicine Notes)

- ❑ deep palmar space infections
  - uncommon, involve thenar or mid-palm, treated in operating room
- ❑ herpetic whitlow
  - painful vesicle around finger tip of medical personnel
  - treatment is protection (cover), but some recommend oral acyclovir
- ❑ gonococcal arthritis (uncommon)
  - high index of suspicion based on history (STD, IV drugs)
  - can destroy entire joint in short time
  - treatment: penicillin

RHEUMATOID HAND

- ❑ general principles
  - non-surgical treatments form the foundation in the management of the rheumatoid hand
  - surgery reserved for selected cases in which patient's goals of improved cosmesis or function may be achieved
- ❑ common problems
  - Synovitis
    - proliferation of synovium can lead to invasion into and subsequent rupture of tendons (usually extensor), requires tendon repair
    - proliferation of synovium leads to increased pressure in carpal tunnel and subsequent carpal tunnel syndrome
    - trigger finger (see "Common Flexor Tendon Deformities")
  - Ulnar drift
    - multifactorial etiology; results in radial deviation of wrist, ulnar deviation of MCP's, and subluxation of carpal bones
    - often results in severe functional loss of both precision pinch and power grip strength
    - treatment may include MCP arthroplasty, resection of distal ulna, soft tissue reconstruction around wrist
  - Thumb deformities
    - can be succesfully treated by arthrodesis
  - Swan Neck
    - PIP hyperextension, DIP flexion
    - treatment can include soft tissue reconstruction, arthrodesis, or arthroplasty
  - Boutonniere
    - patients generally have functional loss due to DIP hyperextension rather than PIP flexion (e.g. holding a cup)
    - release of the extensor tendon allowing flexion of DIP provides excellent results

THERMAL INJURIES

Physiology of the Skin

- ❑ skin: epidermis and dermis
- ❑ blood vessels and nerves are found in the dermis
- ❑ acts as a barrier to infection, prevents loss of fluids, maintains body temperature

BURNS

- ❑ etiology: Children – scald burns
  Adults – flame burns

ZONES OF THERMAL INJURY

- ❑ zone of coagulation - cells irreversibly damaged
- ❑ zone of stasis - cells injured and will die in 24-48 hours without proper treatment; sludging of capillaries (need to prevent swelling and infection)
  - factors favoring cell survival: moist, aseptic environment, rich blood supply
- ❑ zone of hyperemia - cells will recover in 7 days

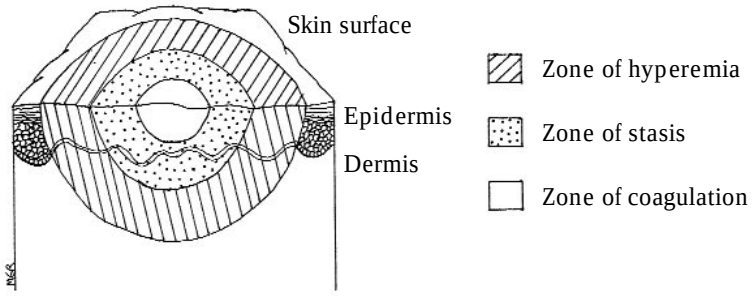

Figure 15. Zones of Thermal Injury

Drawing by M. Gail Rudakewich

DIAGNOSTIC NOTES

- ❑ estimate burn size (total body surface area = TBSA) - rule of 9's
  includes second and third degree burns only (different in children)

