ProCare Training Manual
Chapter 2
Types of Wounds and How They Heal

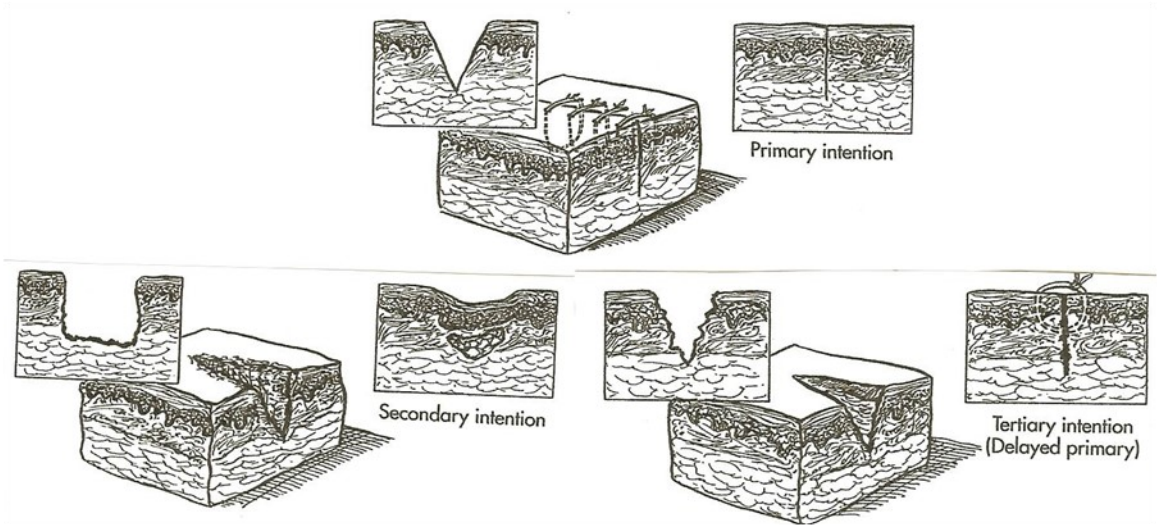
Any break in the skin is considered a wound. A "clean" wound is a wound created by surgery. A wound is described as "dirty" if it contains bacteria or debris. Trauma typically produces dirty wounds. The rate of recovery is influenced by the extent and type of damage incurred as well as other factors such as age, circulation, nutrition and hydration. However, regardless of the cause of a wound, the healing process is pretty much the same.

Types of Wound Healing

Wounds are classified by the way the wound closes. A wound can close by primary intention, secondary intention, or tertiary intention.

- Primary Intention – Involves reepithelization, in which the skin's outer layer grows closed. Cells grow in from the margins of the wound and out from epithelial cells lining the hair follicles and sweat glands. Wounds that heal by this process don't usually involve loss of tissue. These wounds usually heal within 4 to 14 days with minimal scarring.
- Secondary Intention – A wound that involves some degree of tissue loss heals by secondary intention. The edges of this wound cannot be easily approximated. The wound is partial or full thickness, depending on the depth. Partial –thickness wounds extend through the epidermis and into, but not through, the dermis. Full-Thickness wounds extend through the epidermis and dermis and may involve subcutaneous tissue, muscle and possibly, bone. Wounds that heal by secondary intention fill with granulation tissue, a scar forms, and reepithelization occurs, primarily from the wound edges. Pressure ulcers, burns, dehisced surgical wounds, and traumatic injuries are examples of this type of wound. These wounds usually leave scars and take longer to heal.
- Tertiary Intention – This is when a wound is kept open to allow edema or infection to resolve or to permit removal of exudates; the wound heals by tertiary intention, or delayed primary intention.

