THE UNIVERSITY OF JORDAN

Normal Wound Healing

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Topic : wounds and bleeding

Pointers :
Lacerated, Incised and Punctured wounds are all different

Types of wounds :

- Incised Wounds
- Lacerated Wounds
- Abrasion/Graze Wounds
- Contused Wounds
- Punctured Wounds
- Gunshot Wounds

any puncture or penetrating wound >> Exploration must be done
- ✓ To look for any hidden damage
- ✓ To look for any devitalized tissue

Lacerated wound:
Unclean cut; blunt object
E.g Rock, Blunt scissors

Incised wounds :
Clean cut; sharp object
E.g Scissors, knife

Abrasion/Grazed wound:
Friction
E.g falling down on a Beach

healing by regeneration

ABRASION

DEFINITION:
- 1. It is a superficial injury involving only the superficial layers of skin. (epidermis).
- 2. The outer layers of skin are scratched or removed leaving a bare area with little or no bleeding.
- 3. These heal rapidly in few days and leave no scar.

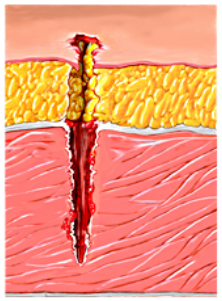
Puncture wounds:
Piercings
E.g Snake bites, nails

Gunshot Wounds :
Gun Shot; round wound
E.g Gunshot

Contused wound:
Bruises; blood clot
E.g knocking onto hard walls.

Laceration

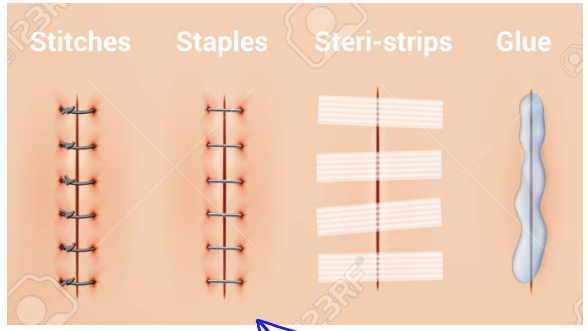
Puncture wound



Avulsion

- Layers of skin torn off completely or only flap of skin remains
- Same mechanism as laceration, but to extent that tissue is completely ripped from it's source
- May be considerable bleeding

Avulsions – an injury in which a portion of the skin and sometimes other soft tissue is partially or completely torn away (amputation)



- Wound closure:

A. Primary closure: Immediate suturing of the wound = healing by Primary intension >> immediate approximating of the wound edges

B. Delayed primary closure: Leave stitches in the wound and close it after 3-5 days when wound is clean. We do this method for contaminated wounds.

بنحط الستيتشيز و بنتركها بدون تسكير ، بعدها بنشيك بعد 3-5 أيام إذا تمام بنسكرها بالعيادة أو الطابق بدون الحاجة لعملية

C. Secondary closure: By scar formation and epithelisation.

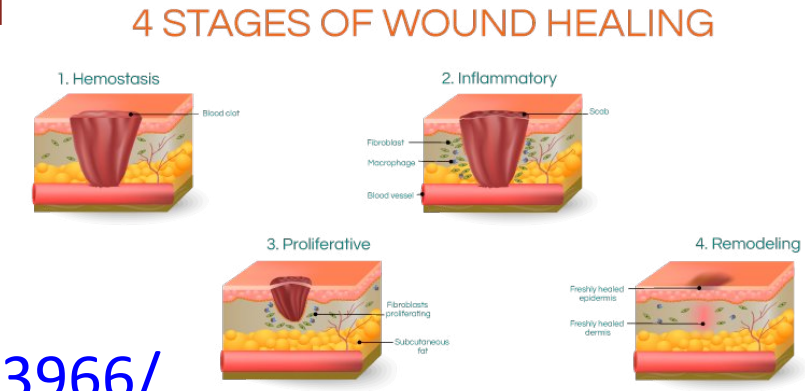
D. Tertiary: By graft or flap. tissue transfer

- Phase of Wound Healing: Look at the diagram

A. Inflammatory

B. Proliferative phase

C. Remodeling phase



Please refer to these links:

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2903966/

✓ In collagen , Proline and lysine residues are hydroxylated to hydroxyproline and hydroxylysine, respectively, which contribute to the formation of collagen crosslinks to form Collagen triple helix

This process (collagen maturation) has many Cofactors , most importantly :
ferric (Fe+3) , vitamin C , Zinc
>> Vitamin C def. >> Scurvy
iron def anemia >> Must be managed before surgery as it delays wound healing

Shortening of the scar especially over joints , causing limitations in movement of that joint

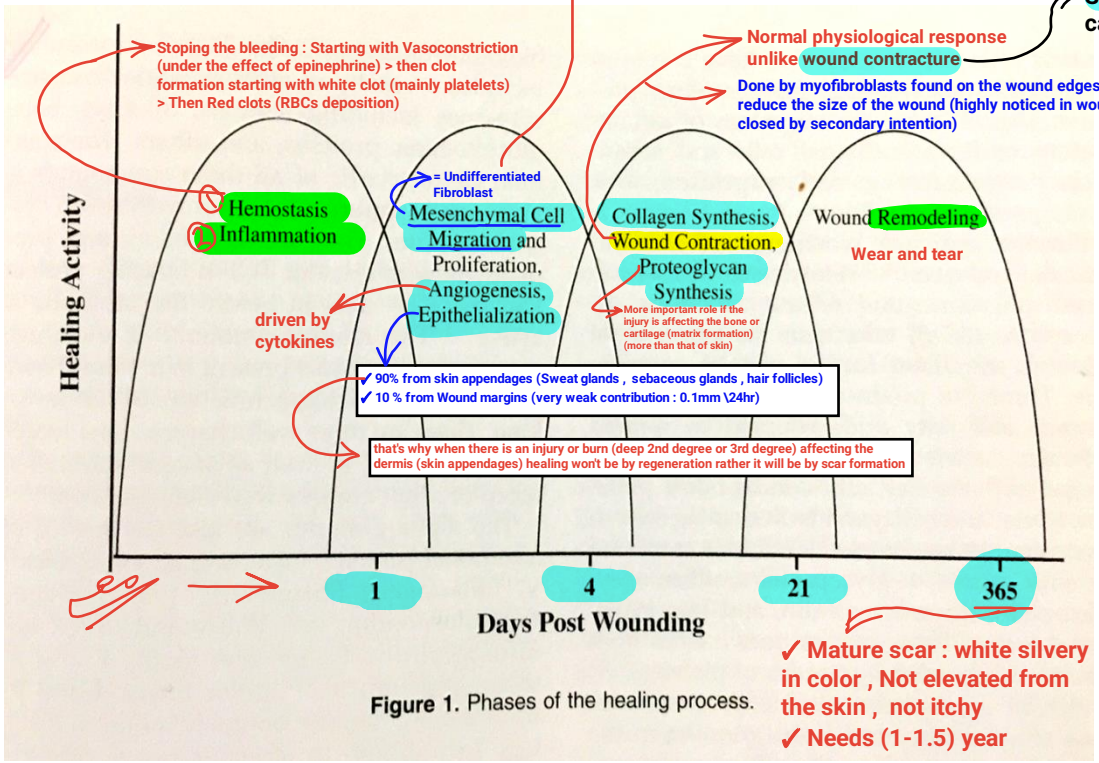


Figure 1. Phases of the healing process.

✓ Mature scar : white silvery in color , Not elevated from the skin , not itchy
✓ Needs (1-1.5) year

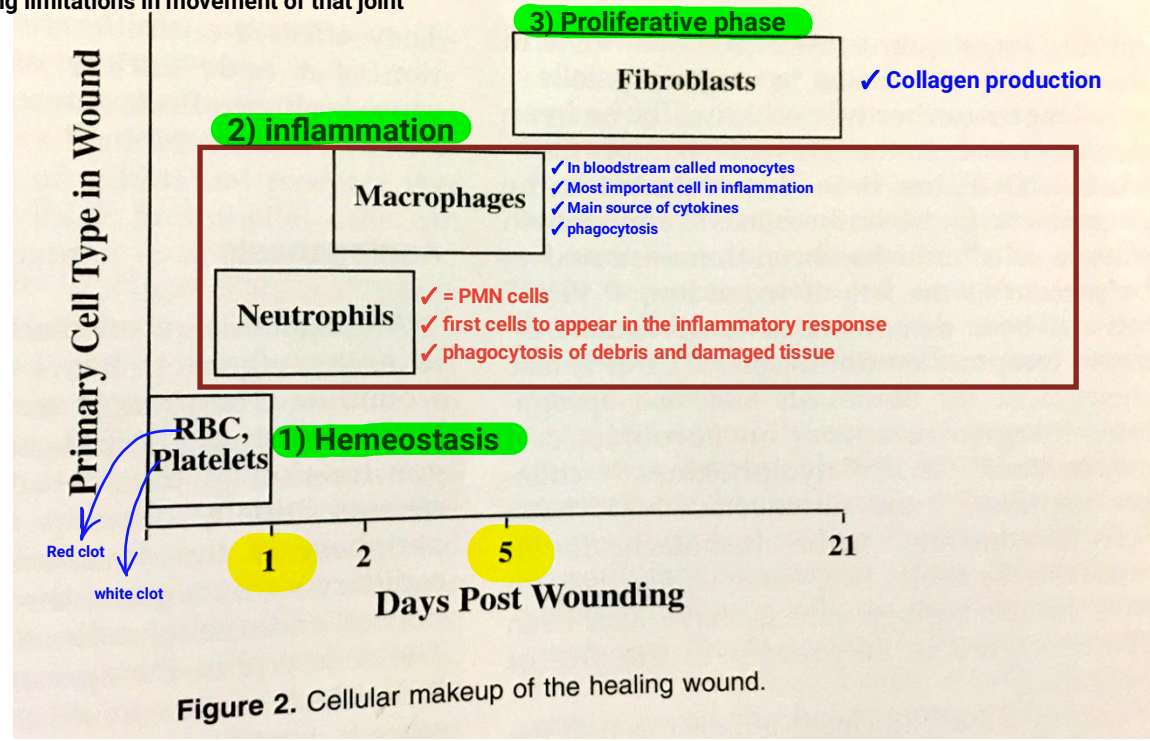


Figure 2. Cellular makeup of the healing wound.

