

A Review: On Role of Medicinal Plants in Wound Healing

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ABSTRACT

Wound healing is a complex biological process involving hemostasis, inflammation, proliferation, and tissue remodeling. Medicinal plants, due to their wide spectrum of phytochemicals including flavonoids, alkaloids, tannins, terpenoids, and saponins, offer a safer and cost-effective alternative. Medicinal plants have been widely used in traditional medicine systems for accelerating wound healing due to their antimicrobial, anti-inflammatory, antioxidant, and collagen synthesis-promoting properties. This review highlights the role of selected medicinal plants, their phytoconstituents, and mechanisms of action in wound repair.

KEYWORDS: Wound healing, Medicinal plants, Antimicrobial activity, Phytoconstituents.

I. INTRODUCTION

- In the human body, the skin is the largest organ by surface area. It is the essential structure that shields mechanical injury, ultraviolet radiation, microbial infection, and intense temperature from internal tissues. Wounds are serious cases of physical disability. A wound that is caused by human, biological, immunological, microbial injury, or usually associated with lost function disrupted tissue condition. It can lead to pain, discomfort, inflammation, infection, and occasionally organ failure if the wound stays untreated. Wound healing is a complex and complicated mechanism involving a sequence of arranged events, including bleeding, clotting, initiation of an acute inflammatory response to initial damage, regeneration, migration, and proliferation of connective tissue and parenchyma cells, as well as extracellular matrix protein synthesis, remodeling of new parenchyma and connective tissue, and deposition of collagen.^[1]
- Medicinal plant materials and herbal remedies derived from them represent a substantial portion of the global medicinal market. Herbal remedies and drugs have played a significant role in curing diseases throughout the history of mankind. Though a large amount of

literature is available on their curative properties, standard procedures for quality control of plant materials with respect to their identification (phytochemical, pharmacological, and therapeutic activity) are not available. Standardization of medicinal plants ensure their consistency and therapeutic effectiveness. Herbal products are evaluated for their identity (characterization), quality, and quality of the extracts present, as it is required to evaluate their therapeutic efficacy, i.e., to know their pharmacological action to evidence authenticity.^[2]

- Designing and developing an appropriate wound dressing for healing acute and chronic wounds is a global challenge. Wound healing being a complex process, an ideal wound dressing should have the following characteristics: preserving moisture around the wound, enabling gaseous transmission, biocompatibility, biodegradability, nontoxicity, stimulation of growth factors, ease of changing and removing wound dressings, ability to transfer bioactive compounds to wound sites, and wound protection from infections and microbial growth.^[3]
- Wound healing represents a global public health problem when it is not treated correctly, which can cause complications for the patient, such as functional loss of an organ, amputation, and even death. At a biological level, wound healing involves a complex mechanism in which the immune system and cellular biochemical cascades intervene in a coordinated manner, whose development occurs in stages such as inflammation, proliferation, and remodeling. Therefore, therapies have been developed to accelerate wound healing and have proven effective.^[4]
- Antioxidants such as astaxanthin, beta-carotene, epigallocatechin gallate, delphinidin, and curcumin have shown efficacy in promoting cell proliferation, migration, angiogenesis, and inflammation control, presenting a promising approach for developing innovative treatments for cutaneous conditions. Natural dietary

antioxidants rich in flavonoids have been shown to influence keratinocyte physiology demonstrating notable skin repair benefits across different stages of the wound-healing process, including cell-cell and cell-matrix interactions, as well as collagen synthesis. The effectiveness of combined herbal medications may be attributed to the synergy of diverse plant classes, each contributing different mechanisms that collectively lead to a more comprehensive therapeutic outcome.^[5]

II. CLASSIFICATION OF WOUNDS

Wounds are generally classified according to the underlying cause of the development of wounds:

Acute wounds

In acute wounds, there is tissue damage/injury that generally occurs through an orderly and time-reparative phase that results in the anatomical and functional integrity being restored sustainably. Acute wounds are typically caused by the cuts or surgical incisions.

Closed wounds

The blood escapes from the circulatory system in closed wounds but stays inside the body. It becomes evident in the form of bruises.

Open wounds

Blood leaks from the body through an open wound and bleeding is clearly noticeable. The open wound may be divided further into categories according to the source causing the wound.

Incised wounds

This is a wound with no loss of tissue and minor damage to tissue. It is caused primarily by sharp objects like a scalpel or knife.

Tear or laceration wounds

This is the non-surgical injury in conjunction with other types of trauma which results in tissue loss and damage.

Puncture wounds

These are caused by an object which, like a nail or a needle, which punctures the skin. Since dirt may penetrate deep into the wound, chances of infection are common in them.

Abrasive or superficial wounds

Sliding slip onto a rough surface induces abrasion. During this time, abrasion is scraped off the top layer of the skin, i.e., epidermis which exposes nerve endings resulting in a painful injury.

Penetration wounds

Penetration wounds are chiefly caused by an object like a knife going in and out of the skin.

