Wound healing

- Healing of skin wounds- example of combination of regeneration and repair.
- Wound healing can be accomplished in one of the following two ways:
  - Healing by first intention *(primary union)*
  - Healing by second intention *(secondary union)*

Healing by First Intention (Primary Union)

- Healing of a wound which has the following characteristics:
  - clean and uninfected
  - surgically incised
  - without much loss of cells and tissue
  - edges of wound are approximated by surgical sutures

Sequence of events

- Initial haemorrhage- wound is filled with blood which clots, seals the wound against dehydration and infection.

- Acute inflammatory response- polymorphs, replaced by macrophages by 3rd day

- Epithelial changes- basal cells of epidermis start proliferating and migrating towards incisional space.

  - wound is covered by a layer of epithelium in 48 hours.

  - epidermal cells separate the underlying viable dermis from the overlying necrotic material, forming *scab*

  - By 5th day, a multilayered new epidermis is formed

Sequence of events

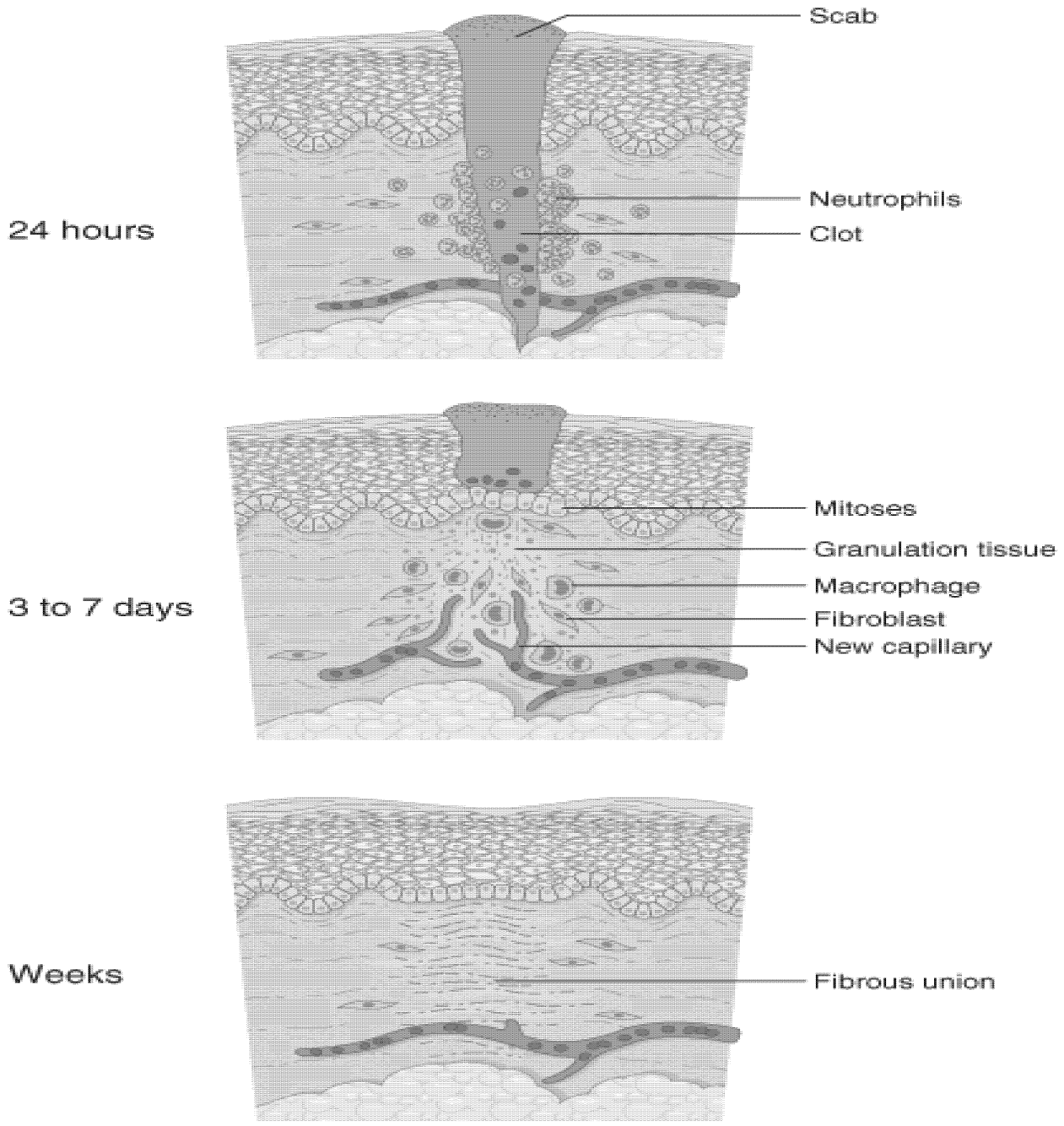
- Organisation-

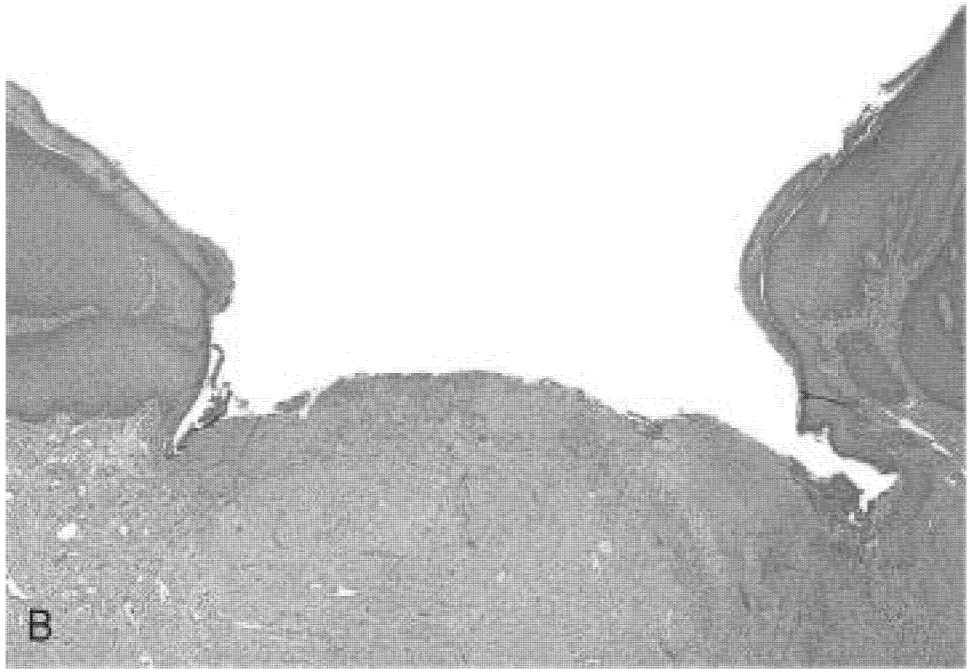
  - By 3rd day, fibroblasts also invade the wound area.

  - By 5th day, new collagen fibrils start forming which dominate till healing is completed.

  - In 4 weeks, the scar tissue with scanty cellular and vascular elements is formed.

HEALING BY FIRST INTENTION

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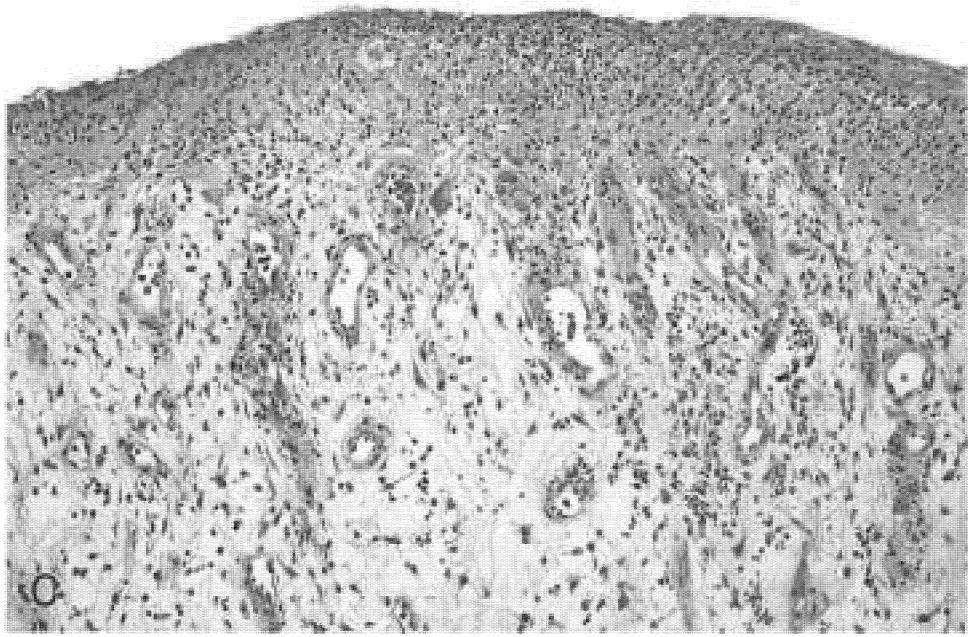

