

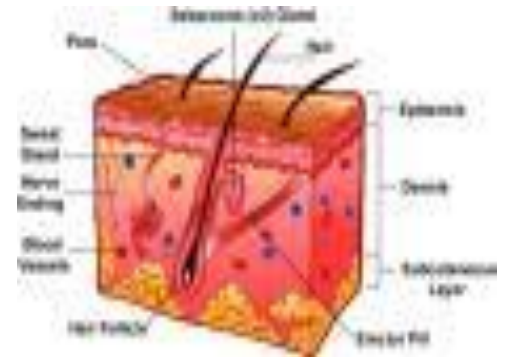
Wound Healing in traumatic wound

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Skin: structure and function

- Largest organ of the body
- Primary function is protective
- Composed of several layers
 - Outer **Epidermis**
 - **Dermis**, containing the capillary network
 - **Subcutaneous layer (hypodermis, adipose layer)**



Click image to enlarge



Skin: structure and function

- Thickness varies from a thin membrane at internal flexures (e.g. elbows), to thicker at the soles of the feet which bear considerable pressures
- Hair follicles, sebaceous glands, and sweat glands pass through the epidermis, but arise from the dermal layer



Classifying wounds

A wound can be defined as:
“A cut or break in the continuity of any tissue, caused by injury or operation”

(Baillière's 23rd Ed)

Wounds can be classified according to their nature:

- Abrasion
- Contusion
- Incision
- Laceration
- Open
- Penetrating
- Puncture
- Septic etc.....





Classifying wounds

Wounds may be classified according to the number of skin layers involved:

- **Superficial**
 - Involves only the epidermis
- **Partial Thickness**
 - Involves the epidermis and the dermis
- **Full Thickness**
 - Involves the epidermis, dermis, fat, fascia and exposes bone





Classification

- Clean - (non traumatic)
- Clean contaminated
- Contaminated
- Dirty



The ways in which wounds heal

Three basic classifications exist:

- **Healing by primary intention**

Two opposed surfaces of a clean, incised wound (no significant degree of tissue loss) are held together. Healing takes place from the internal layers outwards

- **Healing by secondary Intention**

If there is significant tissue loss in the formation of the wound, healing will begin by the production of granulation tissue wound base and walls.

