Wound Healing Stages and Treatment Methods

Nasir Iqbal[1], Hatice Özlem Nisbet[1], Abdul Mateen[2,*], Zubair Nazir[3] and Muhammad Tasadaq Hameed[3]

[1]Department of Veterinary Surgery, Ondokuz Mayis University, Samsun
[2]Department of Clinical Sciences, College of Veterinary and Animal Sciences. Jhang
[3]Faculty of Veterinary & Animal Sciences, the Islamia University of Bahawalpur
*Corresponding author: abdul.mateen@uvas.edu.pk

Abstract

The deterioration of the integrity and functioning of the tissues is called a wound. The restoration of this functioning and the recovery of tissue integrity is called wound healing. Acute wounds are clean wounds that are caused by trauma or surgery, usually responding well to the healing process. Chronic wounds, on the other hand, are wounds that heal late or difficult or do not heal. The most common causes of chronic wounds can be listed as diabetic foot, venous ulcer, pressure ulcer, arterial insufficiency wound and radiation damage. There are three separate but intertwined steps in wound healing: the inflammation phase, the proliferation phase, the maturation and remodeling phase. Many cytokines also play an active role in the wound healing process. The field of wound treatment has long used a variety of techniques and medications. Technology developed through bioengineering techniques has also begun to be applied to wound care in recent years. These products are gradually becoming better mimics of living skin. Nonetheless, items that have been utilized for hundreds of years, like aloe vera and silver, continue to have therapeutic benefit. Different treatment modalities are used for different kinds of wounds. Treating wounds is challenging, takes time, and calls for a multidisciplinary approach.

Keywords: Wound, Skin, Recovery, Chronic, Maturation, Remodeling

Cite this Article as: Iqbal N, Nisbet HÖ, Mateen A, Nazir Z, and Hameed MT, 2025. Wound healing stages and treatment methods. In: García-Rubio VG, Alvi MA, Saeed Z and Ahmad M (eds), Foundations of Holistic Healing: Complementary and Alternative Medicine. Unique Scientific Publishers, Faisalabad, Pakistan, pp: 210-216. https://doi.org/10.47278/book.HH/2025.193

A Publication of Unique Scientific Publishers

Chapter No: 25-029

Received: 30-Jan-2025
Revised: 07-Apr-2025
Accepted: 13-May-2025

Introduction

When the integrity of the skin or other bodily tissues is compromised, an injury known as a wound result. Cuts, burns, abrasions, punctures, and surgical treatments are only a few of the causes of accidents. Minor cuts and abrasions to major cuts or traumatic injuries are all possible types of wounds. The body's natural reaction to a wound is to begin the healing process. Hemostasis (blood clotting), inflammation, proliferation (tissue rebuilding), and remodeling (maturation of new tissue) are some of the steps that are usually included in the process. The body attempts to cleanse the wound, eliminate damaged tissue, combat infection, and create new tissue to mend the affected area during the healing process. In order to facilitate healing, wounds must be properly cleaned and dressed. Depending on the kind and extent of the wound, medical care may be necessary, including suturing or stapling, topical medication application, or even surgery. It's critical to treat serious or complex wounds appropriately, reduce complications, and get the right medical care (Bos et al., 1987).

Wound Healing Phases

There are specific phases that are followed in a clear order by normal wound healing. Depending on the person and the kind of wound, these stages may overlap and last different amounts of time. According to Ellis et al. (2018), hemostasis, inflammation, proliferation, and remodeling are the general phases of normal wound healing.

Hemostasis

The body starts the hemostasis phase as soon as a wound arises in order to halt the bleeding. At the site of injury, platelets clump together to help seal the wound and stop the bleeding (Almadani et al., 2021).

Inflammation

An essential early reaction to wound healing is inflammation. It entails bringing immune cells to the wound site and widening blood vessels. Neutrophils and macrophages are examples of inflammatory cells that remove germs, cell debris, and damaged tissues. Usually, the inflammatory phase lasts for a few days (Lux, 2022).

Proliferation

New tissue is created at this point to replace any lost or damaged tissue. Collagen, a protein that gives the wound strength and structure, is produced by fibroblasts, a type of cell (Grinnell et al., 1981). New blood vessels, known as angiogenesis, grow to deliver oxygen and nutrients

to the mending tissue. Epithelialization is the process by which epithelial cells at the edges of the wound start to move and seal the wound. The proliferation phase can persist for several weeks.