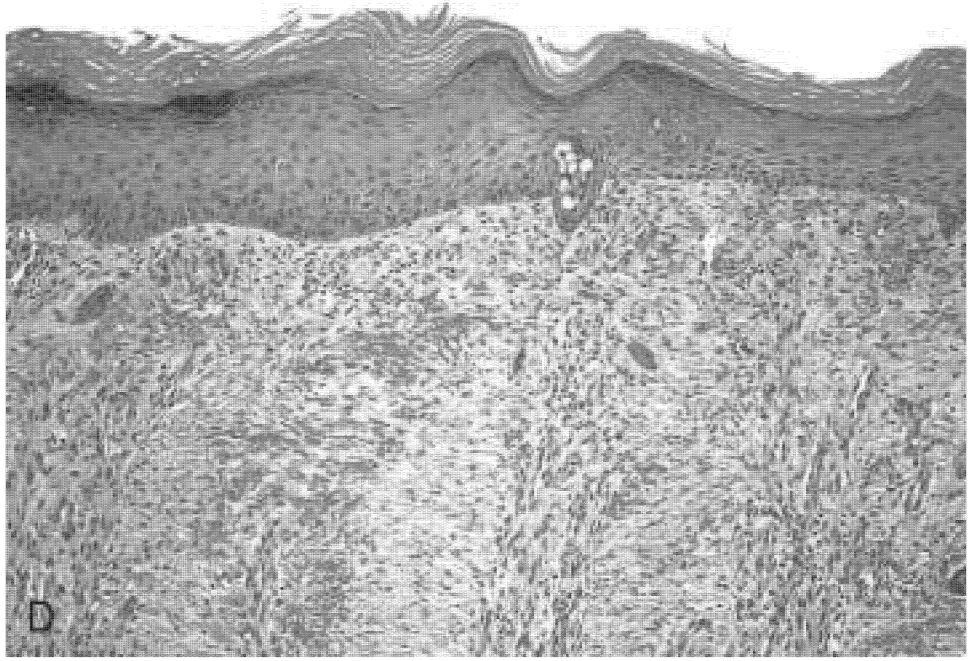
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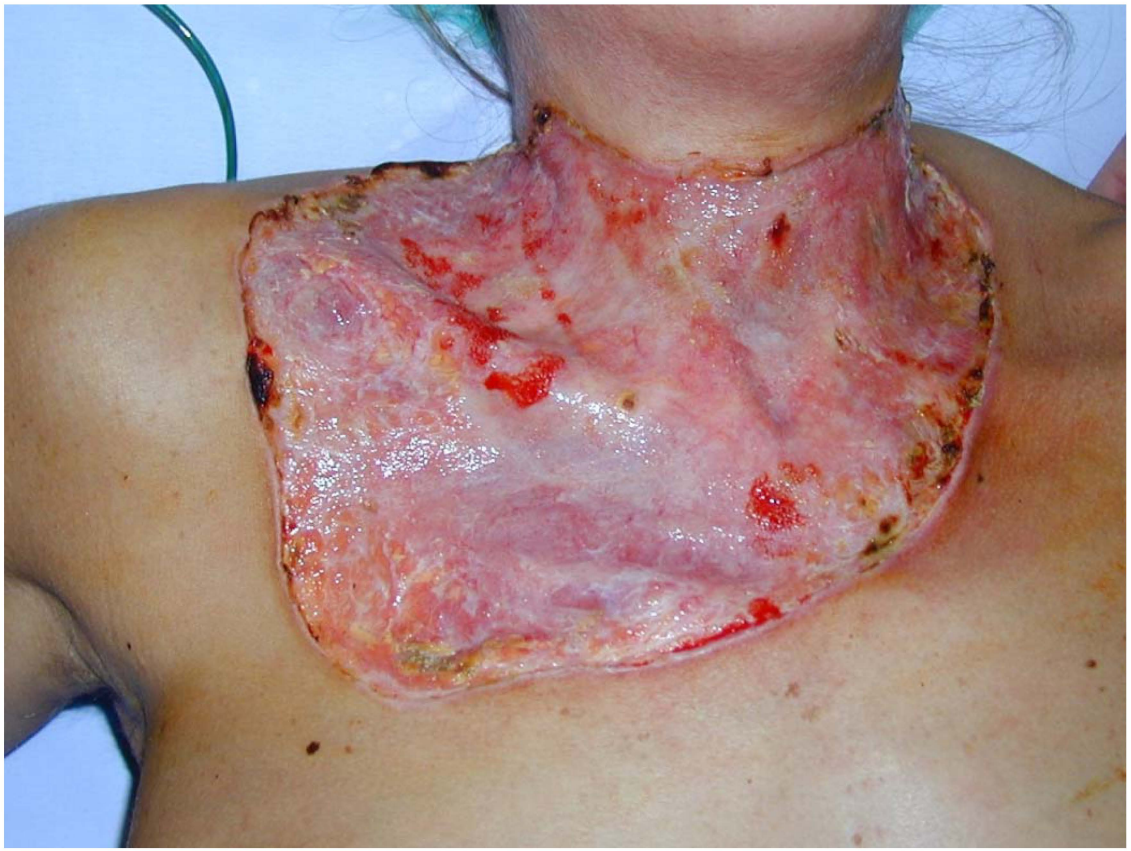
Healing by Second Intention (Secondary Union)