- **Delayed primary healing**

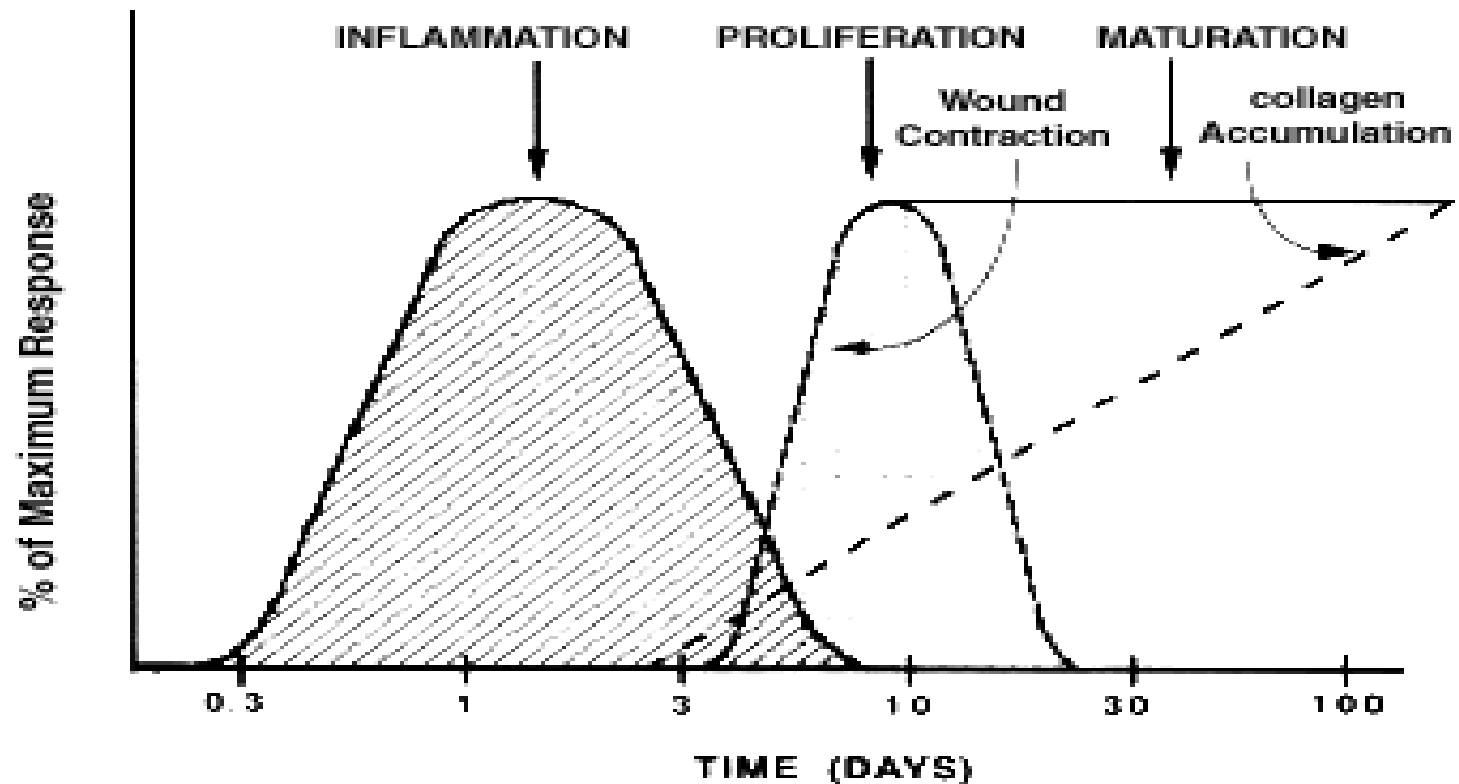
If there is high infection risk – patient is given antibiotics and closure is delayed for a few days e.g. bites



Wound healing

- All wounds heal following as a specific sequence of phases which may overlap
- The process of wound healing depends on the type of tissue which has been damaged and the nature of tissue disruption
- The phases are:
 - Inflammatory phase
 - Proliferative phase
 - Remodelling or maturation phase

Schematic Diagram of the Phases of Wound Healing





The healing process

- Day 0 – 5
- The healing response starts at the moment of injury – the clotting cascade is initiated
- This is a protective tissue response to stem blood loss
- The inflammatory phase is characterised by heat, swelling, redness, pain and loss of function at the wound site
- Early (haemostasis)
- Late (phagocytosis)
- This phase is short lived in the absence of infection or contamination



Granulation

- Day 3 – 14
- Characterised by the formation of granulation tissue in the wound
- Granulation tissue consists of a combination of cellular elements including:
 - Fibroblasts, inflammatory cells, new capillaries embedded in a loose extra-cellular collagen matrix, fibronectin and hyaluronic acid



Angiogenesis

- Collagen first detected at day 3 and rapidly increases for approx. 3 weeks, then more gradually for the next 3 months
- Fibroplasia (fibroblast proliferation and synthetic activity) continues in parallel with re-vascularisation
- Endothelial cells from the side of venules closest to the wound begin to migrate in response to angiogenic stimuli (angiogenesis) forming capillary buds, then loops



Epithelialisation

- The epidermis immediately adjacent to the wound edge begins to thicken within 24hrs after injury
- In approximated incised wounds re-epithelialisation is usually complete within 48hrs.



Maturation

- Can last up to 2 years
- New collagen forms, changing the shape of the wound and increasing the tensile strength
- Scar tissue, however is only ever approx. 50-80% as strong as the original tissue
- During the remodelling process there is a gradual reduction in cellularity and vascularity of the reparative tissue



Contraction

- Only undesirable where it leads to unacceptable tissue distortion and an unsatisfactory cosmetic result
- Wound contraction usually begins from day 5 and is complete at approx. day 12 - 15



Moist wound healing

- Basic concept is that the presence of exudate will provide an environment that stimulates healing
- Exudate contains:
 - Lysosomal enzymes, WBC's, Lymphokines, growth factors.....
- There are clinical studies which have shown that wounds maintained in a moist environment have lower infection rates and heal more quickly