✓ Elastin is responsible for skin elasticity
✓ When there's a wound collagen is reproduced but Elastin No

✓ Each event is controlled by more than one type of cytokines
✓ Each type of cytokines causes more than one event

Table 1. CYTOKINE INVOLVEMENT IN WOUND HEALING FUNCTIONS

Healing Function	Cytokines Involved
Inflammatory Cell Migration	PDGF
	TGF-β
	TNF-α
Fibroblast Migration	PDGF
	TGF-β
	EGF
Fibroblast Proliferation	PDGF
	TGF-β
	EGF
	IGF
	TNF-α
	IL-1
Angiogenesis	bFGF (FGF2)
	aFGF (FGF1)
	TGF-β
	TGF-α
	EGF
	TNF-α
	VEGF
	IL-8
	PD-ECGF
Epithelialization	EGF
	TGF-α
	KGF (FGF7)
	bFGF (FGF2)
	IGF
	HB-EGF
Collagen Synthesis	PDGF
	TGF-β
	bFGF (FGF2)
	EGF

PDGF = platelet-derived growth factor; TGF-β = transforming growth factor-β; TNF-α = tumor necrosis factor-α; EGF = epidermal growth factor; IGF = insulin-like growth factor; IL-1 = interleukin-1; bFGF = basic fibroblast growth factor; aFGF = acidic fibroblast growth factor; TGF-α = transforming growth factor-α; VEGF = vascular endothelial growth factor; IL-8 = interleukin-8; PD-ECGF = platelet-derived-endothelial cell growth factor; KGF = keratinocyte growth factor; and HB-EGF = heparin binding epidermal growth factor.

*** The only commercially available cytokine is PDGF and only it gives acceptable results in healing of diabetic foot (in the form of spray)

We can say that this wound is chronic , when looking at the time needed for healing + taking into consideration :

✓ Host (age , comorbidities ..etc)

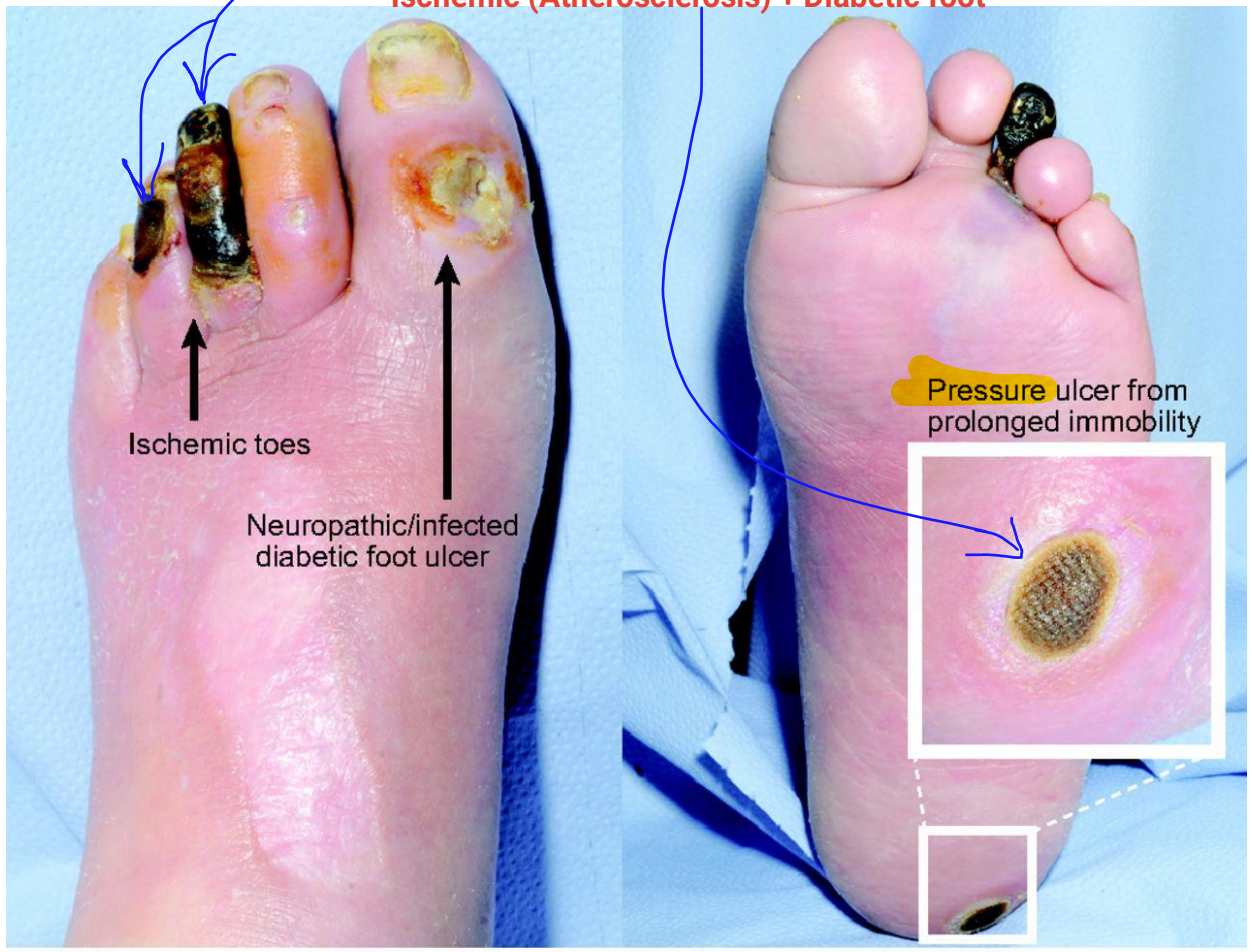
✓ Location of the wound

✓ Cause of the wound

Chronic Wound

venous ulcer on medial malleolus

Ischemic (Atherosclerosis) + Diabetic foot



Dorsal surface

Plantar surface

Chronic Wound

Bed sore \ pressure ulcer on sacral area

Vasculitis rash

Vasculitis gives u chronic ulcers

Factors contributing to impaired wound healing

A. Local factors (8)	B. Systemic factors (5)
❖ Arterial insufficiency } PVD ❖ Venus insufficiency ❖ Edema ❖ Infection ❖ Pressure ❖ Radiation ❖ Foreign material ❖ Necrotic tissue	❖ DM ❖ Malnutrition Protein calorie malnutrition or vitamin (C) def , zinc def ..etc ❖ Vitamin deficiency ❖ Chemotherapy bone marrow suppression > no inflammatory response ❖ Smoking causing peripheral vascular constriction ❖ Aging (?) ❖ Steroids exogenous or Cushing