Figure 2-A Wound Healing



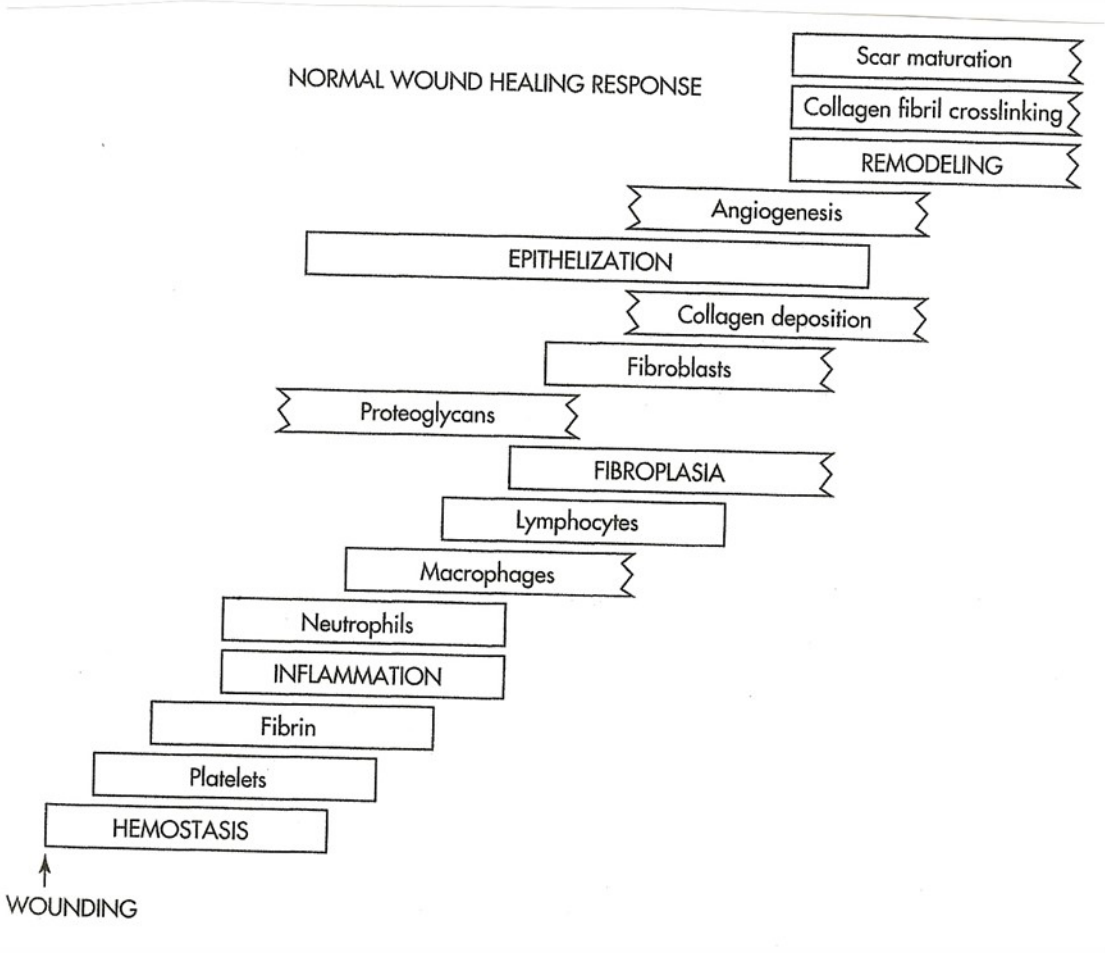
Phases of Wound Healing

The healing process is the same for all wounds regardless of their origin. These phases are:

- Hemostasis
- Inflammation
- Proliferation
- Maturation

These phases do not occur in a specific strict order, they tend to overlap.

Figure 2-B Phases of Wound Healing



Hemostasis

Immediately after an injury, the body releases chemical mediators and intercellular messengers called growth factors that begin the process of cleaning and healing the wound. When blood vessels are damaged, the small muscles in the walls of the vessels contract (vasoconstriction), reducing the flow of blood to the injury and minimizing blood loss. Vasoconstriction can last up to 30 minutes.

Next, blood leaking from the inflamed, dilated, or broken vessels begins to coagulate. Collagen fibers in the wall of the damaged blood vessels activate the platelets in the blood in the wound. Aided by the action of prostaglandins, the platelets enlarge and stick together to form a temporary plug in the blood vessel. This helps prevent further bleeding. The platelets also release additional vasoconstrictors – such as serotonin – which also helps to prevent further blood loss. Thrombin forms in a cascade of events stimulated by the platelets, and a clot forms to close the small vessels and stop bleeding.

This phase of healing begins almost immediately after an injury occurs and works quickly in small wounds; it is less effective in large wounds.

Inflammation

During this phase the wound is cleaned and the process of rebuilding begins. This phase is marked by swelling, redness, and heat at the wound site. This phase is both a defense mechanism and a crucial component of the healing process.

The cleanup process begins with the neutrophils (one type of white blood cell), which enter the site and destroy bacteria and other contaminants through phagocytosis. As neutrophil infiltration slows, monocytes appear. Monocytes are converted into activated macrophages and continue cleaning up the wound. The macrophages also play a key role in the granulation process and reepithelization by producing growth factors and by attracting the cells needed for the formation of new blood vessels and collagen. This process lasts about 36 hours, however, in dirty or infected wound it can last much longer.