Remodeling

The freshly generated collagen fibers undergo strengthening and reorganization during the remodeling phase. Special cells known as fibroblasts break down and eliminate excess collagen. Over time, the wound gets stronger and less obvious. Months or years may pass during this stage. The location and intensity of the initial damage are two examples of variables that can affect how the healing wound looks in the end. It is crucial to remember that the typical wound healing process can be impacted by a few factors. Wound healing can be hampered by long-term health issues such diabetes, poor circulation, malnourishment, and immunological problems (Spielman et al., 2023). In addition, infections, acute inflammation, repetitive stress to the wound site, some drugs used might delay the healing process or hinder recovery. Taking good care of a wound, which includes cleaning and shielding it (Daly, 1982).

Wound healing is a normal physiological response to tissue damage, but it is a complicated process that involves many different cell types, cytokines, mediators, and the vascular system. First, blood vessels constrict and platelets migrate to stop bleeding, and then different inflammatory cells, starting with neutrophils, flow in and release different mediators and cytokines to promote angiogenesis, thrombosis, and epithelialization. Fibroblasts then leave behind extracellular components that will serve as scaffolds (Yang et al., 2021).

Phases of Wound Healing

The inflammatory phase is characterized by hemostasis, chemotaxis, and increased vascular permeability, limiting further damage, closing the wound, removing cellular debris and bacteria, and promoting cellular migration. The duration of the inflammatory phase usually lasts several days. The proliferative phase is characterized by granulation tissue formation, epithelialization, and neovascularization. This stage can last for several weeks. The maturation and remodeling phase is where the wound reaches its maximum strength as it matures (Lux 2022).

When an injury occurs, the first stage is always the spilling of lymphatic fluid and blood. During this procedure, adequate hemostasis is achieved. Both extrinsic and intrinsic coagulation pathways are activated and play a role in stopping blood loss. After arterial vasoconstriction, platelets migrate to the injured endothelium lining. Adenosine 5' diphosphate (ADP) is released when platelets clump together, initiating the thrombosis process. Vasodilation occurs right after this brief vasoconstriction, allowing more platelets and white blood cells to enter the bloodstream. The inflammatory phase begins with hemostasis and chemotaxis. White blood cells and platelets both accelerate inflammation by producing more mediators and cytokines. Other chemicals promote fibroblast transformation, collagen breakdown, re-epithelialization, and the production of new capillaries in addition to platelet-derived growth factor. It happens when all of the processes are operating concurrently and cooperatively. Histamine and serotonin are among the mediators released by platelets that raise cellular permeability (Pavletic, 1997).

Fibroblast chemotaxis is stimulated by platelet-derived growth factor, which also causes fibroblast division and proliferation via TGF. The stimulated fibroblasts are responsible for collagen deposition. After platelets are activated, neutrophils, monocytes, and endothelial cells infiltrate the fibrin mesh that is created. Through the phagocytosis of bacteria and cellular debris, neutrophils aid in the wound's environmental cleanup. The proliferative or granulation phase, according to Hanby et al. (1993), never stops happening and always operates in the background. Fibroblasts begin secreting new collagen and glycosaminoglycans 5-7 days after surgery. The proteoglycans that are deposited in the wound's core help to fortify the healing wound. Cell movement from surrounding tissues and the edges of the wound leads to blurring of the edges signifying that epithelialization has set in (Eming et al., 2014). At first, just a small band of surface epithelial cells forms, but as time passes, the wound is encased in a larger, more resilient band of cells. Following that, two processes occur: vasculogenic, which is the process by which new blood vessels originate from endothelial progenitor cells (EPCs), and neovascularization, which is the growth of new blood vessels from preexisting ones. The wound starts the maturation process once the collagen fibers are positioned to lie inside the fibrin frame. In a similar vein, the wound seems to be getting smaller. (Stadler et al., 2001).

Types of Wounds

There are several types of wounds, each with its own characteristics and special considerations for treatment.

Cut Wounds

These wounds are caused by sharp objects such as knives or glass and have clean, straight edges. They tend to bleed more than other types of wounds.

Abrasions

Abrasions, also known as grasslands or scrapes, are shallow wounds caused by rubbing or rubbing against a rough surface. It typically involves removing the superficial layers of the skin, resulting in a raw and painful area (Robson, 1997).

