PLASTIC SURGERY

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BASIC PRINCIPLES

STAGES OF WOUND HEALING

- ❑ growth factors released by tissues play an important role
- ❑ 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
  - at 6 weeks the wound strength is at 40% and is strong enough to tolerate moderate forces
- ❑ 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

- ❑ hypertrophic scars (these generally improve with time if left to heal)
  - 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 (these do not resolve spontaneously)
  - tissue extends beyond the scar boundaries (unlike hypertrophic scars)
  - common sites include sternum, deltoid, earlobe
  - collagen: whorls rather than bundles
  - increased frequency in darker skinned people
  - treatment: pressure dressings, silicone sheets, topical steroids, intralesional steroid injection, radiation therapy, surgical resection
  - may recur with surgical revision
- ❑ chronic wounds
  - fail to heal within 3 months
  - examples: diabetic ulcers, pressure ulcers, venous stasis ulcers
  - may heal with meticulous wound care, but many will require surgical intervention

FACTORS INFLUENCING WOUND HEALING

Local (reversible):

- ❑ mechanical (local trauma, tension)
- ❑ infection
- ❑ hematoma/seroma
- ❑ blood supply
- ❑ retained foreign body
- ❑ cancer
- ❑ previously irradiated tissues
- ❑ self induced (diagnosis of exclusion)

General (often irreversible):

- ❑ nutrition (protein, vit C, O_2)
- ❑ peripheral vascular disease (PVD)
- ❑ smoking
- ❑ diabetes
- ❑ chronic illness
- ❑ immunocompromised (steroids, chemotherapy)
- ❑ hypertension (HTN)
- ❑ uremia
- ❑ remote infection
- ❑ obesity
- ❑ collagen vascular disease (CVD)

WOUND CLOSURE

Primary Closure (First Intention)

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

Secondary Closure (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 Closure (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 (< 24 hr)
- debridement: surgical (blade, irrigation)
- closure: primary closure with monofilament (contraindications to primary closure: animal and human bites, crush injuries)
- cleanse and copiously irrigate open wound with physiologic solutions i.e. Normal Saline (NS) or Ringer's Lactate (RL) (no soap, alcohol, or other irritants)
- systemic antibiotics if wound older than 8 hours
- +/– tetanus (Tetanus toxoid (Td) 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
- follow up in 48 hours

❑ chronic contaminated wounds (e.g. lacerations > 24 hours, ulcers)
- debridement: surgical or mechanical (e.g. wet-to-dry dressings)
- closure: final closure via delayed wound closure (tertiary closure) or skin graft
- successful closure depends on decreasing bacteria count to 100,000/gram or less prior to closure and frequent dressing changes
- topical antibacterial creams (see Table 9)
- systemic antibiotics are not useful - no penetration into the bed of granulation tissue

DRESSINGS

❑ goals are absorption, protection, compression, cosmesis
❑ 1st layer (contact layer)
- clean wounds: heal by re-epithelialization.
  - protect new epithelium
  - use nonadherent impregnated gauze (e.g. Jelonet, Bactigras or Sofratulle)
- chronic/contaminated wounds:
  - mechanically debride nonviable tissue
  - use adherent Saline or Betadine soaked gauze ("wet-to-dry" dressing)
  - dead tissue adheres to gauze and is removed with dressing change

❑ 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, ears and tissue edges (small skin flaps)
❑ 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 CNS excitation followed by CNS, respiratory and cardiovascular depression

Sutures (see Table 1)
❑ use of a particular suture material is highly dependent on surgeon preference
❑ bacterial infection: monofilament < multifilament (braided)
❑ tissue reaction: synthetic < organic
❑ dehiscence of tissue under stress: nonabsorbable < absorbable

Table 1. Suture Types

Type	Description	Indications
Surgical gut (plain or chromic)	Organic, absorbable monofilament	Subcutaneous closure and ligation
Polyglycolic acid	Synthetic, absorbable monofilament (e.g. Monocryl) and braided (e.g. Vicryl, Dexon)	Transcutaneous and subcuticular closure
Nylon	Synthetic, nonabsorbable monofilament (e.g. Ethilon) and braided (e.g. Nurolon)	Soft tissue approximation and microsurgery procedures
Polypropylene (e.g. Prolene)	Synthetic, nonabsorbable monofilament	General soft tissue approximation, used in contaminated/infected wounds
Silk	Nonabsorbable multifilament	Transcutaneous closure

Basic Suturing Techniques

- ❑ basic principles
  - minimize tissue trauma: follow curve of needle, handle wound edges gently (use toothed forceps)
  - enough tension to approximate edges - do not strangulate
  - use the finest needle and suture possible
  - to ensure good cosmesis:
    - evert skin edges when closing
    - avoid tension on skin (close in layers)
    - ensure equal width and depth of tissue on both sides
    - remove sutures within 7-10 days (5 days for the face; 14 days if over a joint)
- ❑ basic suture methods
  - simple interrupted – for face and when scarring is less important
  - subcuticular - good cosmetic result; weak, used in combination with deep sutures
  - vertical mattress - for areas difficult to evert (e.g. dorsum of the hand)
  - horizontal mattress - everting, time saving
  - continuous over and over - time saving

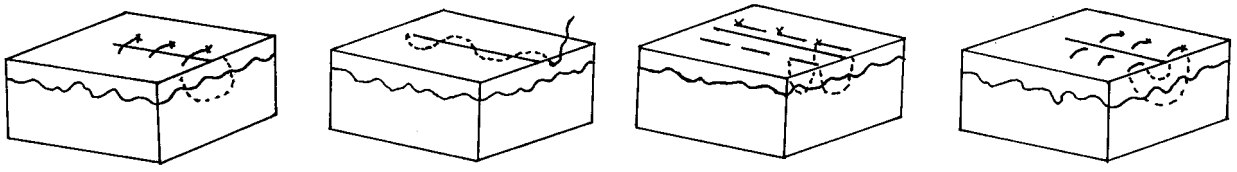

Figure 1. Basic Suture Methods

Illustration by Baseer Khan

SKIN GRAFTS

- ❑ definition: a segment of skin detached from its blood supply and dependent on revascularization from the recipient site
- ❑ donor site selection
  - must consider size, color, 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
  - plasmatic imbibition - nourishment via diffusion (first 48 hours)
  - inosculation - vessels in graft connect with those in recipient bed
  - 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
- ❑ mesh graft
  - prevents accumulation of fluids
  - covers a larger area
  - has significant contractures
  - not cosmetically appealing
  - best for contaminated recipient site

Table 2. Skin Grafts

	Split Thickness Skin Graft (STSG)	Full Thickness Skin Graft (FTSG)
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
Advantage	Take well in less favorable conditions	Resist contraction, potential for growth, texture/pigment more normal
Disadvantage	Contract significantly, abnormal pigmentation, high susceptibility to trauma	Require well vascularized bed