نسبة تحمل ال scar قوة شد بالنسبة للجلد الطبيعي

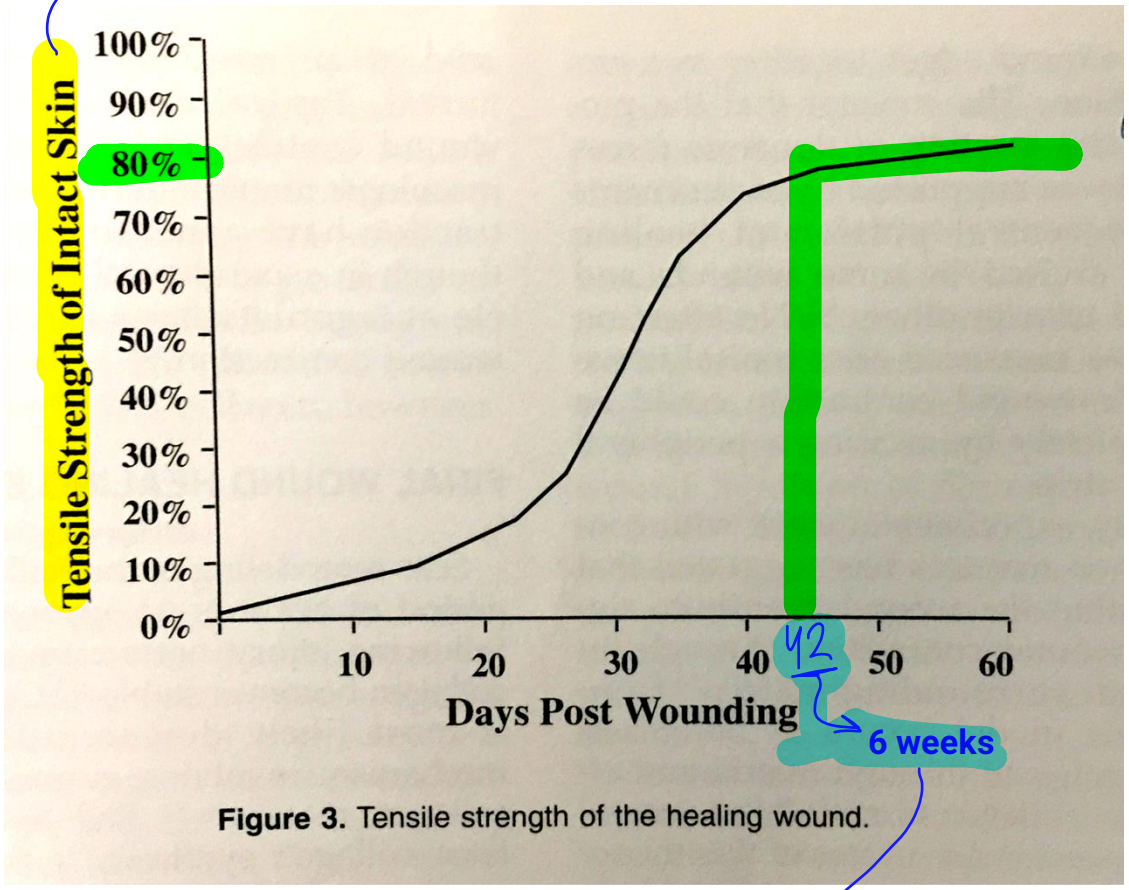


Figure 3. Tensile strength of the healing wound.

Table 1. THE ESTIMATED PREVALENCE AND HEALTH CARE COSTS OF CHRONIC WOUNDS.

Wound Type	Total Prevalence	Estimated Annual Cost
Pressure Ulcer[1]	0.04–0.08%	$1.3 billion
Venous Ulcer[2]	1–2%	$1 billion
Diabetic Ulcer[3]	Total 0.15–0.3% (Diabetics 5–10%)	$1 billion

= Trophic ulcer

Remodeling continues but with no increase in tensile strength

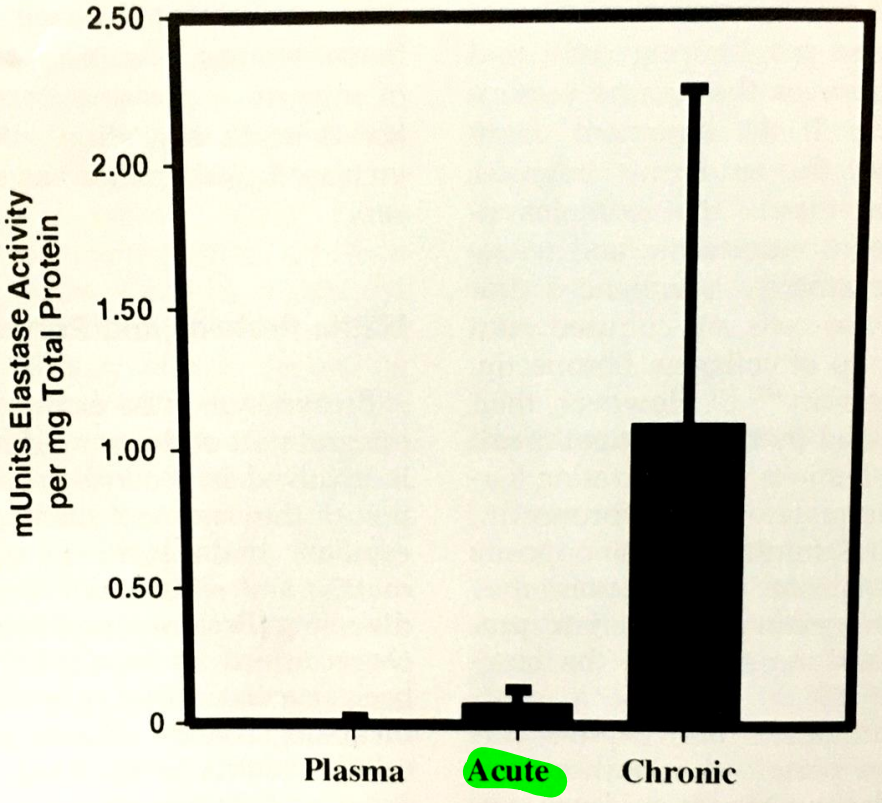


Figure 2. Levels of elastase activity are significantly higher in chronic wound fluid compared with acute wound fluid. Elastase activity was determined by a colorimetric assay using methoxysuccinyl-ala-ala-proval-p-nitoanilide substrate. (*From* Yager DR, Chen SM, Ward BS, et al: Ability of chronic wound fluid to degrade peptide growth factors is associated with increased levels of elastase activity and diminished levels of proteinase inhibitors. Wound Repair and Regeneration 5:23, 1997; with permission.)

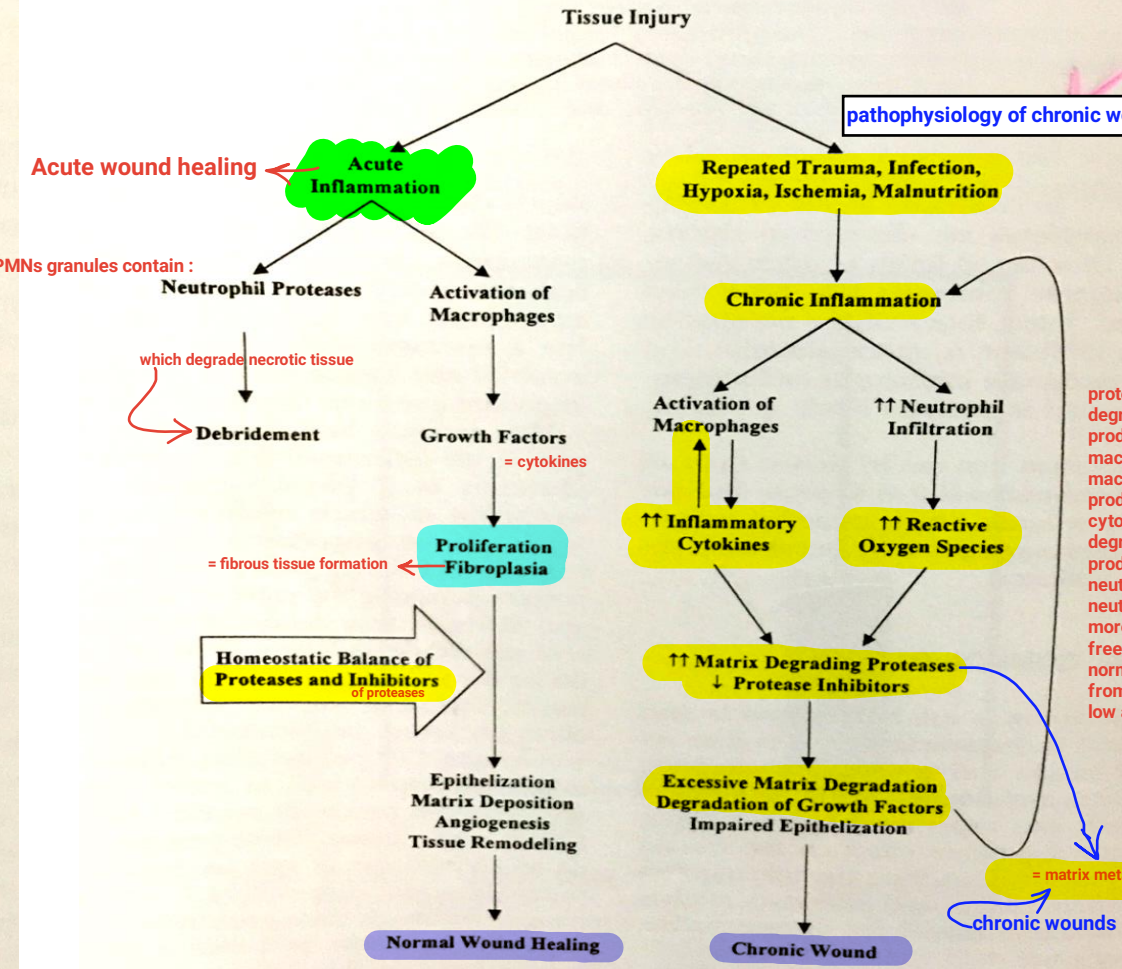


Figure 4. The final common pathway in the pathophysiology of chronic wounds.