Contusions

Contusions, often called bruises, occur when blunt force trauma damages the blood vessels beneath the skin, causing localized bleeding and discoloration. Although there are no open wounds, contusions can be painful and indicate underlying tissue damage (Baron et al., 2020).

Lacerations

Lacerations are the wounds which are usually irregular and are jagged wounds, usually caused by any blunt force traumatic object or any accidents (Brickley et al., 1960). They may have torn and uneven edges of wound, and they can also damage the underlying tissues like blood vessels, muscles, tendons, or bone as shown in Figure 1.

Fig. 1: Image of lacerated wound due to injury in a dog.

Fig. 2: Image of avulsion wound in a dog

Puncture Wounds

A puncture wound occurs when a sharp object, such as a nail or needle, pierces the skin. The entry point is usually small, but can extend deep into the tissue. Perforated wounds have narrow openings that can allow bacteria to enter and increase the risk of infection (Abazari et al., 2022).

Avulsions

Avulsions are wounds in which part of the skin or tissue is torn. They can be partial or complete, and the degree of tissue loss depends on the severity of the injury as shown in figure 2. Avulsions are usually caused by accidents, bites, or surgical procedures (Abazari et al., 2022).

Thermal Burns

Thermal burns are caused by exposure to flames, hot liquids, or very hot objects. Burns could be classified as first degree where the burn only damages the upper layer of skin or deep burns which damage all the layers of skin and the tissues below it (Baron et al., 2020).

Chemical Burns

Chemical Burns are caused by the exposure of skin to strong alkaline substances, acids and strong solvents. These types of burns could prove fatal as they could damage the skin and could lead to destruction of tissues as well, so it is important to wash and neutralize the affected area immediately to avoid further damage (Abazari et al., 2022).

Pressure Ulcers

Pressure ulcers also called bedsore, or pressure sore occur on the skin as a result of excessive pressure, when the individual is immobile or in case, they remain bedridden for a long period of time. The ulcers are usually found on the bony areas and if not taken care of, could worsen from simple skin irritation to a very serious sore (Baron et al., 2020).

Infected Wounds

At times, wounds caused by damage to the skin can get inflamed due to contact with bacteria as shown in figure 3. There are few visible signs such as pus formation, foul smell, growing redness, augmentation of the skin surface, and swelling (Abazari et al., 2022). The average healing time for each variety of wound, and the applicable treatments, is determined by a variety of factors: the depth of the wound, its size and its location, and hopefully the patient is not at risk of any other complications. Severe or infected wounds need to be treated by a doctor (Brickley et al., 1960).

General Principles of Wound Treatment

What is missing, is an explanation of the principles of wound care together with guidelines. It was noted that the specifics of the approach can be dependent on the type and the degree of the wound (Abazari et al., 2022).

Bleeding Control

In the event the wound is bleeding profusely, the first measure to take is to directly use a clean cloth or sterile dressing to cover the wound (Attinger et al, 2006). Raising the bloody part also can lessen bleeding. Seek immediate medical attention if direct pressure does not manage to stop the bleeding.

Wound Cleaning

Measuring, for starters, encourages managing hostile bacteria, which in turn helps eliminate debris. The role of cleaning the wound is therefore, instrumental in healing. The use of sterile saline or simple water can assist in washing the area out, which can then be followed up

Fig. 3: Image of infected wound in cat.

with further instructions from a medical practitioner. Do not put too much effort into using soaps, hydrogen peroxide and harsh antiseptics that could potentially injure back tissue (Lux., 2022).

Application of Antibiotics

Application of antibiotic ointment After scrubbing the wound, a thin layer of antibiotic cream can be spread over the wound; this promotes healing while also reducing the chances of infection occurring. Consider seeking an expert for more suitable ointments as well as dressings. This is especially useful for those with deep or contaminated injuries (Lux., 2022).

Wound Dressing

According to medical professionals, putting a dressing on a wound that has recently been injured can largely help in protecting it from being infected or further contaminated. Sterile gauze pads, adhesive bandages (Baron et al., 2020).

Wound Coverage

Covering the wound with an appropriate dressing helps create a barrier against further contamination and provides an optimal environment for healing. Use sterile gauze pads, adhesive bandages, or special wound dressings depending on the size, location, and severity of the wound. Change the dressing regularly as recommended by health professionals (Saeg et al., 2021).