Proliferation

During this phase the body fills the wound with connective tissue (granulation), contracts the wound edges (contraction) and covers the wound with epithelium (epithelialization). All wounds go through the proliferation phase, but it takes much longer for wounds with extensive tissue loss. The proliferation phase involves regeneration of blood vessels (angiogenesis) and the formation of connective granulation tissue.

The development of granulation tissue requires an adequate supply of blood and nutrients. Endothelial cells, in blood vessels in surrounding tissue, reconstruct the damaged and destroyed vessels by first migrating and then proliferating to form new capillary beds. As the beds form, the area takes on a red, granular appearance. This tissue is a good defense against bacteria but it is also very fragile.

During this phase, growth factors prompt fibroblasts to migrate to the wound. Fibroblasts are the most common cell in connective tissue and are responsible for making fibers and the extracellular matrix. The extracellular matrix provides support to cells. The most important thing that the fibroblasts do is synthesize collagen fibers, which in turn, produces keratinocyte, a growth factor needed for reepithelization.

If this process yields too much collagen, excessive scarring can occur. Because fibroblasts require a supply of oxygen to perform their tasks capillary bed regeneration is crucial to the process.

Maturation

The final phase of the wound healing process is maturation, which is marked by the shrinking and strengthening of the scar. This phase can continue for months or even years after the wound has healed.

During this phase, fibroblasts leave the site of the wound, vascularization is reduced, the scar shrinks and becomes pale, and the mature scar forms. Scar tissue is always less elastic than the surrounding skin and less strong.

Influences on the Healing Process

There are many factors that influence the healing process the most important are:

- Nutrition
- Oxygenation
- Infection
- Age
- Chronic health conditions
- Medications
- Smoking

Nutrition

Nutrition is a wide spread problem in older patients and it is estimated that malnutrition is present in 53% to 74% of older hospitalized patients. Poor nutrition prolongs hospitalization and increases the risk of medical complications. In older patients, malnutrition is known to increase the risk of pressure ulcers and delay wound healing. They also contribute to poor tensile strength and dehiscence in wounds.

Protein is critical for wounds to heal properly. Wound patients need to double the recommended dietary allowance of protein from 0.8g/kg/day to 1.6g/kg/day. If a significant amount of body weight has been lost, 50% of it must be regained before healing can occur.

The body needs protein to form collagen during the proliferation phase. Without adequate protein, collagen formation is reduced or delayed and the healing process is slow. Studies of malnourished patients indicate that they have lower levels of serum albumin, which results in slower oxygen diffusion and in turn, a reduction in the ability of neutrophils to kill bacteria. Wound exudates alone can contain up to 100 g of protein per day.

Milk and eggs are a very good source of protein. Other sources are red meat, chicken, turkey, fresh fish, shellfish, tuna, cheese, cottage cheese, pork, Canadian bacon and all varieties of beans. When instructing a patient to increase their amount of protein intake, it may also be beneficial to use protein supplements such as powders and concentrated prepared drinks or nutrition bars.

In addition to protein it is important that the patient gets fatty acids, vitamins C, B-complex, A, and E and the minerals iron, copper, zinc, and calcium.. A zinc deficiency adversely affects the proliferation phase by slowing the rate of epithelialization and decreasing the strength of collagen produced. In addition to protein and zinc, collagen synthesis requires supplies of carbohydrates and fat. Below is a table of various nutrients and their affect on wound healing.

See figure 2-C.

Figure 2-C Nutritional requirements

Requirements	Healthy Individuals	Patients w/ wounds (loss of <15% lean body mass -
Calories	1200-2000 kcal/day	30 kcal/kg/day
Protein	0.8 g/kg/day lbm	1.5-2.0 g/kg/day lbm
Fluids	Average 3 liters/day	1ml water/calorie
Carbohydrates	60% of kcal = ≈ 300 gms	50-60% of kcal
Fat	30% of kcal = ≈ 65 gms	25% of kcals
Vitamin A	mg/day for adult man 0.8 mg/day for adult woman 6mg of beta carotene = 1 mg of Vitamin A	1600-2000 mg/day (1 microgram= 3.33 IU)
Vitamin B complex	100-300 mg/day	200% RDA
Vitamin C	60 mg	100-1000 mg
Vitamin D	200 IU/day	N/A
Vitamin E	10 mg/day men 8 mg/day women 3mg/day infant	150% RDA
Zinc	15mg	15-30 mg/day
Iron	10 mg for men 15 mg for women	20-30 mg/day
Copper	1.5-3.0 mg/day	N/A

Oxygenation

Oxygen is crucial to healing. If the supply of oxygen is low, the ability of the leukocytes to destroy bacteria and the fibroblasts to stimulate collagen synthesis is impaired.