Excessive Wound Healing

1. Keloids
2. Hypertrophic scars

Please refer to this link:

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4129552/

New areas of research in wounds healing :
1) applying cytokines >> PDGF in diabetic foot
2) injecting stem cells at the wound site
3) New type of dressings that keeps the wound wet + Do Auto-debridement

✓ Keloids : cancer 🦀 like
✓ More common in black people (Negros)
✓ There's genetic predisposition (multiple genes on short arm of ch.7)
✓ Beyond the site of trauma
✓ Won't improve with time
✓ If excised surgically >> re-occurs (genetics)

✓ Hypertrophic scars
✓ not related to a special ethnic group (all the same)
✓ No genetic predisposition
✓ at the site of trauma
✓ May improve with time

collar incision for Thyroidectomy

Keloids Vs. Hypertrophic scars

In both there's increase in # mast cells when compared to normal wound scar (that's why they are more itchy)

- Etiology: Genetics in keloids Vs. Minor trauma , infection , suturing under tension causing ischemia , sheering forces in Hypertrophic scars
  - as in scars over large joints or over the sternum (CABG) (Sheering force from breathing)
- Histology: Both the same under light microscope \\ to differentiate u need an electric microscope
  - 1) Same # of cells in both but with different functioning ability (collagen production) (more for keloids)
  - 2) How collagen fibers are aligned >> circles (in Keloids) Vs. parallel to the wound (in Hypertrophic scars)
- Treatment

❖ Surgical excision: Not enough in keloids as it will re-occur WHILE in Hypertrophic scars if u make sure that there's no more infection or sheering forces (or whatever the cause was) surgical excision will treat it

→ Usually we combine it with other modalities of Tx such as Silicone sheet or silicone gel or pressure garment

Scar Revision techniques

❖ Z-Plasty: To re orientate the long axis of the scar to be along with or parallel to the line of minimal tension (Creases)

❖ W-Plasty: >> Any incision perpendicular over the line of minimal tension carries Higher risk of Excessive healing and wound contracture

Causes visual illusion reducing حدة الندبة للناظر إليها

→ Z plasty is great for releasing scar contractures.

❖ Steroids → Intralesional injections of "Triamcinolone" (antiinflammatory prevents wound healing and collagen deposition from the beginning)

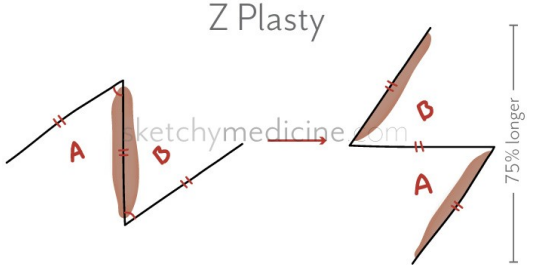
❖ Silicon → Silicon Sheet + Silicon gel \ MOA as an anti-scar isn't well established

❖ Pressure garment رباط طبي →
- ✓ increasing the temperature over the scar >> preventing enzymes from working to produce collagen
- ✓ Re-alignment of collagen fibers

❖ Laser > Fibroblast inhibition \\ efficacy is controversial > as it can't penetrate thick scars

❖ Interferon

> Interferon gamma is a lymphokine (cytokine produced by lymphocytes) that can down-regulate collagen synthesis therefore, has potential therapeutic benefit in the management of abnormal scars.



** affects obvious parts of human face like (nose , cheeks , ear) or digits (hands, feet)

** Common in patients with systemic disease : diabetes , HTN (Anti-HTN drugs cause vasoconstriction) homeless , very young \ old , immunosupressed patients , psychological problems , improper clothing

small fragile blood vessels

Atherosclerotic blood vessels

Frostbite

Subzero Temp.

Only occur when atmospheric temp. below 0

gangrene of ear pinna

mountain climbers complete loss of cartilage of the nose \ cheeks\ neck

Trench foot

خندق

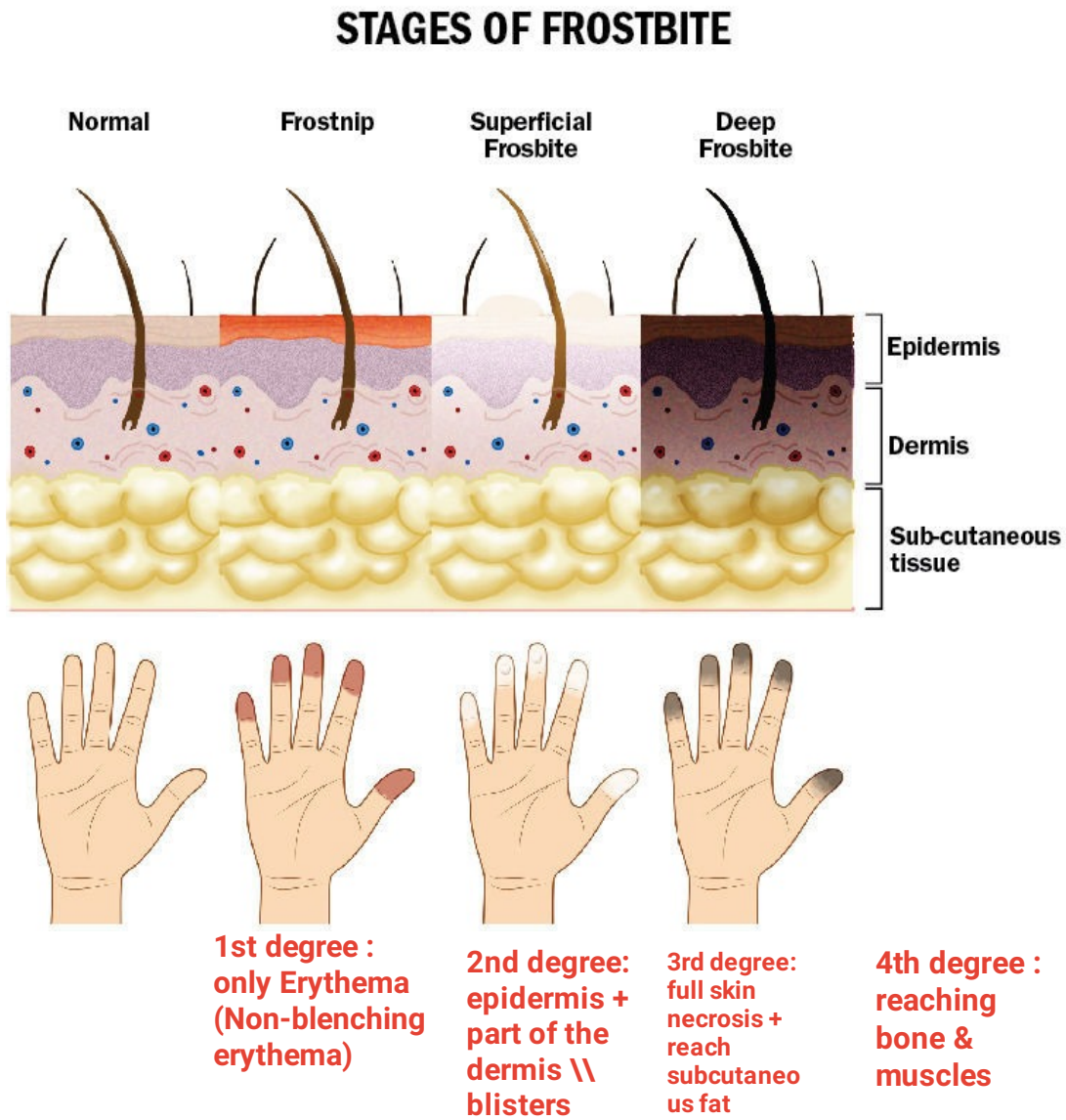
Temp. higher than 0 + Humidity (wet environment)