Pain Treatment

If the wound is painful, over-the-counter pain relievers such as acetaminophen or nonsteroidal anti-inflammatory drugs (NSAIDs) may help ease the discomfort. Follow the recommended dosage and consult your doctor if the pain persists or worsens (Baron et al., 2020).

Prevent Infection

Wound infections can significantly impede healing and lead to complications. Watch for signs of infection, such as increased pain, redness, swelling, warmth, or discharge. If any signs of infection appear, seek medical attention immediately for appropriate treatment, which may include antibiotics (Schultz et al., 2003).

Promote Healing

It is very important to support the wound healing process. Keep the wound environment clean and moist, as excessive dryness or moisture can interfere with healing. Follow the health care provider's instructions for wound care, including dressings, topical medications, or special treatments if necessary (Yang et al., 2021).

Protection against Tetanus

For deep, puncture wounds or wounds contaminated with dirt or other substances, make sure your tetanus vaccine is up to date. Tetanus is a serious bacterial infection that can result from exposure to certain types of bacteria commonly found in soil and animal feces (Ellis et al., 2018).

Watch for Complications

Check the wound regularly for signs of complications such as increased pain, redness, swelling, discharge, or delayed healing. If you have any concerns, seek medical attention. It is important to note that these policies provide general guidelines for minor wounds. For deep, large, contaminated or serious wounds or wounds that do not show signs of healing, it is essential to seek immediate medical attention for proper evaluation and treatment (Attinger et al., 2006).

Wound Treatment with Silver Nitrate

Of all the elements, silver has the most ability to assist eating of his skin wounds. Silver nitrate has a wide range of anti microbial effects, thus enabling it to serve as a protective agent for many kinds of wounds. Medical silver seems to be a silver co mpound that has been employed for therapeutic purposes in humans and livestock for numerous years. Here's some information on the science bas es of using silver nitrate to treat wounds: There are quite a number of silver nitrate effects; one such effect is the pores of skin effects. This perspective is complicated by silver cauterization of the tissues surrounding the wound in which silver nitrates were used. A history of using silver blast purifies and annexes tissue surrounding the affected area resulting in reorganization around or pressing in on the affected area. The composition and mechanisms of production of silver nitrate have not been well understood and warrant furth er study. This treatment approach prevents the need to bury tissue, reduces patient suffering and scarring, and minimizes further surgeries (Vishwanath et al., 2022). In easy words, this treatment is primarily directed towards preventing the reoccurrence or frostin g of the hypertrophic tissue. Dressings made from silver nitrate can help sustain a moist expanse within the wound area. It is important to note that while silver nitrate may be effective in certain situations, it is not suitable for all types of wounds. Its use should be based on the assessment

and advice of a healthcare professional who can determine the appropriate treatment based on the specific characteristics and needs of the wound. In addition, silver nitrate may have side effects and limitations. It can cause staining of the skin and surrounding tissues, which is usually temporary but can be cosmetically disturbing (Martinez et al., 2023). It should be used with caution on sensitive areas such as the eyes or mucous membranes, as it may cause irritation or injury. In addition, the use of silver nitrate should be avoided or carefully monitored in people with a known allergy or sensitivity to silver. Following medical professionals' instructions is crucial when applying silver nitrate to wounds in order to guarantee correct application, reduce potential risks, and maximize its positive effects (Siddiqui and Bernstein, 2010).

Treatment of Wounds with Zinc

Zinc is a mineral that is necessary for many physiological processes, including wound healing; it is important for cell division, protein synthesis, collagen formation, and immunity functions, all of which are critical to the wound healing process; it encourages the migration and proliferation of different cells involved in wound healing, including fibroblasts, which are responsible for collagen production and support for tissue regeneration; it has some antimicrobial properties, particularly against certain bacteria and fungi; it can help prevent the growth of microorganisms and lower the risk of wound infection by creating a healthier environment for wound healing. An essential part of the extracellular matrix, collagen promotes wound closure and offers structural support. Zinc aids in the formation and maturation of collagen, strengthening newly produced tissue and accelerating the healing of wounds (Saeg et al., 2021). Zinc can help lessen inflammation at the wound site because of its mild anti-inflammatory qualities. It can lower the synthesis of pro-inflammatory cytokines, alter the immune response, and create a more balanced inflammatory milieu that aids in healing. Zinc can be applied topically in various forms for treating wounds (Yang et al., 2022). Zinc oxide ointments or creams are commonly used to protect the wound and maintain a moist environment. They also have some antibacterial properties. Zinc-based dressings, like hydrogels or gauze impregnated with zinc, can also be used to encourage the healing of specific wound types. Systemic zinc supplementation may be explored in certain situations, particularly in those who have impaired wound healing or zinc insufficiency. However, the use of oral zinc supplementation for wound healing is often recommended if zinc is listed in the composition (Gosselin et al., 2004).