Some causes of poor blood flow to a wound area include pressure, arterial occlusion, or prolonged vasoconstriction, possibly associated with such medical conditions as peripheral vascular disease and atherosclerosis.

Hyperbaric oxygen therapy may be helpful in patients with low oxygen levels at the wound site. TCPO2 tests can be performed to check these levels.

Infection

Infection can be systemic or localized in the wound. A systemic infection such as pneumonia increases the patient's metabolism and thus consumes the fluids, nutrients and oxygen the body needs for healing the wound.

A localized infection in the wound itself is more common. Any break in the skin can allow bacteria to enter and an infection to occur. An infection can interfere with the formation of new blood vessels and the synthesis of collagen.

Signs of an infection are:

- Redness and warmth of the margins and tissue around the wound
- Fever
- Edema
- Pain
- Pus
- Increase in exudates or a change in its color
- Odor
- Discoloration of granulation tissue
- Further wound breakdown or progress toward healing

Age

Skin changes associated with aging can cause prolonged healing times. Although delayed healing is partially due to these physiologic changes, it is usually complicated by other problems associated with aging, such as poor nutrition, hydration, chronic condition of patient or multiple medications.

Chronic Health Conditions

There are many chronic health conditions that can interfere with wound healing. Respiratory problems, atherosclerosis, diabetes and malignancies are some of the most common.

Impaired circulation, a common problem for patient with diabetes and other disorders, can cause tissue hypoxia (lack of oxygen). Neuropathy associated with diabetes reduces a person's ability to sense pressure. As a result, a diabetic patient may experience trauma, especially to the feet without realizing it. Insulin dependency can impair leukocyte function, which adversely affects cell proliferation.

Hemiplegia and quadriplegia involve the breakdown of muscle tissue and reduce the padding around the large bones of the lower body. These patients are at an increased risk for chronic pressure ulcers due to these conditions.

Normally, a healthy person shifts positions every 15 minutes or so, even during sleep. This prevents tissue damage due to ischemia. Anything that prevents the shifting of positions puts the patient at a greater chance of getting a wound.

Medications

There are many medications that may impair the healing process. Sedatives and tranquilizers may inhibit the patient's ability to sense and respond to pressure and reduce movement. Movement is important for peripheral blood flow and oxygen to the extremities. Any reduction in movement can reduce the oxygen to these areas.

Steroids and chemotherapy agents can reduce the body's ability to heal by interfering with the inflammatory response. This is especially true in patients with compromised immune systems.

Smoking

Carbon monoxide binds to the hemoglobin in blood in the place of oxygen. This reduces the amount of oxygen circulating in the bloodstream, which can impede wound healing.

Complications of Wound Healing

The most common complications associated with wound healing are hemorrhage, dehiscence and evisceration, infection, and fistula formation.

- Hemorrhage – internal hemorrhage is the result of internal bleeding and can result in the formation of a hematoma. They are commonly found around bruises. External hemorrhage is visible bleeding from the wound. While external bleeding is common wounds need to be protected by a dressing to keep the newly developed blood vessels from rupturing. Every time the new blood vessels suffer damage, healing is delayed.
- Dehiscence and Evisceration – Dehiscence is a separation of skin and tissue layers. It's most likely to occur 3 to 11 days after the injury was sustained and may follow surgery. Evisceration is similar but involves protrusion of underlying visceral organs as well. Dehiscence and evisceration may constitute a surgical emergency, especially if they involve an abdominal wound. Poor nutrition and advanced age are two factors that increase a patient's risk of dehiscence and evisceration. See figure 2-D.
- Infection – This is a common complication of wound healing and should be treated promptly. Infection can lead to cellulites or bacterial infection that spreads to surrounding tissue
- Fistula – A fistula is an abnormal passage between two organs or between an organ and the skin. In a wound, it may appear as undermining or a sinus tract in the skin around the wound. If a sinus tract (or tunneling) is present, it's important to determine its extent and direction.

Figure 2-D Comparison of Wound Dehiscence and Evisceration