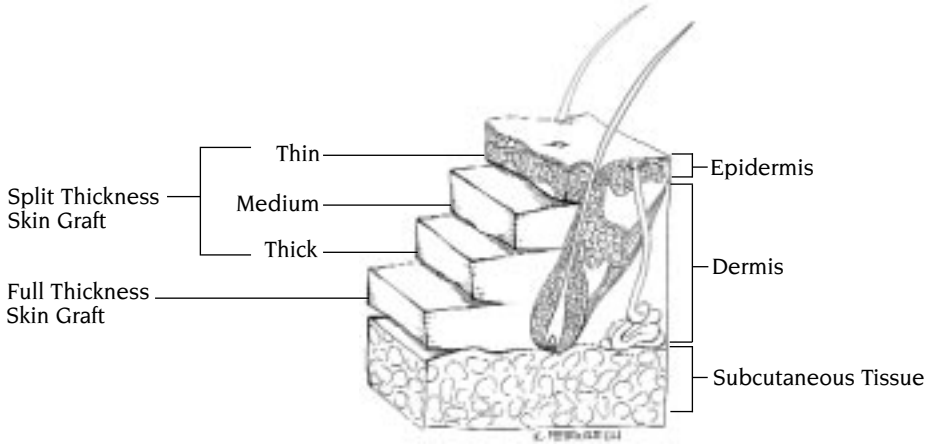

Figure 2. Split and Full (Whole) Thickness Skin Grafts

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 (not dependent on neovascularization) 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) via mechanical stretching
  - consists of subcutaneous silicon reservoir into which saline is injected intermittently over several weeks
- ❑ main complication: flap necrosis, caused by
  - extrinsic compression (dressing too tight)
  - excess tension on wound closure
  - vascular thrombosis (poor microsurgical anastomosis)
  - hematoma
- ❑ need to monitor flap viability
  - skin colour, capillary refill, post puncture bleeding, Doppler monitoring

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)
- ❑ types
  - rotation
  - Limberg (rhombic)
  - Z-plasty - used to gain or to change the line of direction of the central limb of Z (i.e. release of scar contractures)
  - advancement flaps (single/bipedicle, V-Y, Y-V)

Axial Pattern Flaps
- ❑ flap contains a well defined artery and vein
- ❑ allows greater length: width ratio (5-6:1)
  - peninsular flap - skin and vessel intact in pedicle (see Figure 4a)
  - island flap - vessel intact (see Figure 4b)
  - 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

Free Flaps
- ❑ transplanting expandable donor tissue from one part of the body to another
- ❑ tissue must be able to survive on a single-pedicled blood supply with an artery and draining vein
- ❑ use microsurgical technique
  - the transplanted part is reanastomosed to recipient site vessels to reestablish blood flow
  - survival rates > 95%
  - e.g. Transverse Rectus Abdominal Myocutaneous (TRAM), radial forearm, scapular
  - can be fascicutaneous, muscle flap, or osseous

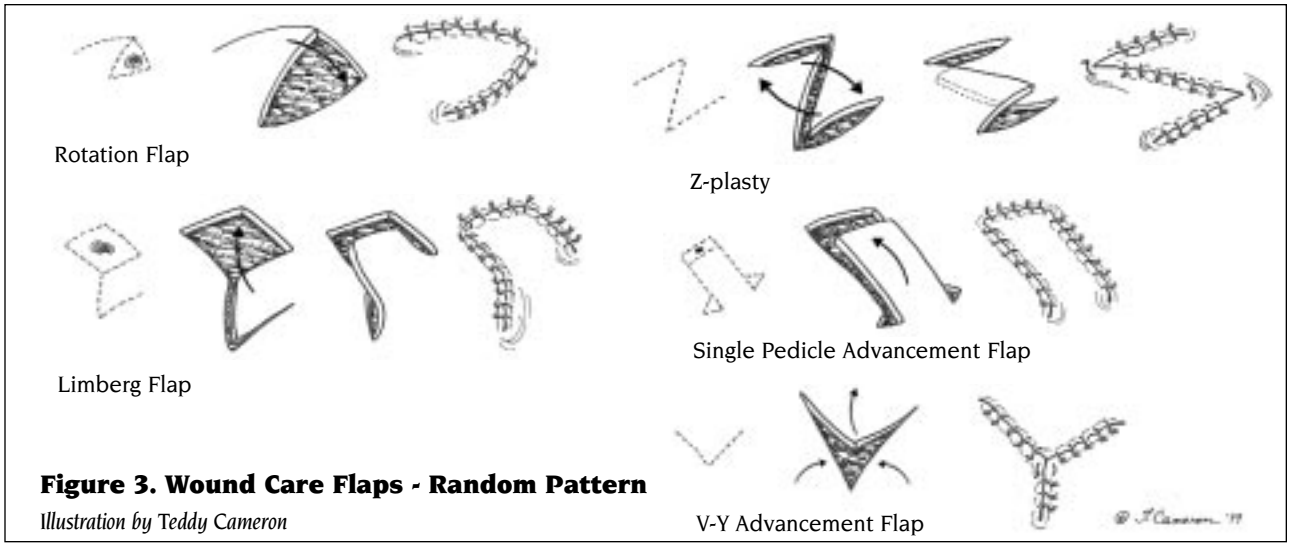

Figure 3. Wound Care Flaps - Random Pattern

Illustration by Teddy Cameron

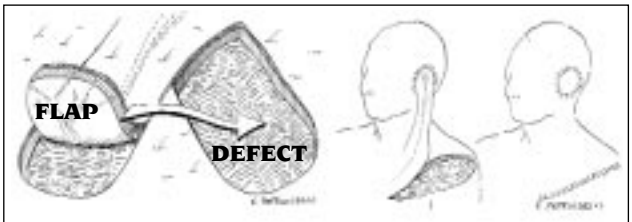

Figure 4a. Peninsular Axial Pattern Flap

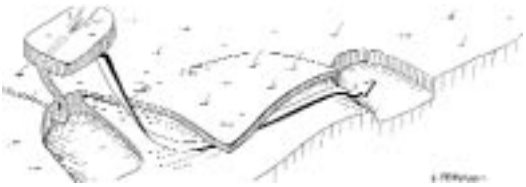

Figure 4b. Island Axial Pattern Flap

Illustrations by Karen Petruccelli

THE HAND

HISTORY

❑ 4 basic questions: 1. mechanism of injury, 2. occupation, 3. hand dominance, 4. history of previous hand injury

GENERAL ASSESSMENT

❑ expose entire upper extremity
❑ compare with unaffected region/hand
❑ inspection
- posture of hand, color, swelling/edema, lesions, scars

❑ vascular
- temperature, capillary refill (< 1 second), radial pulse, ulnar pulse, Allen's test (< 5 seconds), skin turgur, Doppler probe

❑ neuromotor
- hand (see Table 4)
- fingers: assess digital nerves at distal tips with two-point discrimination on radial and ulnar aspects (> 6 mm indicates axonal loss)
- in children two point discrimination may not be practical
- immersion test – immerse hand in water for 5-10 minutes (skin on palmar surface of hand should wrinkle)
- skin moisture (skin becomes dry with loss of sympathetic innervation)
- pinch and grip strength

❑ tendons
- each joint in the hand has a prime mover (see Table 5)
- palpate tendons
- measure passive and active range of motion (ROM) of wrist, metacarpophalangeal (MCP) joint, and interphalangeal (IP) joint of each digit
- never test tendons against resistance if tendon laceration is suspected - let patient actively move joints themselves

❑ phalangeal fractures
- look for a) rotation or "scissoring" b) shortening of digits
- tenderness to palpation

Table 4. Peripheral 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)	extend wrist and thumb (extensor pollicis longus, extensor carpi radialis)
Motor intrinsic	thumb to ceiling with palm up (abductor pollicis brevis)	abduct index finger (first dorsal interosseous)	