Wound Treatment with Aloevera

Aloevera is a plant with gel-filled leaves, has been utilized for a really long time for its therapeutic properties, including wound healing. It contains various bioactive mixtures that add to its helpful impacts. Aloevera gel has been displayed to have a few properties that can help with wound healing. It has antimicrobial, anti-inflammatory and cancer prevention properties that aids to the production of an ideal climate for healing. Aloevera contains mixtures like, acemannan that display anti-inflammatory properties. By lessening irritation, aloevera can assist with easing in granulation, enlarging, and redness at the injury site, giving a better healing. Aloevera gel has been found to have antimicrobial properties against different microbes, parasites, and infections. These antimicrobial impacts help forestall or lessen the gamble of wound and diseases that can disrupt the cycle of infection. Aloevera has been displayed to increase collagen, a significant part of the extracellular network associated with wound healing. Collagen gives underlying scaffolding and helps in the arrangement of new tissue in the injury region, guaranteeing appropriate healing of the injury (Alven et al., 2021). Aloevera gel has saturating properties and can assist with keeping an ideal moisture level in the injury. Aloevera can add to wound compression, which is the cycle by which wound edges meet up. This withdrawal diminishes the size of the injury, helping it close and heal quicker. Aloevera gel has been accounted for to have pain relieving properties and associated benefits related with wounds. It can assist with reducing distress and work on the general healing experience for individuals with wounds (Liang et al., 2021). Aloevera gel can be applied topically to wounds in various ways, for example, straightforwardly from the plant or as a fixing in economically accessible injury dressings, creams, or gels. In any case, it's critical to take note of that while aloevera can be worthwhile for some individuals, certain individuals might be delicate or sensitive to it. Prior to applying aloevera to a bigger injury, it is suggested that you do a fix test or counsel a medical care proficient for legitimate use and ensure it is viable with individual circumstances. It's likewise significant that in spite of the fact that aloevera can advance injury healing, it's frequently utilized for minor injuries (Alves et al., 1997).

Wound Treatment with Antibiotics

Anti-microbials assume a vital part in the treatment of wounds, particularly in situations where there is an expanded chances of disease or a current contamination. Here are a few data about the utilization of anti-microbial agents in injury treatment and the science behind their viability (Ladhani et al., 2021).

Wound Treatment by other Surface Applicants

In addition to antibiotics, there are various surface treatments that can be used in the treatment of wounds. These applications serve different purposes and can aid wound healing through different mechanisms (Eming et al., 2014). Here are some commonly used surfaces referencing agents for wound treatment and the science behind their effectiveness.

Antiseptics

Antiseptics are topical agents that help reduce the microbial load on the wound and prevent or treat infection. They work by disrupting the cell membranes or metabolic processes of microorganisms. Common antiseptics used in wound care include iodine, hydrogen peroxide, chlorhexidine, and povidone-iodine. However, it is important to note that some antiseptics can be cytotoxic to healthy cells and interfere with wound healing if used in excessive concentrations or for long periods of time (Baron et al., 2020).

Topical Ointments

Some topical agents specifically target microorganisms while minimizing damage to healthy tissue. These agents may consist of silver-

based products that may release silver ions having antimicrobial properties or honey-based topical dressings that are of natural antimicrobial properties. Such healing agents can also help to control bacterial growth, helps to lower the chances of the secondary infection, and also helps in wound healing. To maintain a moist environment is beneficial for wound healing. It can avoid wound drying, promote migration of cell towards affected site, and also promotes formation of the granulation tissue. Moist wound dressings are available like hydrocolloids, hydrogels, or foam dressings that can provide a moist environment as well as protect the wound from other contaminants. Such dressings in addition to moisture, can also help to absorb excess exudate or wound fluid and we can say provide a moist interface for wound healing (Lux., 2022).