Factors affecting healing

- Immune status
- Blood glucose levels (impaired white cell function)
- Hydration (slows metabolism)
- Nutrition
- Blood albumin levels ('building blocks' for repair, colloid osmotic pressure - oedema)
- Oxygen and vascular supply
- Pain (causes vasoconstriction)
- Corticosteroids (depress immune function)



Practical considerations

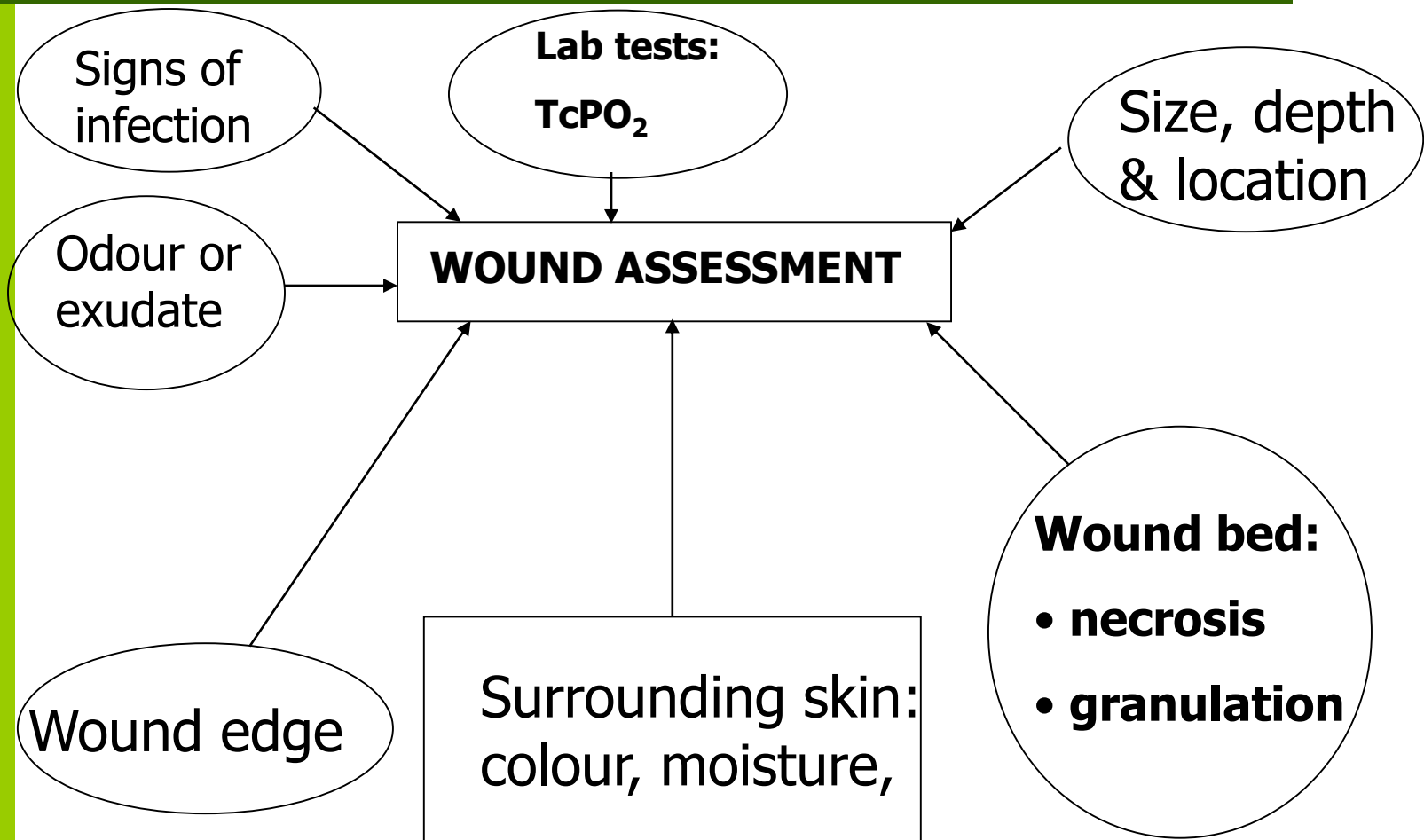
- The cause of the wound
- Underlying disease processes
 - Current health status
- Medication
- Acute or chronic?
- Attitude to the wound
- Availability of care