Table 5. Tendon Examination of the Hand

Extrinsic Flexor Tendons
Flexor pollicis longus (FPL): flex IP joint of thumb
Flexor digitorum profundus (FDP): flex DIP of finger (PIP held in extension)
Flexor digitorum superficialis (FDS): flex PIP of finger (other fingers held in extension to block profundus function)
Flexor carpiulnaris (FCU)/ Flexor carpiradualis (FCR)/ Pollicis longus (PL): flex wrist and oppose thumb to small finger (examiner palpates volar tendons – PL lies between FCR radially and FCU ulnarly)

Extrinsic Extensor Tendons
APL/EPB: move thumb out to side (palpate tendons on dorsal-radial aspect of thumb)
ECRL/ECRB: extend wrist against resistance (palpate tendons over dorsal-radial aspect of wrist)
EPL: extend thumb with hand flat
Extensor digitorum communis (EDC): extend MCP/PIP/DIP
Extensor indicis (EI): extend MCP/PIP/DIP of index finger with other fingers bent in a fist
EDM: extend MCP/PIP/DIP of small finger with other fingers bent in a fist
ECU: extend and ulnarly deviate wrist (palpate tendon on ulnar aspect of wrist)

Intrinsic Muscles
Abductor pollicis brevis (APB)/Opponens pollicis (OP)/Flexor pollicis brevis (FBP): touch the thumb and small finger together with nails parallel
Abductor pollicis (ADP): forcibly hold a piece of paper between thumb and radial side of index finger of both hands (Froment's sign: thumb IP joint flexes when AdP is weak)
Lumbricals (interosseous): flex MCP joint and extend IP joints
Interosseous: spread fingers apart
Abductor digiti minimi (ADM)/Flexor digiti minimi brevis (FDM)/Opponens digiti minimi (ODM): ulnarly deviate little finger (inspect for dimpling of hypothenar skin)

Table 6. Extensor Tendon Compartments

Extensor Compartments

1) Abductor pollicis longus (APL)
   Extensor pollicis brevis (EPB)
2) Extensor carpi radialis longus (ECRL)
   Extensor carpi radialis brevis (ECRB)
3) Extensor pollicis longus (EPL)
4) Extensor communis (comprised of 4 tendons, which make up extensor digitorum tendons)
5) Extensor digiti minimi (EDM)
6) Extensor carpi ulnaris (ECU)

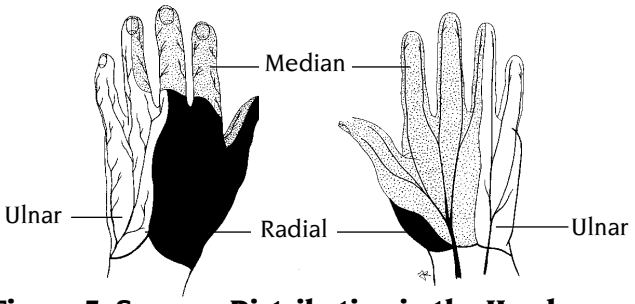

Figure 5. Sensory Distribution in the Hand

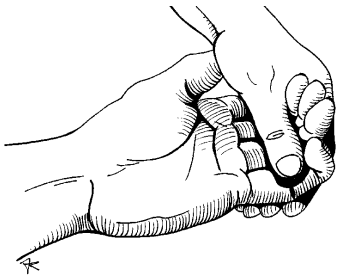

Figure 6. Testing Profundus (Inserts into DIP)

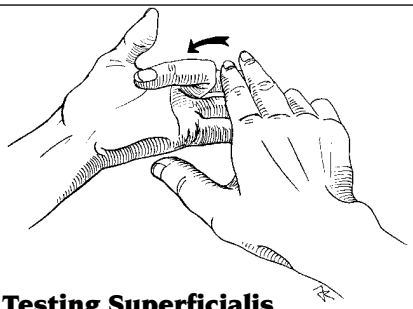

Figure 7. Testing Superficialis (Sublimus) (Inserts into PIP)

Illustrations by Jackie Robers

GENERAL MANAGEMENT

Nerves
- ❑ primary repair for a clean injury within 14 days 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 color, capillary refill, skin turgur, 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

Clinical Pearl
- ❑ **Arterial bleeding from a volar digital laceration may indicate nerve laceration (nerves in digits are superficial to arteries).**

Red Flag
- ❑ **Compartment Syndrome: Watch out for these signs with a closed or open injury: tense, painful extremity (worse on passive stretch), distal pulselessness (often late in process), parasthesia/paralysis, and contracture (irreversible ischemia). Intracompartmental pressures over 30 mm Hg for more than 8 hours require urgent fasciotomy.**

Red Flag
- ❑ **High pressure injection injury deceptively benign-looking (small pinpoint hole on finger pad) often with few dimical signs.**

AMPUTATIONS

Hand or Finger

❑ emergency management: injured patient and amputated part require attention
- patient: radiographs, NPO gauze, clean wound and irrigate with NS, dress stump with nonadherent, cover with dry sterile compression dressing, tetanus and antibiotic prophylaxis (cephalasporin/erythromycin)
- amputated part: radiographs, gently irrigate with Ringers lactate, wrap amputated part in a NS/RL soaked sterile gauze and place inside waterproof plastic bag in container of ice water (approximately 4°C)

❑ 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 amputation, clean amputation at hand or 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 8)

❑ mallet finger (zone 1) (see Figure 9)
- DIP in flexion with loss of active extension
- caused by extensor tendon rupture at DIP joint
- if trauma, suspect if sudden blow to tip of extended finger

❑ Boutonniere deformity (zone 3) (see Figure 10)
- PIP in flexion, DIP in hyperextension
- injury or disease affecting the extensor tendon insertion into the dorsal base of the middle phalynx
- associated with rheumatoid arthritis (RA)
- if trauma, suspect if laceration, volar dislocation, or acute forceful flexion of PIP

❑ Swan Neck deformity (zone 3)
- PIP hyperextension, DIP flexion
- associated with RA, certain types of spasticity, old mallet finger deformity
- if trauma, suspect in PIP volar plate injury

❑ de Quervain's tenosynovitis (zone 7)
- inflammation in 1st dorsal wrist compartment (APL and EPB)
- +ve Finkelstein's test (pain induced by making fist, with thumb in palm, and ulnar deviation of wrist)
  - pain localized between 1st extensor compartment and the carpometacarpal (CMC) joint of the thumb
- tenderness and crepitation over radial styloid may be present
- differentiate from CMC joint arthritis

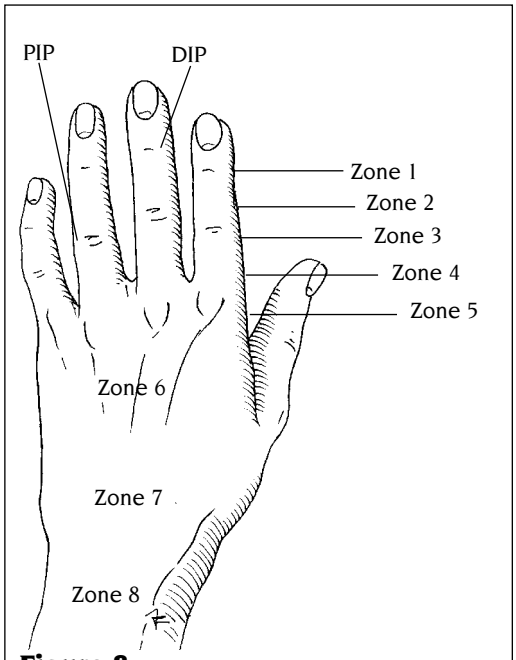

Figure 8.
Zone of Extensor Tendon Injury

Figure 9. Mallet Finger Deformity

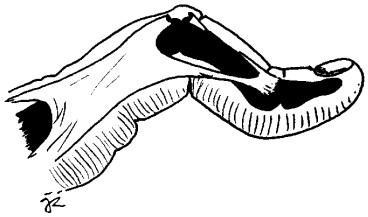

Figure 10. Boutonniere Deformity

Illustrations by Jackie Robers

Flexor Tendon (see Figure 11)
- ❑ flexor tendon zones (important 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