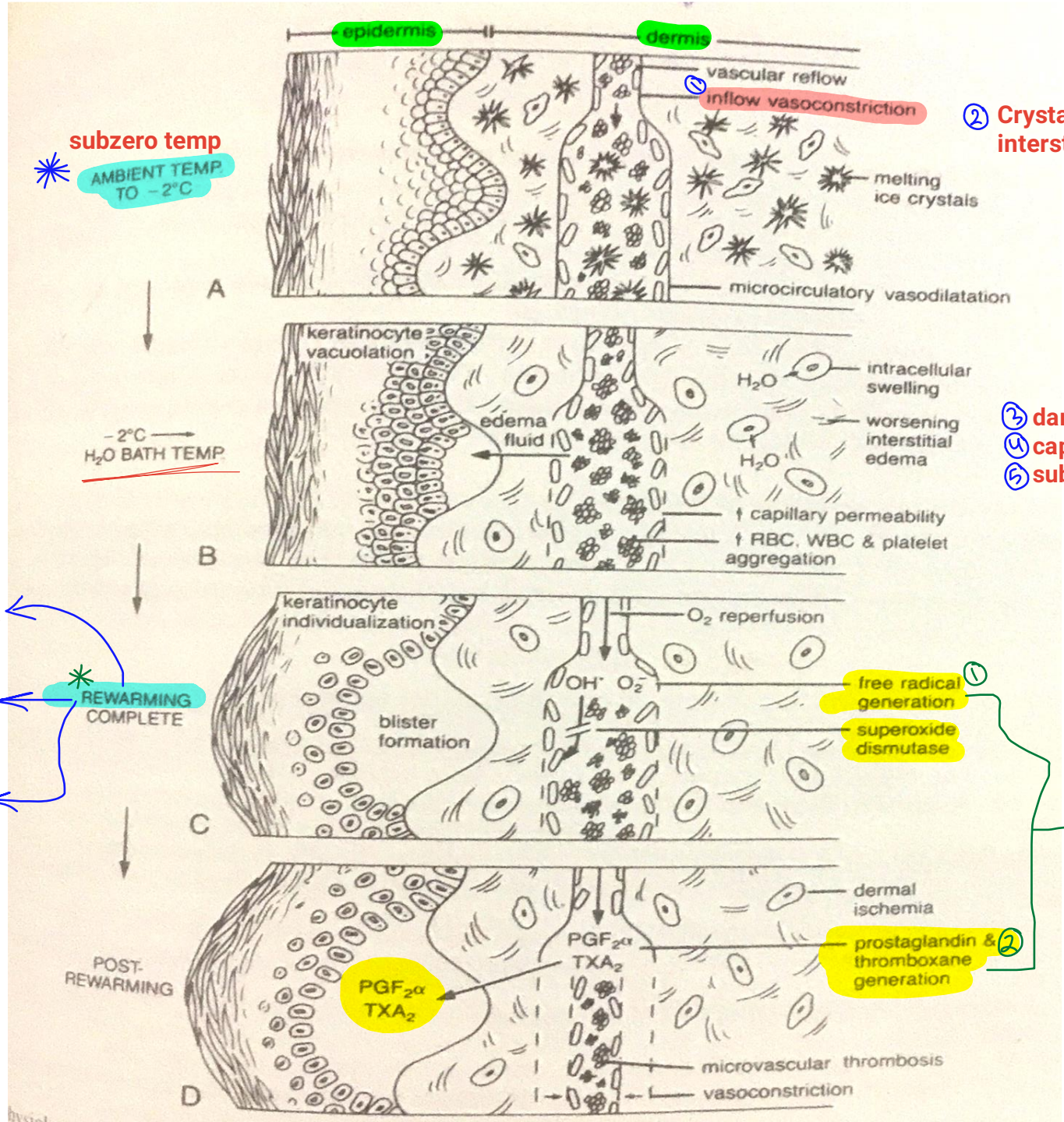
occured to soldiers during world war 2 اللي بالخنادق >> humidity

Please refer to this link:
https://medlineplus.gov/frostbite.html
https://www.healthline.com/health/trench-foot#qa

- Predisposing risk factors
- Classification Of forstbite
- Pathopgysiology Of forstbite

Next slide





subzero temp

AMBIENT TEMP TO −2°C

−2°C → H_2O BATH TEMP

REWARMING COMPLETE

The only mode of Tx

at 42° not more than this to prevent Burns

causes more edema thus larger blisters

Rewarming is done to prevent further damage to other blood vessels and capillaries surrounding the damaged (thrombosed) vessels not to treat the them

① vascular reflow inflow vasoconstriction

② Crystalization of water molecules in the interstitium + intravascularly

③ damage to the endothelial lining
④ capillary leak
⑤ subdermal edema >> Blister formation

will add more injury to the endothelium causing more edema and larger blisters

- Treatment

❖ Re-warming

❖ Analgesia ischemia is painful

❖ Massaging X Contraindicated as it will release more oxygen free radicals and cytokines

❖ Antibiotics X As in burns

❖ Steroids X

❖ Debridement Never done before demarcation between viable and non viable tissues occurs

❖ Elevation To relieve edema

❖ Topical thromboxane inhibitor

TXA_2

Example : Aloe vera

❖ Systematic antiprostaglandin agent

❖ T.T = Tetanus Toxoid >> as any burn or wound tetanus infection may occur

❖ Dressing > to prevent 2° infections

❖ Amputation Never done before demarcation between viable and non viable tissues occurs

❖ Adjuvant therapy: alpha blocker, free radical scavengers, thrombolytics

Causes vasodilatation (protecting other vessels from injury)

only given in early hours

❖ Late sequelae.

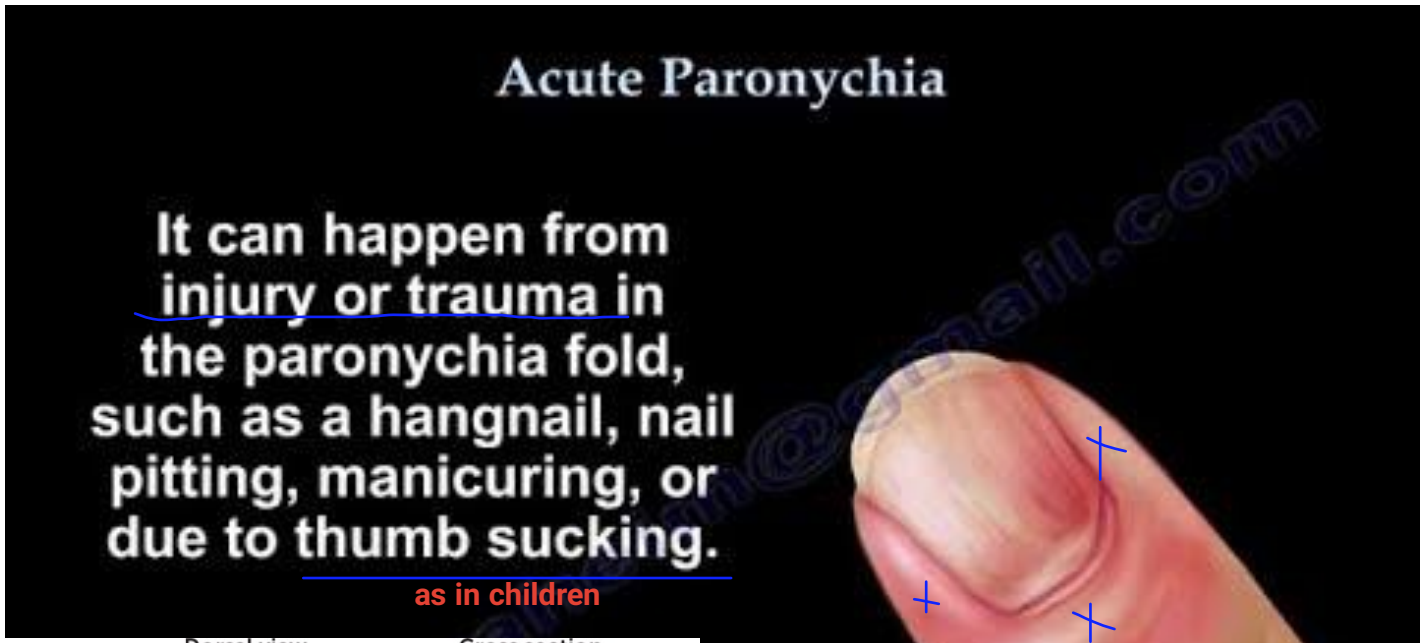
1) Damage to the epiphyseal plate in children > limb shorter than the other > Limbing
2) Arthritis (joint)
3)Cold sensitivity > pain in every time it get cold > especially if the ear or nose were affected
4) Bad scars & contractures

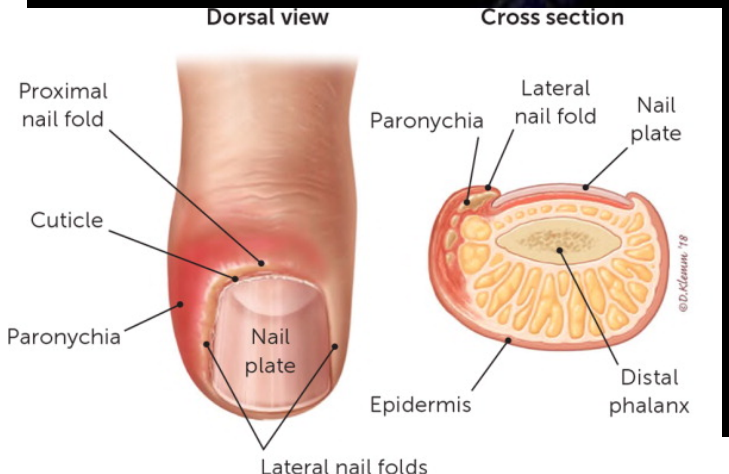
Common hand conditions

- Paronychia — inflammation of the skin folds surrounding the nail

Refer to the following link:

https://www.health.harvard.edu/a_to_z/paronychia-a-to-z





redness of the skin fold surrounding the nail > Acute Paronychia

pus from the nail fold >> لو احنا ما عملنا drainage و تركناه ممكن يطلع لحاله

Normal nail >> Acute Paronychia
Abnormal nail > Chronic Paronychia

Treatment of paronychia >> incision & drainage + antibiotic (most common organism > Staph and strep)

Fungal infection of the nails

pitting nail

✓ Abnormal nails >> Chronic Paronychia

✓ Chronic Paronychia : etiology : fungal infections >> Most common fungus : Candida albicans

✓ Candida albicans infection most commonly in housewives and people who use detergent alot and farmers who are using alot of pesticides