Other Therapies

Various types of Growth factors and some cytokines are naturally available substances that can regulate several cellular processes in the wound healing. Such substances applied either topically or can be incorporated into the dressings to enhance angiogenesis, cellular growth, as well as extracellular matrix formation. Examples include epidermal growth factor (EGF), transforming growth factor-beta (TGF-β), and platelet-derived growth factor (PDGF). Other therapy is NPWT which involves application of a vacuum-sealed dressing over the wound by the use of negative pressure to remove some extra fluid, and to encourage blood flow which can ultimately help in wound healing. It can mainly use for chronic wounds. The HBOT involves providing patient to the high levels of the oxygen in a pressurized chamber which helps in the tissue healing, can reduces the risk of infection and also promotes the growth of the new blood vessels. HBOT is used for non-healing wounds like diabetic foot ulcers. It is very important to focus that wound management is very complex process, and some factors like the presence of infection, the stage of healing of the wound, individual factors like age or sex, and professional expertise plays crucial role in their selection for wound healing. Proper post-operative care and management of the wound with proper and regular follow-up is very important for the effective wound treatment and the optimal healing outcomes (Yang et al., 2021).

Wound Treatment using skin Grafts

According to Bacchetta et al. (1975), skin grafts are a surgical technique used to treat wounds that have significant tissue loss or are difficult to heal. In a skin graft, healthy skin is transferred from a donor site—a part of the body—to a recipient site, which is a wound. Here is some information about the use of skin grafts in wound healing and the science behind their success. The primary objective of a skin graft is to cover a wound that does not heal on its own. The graft promotes wound closure and speeds up the healing process by serving as a temporary or permanent substitute for lost or damaged skin. A skin graft needs to endure and blend in with the recipient area in order to be successful. The skin's dermis (inner layer) and epidermis (outer layer) are both included in the graft. Blood vessels will develop from the recipient's area inside the graft during the healing process, giving it the oxygen and nutrition it needs to survive. In order for the graft to blend in with the surrounding tissue, it also produces new blood vessels. Skin grafts come in a variety of forms, such as split-thickness and full-thickness. Split-thickness grafts only include a portion of the dermis and epidermis, whereas full-thickness grafts transfer the complete dermis as well as the epidermis. The features of the wound and the availability of donor sites determine the type of transplant to use (Luze et al., 2022). The size and location of the wound, the availability and quality of the skin, and the patient's general health are some of the factors that are typically taken into consideration when selecting the donor site for a skin graft. Typical donor locations are the back, upper arm, buttocks, or thigh. The donor site itself will also require wound care and healing. Sutures, staples, or adhesive wrapping are typically used to stabilize the graft in order to facilitate successful graft removal and integration. The purpose of dressing is to preserve the graft and create a moist healing environment. These dressings could have silicone, absorbent, or non-adhesive layers. Following vaccination, careful observation and suitable post-operative care are crucial. The patient may need to restrict mobility or weight bearing in the graft location to avoid degeneration or injury (Hussainet al., 2020).

In the healing process, wound care, infection prevention, and pain management are crucial. The grafted region may narrow somewhat as it heals over time. The graft and surrounding skin may alter in texture and appearance as a result of this contraction. To reduce scarring and maximize cosmetic outcomes, scar care treatments including massage, pressure garments, or silicone gel sheets can be applied. A useful therapeutic alternative for wounds that don't heal on their own is skin grafting. A number of variables, such as graft survival, integration, and appropriate postoperative care, affect the outcome of a skin graft. The most suitable transplanting strategy will be assessed and decided by a medical expert with experience in wound care and wound surgery (Iqbal et al., 2020). Frequent follow-up appointments are required to track the progress of the graft and guarantee the best possible healing outcomes (Bacchetta et al., 1975).