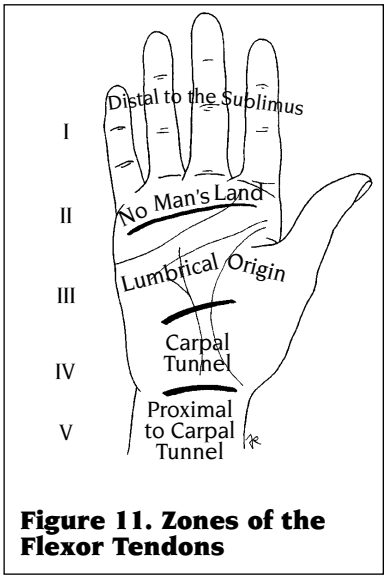

Figure 11. Zones of the Flexor Tendons

Illustration by Jackie Robers

Common Flexor Tendon Deformity
- ❑ stenosing tenosynovitis (trigger finger/thumb)
  - majority idiopathic
  - ring or middle fingers most commonly affected
  - tendon/pulley size discrepancy causes locking of thumb or finger in flexion/extension
  - may palpate nodule at palmar aspect MCP
  - palpation of flexor tendon over MCP joint may be painful
  - 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
- ❑ position of function (like a hand holding a pop can) (see Figure 12)
  - wrist extension 15°
  - MCP flexion 45°
  - 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) (see Figure 13)
  - wrist extension 45° (position most beneficial for hand function if immobilized)
  - MCP flexion 60° (maximal collateral ligament stretch)
  - PIP and DIP in full extension (maximal volar plate origin stretch)
  - thumb abduction and opposition (functional position)

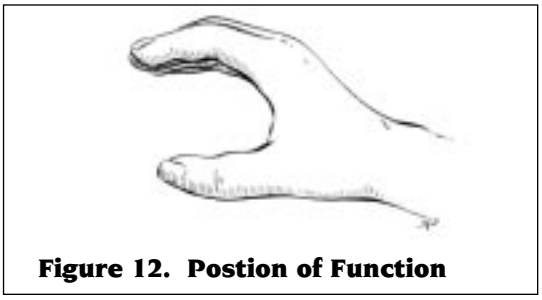

Figure 12. Postion of Function

Illustration by Jen Polk

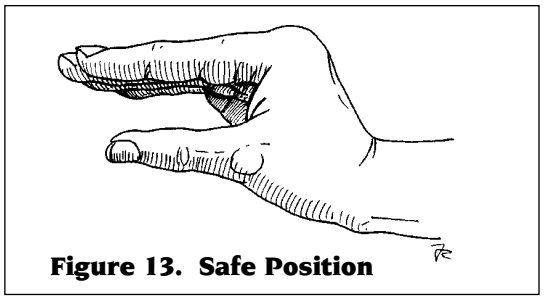

Figure 13. Safe Position

Illustration by Jackie Robers

Distal Phalanx Fractures
- ❑ require symptomatic protection
- ❑ soft tissue injuries more important than bone
- ❑ suspect if subungual hematoma

Proximal and Middle Phalanx Fractures
- ❑ undisplaced or minimally displaced - buddy tape to neighboring stable digit, elevate hand, motion in guarded fashion 10-14 days post injury
- ❑ displaced - percutaneous pins (K-wires), splinting check for malrotation of finger ("scissoring") on making a fist

Metacarpal Fractures
- ❑ Boxer's fracture: acute angulation of the head or neck of metacarpal of little finger into the palm (see Figure 14)
  - mechanism: blow on the distal-dorsal aspect of closed fist
  - loss of prominence of metacarpal head, scissoring of fingers on making a fist
  - volar displacement of head
  - up to 30-40° angulation acceptable unless reduced range of motion or aesthetic problem
  - if stable splint X 3 weeks with PIP and DIP joints free, otherwise surgery

- ❑ Bennett's fracture: intra-articular fracture/dislocation of the base of the thumb metacarpal (see Figure 15)
  - unstable fracture
  - abductor pollicis longus pulls MC shaft proximally and radially causing adduction of thumb
  - treat with percutaneous pinning, thumb spica x 6 weeks
- ❑ Rolando's fracture: T or Y-shaped intra-articular fracture of the base of the thumb metacarpal (see Figure 16)
  - treat with open reduction and internal fixation (ORIF)

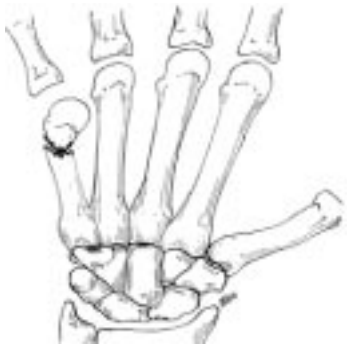

Figure 14. Boxer's Fracture

Illustration by Betty Lee

Figure 15. Bennett's Fracture

Illustration by Meaghan Brierley

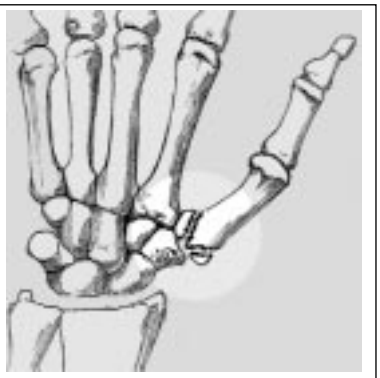

Figure 16. Rolandos's Fracture

Illustration 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)
  - over treatment (prolonged immobilization) causes stiffness
- ❑ 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 DISEASE

- ❑ contraction of longitudinal palmar fascia, forming nodules, fibrous cords and eventually joint contractures
- ❑ flexor tendons not involved
- ❑ genetic disorder (unusual in Orientals and blacks), associated with but not caused by repetitive trauma, alcohol, liver disease, and diabetes
- ❑ men > women
- ❑ order of digit involvement (most common to least common): ring > little > long > thumb >index
- ❑ may also involve feet (Dupuytren's) and penis (Peyronie's)
- ❑ 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; however, it does not cure the disease
- ❑ may recur, especially in Dupuytren's diathesis
  - early age of onset, strong family history, and involvement of sites other than palmar aspect of hand

CARPAL TUNNEL SYNDROME (see Neurosurgery Chapter)

- ❑ see Surgical Procedures section

HAND INFECTIONS

Principles

- ❑ trauma is most common cause
- ❑ 5 cardinal signs: rubor (red), calor (hot), tumor (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*, S*trep. viridans*, G*roup* A S*trep*., S. *epidermis*, and B*acteroides melanin*
- ❑ infection vs. inflammation sometimes diagnostically challenging; look at history, physical (severe pain on axial compression of finger suggests infection), WBC count, radiographs, etc.