Healing of a wound having the following characteristics:

- open with a large tissue defect, at times infected
- having extensive loss of cells and tissues
- the wound is not approximated by surgical sutures but is left open



Sequence of events

- Similar to primary union
- Differs in having a larger tissue defect which has to be bridged.
- The healing by second intention is slow and results in a large, at times ugly, scar as compared to rapid healing and neat scar of primary union.
- Healing with more inflammation and granulation tissue formation, and more scarring

Sequence of events

- Initial haemorrhage
- Inflammatory phase
- Epithelial changes
- Granulation tissue

  - Main bulk of secondary healing is by granulation

  - With time, the scar on maturation becomes pale and white due to increase in collagen and decrease in vascularity.

  - Specialised structures of the skin like hair follicles and sweat glands are not replaced

Sequence of events

- Wound contraction

  - not seen in primary healing.

  - due to action of myofibroblasts, wound contracts to one-third to one-fourth of its original size.

- Presence of infection- Bacterial contamination delays the process of healing due to release of bacterial toxins that provoke necrosis, suppuration and thrombosis.

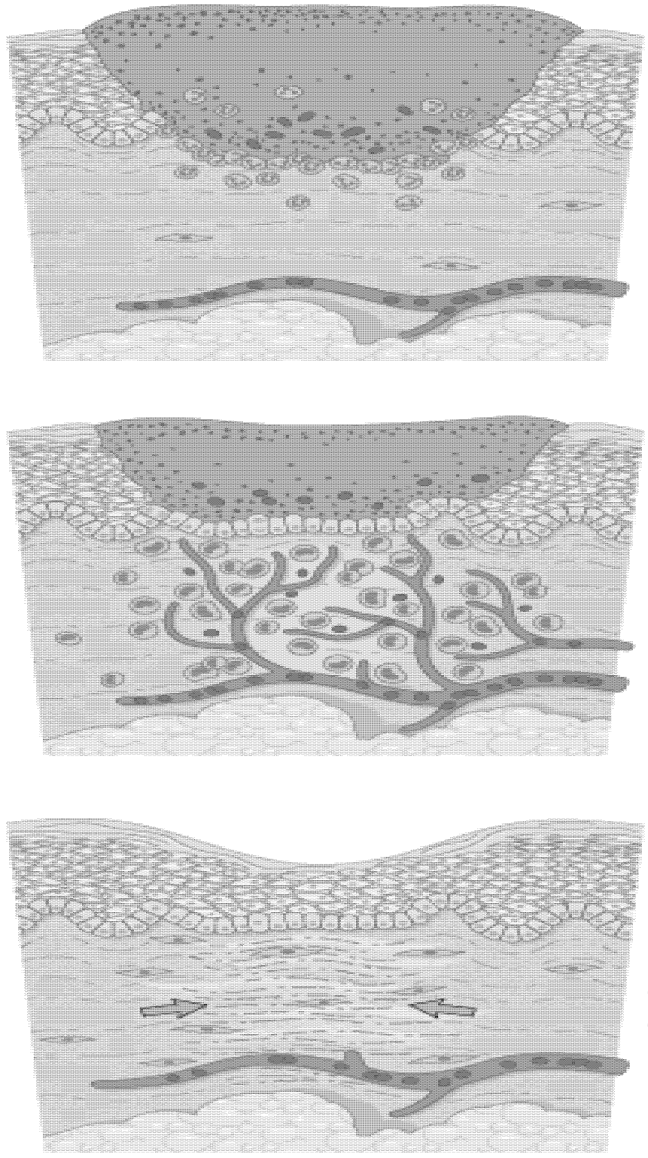
  - Surgical removal of dead and necrosed tissue, (debridement), helps