Conclusion

In conclusion, wound healing is a kind of dynamic and multi-phase healing process that involves stages inflammation, proliferation, and maturation. Firstly, the body used to respond to the injury with an initial inflammatory phase, where the immune system removes debris as well as pathogens. This is then followed by the phase, proliferative phase; that is characterized by tissue formation, then angiogenesis, and later on epithelialization, which may contribute towards wound closure. Lastly, the maturation phase usually involves the collagen remodeling and also the scar formation that leads to the tissue strength and the functionality as well. Treatment methods of wound may vary depending on the wound type, its size, and severity, with the other options ranging from the basic wound care such as cleaning and dressing to the advanced treatments such as negative pressure wound therapy, or stem cell therapy, and skin grafts. Effective management of wound also includes controlling of infection, while minimizing the movement, and promoting a moist healing environment for quick and smooth recovery. Ongoing research into the novel treatments, like growth factors and the latest bioactive dressings, continues to improve the clinical outcomes along with providing hope for the smooth, faster and more efficient wound healing in the near future.

References

Abazari, M., Ghaffari, A., Rashidzadeh, H., Badeleh, S. M., & Maleki, Y. (2022). A systematic review on classification, identification, and healing process of burn wound healing. *The International Journal of Lower Extremity Wounds*, 21(1), 18-30.

Aiello, S. E., Moses, M. A., & Allen, D. G. (Eds.). (2016). The Merck Veterinary Manual (p. 3325). White Station, NJ, USA: Merck & Company, Incorporated.

Almadani, Y. H., Vorstenbosch, J., Davison, P. G., & Murphy, A. M. (2021). Wound healing: a comprehensive review. In Seminars in plastic surgery (Vol. 35, No. 03, pp. 141-144). Thieme Medical Publishers, Inc.

Alven, S., Khwaza, V., Oyedeji, O. O., & Aderibigbe, B. A. (2021). Polymer-based scaffolds loaded with aloe vera extract for the treatment of wounds. *Pharmaceutics*, 13(7), 961

Alves, A. P., Mulloy, B., Diniz, J. A., &. Mourão, P. A. (1997). Polysaccharides sulfated from the egg jelly layer are species-specific inducers of the acrosomal reaction in sperm of sea urchins. *Journal of Biological Chemistry*, *272*(11), 6965-6971.

Attinger, Christopher E. M.D.; Janis, Jeffrey E. M.D.; Steinberg, John DPM; Schwartz, Jaime MD; El-Attar, Ali M.D.; Sofa, Kara M.S., C.R.N.P., C.W.S. Clinical approach to wounds: debridement and wound bed preparation, including the use of dressings and wound-healing adjuvants. *Plastic and Reconstructive Surgery*, 117(7S): p 72S-109S, June 2006. | DOI: 10.1097/01.prs.0000225470.42514.8f

B.C., N. (1998). Physiology of chronic wound. *Clinics in Plastic Surgery*, 25, 341-356.

Bacchetta, C. A., Magee, W., Rodeheaver, G., Edgerton, M. T., & Edlich, R. F. (1975). Biology of infections of split thickness skin grafts. *The American Journal of Surge*ry, 130(1), 63-67.

Baron, J. M., Glatz, M., &. Proksch, E. (2020). Optimal support in wound healing: New Insights. *Dermatology*, 236(6), 593-600.

Bos, J. D., Zonneveld, I., Das, P. K., Krieg, S. R., van der Loos, C. M., &. Kapsenberg, M. (1987). Skin immune system (SIS): Distribution and immunophenotype of lymphocyte subpopulations in normal human skin. *Journal of Investigative Dermatology*, 88(5), 569-573.

Brickley, H. D., Kaplan, A., Freeark, R. J., & Broccolo, E. (1960). Sudden and delayed rupture of the extrahepatic biliary tract following blunt abdominal trauma. *American Journal of Surgery*, 100(1), 107-109.

Daly, C. H. (1982). Biomechanical properties of the dermis. *Journal of Investigative Dermatology*, 79(1), 17-20.

Diller, R. B., & Tabor, A. J. (2022). The role of the extracellular matrix (ECM) in wound healing: a review. Biomimetics, 7(3), 87.

Ellis, S., Lin, E. J., & Tartar, D. (2018). Immunology of wound healing. *Current Dermatology Reports*, 7, 350-358.

Eming, S.A., Martin, P., & Tomic-Canic, M. (2014). Wound repair and regeneration: mechanisms, signaling and translation. *Science of Translational Medicine*, 6(265), 265sr6-265sr6.

Gosselin, R. A., Roberts, I., &. Gillespie, W. J. (2004). Antibiotics to prevent infection in fractures of open limbs. *Cochrane Database of Systematic Reviews*, (1).