Healing requirements

- Identification of the hindrance to healing
- Adequate nutritional status
- Adequate perfusion and oxygenation
- High quality, research-based patient and wound management
- Correction of the underlying cause of the problem
- Disease management

Wound assessment





Classifying wounds

Grading by tissue Involvement

Grade I – non-blanchable erythema of intact skin. Discoloration of the skin, warmth, oedema, induration or hardness may also be used as indicators in people with dark skin.

Grade II – partial-thickness skin loss involving epidermis, dermis or both. The ulcer is superficial and presents clinically as an abrasion or blister.

Grade III – full thickness skin loss involving damage or necrosis of subcutaneous tissue that may extend down to but not through underlying fascia

Grade IV – extensive destruction, tissue necrosis or damage to muscle, bone or supporting structures with or without full thickness skin loss.

EPUAP 1999



Clinical appearance

**Describes the type of material present
In the base of the wound:**

- Slough (yellow)
- Necrotic tissue (black)
- Infected tissue (green)
- Granulating tissue (red)
- Epithelialising (pink)

Sloughy wound



- **Aim:** to liquefy slough and aid its removal
- Dead cells accumulated in exudate
- Prepare wound bed for granulation
- Assess wound depth and exudate levels
- Hydrogels, hydrocolloids, alginates and hydrofibre dressings

Necrotic wound



- **Aims:** to debride and remove eschar
- Provide the right environment for autolysis
- Assess wound depth and exudate levels
- Hydrogels, hydrocolloid dressings

Infected wound



- **Aims:** reduce exudate, odour and promote healing
- Clinical signs of infection
- Swab wound – systemic antibiotics
- Treat symptomatically: exudate and odour control
- Change dressings daily

Granulating wound



- **Aims:** support granulation, protect new tissue, keep moist
- Assess depth and exudate levels
- Moist wound surface – non-adherent dressing
- Treat over-granulation
- Hydrocolloids, foams, alginates

Epithelialising wound



- **Aims:** to provide suitable conditions for re-surfacing
- , films, hydrocolloids
- Disturb as little as possible



Wound characteristics

- Exudate
- Odour
- Condition of tissue within the wound
- Condition of the surrounding skin

The surrounding skin

- Eczema
- Psoriasis
- Maceration/excoriation due to exudate or bowel contents
- Self-inflicted damage



Monitoring healing progress

- Wound dimensions
 - Wound assessment charts
- Photography
 - Frequency of assessment
 - Plan of care
 - Useful information
 - Other methods



Dressing choice

- What is available?
- How do we choose?
- Does the patient have a say?
- Do we consider cost?
- Are choices restricted by a protocol?
- How do we evaluate?



Dressing choice

The purpose of dressings:

- To aid debridement
- To remove excess exudate
- To control bleeding
- To protect a wound
- To support healing

The ideal dressing

- A dressing that creates the optimum environment
- Wound debridement
- Wound cleansing
- Alternative therapies



Dressing choice

- Non-adherent wound contact materials
- Films
- Hydrogels
- Hydrofibre dressings
- Hydrocolloids
- Foams
- Alginates
- Miscellaneous



Dressing choice

Film dressings

- Semi-permeable primary or secondary dressings
- Clear polyurethane coated with adhesive
- Conformable, resistant to shea
- Do not absorb exudate
- Examples: Suprasorb F, Op-sit





Dressing choice

Hydrocolloids

- Pectin, gelatin, carboxymethylcellulose and elastomers
- Environment for autolysis to debride sloughy or necrotic wounds
- Occlusive --> hypoxic environment to encourage angiogenesis
- Waterproof
- Different presentations e.g. Suprasorb H





Dressing choice

Foam dressings

- Advanced polymer technology
- Non-adherent wound contact layer
- Highly absorptive
- Semi-permeable
- Various types
- Adhesive and non-adhesive