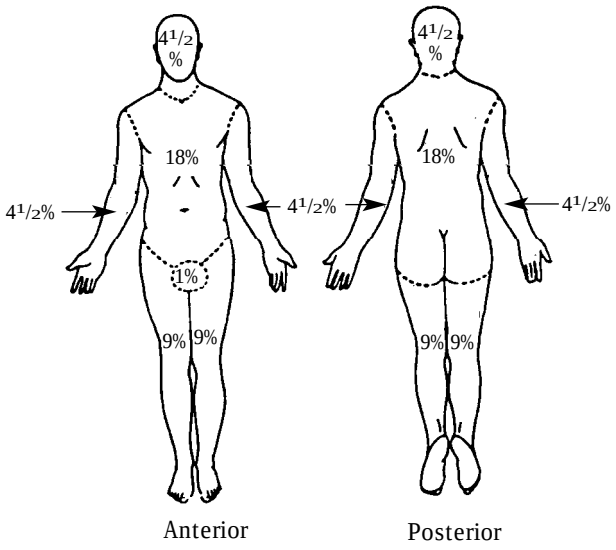

Figure 16. Rule of 9's for TBSA

- ❑ age - more complications if < 3 or > 60 years old
- ❑ depth classification
  - see Table 6
- ❑ location
  - face, hands, feet, perineum cause special problems and warrant hospitalization
  - circumferential burns are managed with escharotomy (an incision down to and including fat) to prevent tourniquet effect of eschar
- ❑ watch for inhalation injury, associated injuries (fractures), co-morbid factors (concurrent disability - alcoholism, renal disease)

Table 6. Staging of Burns

Nomenclature	Traditional Nomenclature	Depth	Clinical Features
superifical thickness	first degree	epidermis	erythema, white plaque
superficial partial thickness	second degree	into superifical dermis	clear fluid, superficial blisters, painful
deep partial thickness	second degree	into deep dermis	difficult to distinguish from full thickness
full thickness	third degree fourth degree	through dermis involves underlying tissue	hard, leather-like texture of skin eschar formation purple fluid, insensate

INDICATIONS FOR ADMISSION

American Society of Plastic and Reconstructive Surgeons
- ❑ total 2º and 3º burns > 10% TBSA in patients < 10 or > 50 years of age
- ❑ total 2º and 3º burns > 20% TBSA in patients any age
- ❑ 3º burns > 5% TBSA in patients any age
- ❑ threat of serious functional or cosmetic impairment (i.e. face, hands, feet, genitalia, perineum, major joints)
- ❑ inhalation injury
- ❑ electrical burns
- ❑ chemical burns posing threat of functional or cosmetic impairment
- ❑ burns associated with major trauma

ACUTE CARE OF BURN PATIENTS

Respiratory Distress
- ❑ if inhalation injury suspected (burn sustained in closed space, singed nose hairs/eyebrows, soot around nares and oral cavity, history of explosions or flash burns), intubate immediately before edema occurs
- ❑ acute causes
  - CO poisoning (treat with 100% O_2-decreases half-life of carboxyhemoglobin from 210 minutes to 59 minutes)
  - eschar encircling chest (perform escharotomy)
- ❑ late onset
  - due to smoke inhalation and pulmonary injury
  - risk of pulmonary insufficiency (up to 48 hours) and pulmonary edema (48-72 hours)
  - if humidified O_2 not successful, may need to intubate and ventilate
  - watch for secondary lung infections (after 1 week)

Burn Shock
- ❑ definition: hypovolemia due to movement of H_2O and Na^+ in zone of stasis and generalized increased capillary permeability in all organs (occurs if > 30% TBSA)
- ❑ resuscitation with Parkland formula: 4 cc Ringer's/kg/% TBSA over first 24 hours
  - TBSA does not include 1st degree areas
  - 1/2 of this in 1st 8 hours *post burn*, rest in next 16 hours
  - in following 6 hours give 0.35-0.5 cc plasma/kg/%TBSA, then D5W at rate to maintain normal serum sodium
  - Parkland underestimates fluid requirements in electrical and inhalation injuries
- ❑ monitor resuscitation
  - maintain urine output > 0.5 cc/kg/hr (adults) and 1.0 cc/kg/hour (children < 12 years)
  - also maintain a clear sensorium, HR < 120/minute, mean blood pressure > 70 mmHg

Burn Wound
- ❑ goals of 3rd degree burn wound care
  - prevent infection (one of the most significant causes of death in burn patients) —> most common organisms include *S.aureus, P. aeruginosa* and *C. albicans*
  - remove dead tissue
  - cover wound with skin as soon as possible
- ❑ surgically debride necrotic tissue, excise to viable (bleeding) tissue
- ❑ topical antimicrobials to prevent bacterial infection (from patient's gut flora or caregivers) and secondary sepsis
- ❑ important to obtain early wound closure
- ❑ deep second or third degree burn > size of a quarter: indication for skin graft
- ❑ prevention of wound contractures: pressure dressings, joint splints, early physiotherapy