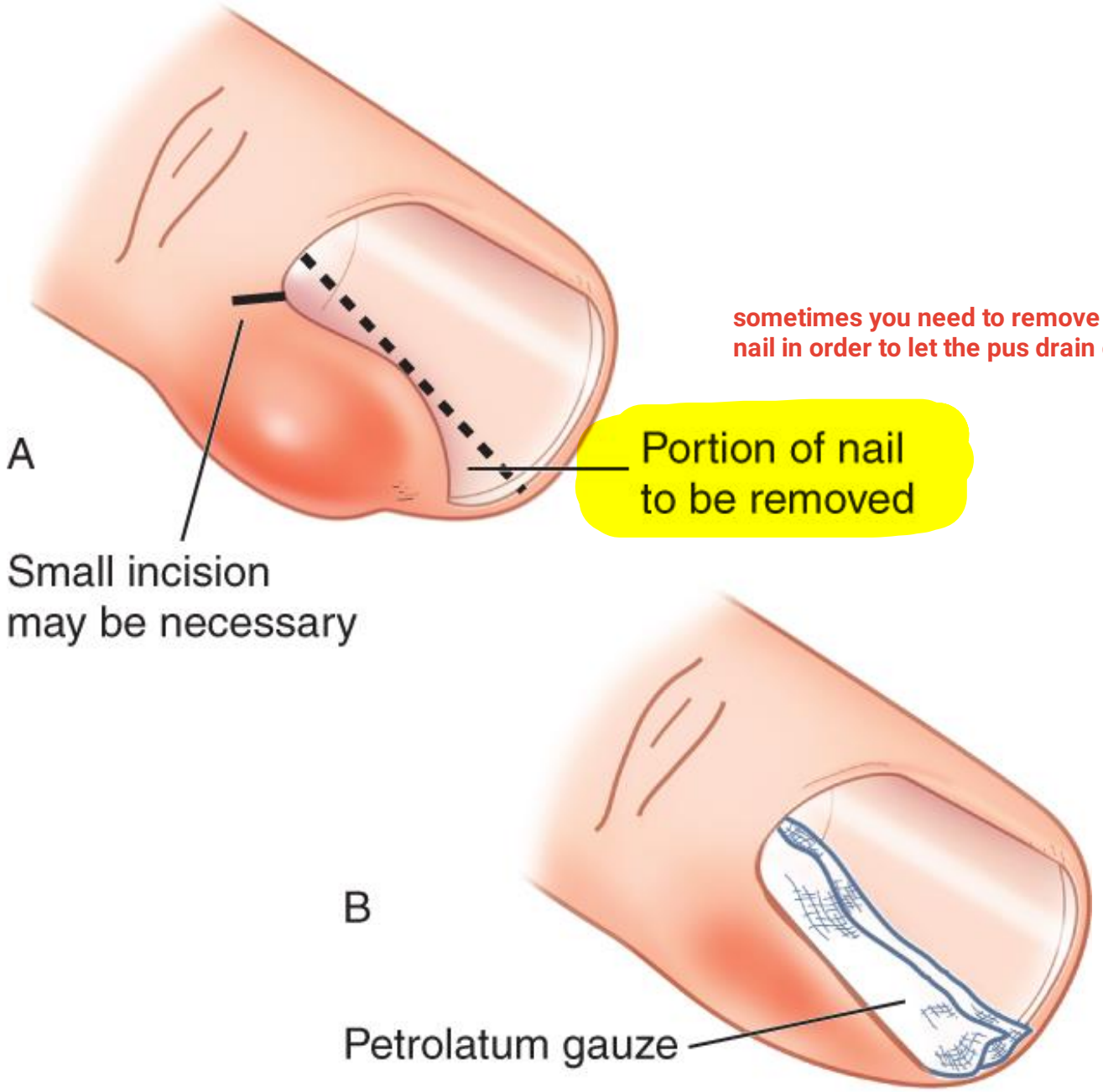
Tx : Systemic + local antifungal

if not drained by itself > incision & drainage

A

B

ILLUSTRATIONS BY DAVE KLEMM



sometimes you need to remove part of the nail in order to let the pus drain completely

Common hand conditions

②

- Felon (Pulp abscess)

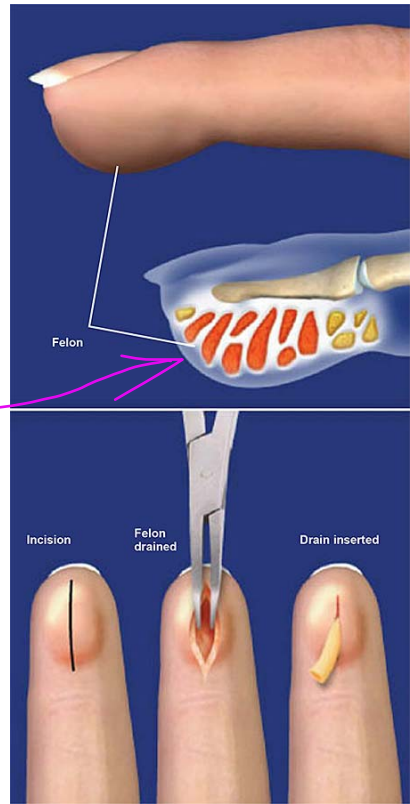
https://www.health.harvard.edu/a_to_z/felon-a-to-z

This is the 1st step \ not antibiotics not elevation not analgesia..etc

Tx : EMERGENT incision & drainage
+ Antibiotics (if the patient is immunosuppressed give systemic antibiotics if healthy give oral antibiotics
+ continuous changing of the dressing to make sure of the healing