Dressing choice

Hydrogels

- Sheets or gels
- Starch and polyacrylamide (94% water)
- Low exudate, shallow wounds
- Re-hydrates necrotic tissue
- Secondary dressing needed
- May cause skin maceration





Dressing choice

Alginates

- Seaweed dressings
- Form a gel over the wound
- Moderate to high exudate wounds
- Easily removed
- Can cause pain
- Help to debride a wound
- Different presentations



Debridement methods

- Hydrogels
- Hydrocolloids
- Alginates
- Hydrofibre dressings
- Surgical
- Wet to dry dressings
- Whirlpool





Tissue Viability

Documenting wound care

- Potential for litigation
- Good staff communication
- Continuity of care
- To assess progress or deterioration
- Should be factual not subjective
- Wound assessment charts



Conclusion

- Wound care is becoming more complex as the range of wounds increases
- Correction of the underlying causative factors is essential
- Key principles must be adhered to with regard to basic patient and wound assessment



Traumatic Wound

- To discuss the basic approach to wounds
 - Wound evaluation
 - Wound examination
- Discuss wound preparation
- Wound repair techniques
- Special considerations and concerns



Historical Background

- In ancient Egypt and Greece they went on to define two entities; acute and chronic wounds. The Ebers Papyrus, circa 1500 BC, talks of the use of lint, animal grease and honey as topical treatment for wounds.
- Galen of Pergamum, a Greek surgeon, served the Roman gladiators and is credited for many contributions to this particular field.
- The most significant advances came in the 19th century with the development of microbiology and advances in cellular pathology.
- Through time and science we have come to recognize the importance of using sterile surgical techniques and attempt to decrease complications.



Epidemiology

- It is estimated that 11.5 million patients with wounds are seen in American ED's each year
- This is roughly 12 percent of all ED presentations
- Reports note that a majority of these wounds occur in the face and scalp, then upper extremities and lower extremities



Epidemiology

- There is a reported infection rate of 3.5% to 6.5% of all adult lacerations treated in the ED
- Although all wounds have the potential to become infected, there are several that have a higher propensity for such outcomes
- In pediatric population the laceration infection rates are lower at 1.2%



Wound Examination/Exploration

- Initial steps:
 - Patient comfort and safety
 - Positioning: Patient should be supine to avoid fainting. Any observers should be seated as well
 - Initial Hemostasis
 - Should be established with simple direct pressure
 - When you are ready (well lit area, repair tools available) you can use more invasive measures
 - Remove all rings and other jewelry from the injured area (i.e. finger)



Wound Examination/Exploration

- Initial steps:
 - Pain relief
 - Begins with gentle and empathetic handling of the injury
 - Continues with a specific pain management plan
 - Wound care delay
 - If there are going to be delays in your repair then please dress the wound with some moistened gauze



Wound Examination/Exploration

- Basic and key history should be collected:
 - Mechanism of injury (what caused the injury)
 - Age of the wound (time since injury)
 - Allergies
 - Tetanus immunization status
 - Medical history
 - Diabetes
 - Immunosuppression
 - Peripheral vascular disease



Wound Examination/Exploration

- Screening examination
 - Basic vital signs
 - A forehead laceration with hypotension and tachycardia is a more concerning injury
 - Wounds and lacerations are often the visual result of systemic issues
 - The laceration from a fall should lead to a discussion of why the person fell
 - General examination should be performed
 - The only injury is the one you visualize



Wound Examination/Exploration

- Wound assessment
 - A complete evaluation of an injury must include documentation of the following elements
 - Location
 - Length
 - Estimated depth (visible tissues)
 - Shape of wound
 - Proximal and distal nerve function
 - Tendon function



Wound Examination/Exploration

- Wound assessment continued:
 - Examination elements cont:
 - Vascular integrity (blood flow through area)
 - Evidence of foreign body or contamination
 - Evidence of fracture
 - Alterations in range of motion



Wound Preparation

- Once you have decided to repair the wound, the area must be prepared
- This process involves several components
 - Peripheral area cleansing
 - Provision of anesthesia
 - Wound irrigation and cleansing
 - Wound exploration and or debridement