Table 7. Topical Antibiotic Therapy

Antibiotic	Pain with Application	Penetration	Adverse Effects
Silver nitrate	None	Minimal	Methemoglobinemia, stains
Silver sulfadiazine	Minimal	Medium	Slowed healing, leukopenia
Mafenide Acetate	Moderate	Well	Slowed healing, acid-base abnormalities

Other Considerations
- ❑ nutrition: calories, vitamin C, vitamin A, Cu, Zn, Fe
- ❑ immunosuppression and sepsis
- ❑ GI bleed (tube feeding or NPO and H_2 blockers)
- ❑ renal failure secondary to hypovolemia - rare
- ❑ tetanus toxoid

CHEMICAL BURNS
- ❑ severity depends on: type of chemical (acid and alkalai), concentration, quantity, and contact time
- ❑ inspect eyes
- ❑ common agents: cement, hydrofluoric acid, phenol
- ❑ treatment
  - dilution with water
  - wash eyes out with saline and refer to ophthalmology
  - local care after 12 hours: debridement, topical antibiotics
  - beware: fluid resuscitation, renal, liver, and pulmonary damage

ELECTRICAL BURNS
- ❑ depth of burn depends on voltage and resistance of the tissue
- ❑ in decreasing order of resistance: bone, fat, tendon, skin, muscle, blood, and nerve
- ❑ often small punctate burns on skin with massive deep tissue damage which requires debridement
- ❑ watch for
  - cardiopulmonary injuries e.g. ventricular fibrillation
  - renal: myoglobinuria/hemoglobinuria
  - fractures and dislocations, especially shoulder and spine
  - tissue necrosis secondary to vessel thrombosis
  - decrease in RBC (beware of hemorrhages)
- ❑ electrical burns require ongoing monitoring as latent injuries become manifest

FROSTBITE
- ❑ ice crystals form between cells
- ❑ mechanisms of tissue injury
  - cellular dehydration
  - ischemia (secondary to peripheral vasoconstriction)
- ❑ superficial frostbite: only skin and subcutaneous tissues frozen
- ❑ deep frostbite: underlying tissues frozen as well
- ❑ management
  - rewarm in water bath (40-42ºC)
  - after rewarming, tissue becomes purple, edematous, painful blisters may appear, resolving after several weeks
  - leave injured region open to air
  - leave blisters intact
  - debride skin gently with daily whirlpool immersion (scrubbing, massage and topical ointments not required)
  - surgery may be needed to release constrictive, circumferential eschars

SOFT TISSUE INFECTIONS

CELLULITIS
- ❑ non-suppurative infection of skin and subcutaneous tissues
- ❑ signs and symptoms
  - pain, tenderness, edema, erythema with poorly defined margins
  - fever, chills, malaise
  - can lead to lymphangitis (visible red streaking in areas proximal to infection)
- ❑ skin flora most common organisms: *S. aureus*, ß-hemolytic *Streptococcus*
- ❑ treatment is antibiotics: first line Pen G 1.2 million units q6-8h IV + cloxacillin 1 g q6-8h IV

NECROTIZING FASCIITIS

- ❑ infection leading to gangrene of subcutaneous tissue, and subsequent necrosis of more superficial layers
- ❑ Type I: ß-hemolytic streptococcus, Type II: polymicrobial
- ❑ natural history
  - severe pain, fever, edema, tenderness
  - infection spreads very rapidly
  - patients are often very sick and toxic in appearance
  - skin turns dusky blue and black (secondary to thrombosis and necrosis)
  - induration, formation of bullae
  - cutaneous gangrene, subcutaneous emphysema (Type II)
- ❑ diagnosis
  - severely elevated CK
  - hemostat easily passed along fascial plane
  - fascial biopsy
- ❑ treatment
  - surgical debridement: removal of necrotic tissue, copious irrigation, often requires repeated trips to the OR
  - IV antibiotics: clindamycin 900 mg q8h IV + Pen G 6 million units q4h IV

MALIGNANT SKIN LESIONS

(see Dermatology Notes)