Types of Infections

- ❑ paronychia
  - infection of soft tissue around fingernail, often begins as "hangnail"
  - most commonly staphylococcus infection
  - signs: red, swollen, painful, purulent discharge at margin of nail
  - treatment: antibiotics (drainage if abscess present)
- ❑ felon: deep infection of distal segment pulp space
  - most commonly staphylococcus infection
  - signs: red, swollen, and extremely painful
  - may be associated with osteomyelitis
  - treatment: incision and drainage and antibiotics (oral cloxacillin)
- ❑ flexor tendon sheath infection (acute suppurative tenosynovitis)
  - Kanavel's 4 cardinal signs:
    - tenderness along flexor tendon sheath (most important)
    - severe pain on passive extension of DIP (second most important)
    - fusiform swelling of digit
    - flexed or semi-flexed attitude (posture) of finger
  - most commonly staphylococcus or streptococcus infection
  - treatment: OR incision and drainage, irrigation, and antibiotics
- ❑ human bites
  - most common over dorsum of MCP (punch in mouth)
  - serious, may lead to septic arthritis as mouth has 10^9 microorganisms/mL, (get trapped in joint space when MCP's extended and can cause septic arthritis)
  - radiographs prior to therapy to rule out foreign body/fracture
  - wounds cultured for aerobic and anaerobic organisms, gram stain
  - surgical exploration of joint, drainage and debridement of infected tissue
  - wound must be copiously irrigated
  - treatment: clavulin, secondary closure (see Emergency Medicine Chapter)
- ❑ dog and cat bites (pathogens: *Pasteurella multocida*, S. *aureus*, S. *viridans*)
  - wounds cultured for aerobic and anaerobic organisms
  - radiographs prior to therapy to rule out foreign body/fractures
  - surgical exploration of joint, drainage and debridement of infected tissue
  - wound must be copiously irrigated
  - treatment: Clavulin (antibiotics started immediately)
  - secondary closure for small wounds, loose approximation and insertion of drains for large wounds (see Emergency Medicine Chapter)
- ❑ deep palmar space infections
  - uncommon, involve thenar or mid-palm, treated in operating room
- ❑ herpetic whitlow
  - painful vesicle around finger tip (often found in medical personnel)
  - treatment: protection (cover), consider oral acyclovir
- ❑ gonococcal arthritis (uncommon)
  - high index of suspicion based on history (STD, IV drugs)
  - can destroy entire joint in short time
  - treatment: penicillin

Red Flag

❑ **Suspect human bite when lacerations above MCP of patient's hand. This can lead to rapid septic arthritis. Must ask patient if they have punched another person in the mouth.**

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
- ❑ surgical treatment of common problems
  - Synovitis
    - requires tendon repair if ruptured
    - can lead to carpal tunnel syndrome and trigger finger
  - Ulnar drift
    - MCP arthroplasty, resection of distal ulna, soft tissue reconstruction around wrist
  - Thumb deformities
    - can be successfully treated by arthrodesis
  - Swan Neck deformity
    - soft tissue reconstruction, arthrodesis, or arthroplasty
  - Boutonniere deformity (see Figure 10)
    - 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 – most commonly scald burns
  Adults – most commonly flame burns

PATHOPHYSIOLOGY OF BURN WOUND (see Figure 17)
- ❑ zone of coagulation - cells irreversibly damaged = cellular death
- ❑ zone of stasis – poorly perfused, 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, equivalent to superficial burn

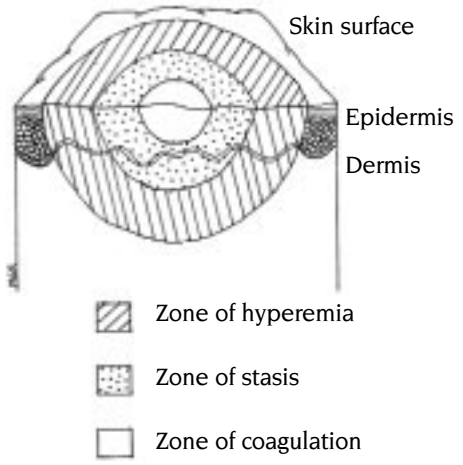

Figure 17. Zones of Thermal Injury

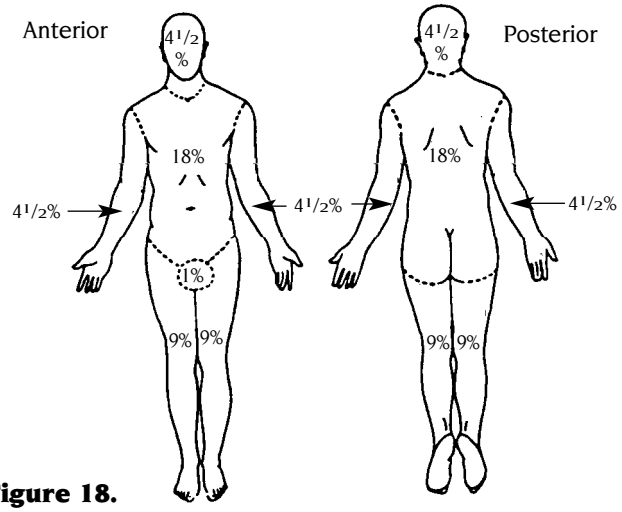

Figure 18. Rule of 9's for Total Body Surface Area

Illustration 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 (children under age 10 use a Lund-Browder chart)
- ❑ for patchy burns, patient's palm represents approximately 1% of the TBSA
  - TBSA > 50% have basal metabolic rate (BMR) 1.5-2x predicted
- ❑ age - more complications if < 3 or > 60 years old
- ❑ depth classification (see Table 7)
- ❑ location
  - face, hands, feet, perineum are critical areas requiring special care of a burn unit
  - 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)

Red Flag
- ❑ **Suspect inhalation injury if burn sustained in closed space, singed nasal hairs/eyebrows, soot around nares/oral cavity, hoarseness, and conjunctivitis. Requires immediate intubation due to impending airway edema.**

Table 7. Burn Depth (see Colour Atlas PL)

Nomenclature	Traditional Nomenclature	Depth	Clinical Features
Partial thickness (superficial)	First degree	Epidermis	Erythema, white plaque
Partial thickness (Deep)	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, muscle, bone	Hard, leather-like texture of skin eschar formation, purple fluid, insensate

INDICATIONS FOR TRANSFER TO BURN CENTRE

American Burn Association Criteria
- ❑ 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
- ❑ 2º or 3º burns with threat of serious functional or cosmetic impairment (i.e. face, hands, feet, genitalia, perineum, major joints), contractures
- ❑ inhalation injury (may lead to respiratory distress)
- ❑ electrical burns (internal injury underestimated by TBSA)
- ❑ 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, hoarseness, conjunctivitis, history of explosions or flash burns), intubate immediately before edema occurs
- ❑ acute causes
  - carbon monoxide (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)
  - causes chemical injury to alveolar basement membrane and pulmonary edema
  - if humidified O_2 not successful, may need to intubate and ventilate
  - watch for secondary lung infections (after 1 week) leading to progressive pulmonary insufficiency
  - watch for bronchopneumonia (up to 25 days)

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 to restore plasma volume and cardiac output (see Table 8)
  - 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 Na^+
- ❑ extra fluid administration required in burns greater than 80% TBSA, associated traumatic injury, electrical burn, inhalation injury, delayed start of resuscitation, pediatric burns, and 4º burns
- ❑ monitor resuscitation
  - urine output is the best measure
  - 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 BP > 70 mmHg