Wound Preparation

- Peripheral cleansing:
 - The area adjacent to the wound should be as free of dirt and contaminants as possible
 - Goal is to remove dirt, dried blood and other debris
 - It should be visibly clean to the eye



Wound Preparation

- Provision of Anesthesia:
 - In most cases the wound should be anesthetized prior to irrigation
 - It is difficult and often ineffective to attempt to irrigate a painful wound
 - Depending on the location and extent of the injury one can choose local wound infiltration, versus a regional nerve block



Wound Irrigation/Exploration

- Once good anesthesia has been achieved
- “The solution to pollution is dilution.”
- Irrigation is the most effective way to:
 1. Remove debris and contaminants from a laceration
 2. Reducing bacterial counts on wound surfaces.
- We know that higher pressure irrigation is superior to low pressure systems



Wound Irrigation/Exploration

- The Current practice is based on a study using a 35 ml syringe attached to a 19 gauge catheter (7-8 psi)
- Most clinicians use normal saline as irrigation fluid
- However there are other solutions
 - 10-20 parts saline with 1 part 10% povidone-iodine solution
- No proven advantage to this solution



Wound Irrigation/Exploration

- Moistened sponges can be used to cleanse the wound periphery
- Irrigation can be achieved with:
 - 20ml or 35ml syringe attached to either
 - A 18-19gauge catheter
 - Or a Zerowet splash guard
 - One can fashion a similar device by piercing the base of plastic medicine cup and placing it over the syringe and needle or catheter



Wound Irrigation/Exploration

- Irrigation should continue until there is no visible skin or wound contaminates
- The amount of irrigation varies depending on the size, location and amount of contamination
- Typically 200-500ml
- The clean wound should appear pink with viable issue, may have some mild bleeding



Wound Irrigation/Exploration

- Should there be any contaminate not removed by the irrigation
- Then a moist 4x4 gauze can be used for manual debridement
- If unsuccessful then sharp debridement can be pursued with tissue scissors or a surgical scalpel.



Wound Irrigation/Exploration

- As part of the irrigation process the wound should be *explored* to the base
- Searching for any foreign material that could be a focal point for infection
- Also directly inspect for function of relevant nerves, tendons, arteries and joints
- Irrigation without exploration is incomplete at best.



Wound Closure

- There are 3 types of wound closures and they can be achieved with several different options.
- These types are:
 - Primary closure (Primary intention)
 - Secondary closure (Secondary intention)
 - Tertiary Closure (Delayed primary closure)



Wound Closure

- Primary Closure:
 - Is mainly carried out on a laceration that is relatively clean, maybe minimally contaminated
 - The wound is without devitalized tissues.
 - Can be achieved by the use of sutures, wound adhesive, wound tapes or staples
 - Is often performed during the “Golden Period.”



Wound Closure

- The golden period refers to the first 6-8hrs following the time of the laceration or wound
- In clinical practice this period can extend up to 24hrs after the actual injury.
- There are no rigid guidelines but typically any injury that can be converted to a fresh appearing wound, after usual wound preparation can be primarily closed.



Wound Closure

- Secondary Closure:
 - Refers to wounds that are not closed by sutures but are allowed to heal by the formation of granulation tissue
 - Is best for ulcerations, skin infections, abscess cavities, puncture wounds, partial thickness dermal burns and abrasions



Wound Closure

- Tertiary Closure:
 - Applies to wounds that on initial presentation were not good candidates for primary closure
 - Wounds that were contaminated by feces, saliva, vaginal secretions, or significant soil.
 - Usually undertaken 4-5days after the initial cleansing , debridement and observation.
 - Theoretically you delay closure to avoid the high risk of closing a contaminated wound



Methods for Closure

- Sutures:

- There are several different types of sutures, which are then further divided based on the size of the needle
- Can be broken down into two groups
 1. Absorbable:
 - Gut, chromic gut, Polyglycolic-acid(PGA), Polyglactin 910(vicryl), Polydioxanone(PDS)
 2. Non-absorbable:
 - Silk, Nylon(ethilon, Dermalon), Proypropylene (Prolene), Dacron(Mersilene)

Prolene Suture



- One example of non absorbable suture. Prolene has a blue color making it easier to see in areas where hair is involved.