MANAGEMENT

- ❑ basal cell carcinoma (see Colour Atlas A21)
  - curettage and electrodesiccation: for smaller lesions; include a 2-3 mm margin of normal skin
  - surgical excision: deep infiltrative lesions; 3-5 mm margins beyond visible and palpable tumour border; may require skin graft or flap
  - x-ray therapy: less traumatic and useful in difficult areas to reconstruct, requires a skilled physician because of many complications
  - cure rate is the same (approximately 95%) for the above procedures in competent hands
- ❑ squamous cell carcinoma (see Colour Atlas A17)
  - same options for treatment as for basal cell carcinoma
  - more aggressive treatment because more malignant than BCC
- ❑ melanoma (see Colour Atlas A23)
  - excision is primary management
  - for lesions < 0.75 mm thickness: a 1 cm margin is recommended
  - for lesions > 0.75 mm thickness: a 2.5 cm margin is recommended
  - node dissection for lesions > 0.75 mm
  - beware of lesions that regress - tumour is usually deeper than one anticipates

PRESSURE SORES

- ❑ common sites: greater trochanter, ischial tuberosity, sacrum, heel, elbows, occiput
- ❑ stages
  - hyperemia - disappears 1 hour after pressure removed
  - ischemia - follows 2-6 hours pressure
  - necrosis - follows > 6 hours pressure
  - ulcer - necrotic area breaks down
- ❑ prevent with good nursing care: clean skin, frequent log rolling, special beds (Kinair), egg crate mattress
- ❑ treatment
  - debridement of necrotic tissue (with dressings ± surgical debridement)
  - continue with preventative methods
  - topical antibiotics of questionable value
  - osteotomy and closure with myocutaneous flap in selected cases

LEG ULCERS

Venous Stasis Ulcers

- ❑ due to venous hypertension, valvular incompetence
- ❑ painless, dependent edema, discoloration, commonly over medial malleolus
- ❑ treatment
  - elevate, pressure stockings, may need skin graft

Ischemic Ulcers

- ❑ secondary to small and/or large vessel disease
- ❑ usually located on the lateral aspects of the great and fifth toes and dorsum of foot
- ❑ painful, distal, punched out ulcers with hypersensitive/ischemic surrounding skin
- ❑ treatment
  - rest, no elevation, modify risk factors (stop smoking, exercise, diet, etc...)
  - treat underlying condition (diabetes, proximal arterial occlusion, etc...)
  - ultimately, may use skin graft, flap, or amputation

Diabetic Ulcers

- ❑ due to decreased sensation (neuropathy) and decreased regional blood flow
- ❑ painless
- ❑ usually located on the plantar surface of foot over the metatarsal heads or heel
- ❑ treatment
  - debride necrotic tissue, topical and/or systemic antibiotics, fastidious foot care

Traumatic Ulcers

- ❑ failure of lesion to heal, usually due to compromised blood supply and unstable scar
- ❑ usually over a bony prominence
- ❑ treatment
  - resection of ulcer, unstable scar and thin skin
  - reconstruction with local or distant flap

- ABC's of trauma - always remember to ensure airway, ensure breathing, prevent aspiration, control bleeding and check cervical spine
- consider intracranial trauma
- forces involved
  - low velocity vs. high velocity injuries determine degree of damage
  - frequency
    - nasal > zygomatic > mandibular > maxillary

RADIOGRAPHIC EXAMINATION

Table 8. Imaging of the Craniofacial Skeleton

Structure	Appropriate Imaging
mandible	panoramic (panorex)* P-A of mandible Towne's view (A-P "from above") lateral obliques
nasal bones	no x-ray required - clincal * diagnosis: may do Water's view and/or lateral
zygomatic and orbital bones	CT scan* Water's view (A-P "from below") Caldwell's view (P-A at 150) submento-vertex
maxilla	CT scan - axial and coronal* (conventional x-rays of little value)

*best imaging method

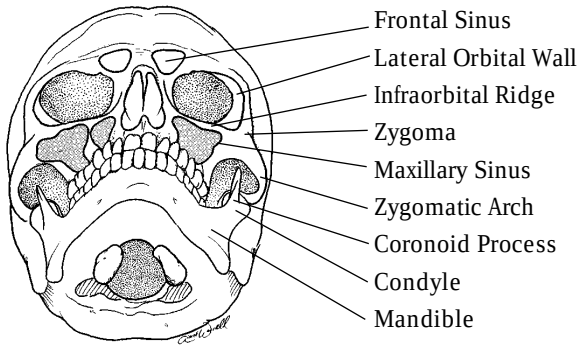

Figure 17. Waters' View

Drawing by Aimeé Worrell

- CT: axial and coronal usually the most accurate especially in fracture of upper and middle face but not good for mandible