Grinnell, F., Billingham, R. E., & Burgess, L. (1981). Distribution of fibronectin during wound healing in vivo. *Journal of Investigative Dermatology*, 76(3), 181-189.

Hanby, A. M., Poulsom, R., Singh, S., Elia, G., Jeffery, R. E., & Wright, N. A. (1993). The spasmolytic polypeptide is a major antral peptide: the distribution of human spasmolytic polypeptide and pS2 of trefoyl peptides in the stomach. *Gastroenterology*, 105(4), 1110-1116.

Hussain, R., Hussain, N., Iqbal, N., Sadiq, A., Aslam, S., Luqman, Z., & Jawad, H. (2020). A study on crop repair by using different ingluviotomy techniques in pigeon. *Advances in Animal and Veterinary Sciences*, 8(7), 753-760.

Iqbal, N., Aslam, S., Hussain, N., Luqman, Z., & Jawad, H. (2020). Dystocia handling by cesarean section in beetal goat in pakistan: a surgical approach. *Journal of Animal Health and Production*, 8(3), 134-137.

Ladhani, H. A., Yowler, C. J., & Claridge, J. A. (2021). Burn wound colonization, infection, and sepsis. Surgical Infections, 22(1), 44-48.

Liang, J., Cui, L., Li, J., Guan, S., Zhang, K., & Li, J. (2021). Aloe vera: a medicinal plant used in skin wound healing. *Tissue Engineering Part B: Reviews,* 27(5), 455-474.

Lux, C. N. (2022). Wound healing in animals: a review of physiology and clinical evaluation. *Veterinary Dermatology*, 33(1), 91-e27.

Luze, H., Nischwitz, S. P., Smolle, C., Zrim, R., & Kamolz, L. P. (2022). The use of acellular fish skin grafts in burn wound management—a systematic review. *Medicina*, 58(7), 912.

Martinez, J. D., Cardenas, J. A., Soria, M., Saenz, L. M., Estrada, K., Delgado, S. M., & Tatu, A. L. (2023). Role of silver nitrate spray for skin wound care in patients with toxic epidermal necrolysis: our experience in 4 patients. *Life*, 13(12), 2341.

Pavletic, M. M. (1997). Skin flap and skin grafting techniques in small animal surgery. *Veterinary Trimester*, *19*(sup1), 24-25.

Robson, M.C. (1997). Wound infection: failure of wound healing caused by an imbalance of bacteria. *North American Surgical Clinics*, 77(3), 637-650.

Saeg, F., Orazi, R., Bowers, G. M., & Janis, J. E. (2021). Evidence-based nutritional interventions in wound care. *Plastic and Reconstructive Surgery*, *148*(1), 226-238.

Schultz, G.S., Sibbald, R. G., Falanga, V., Ayello, E. A., Dowsett, C., Harding, K., & Vanscheidt, W. (2003). Wound bed preparation: a systematic approach to wound management. *Wound Repair and Regeneration*, 11, S1-S28.

Siddiqui, A. R., & Bernstein, J. M. (2010). Chronic wound infection: facts and discussions. *Dermatology Clinics*, *28*(5), 519-526.

Spielman, A. F., Griffin, M. F., Parker, J., Cotterell, A. C., Wan, D. C., & Longaker, M. T. (2023). Beyond the scar: a basic science review of wound remodeling. *Advances in Wound Care*, 12(2), 57-67.

Stadler, I., Lanzafame, R. J., Evans, R., Narayan, V., Dailey, B., Buehner, N., & Naim, J. O. (2001). 830-nm irradiation increases wound tensile strength in the diabetic murine model. *Lasers in Surgery and Medicine: Official Journal of the American Society for Laser Medicine and Surgery*, 28(3), 220-226.

Vishwanath, N., Whitaker, C., Allu, S., Clippert, D., Jouffroy, E., Hong, J., & Garcia, D. R. (2022). Silver as an antibiotic-independent antimicrobial: review of current formulations and clinical relevance. Surgical Infections, 23(9), 769-780.

Yang, F., Bai, X., Dai, X., & Li, Y. (2021). The biological processes during wound healing. *Regenerative Medicine*, 16(4), 373-390.

Yang, N., Venezuela, J., Almathami, S., & Dargusch, M. (2022). Zinc-nutrient element based alloys for absorbable wound closure devices fabrication: current status, challenges, and future prospects. *Biomaterials*, 280, 121301.