Methods for Closure

- Wound Taping
 - Can be considered and used with
 - Straight laceration with little tension
 - Forehead, chin, thorax, non joint areas of the extremities
 - Laceration that have a high potential for infection
 - A Laceration in a patient with thin fragile skin
 - Elderly, those on chronic steroids
 - Support of a sutured wound
 - Cannot be used on the scalp, over the joint surfaces, or in a bleeding wound



Methods for Closure

- Wound Stapling
 - Can be used in the following situations:
 - Linear lacerations of the scalp, trunk and extremities
 - As temporary rapid way to close an extensive laceration in acutely ill patients
 - Should be avoided in areas that you are going to CT.
 - They may also move during the process of obtaining an MRI



Skin Staples used to close Cesarean section surgical laceration





Suture Tools and Technique

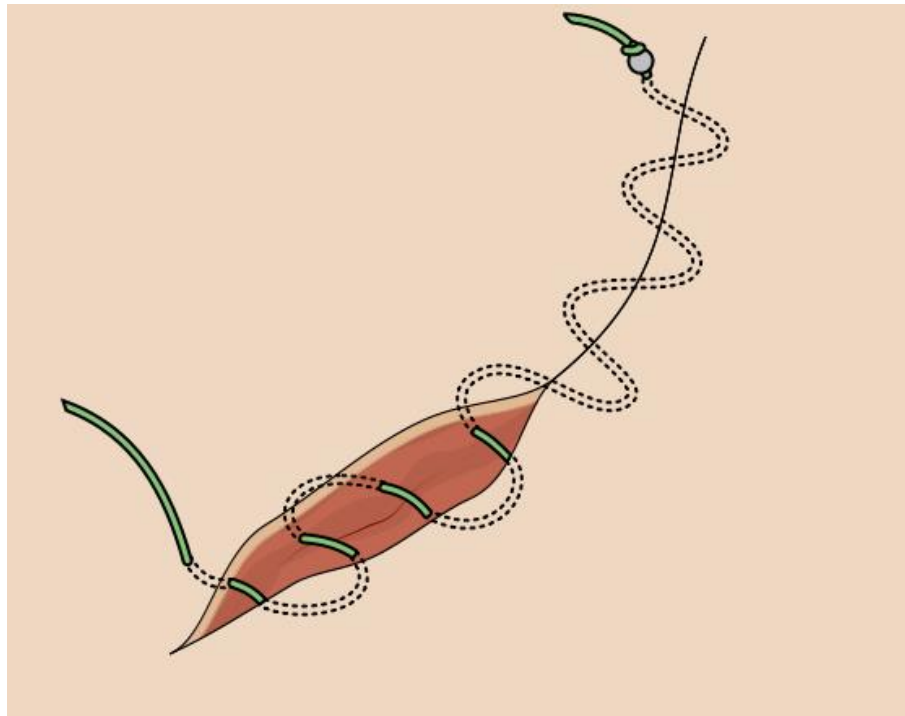
- To repair the wound you will need:
 - Suture Materials
 - Needle driver or hemostat
 - Scissors
 - Forceps