MANDIBULAR FRACTURES

- mechanism
  - anterior force: bilateral fractures
  - lateral force: ipsilateral subcondylar and contralateral angle or body fracture
  - note: classified as open if fracture into tooth bearing area (alveolus)
- signs
  - malocclusion, asymmetry of dental arch
  - intraoral lacerations, submucosal hematoma
  - damaged, loose, or lost teeth

- numbness in V3 distribution
- palpable "step" along mandible on intra-oral or extra-oral palpation

❑ complications
- malocclusion, malunion
- tooth loss
- TMJ ankylosis

❑ treatment
- maxillary and mandibular arch bars wired together (intramaxillary fixation) or ORIF (open reduction and internal fixation) i.e. plates and screws

MAXILLARY FRACTURES

❑ Le Fort classification
- Le Fort I: palatal segment (maxillary alveolus) separated from upper midface
- Le Fort II: pyramidal fragment containing maxillary teeth separated from face via fracture through inferior orbital rims and nose
- Le Fort III: separation of facial from cranial bones; fracture line runs through zygomaticofrontal suture, across floor of orbit and nasofrontal junction

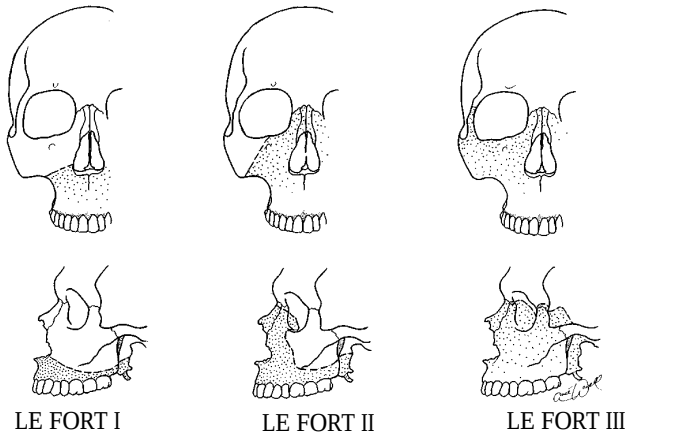

Figure 18. Le Fort Fracture Classification

Drawing by Aimeé Worrell

❑ signs
- dish pan/equine facies (flat or protruding facies)
- periorbital hematoma, epistaxis
- malocclusion
- mobility of maxilla: tested by trying to move maxilla while watching and palpating for mobility of nasal and zygomatic bones (may not move if fragment is impacted)
- Le Fort III: battle sign, bilateral orbital ecchymosis, CSF otorrhea, hemotympanum

❑ complications
- malocclusion
- airway compromise
- post-traumatic facial deformities

❑ treatment
- primary goal is restoration of occlusion and functional rehabilitation (eating, speech)
- intermaxillary fixation (IMF: wiring jaws together)
- usually also require ORIF with screws and plates

NASAL FRACTURES

❑ mechanism
- lateral force —> more common, good prognosis
- anterior force —> can produce more serious injuries
- depression and splaying of nasal bones causing a saddle deformity

- ❑ signs
  - epistaxis, swelling, periorbital ecchymosis, tenderness over nasal dorsum, crepitus, change in nasal contour and movement of nasal bones, septal hematoma, respiratory obstruction
- ❑ treatment
  - nothing
  - always drain septal hematomas as this is a cause of septal necrosis with perforation (saddle nose deformity)
  - closed reduction with Asch or Walsham forceps under anesthesia, pack nostrils with Adaptic, nasal splint for 7 days
  - best reduction immediately or at 4-5 days depending on swelling
  - rhinoplasty may be necessary later for residual deformity (30%)

ZYGOMATIC FRACTURES

- ❑ 2 types
  1. orbitozygomatic complex fractures (tripod fracture)
     - separation of zygoma from maxilla, frontal and temporal bone
  2. depressed isolated zygomatic arch fracture
- ❑ signs
  - periorbital ecchymosis and subconjunctival hemorrhage
  - loss of prominence of malar eminence (view from above)
  - enophthalmos
  - vertical dystopia
  - pain over fractures on palpation
  - palpable step deformity at orbital rim
  - numbness in V2 distribution (infraorbital and superior dental nerves)
  - ipsilateral epistaxis
  - trismus (lockjaw)
  - diplopia
  - often associated with fractures of the orbital floor
- ❑ treatment
  - nothing, if undisplaced and no symptoms
  - ophthalmologic evaluation
  - elevate using Gillies approach: leverage on the anterior part of the zygomatic arch via a temporal incision
  - if Gillies approach fails or a comminuted fracture, then ORIF