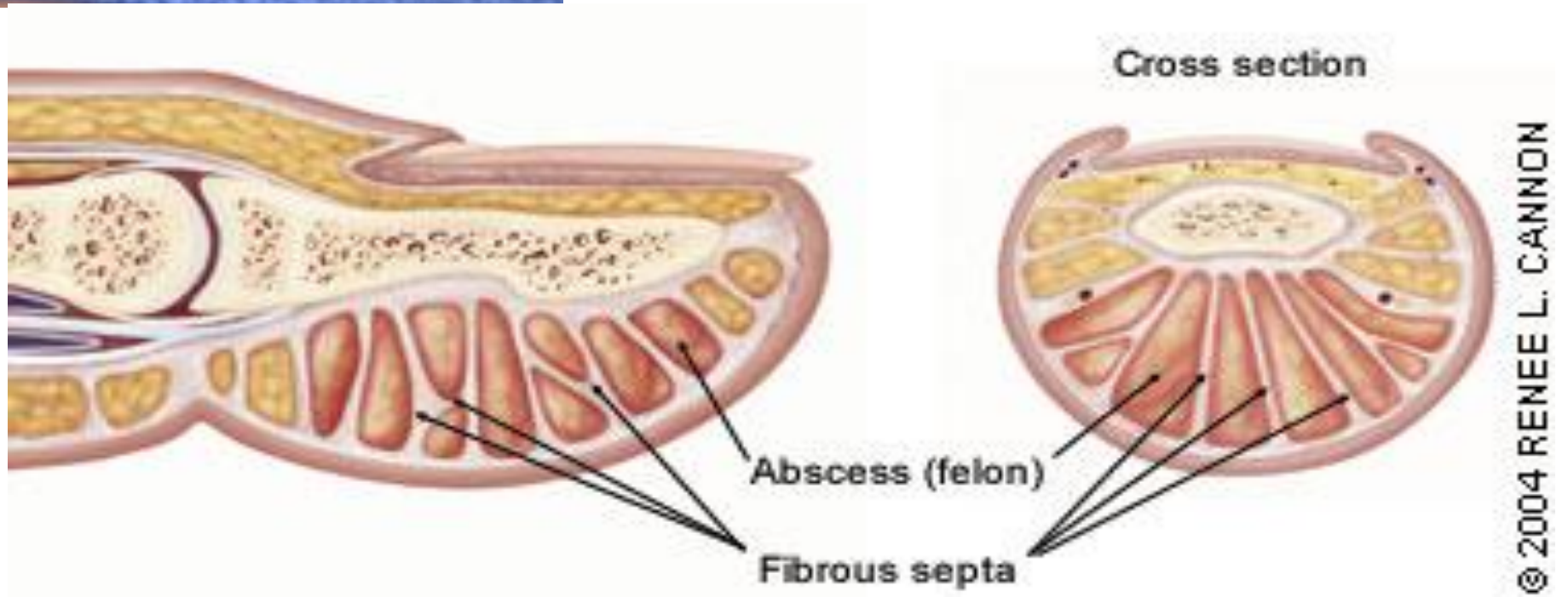
amputation of the distal phalanx

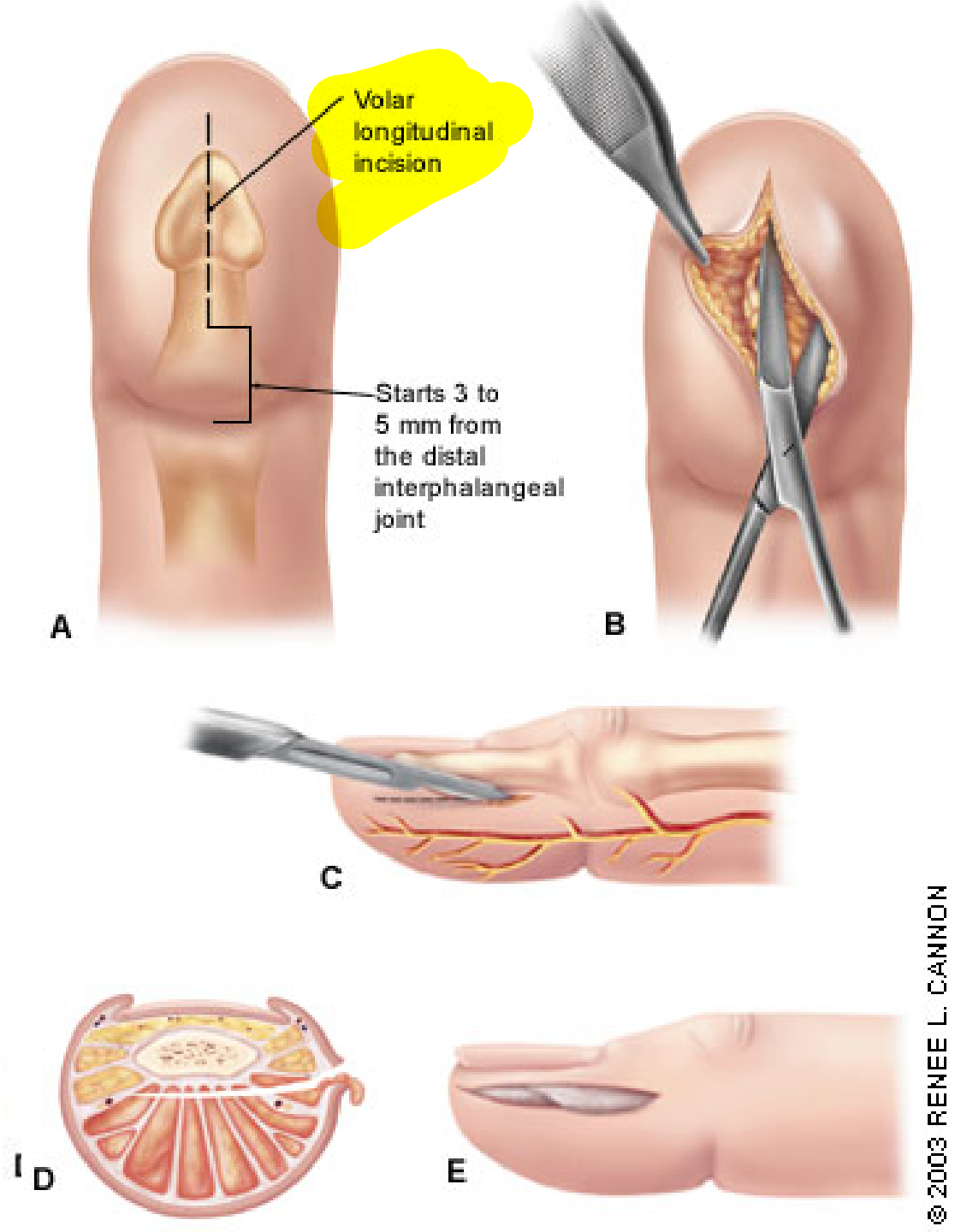
>> if left untreated :
1) Necrosis to the skin of the pulp and gangrene
2) Acute Osteomyelitis to the bone above it
3) Acute tenosynovitis
4) Septic Arthritis




pulp abscess of felon


Felon > Acute Paronychia
Acute Paronychia > Felon
** Anyone can lead to the other


Cross section
Abscess (felon)
Fibrous septa
© 2004 RENEE L. CANNON



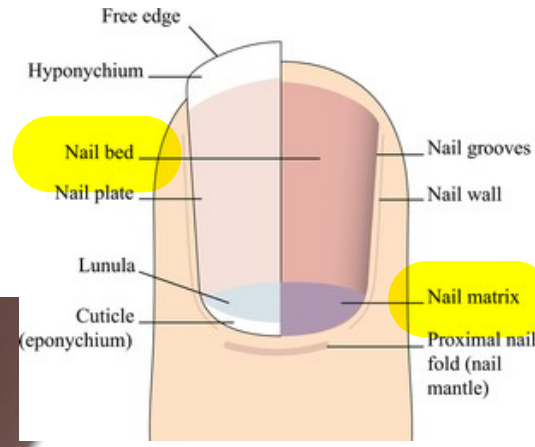
Common hand conditions

caused by trauma to the nail

- Subungual hematoma

Please refer to the following link:

https://www.emedicinehealth.com/subungual_hematoma_bleeding_under_nail/article_em.htm#subungual_hematoma_facts

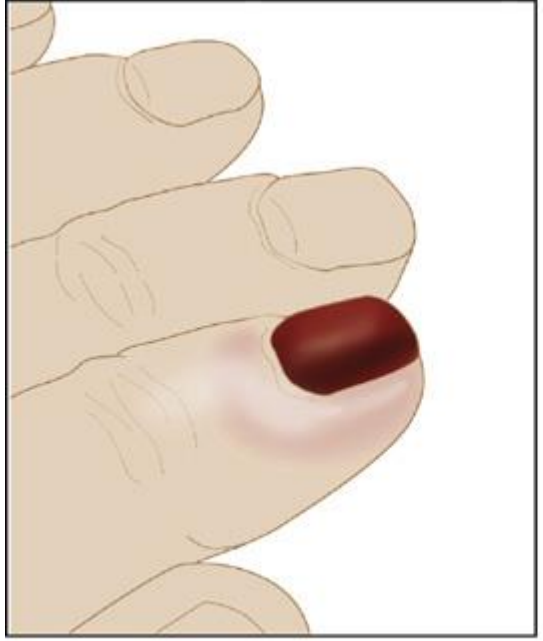


✓ Nail growth >> 90% from the nail matrix and 10% from the nail bed

✓ if the nail bed is injured > Scar formation > growth of the nail will be only from nail matrix and the nail will stop growing once it reached the nail bed >>> nail deformity

Management : if it occupies more than 2/3 of the nail Fold >> you have to remove the nail and repair the nail bed bcz there's injury to the nail bed

NOTE : 50% of cases of subungual hematoma are associated with distal phalanx fractures >> so before doing anything you have to do an x-ray to exclude distal phalanx fracture



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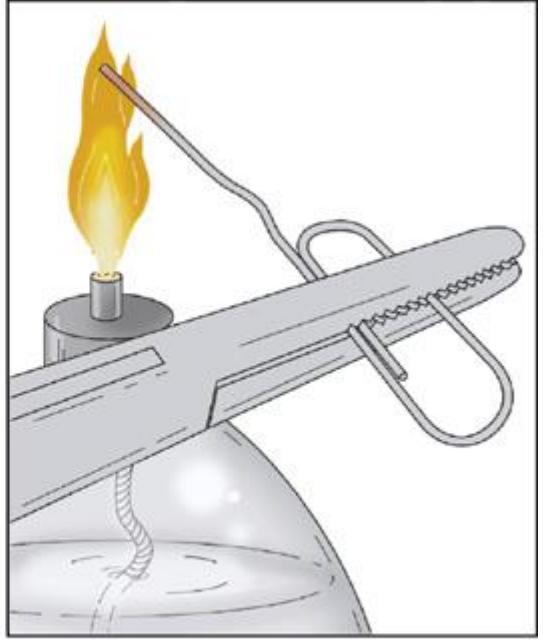

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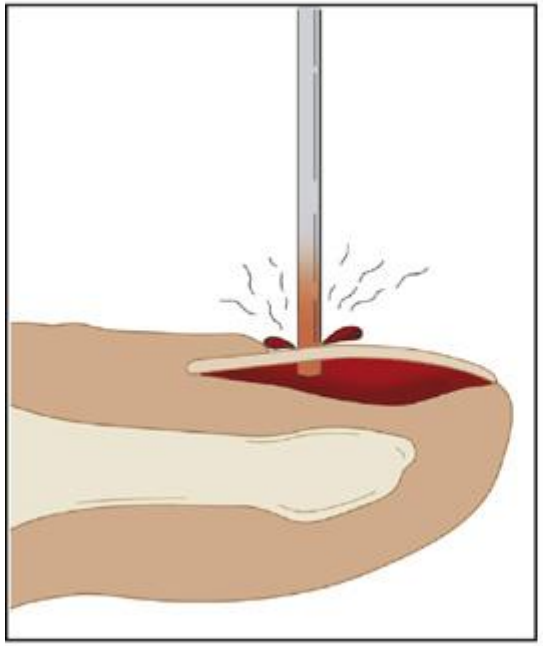

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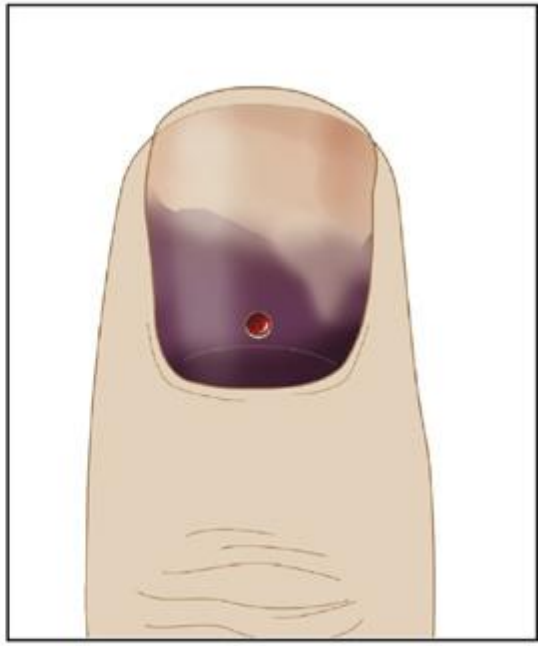