Hemostats



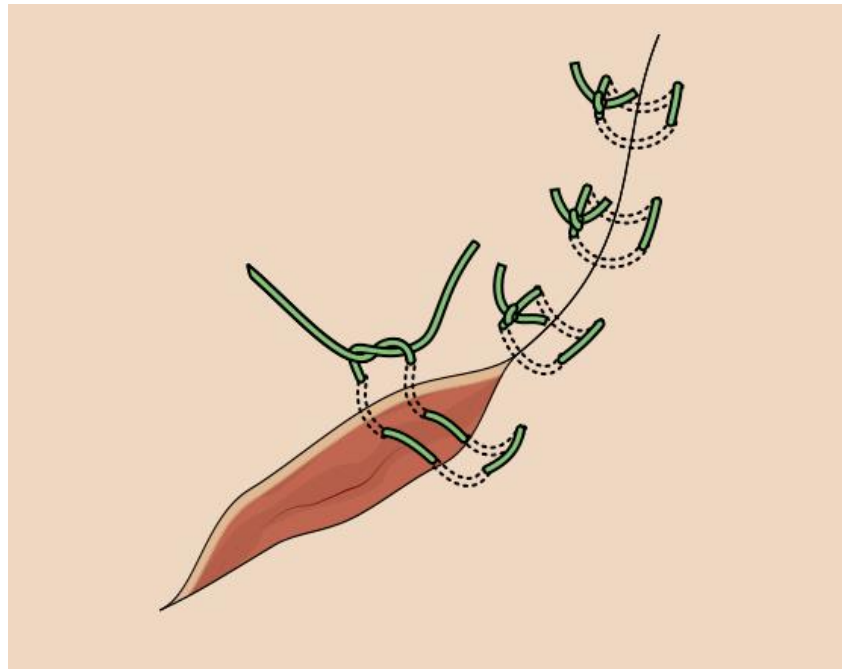


Subcuticular stitch



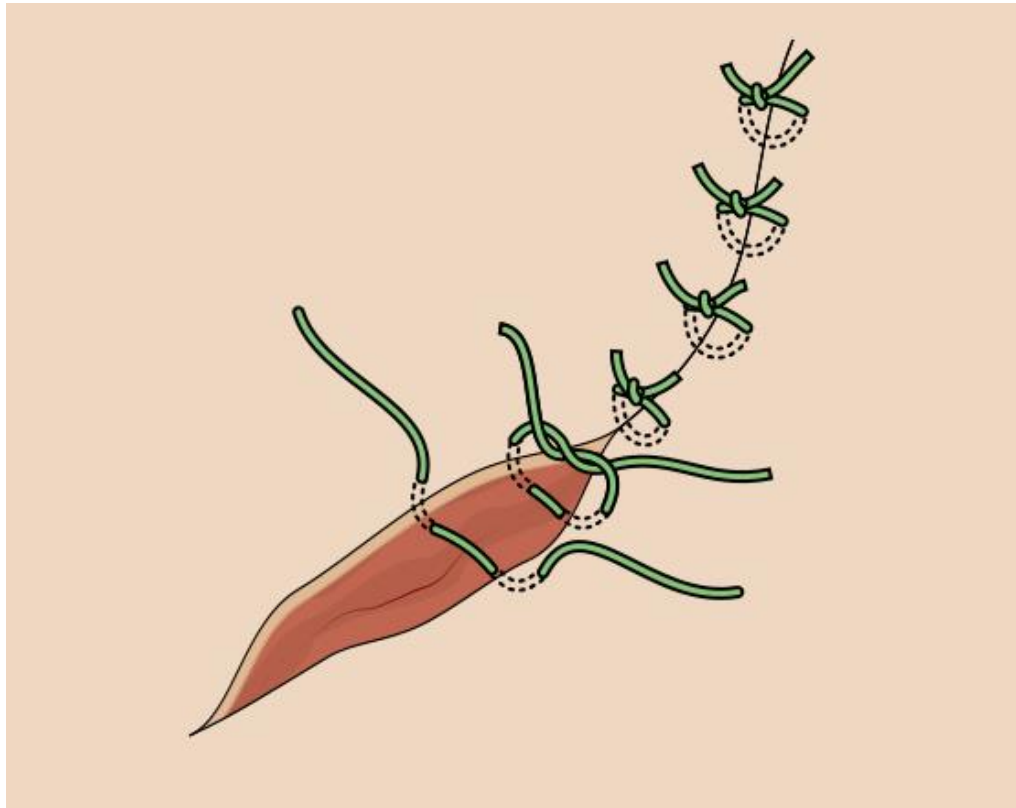


Horizontal Mattress Suture





Simple Interrupted Sutures



Suture Removal Times

Area Sutured	Time to removal (in days)
Face	3-5
Scalp	7-9
Neck	5-8
Upper Extremities	8-14
Lower Extremities	14-21
Trunk	10-14

- These are generalizations. Your patient's time will depend on several factors, general co-morbidities, wound tension, level of wound contamination.



Questions?



Thank you