ORBITAL BLOW-OUT FRACTURES

- ❑ fracture of floor of orbit with intact infraorbital rim
- ❑ mechanism
  - blunt force to eyeball —> sudden increase in intra-orbital pressure (e.g. baseball or fist)
- ❑ signs
  - periorbital and subconjunctival hemorrhage, enophthalmos
  - diplopia looking up or down, due to entrapment of inferior rectus and limited extraocular movements
  - check visual fields and acuity for injury to globe
- ❑ diagnosis
  - skull AP
  - CT (axial axis)
  - forced duction test for entrapment
- ❑ treatment
  - may require open reduction with reconstruction of orbital floor with bone graft or alloplastic material

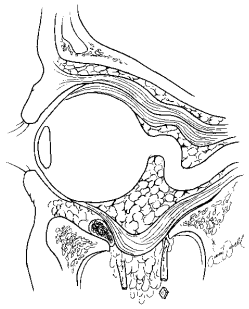

Figure 19.
"Blow-Out" Fracture

Drawing by Aimeé Worrell

PEDIATRIC PLASTIC SURGERY

Notes

CLEFT LIP

- ❑ epidemiology
  - incidence of 1 in 800 in Caucasians, more in Asians less in Blacks
  - may be incomplete, complete, or bilateral
  - 2/3 are unilateral, 2/3 left sided and 2/3 male
- ❑ etiology
  - multifactorial
  - failure of fusion of the maxillary and nasal prominences as well as lack of mesodermal reinforcement
- ❑ treatment
  - contact cleft lip team at time of birth
  - surgical correction at 3 months: Millard or Tennison-Randall
  - multiple corrections to nasal and lip usually necessary later

CLEFT PALATE

- ❑ epidemiology
  - may be submucous, incomplete, unilateral or bilateral
  - may be isolated or in conjunction with cleft lip
  - isolated cleft palate most common in females
- ❑ treatment
  - special bottles for feeding
  - speech pathologist
  - surgical correction at 1 year: Von Langenbeck or Furlow Z-Plasty
- ❑ significance
  - hypo or hyper-nasal speech

SYNDACTYLY

- ❑ congenital fusion of 2 or more digits (failure of digits to separate)
- ❑ simple skin webbing between fingers or more commonly with associated fusion of bone and fingernail bed
  - long and ring finger most common
  - thumb and index least common
- ❑ treatment: surgical separation with good results

MICROTIA

- ❑ severe hypoplasia of external ear with a constricted, blind or absent auditory canal
  - may be associated with other first and second branchial arch abnormalities (Goldenhars, hemifacial microsomia)
- ❑ treatment: multiple staged operations to reconstruct ear with either costal cartilage or a silastic framework

AESTHETIC SURGERY

FACE

- ❑ hair transplants: with grafts or flaps
- ❑ blepharoplasty: removal of excess eyelid skin +/– fat pads
- ❑ rhinoplasty: "nose job"
- ❑ rhytidectomy: "face lift"; lower face and neck or forehead lift
- ❑ otoplasty: for "outstanding" ears

BREAST

- ❑ augmentation: with saline filled implants (subglandular or submuscular)
- ❑ mastopexy: raises nipple in ptotic breasts
- ❑ reduction mammoplasty
- ❑ reconstruction following mastectomy
  - Alloplastic: tissue expander followed by prosthesis +/– lattisimus dorsi myocutaneous flap
  - Autologous: several flaps possible including Trans Rectus Abdominus Musculocutaneous (TRAM) flap
  - Nipple reconstruction using local flaps and grafts
  - Areolar reconstruction: full thickness grafts, tatooing

OTHER

- ❑ abdominoplasty: "tummy tuck"; removal of abdominal pannus (drape of excess fat)
- ❑ liposuction: used for contouring, not weight loss
- ❑ dermabrasion: for scars, irregular skin surface
- ❑ chemical peel: usually perioral
- ❑ laser resurfacing: for scars, wrinkles