Table 8. Burn Shock Resuscitation

Hour 0 – 8	2 cc Ringer's/kg/% TBSA over 8 hours
Hour 8 – 24	2 cc Ringer's/kg/% TBSA over 16 hours
Hour 24 – 30	0.35-0.5 cc plasma/kg/%TBSA
> Hour 30	D5W at rate to maintain normal serum sodium
	* don't forget to add maintenance fluid to resuscitation

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*
    - Day 1-3: Gram positive
    - Day 3-5: Gram negative
  - 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 9. Topical Antibiotic Therapy

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

Other Considerations in Burn Management

- ❑ nutrition: calories, vitamin C, vitamin A, Cu^{2+}, Zn^{2+}, Fe^{2+}
- ❑ immunosuppression and sepsis
- ❑ gastrointestinal (GI) bleed may occur with burns > 40% TBSA
  - treatment: tube feeding or NPO, antacids, H_2 blockers
- ❑ renal failure secondary to hypovolemia – rare
  - beware of nephrotoxic antibiotics in burn care
- ❑ tetanus toxoid should be administered to all patients sustaining burns deeper than superficial partial thickness

CHEMICAL BURNS

- ❑ coagulate tissue proteins causing necrosis
- ❑ severity depends on: type of chemical (alkali worse than acid), concentration, quantity, and contact time, degree of tissue penetration
- ❑ burns are deeper than initially appear and may progress with time
- ❑ inspect eyes
- ❑ common agents: cement, hydrofluoric acid, phenol, tar
- ❑ treatment
  - dilution with water is initial treatment
  - wash eyes out with saline and refer to ophthalmology
  - repeated application of Polysporin for removal of tar
  - local care after 12 hours: debridement, topical antibiotics
  - wound closure same for thermal burn
- ❑ beware: underestimated fluid resuscitation, renal, liver, and pulmonary damage

ELECTRICAL BURNS

- ❑ depth of burn depends on voltage and resistance of the tissue
- ❑ in decreasing order of conduction: nerve, blood, muscle, skin, tendon, fat and bone
- ❑ often small punctate burns on skin with massive deep tissue damage which requires debridement
- ❑ injury more severe in tissue with high resistance (i.e. bone)
- ❑ electrical burns require ongoing monitoring as latent injuries become manifest
- ❑ watch for
  - cardiopulmonary injuries e.g. ventricular fibrillation
  - myoglobinuria/hemoglobinuria
  - fractures and dislocations, especially shoulder and spine
  - tissue necrosis secondary to vessel thrombosis
  - decrease in RBC (beware of hemorrhages)
  - increased creatinine/potassium and acidity indicating tissue destruction
  - seizures
  - intraperitoneal damage
- ❑ treatment
  - topical agent with good penetrating ability (silver sulfadiazine)
  - debride non-viable tissue early and repeat prn (every 48 hrs) to prevent sepsis
  - major amputations frequently required

FROSTBITE

- ❑ intracellular ice crystals leading to cell lysis
- ❑ microvascular occlusions and peripheral vasoconstriction leading to ischemia
- ❑ superficial frostbite: only skin and subcutaneous tissues frozen
- ❑ deep frostbite: underlying tissues frozen as well
- ❑ management
  - rewarm rapidly in water bath (40-42°C)
  - 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 eschar
  - wait until complete demarcation before proceeding with amputations

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 (systemic symptoms differentiate it from simple irritation)
  - can lead to lymphangitis (visible red streaking in areas proximal to infection)
- ❑ skin flora most common organisms: S. *aureus*, β-hemolytic S*treptococcus*
- ❑ treatment is antibiotics: first line Pen G 2 million units q6-8h IV + cloxacillin 1 g q6-8h IV
- ❑ outline area of erythema to monitor success of treatment

NECROTIZING FASCIITIS

- ❑ infection leading to gangrene of subcutaneous tissue, and subsequent necrosis of more superficial layers **(see Colour Atlas PL)**
- ❑ Type I: β-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 O.R.
  - IV antibiotics: clindamycin 900 mg q8h IV + Pen G 6 million units q4h IV

Red Flag

- ❑ **Soft Tissue Infections: Suspect necrotizing fasciitis with rapidly spreading erythema and edema. Must demarcate erythematous area on admission in order to determine amount of spread.**

Table 10. Soft Tissue Infections (Classified by Depth)

Erysipelas	Subcutaneous (epidermis) infection
Cellulitis	Full thickness skin infection
Fasciitis	Fascia
Myositis	Muscle

SKIN LESIONS

(see Dermatology Chapter)

MANAGEMENT

Non-Malignant Lesions

- ❑ includes hyperkeratotic, fibrous, cystic, vascular and pigmented lesions
- ❑ treat with dermatological methods or surgical excision if necessary – to halt further growth, for cosmesis or if clinically suspicious

Malignant Lesions

- ❑ basal cell carcinoma (BBC) **(see Colour Atlas D21)**
  - primarily tangential growth
  - curettage and electrodessication: 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 (SCC) **(see Colour Atlas D17)**
  - primarily vertical growth
  - 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 5 cm margin is recommended
- node dissection for lesions > 0.75 mm
- beware of lesions that regress - tumour is usually deeper than one anticipates
- assess sentinel nodes

Concepts in Excising Any Skin Lesion
❑ incise along normal skin lines to minimize appearance of scar
❑ use spindle shaped incision to prevent "dog ears" (heaped up skin at end of incision)
❑ undermine skin edges to decrease wound tension
❑ use layered closure including dermal sutures when necessary (decreases wound tension)

ULCERS

PRESSURE ULCERS (SORES)
❑ common sites: heel, sacrum, greater trochanter, ischial tuberosity, 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

Table 11. Venous vs. Arterial Ulcers vs. Diabetic Ulcers

Venous (70% of vascular ulcers)	Arterial	Diabetic
Irregular wound margins	Even wound margins	Irregular wound margins
Superficial	Deep	Superficial
Moderately painful	Extremely painful	Painless
Yellow exudate + granulation tissue	Dry / necrotic base	Necrotic base
Gaiter distribution	Distal locations	Pressure point distribution
Venous stasis discoloration	Thin shiny dry skin	Thin dry skin
Normal distal pulses	Decreased distal pulses	Decreased pulses
No rest pain	Claudication / rest pain	No claudication / rest pain

Venous Stasis Ulcers (see Colour Atlas PL4)
❑ due to venous hypertension, valvular incompetence
❑ painless, dependent edema, discoloration, commonly over medial malleolus
❑ treatment
- elevate, pressure stockings, may need skin graft

Aterial Ischemic Ulcers (see Colour Atlas PL5)
❑ 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

ULCERS . . . CONT.