D

Temporary Drainage > to relieve pressure and pain \\ Not the definitive Tx

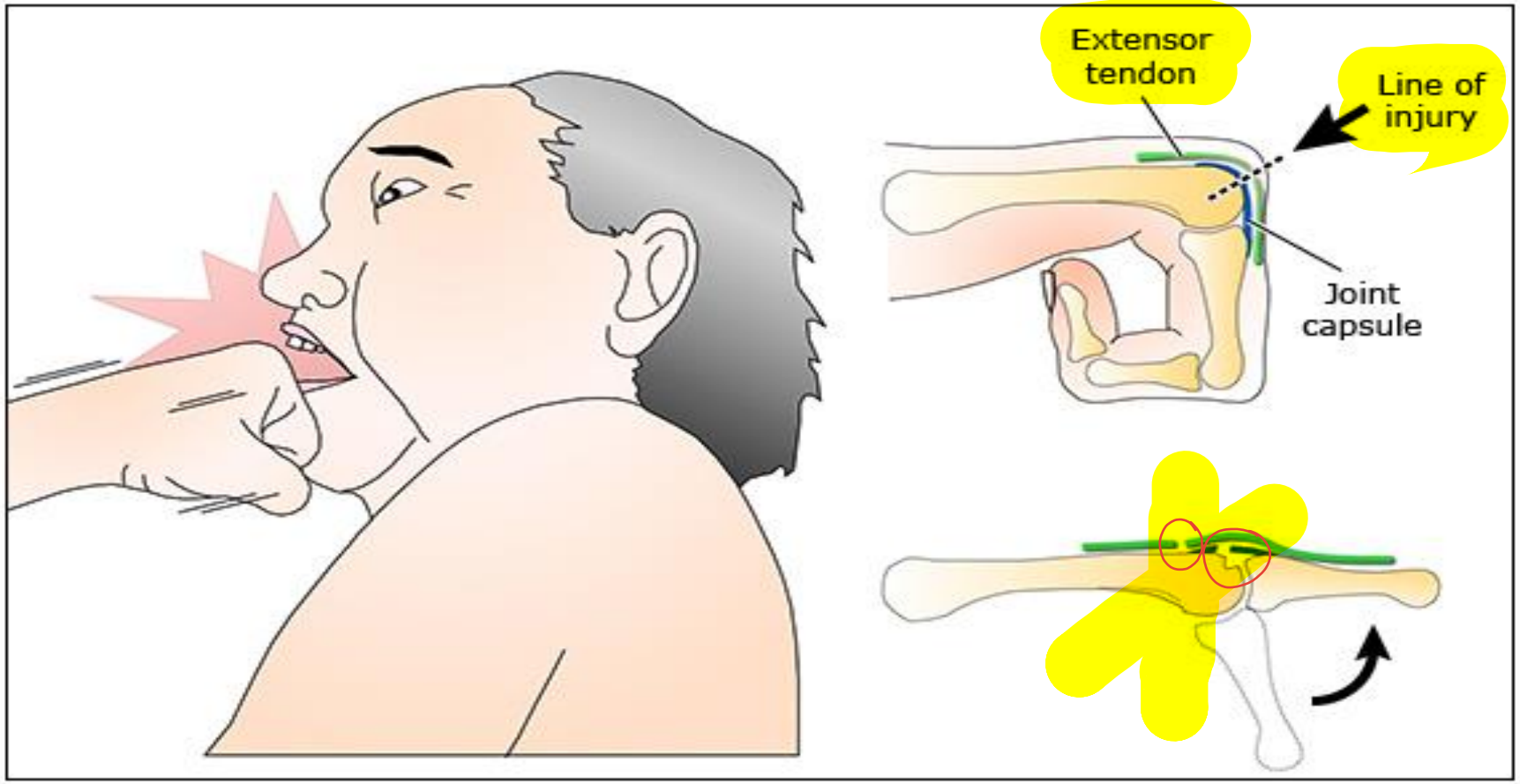
Common hand conditions

= Human bite

- Human fight bite (fist injury)

Acute soft tissue infection caused by the flora of the mouth

+ Septic Arthritis
+ Acute tenosynovitis



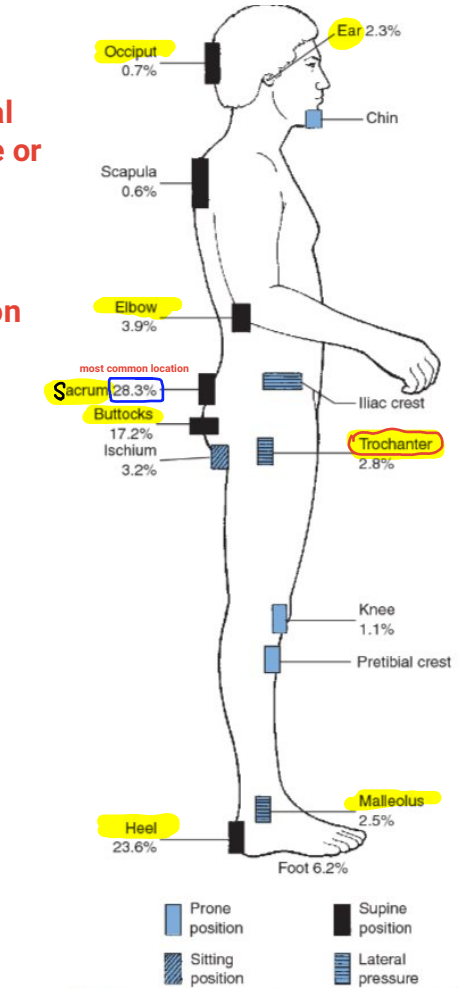
Swollen , Red , Painful , unable to move affected finger or part

Please refer to the following link:
https://epmonthly.com/article/fite-bite/

We give amoxicillin-clavulanate as empiric therapy for treatment of human bite wounds.

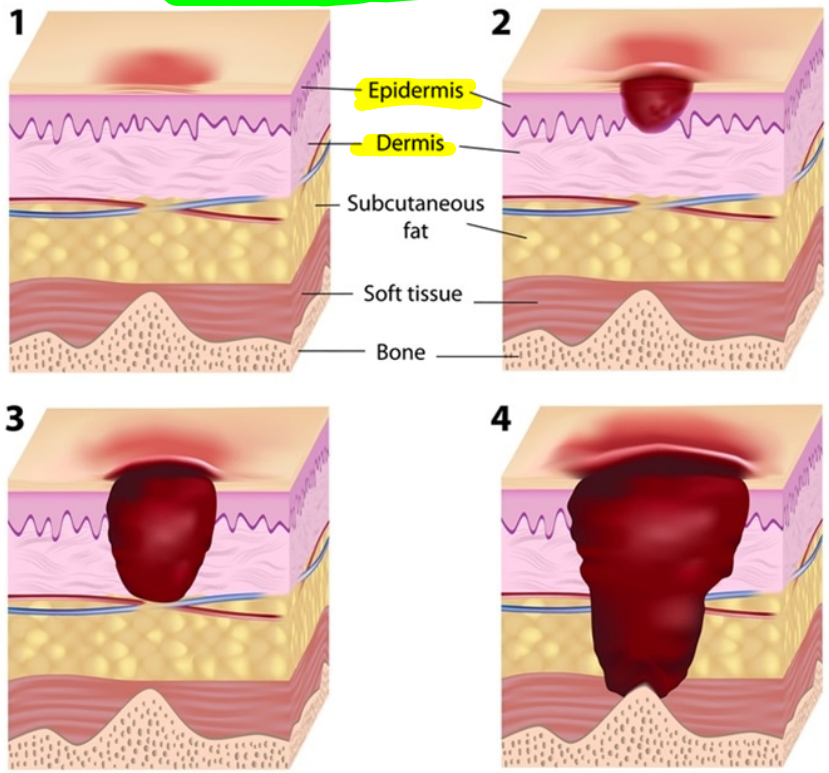
Pressure Ulcers
Bed sores

- Definition >> ulcer that develops over a bony prominence due to prolonged pressure
- Etiology > pressure \ Shear \ friction
- Pre-disposing factors — Fecal & urine incontinence , malnutrition , immobile , decreased LOC as in spinal injuries , comorbidities , vascular insufficiency as in peripheral vascular disease or DM , decreased sensation as in DM
- Locations
- Prevention — mobilization the patient every 2 hours \ correct predisposing factors like incontinence & malnutrition
- Work up
- Treatment : Medical surgical — dressing — Debridement and reconstruction (flap)
- Complications of surgery



Stages of Pressure Sores

> same as burns and frostbite



bedsore over the heel

this is only clinical staging not actually staging

ال **bed sore** من البداية بتكون واصلة العظم ، هاد فقط اللي مبين النا

✓ Muscles are highly susceptible to ischemia (4 hrs) due to their high metabolic demand , so first damage will be in muscles

✓ Skin is the least susceptible (12-18 hrs) so it's damage appears later

>> Thus bedsores are DECEIVING!

>> It's like an inverted cone