Wound Strength

Extracellular Matrix

- The wound is strengthened by proliferation of fibroblasts and myofibroblasts which get structural support from ECM
- In addition to providing structural support, ECM directs cell migration, attachment, differentiation and organisation.
- ECM has five main components: collagen, adhesive glycoproteins, basement membrane, elastic fibres, and proteoglycans.

HEALING BY SECOND INTENTION



Differences between primary and secondary union of wounds

PRIMARY UNION

- Clean
- Generally uninfected
- Margins surgical clean
- Sutures used
- Scanty granulation tissue at the incised gap

- Neat linear scar
- Complications
  Infrequent

SECONDARY UNION

- Unclean
- May be infected
- Irregular
- Not used
- Exuberant granulation tissue to fill the gap
- Contracted irregular wound
- Common

Complications of Wound Healing

- Infection of wound- delays the healing.
- Implantation (epidermal) cyst
- Pigmentation- rust-like colour due to haemosiderin
- Deficient scar formation- due to inadequate formation of granulation tissue.
- Incisional hernia- or wound dehiscence
- Hypertrophied scars and keloid -

  - the scar is excessive, ugly and painful

  - excessive formation of collagen may result in keloid formation, tumour-like projection of connective tissue.
- Excessive contraction- Dupuytren's contracture
- Neoplasia- squamous cell carcinoma in Marjolin's ulcer

Complications of Wound Healing

Factors Influencing Healing

Local factors

- Infection
- Poor blood supply
- Foreign bodies including sutures interfere with healing
- Movement delays wound healing.
- Exposure to ionising radiation delays
- Exposure to ultraviolet light facilitates healing.
- Type, size and location of injury

Factors Influencing Healing

Systemic factors:

- Age- wound healing rapid in young and slow in aged and debilitated people
- Nutrition- deficiency of protein, vitamin C, zinc delays the wound healing
- Systemic infection delays
- Administration of glucocorticoids
- Uncontrolled diabetics- more prone to develop infections and hence delay in healing.
- Haematologic abnormalities- defect of neutrophil functions, neutropenia and bleeding disorders slow the process of wound healing.

Healing in specialised tissues

Fracture Healing

Healing of fracture by callus formation depends on:

- Traumatic or pathological
- Complete or incomplete like green-stick fracture
- Simple, comminuted or compound

Fracture Healing

- Basic events resemble healing of skin wound
- Primary union of fracture - occurs when the ends of fracture are approximated as is done by application of compression clamps.
- Secondary union - more common process of fracture healing.
  - Procallus formation
  - Osseous callus formation
  - Remodelling

Secondary union- Procallus formation

- Haematoma - meshwork is formed by blood and fibrin clot which acts as framework for granulation tissue
- Local inflammatory response - macrophages clear away the fibrin, RBCs, inflammatory exudate and debris, fragments of necrosed bone
- Ingrowth of granulation tissue - neovascularisation and proliferation of mesenchymal cells from periosteum and endosteum.
- Callus composed of woven bone and cartilage- cells of inner layer of the periosteum lay down collagen as well as osteoid matrix in the granulation tissue, osteoid undergoes calcification and is called woven bone callus

Secondary union

- Osseous callus formation-

  - procallus acts as scaffolding on which osseous callus composed of lamellar bone is formed.

  - woven bone is cleared away by osteoclasts

  - newlyformed blood vessels and osteoblasts invade, laying down osteoid which is calcified and lamellar bone is formed by developing Haversian system concentrically around the blood vessels.

- Remodelling-

  osteoblastic laying and osteoclastic removal take place remodelling the united bone ends, which after sometime, is indistinguishable from normal bone.

Complications of fracture healing

- Fibrous union- results instead of osseous union if the immobilisation of fractured bone is not done.
  - a false joint may develop (pseudo-arthrosis)
- Non-union- if some soft tissue is interposed between the fractured ends.
- Delayed union- in infection, inadequate blood supply, poor nutrition, movement and old age.