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

Clinical Pearl
- ❑ **Diabetic ulcers indicate mainly small vessel disease, while gangrene most likely has small and large vessel involvement.**
- ❑ **Large vessel disease can be managed conservatively like peripheral vascular disease (PVD) (stop smoking, lifestyle change, etc.). Arterial reconstruction may be required.**

CRANIOFACIAL FRACTURES

- ❑ ABC's of trauma - always remember to ensure airway, and breathing, prevent aspiration, control bleeding and check cervical spine
- ❑ consider intracranial trauma, rule out skull fracture
- ❑ forces involved - low velocity vs. high velocity injuries determine degree of damage
- ❑ frequency: nasal > zygomatic > mandibular > maxillary
- ❑ management can wait up to 10 days for swelling to decrease before osteotomies are required

CRANIOFACIAL ASSESSMENT (see Emergency Medicine Chapter)

History
- ❑ AMPLE history (allergies, medications, past medical history, last meal, environment)
- ❑ occular history (visual acuity, diplopia)
- ❑ history of previous facial trauma
- ❑ facial anesthesia
- ❑ malocclusion

Physical
- ❑ ABC's!!!
- ❑ C-spine assessment
- ❑ visual assessment (automatically obtain an ophthalmology consult)
  - eno/exopthalmos
  - orbital rim deformity
- ❑ soft tissues (lacerations/bruising)
- ❑ bony tissue palpation
  - step deformities/tenderness/mobility
  - malocclusion/trismus
  - "flattened cheek"
- ❑ cranial nerves (especially facial nerve)

Red Flag
- ❑ **Suspect C-Spine injury with any facial trauma. C-Spine evaluation before radiographs are ordered.**

Investigations
- ❑ plain film (Waters' view, AP, Towne's view)
- ❑ panorex (pure mandible fracture)
- ❑ CT – indicated for complex facial fractures, orbital floor, panface fractures, pre-op assessment

Red Flag
- ❑ **Most facial bone fractures (especially orbital injuries) require Ophthalmology consult.**

Complications
- ❑ diplopia/enophthalmos/blindness
- ❑ cerebrospinal fluid (CSF) leak
- ❑ sinusitis
- ❑ cosmesis
- ❑ functional abnormalities

Superior Orbital Fissure Syndrome
- ❑ fracture of superior orbital fissure causing ptosis, proptosis, paralysis of CN III, IV, VI, and anesthesia in V_1 distribution
- ❑ requires urgent surgical decompression

Orbital Apex Syndrome
❑ same as above plus blindness
❑ requires urgent surgical decompression

RADIOGRAPHIC EXAMINATION

Table 13. 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

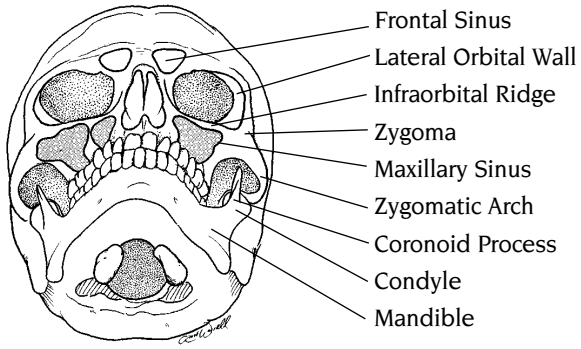

Figure 19. Waters' View

Illustration 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
- tempromandibular joint (TMJ) ankylosis

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

MAXILLARY FRACTURES

❑ Le Fort classification (see Figure 20)
- 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

❑ 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, raccoon eyes, 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

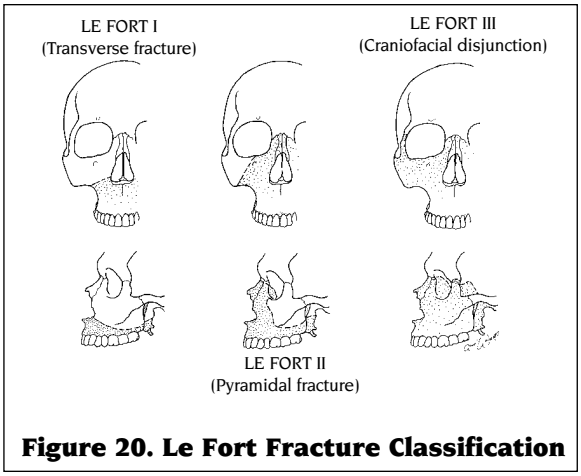

Figure 20. Le Fort Fracture Classification

Illustration by Aimeé Worrell

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
- orbitozygomatic complex fractures (tripod fracture) separation of zygoma from maxilla, frontal and temporal bone
- depressed isolated zygomatic arch fracture

❑ signs
- periorbital ecchymosis and subconjunctival hemorrhage
- loss of prominence of malar eminence (view from above)
- enophthalmos
- vertical dystrophia
- 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
- ❑ may be associated with nasoethmoid fracture
- ❑ 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 (EOM)
  - 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
  - ophthalmologic evaluation mandatory

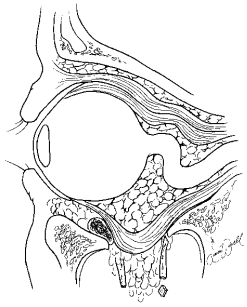

Figure 21.
"Blow-Out" Fracture

Illustration by Aimee Worrell

Red Flag
❑ **Diplopia can present late in orbital blow-out fractures.**

PEDIATRIC PLASTIC SURGERY

CLEFT LIP

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

CLEFT PALATE

- ❑ epidemiology
  - incidence of 1 in 800 in Caucasians, more in Asians, less in Blacks
- ❑ presentation
  - classified as incomplete/complete and unilateral/bilateral
  - may be isolated or in conjunction with cleft lip (unilateral cleft lip and palate most common in males, isolated cleft palate most common in females)
- ❑ treatment
  - special bottles for feeding
  - speech pathologist
  - surgical correction at 6-9 months: Von Langenbeck or Furlow Z-Plasty
- ❑ significance
  - hypo or hyper-nasal speech

SYNDACTYLY

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

POLYDACTYLY
- ❑ definition: congenital duplication of digits
- ❑ presentation
  - thumb duplication most common in Caucasians and Asians
  - fifth finger duplication most common in Afro-Americans and Native Indians
- ❑ treatment: amputate least functional duplicated digit

HEMANGIOMA
- ❑ definition: vascular tumour demonstrating rapid cell turnover or proliferation
- ❑ differential diagnosis: vascular malformation
- ❑ epidemiology
  - 1%-3% of all newborns, 10%-12% at 1 year of age as they appear several weeks after birth
  - 3 females: 1 male
- ❑ presentation
  - sign: erythematous patch or small telangiectasia surrounded by pale halo commonly affecting head and neck region
  - clinical course: stages of rapid growth (first 8 months) followed by spontaneous slow involution
- ❑ prognosis: 75-90% resolve totally by age 7
- ❑ care should be taken not to injure area
- ❑ treatment
  - most involute and regress spontaneously
  - hemangiomas resulting in blockage of airway, visual fields, or ear canal require immediate treatment
  - most common treatments involve steroid therapy (prednisone) or operative excision (usually skin re-contouring post involution)

BREAST RECONSTRUCTION

- ❑ integral part of the treatment for breast cancer
- ❑ two basic methods: implants and autologous tissue
  - choice of method depends on several factors: patient age, prognosis, body weight, characteristics of the chest, contralateral breast, availability of suitable donor tissue for autologous reconstruction, surgical history, radiation treatment, patients attitude, and surgeons experience
- ❑ timing
  - immediate vs. delayed
  - no oncological reason to not perform immediate reconstruction at the time of mastectomy
  - no statistically significant difference in complication rates after immediate versus delayed breast reconstruction
  - immediate reconstruction reduces emotional impact, improved ability to provide breast symmetry (skin flaps pliable and not contracted), preservation of inframammary crease, no sequelae of radiation, cost effective
- ❑ contra-lateral breast
  - may not be possible to reconstruct a breast of the same shape and size as the contra-lateral breast
  - contra-lateral reduction at time of reconstruction in large breasted women maybe considered

IMPLANT RECONSTRUCTION
- ❑ usually involves use of tissue expanders (placed at time of mastectomy) prior to placement of implants due to excessive breast skin excision with the mastectomy therefore not allowing for breast ptosis; no expander required in skin sparing mastectomies allowing good skin coverage and adequate ptosis
- ❑ tissue expanders
  - types: textured vs. smooth, integrated port vs. remote port (axilla location)
    - textured: less capsular reaction, tends to remain in place compared to smooth
    - integrated port: less dissection required, less discomfort, lower chance for puncture of expander compared to remote
  - placement: sub-mammary or sub-pectoral
    - subpectoral preferred: lower incidence of capsular contracture, extra layer of tissue between expander and skin
  - size: depends on chest size, contralateral breast, desired size
    - generally over-expanded to facilitate ptosis
  - timing of expansion: 8-10 week process which begins when wound fully healed (usually 2 weeks post-op), continues weekly or bi-weekly until expansion complete
- ❑ breast implants
  - replaces expander two weeks after expansion is complete
  - types: textured (less capsular thickening) vs. smooth, saline vs. silicone (less rippling), round (less likely to move) vs. contoured (upper pole fullness)
  - complications
    - capsular contraction unique to implants – may pull implant in any direction
    - increased risk of infection, implant is a foreign body
    - risk of complications increased in previously radiated breast

AUTOLOGOUS RECONSTRUCTION

- ❑ considered the gold standard
- ❑ offers reduced long-term morbidity and natural consistency
- ❑ many options: TRAM flap, perforator flaps, latissimus dorsi flaps, gluteal flaps, gracilis flap, tensor fascia lata flap, Rubens flap
- ❑ TRAM flap: Transverse Rectus Abdominis Myocutaneous
  - blood supply: superior epigastric artery supplying pedicled TRAM flap, deep inferior epigastric artery supplying the free TRAM flap since larger of two vessels
  - pass through rectus abdominis and send musculocutaneous perforators to overlying skin (most abundant in peri-umbilical region)
  - four zones based on flap vascularity (Zone IV most distant from pedicle and not reliable)
  - types: Pedicled vs. Free TRAM
    Pedicled TRAM: ipsilateral or contralateral (surgeon choice) rectus abdominis, fascia, and overlying skin supplied by perforators are dissected from its sheath to costal margin and then a tunnel is created between the abdomen and breast area facilitating passage of flap up to chest
  - tunnel must be large enough to allow easy passage, prevent undue pressure (post-operative edema)
  - Free TRAM: rectus muscle, overlying skin, and perforating vessels are incised and harvested
    - usually requires 8 cm pedicle length
- ❑ Rubens Flap
  - blood supply: deep circumflex iliac artery supplying flank skin and fat
  - useful for patients with previous abdominal surgery which precludes TRAM flap
- ❑ Perforator Flaps
  - unlike myocutaneous flaps does not include muscle or fascial harvesting, relies on musculocutaneous perforators supplying overlying fat and skin
  - Deep Inferior Epigastric Perforator (DIEP) Flap
    - same territory as TRAM flap
    - minimizes disruption of abdominal wall
    - may not be as robust as TRAM with regards to venous drainage

Red Flag

- ❑ **Always check for arterial insufficiency (pale pink colour to flap and poor capillary refill) and venous congestion (bluish colour to flap and rapid capillary refill) after vessel anastamoses or flap transfer.**

NIPPLE/AREOLA RECONSTRUCTION

- ❑ final stage of breast reconstruction usually performed 3 months post-reconstruction
- ❑ local vs. distant flaps/grafts
- ❑ local: fish tail flap or skate flap most commonly used; these flaps allow simultaneous nipple and areola reconstruction
- ❑ distant: opposite nipple, earlobes, abdominal skin, costal cartilage
- ❑ usually require tattooing for areola reconstruction

Information for the above section provided courtesy of Dr. P. Neligan

AESTHETIC SURGERY

FACE

- ❑ hair transplants: with grafts or flaps
- ❑ blepharoplasty: removal of excess eyelid skin +/– fat pads
- ❑ rhinoplasty: nose reconstruction
- ❑ 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 mammaplasty (see Surgical Procedures section)

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

SURGICAL PROCEDURES

RELEASE OF TRIGGER FINGER
- ❑ objective: release of trigger finger through:
  - longitudinal incision of involved A-1 flexor tendon sheath to permit unrestricted, full-active finger motion
- ❑ anatomical landmarks: locate flexor tendon involved by palpating nodule or a thick stenotic sheath, problem invariably at proximal portion of the flexor retinacular system (A-1 pulley system)
- ❑ complications: digital nerve laceration

DECOMPRESSION OF CARPAL TUNNEL
- ❑ objective: decompression of median nerve through:
  - incision at midproximal palm up to wrist with incision turned ulnarly to avoid palmar cutaneous branch of median nerve
  - palmar fascia and transverse carpal ligament incised to decompress median nerve
- ❑ anatomical landmarks: median nerve, transverse carpal ligament, superficial transverse vascular arch
- ❑ complications: median motor branch injury, palmar cutaneous branch injury, superficial transverse vascular arch injury

REDUCTION MAMMAPLASTY (Breast Reduction)
- ❑ objective: reduction of breast for relief of physical discomfort, improve size and shape of the breasts through:
  - circular incision around areola, vertical incision from areola incision to infra-mammary fold, and an incision along natural infra-mammary fold
  - fat, breast tissue, and skin removal
  - nipple and areola complex moved to higher position
- ❑ anatomical landmarks: nipple, areola, infra-mammary fold, division between breast tissue and pectoralis major
- ❑ complications: hemorrhage, infection, decreased nipple sensation, unable to breast feed, breast and nipple asymmetry

COMMON EMERGENCIES

AMPUTATIONS
- ❑ minimize delay, more proximal amputations require less delay, ischemia time inversely related to volume of muscle in amputated limb

EXTENSIVE MANGLING INJURIES
- ❑ salvage all viable and useful tissue

MAJOR LACERATION WITH SERIOUS HEMMORHAGE
- ❑ never blindly clamp a bleeding vessel as nerves are often found in close association with vessels

COMPARTMENT SYNDROMES
- ❑ if untreated, end result is Volkmann's ischemic contracture of the extremity

HIGH PRESSURE INJECTION INJURIES
- ❑ initial appearance of the wound is deceptively benign, intense pain and tenderness present along the course the foreign material traveled present a few hours after injury, definitive treatment is exposure and removal of foreign material

REFERENCES

Essentials for students: Plastic and Reconstructive Surgery Fifth Edition. Arlington: Plastic Surgery Educational Foundation, 1998.

Information on *Breast Reconstruction* section provided through courtesy of Dr. Peter Neligan.

Smith DJ, Brown AS, Cruse CW et al. *Plastic and Reconstructive Surgery*. Chicago: Plastic Surgery Educational Foundation, 1987.

The Hand: Examination and Diagnosis (Third Edition). American Society for Surgery of the Hand. Philadelphia: Churchill-Livingston, 1990.

The Hand: Primary Care of Common Problems (Second Edition). American Society for Surgery of the Hand. Philadelphia: Churchill-Linvingston, 1990.

Weinzweig J. *Plastic Surgery Secrets*. Philadelphia: Hanley and Belfus Inc., 1999.