Gunshot wounds

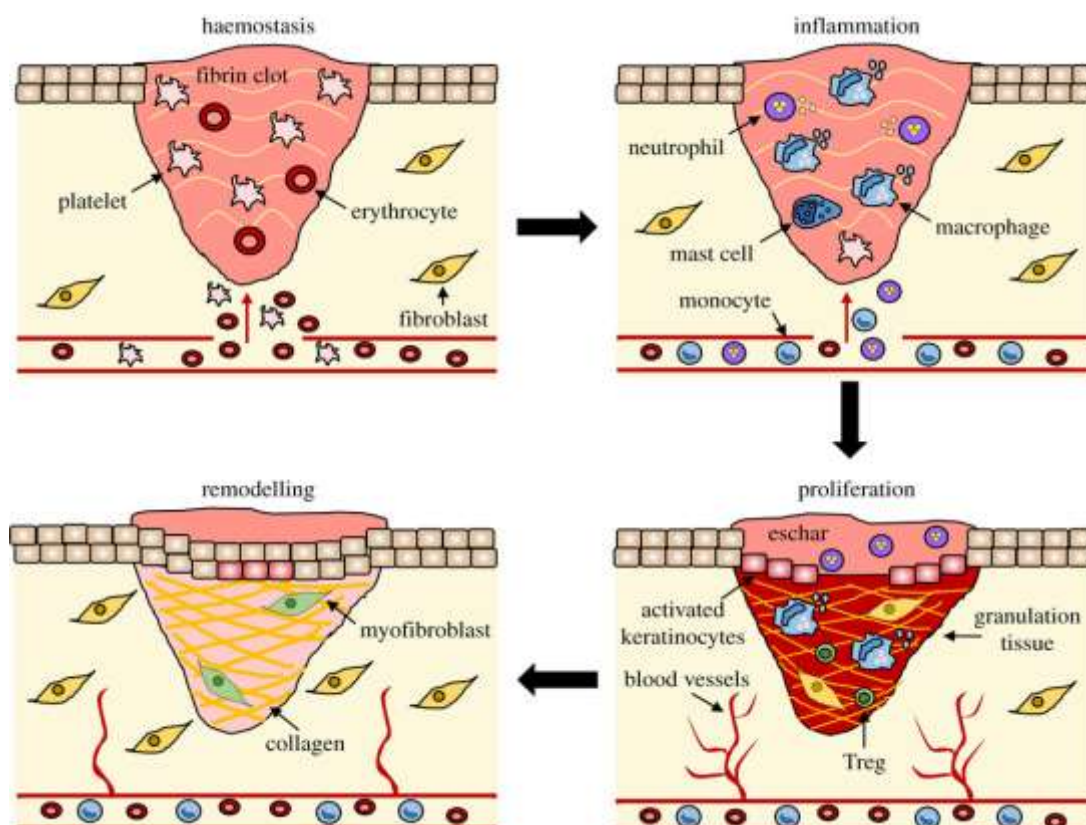
They are typically produced by bullet or similar projectile which drives through or into the body.

Chronic wounds

Chronic wounds are wounds that have not gone through the usual healing stages and hence reach a state of pathologic inflammation. They need extended healing time.^[7]

III. PHASES OF WOUND HEALING

- A. Homeostasis: After injury, the body initiates homeostasis to stop bleeding and form a blood clot at the wound site.
- B. Inflammation: The inflammatory phase involves the recruitment of immune cells to the wound to combat potential infections and clear debris.
- C. Proliferation: During this stage, new tissue is generated to fill the wound gap. Cells such as fibroblasts produce collagen to build a new extracellular matrix, and new blood vessels form through angiogenesis.
- D. Remodeling: In the final phase, the wound undergoes remodeling as the newly formed tissue matures and gains strength. Collagen fibers realign, and the wound's overall tensile strength improves.^[5]



IV. ROLE OF MEDICINAL PLANTS IN WOUND HEALING

Medicinal plants facilitate wound healing through several mechanisms:

- Antimicrobial activity – prevents infection (Neem, Garlic).^[8]
- Anti-inflammatory effect – inhibition of COX and LOX pathways, reducing cytokine levels (Turmeric, Calendula).

- Antioxidant activity – scavenging reactive oxygen species and reducing oxidative stress (Aloe vera flavonoids).
- Collagen synthesis stimulation – asiaticoside from *Centella asiatica* enhances fibroblast proliferation.^[9]
- Angiogenesis promotion – increases VEGF expression and new blood vessel growth (*Centella asiatica*).
- Wound contraction – tannins in *Lawsonia inermis* act as astringents.^[8]

V. IMPORTANT MEDICINAL PLANTS AND PHYTOCHEMICALS

TABLE: MEDICINAL PLANTS WITH WOUND HEALING ACTIVITY^[1]

SL. NO	MEDICINAL PLANTS	FAMILY	PART USED	BIOACTIVE CONSTITUENTS	USES
1	Aloe Barbadensis (Aloe vera)	Aloaceae	Leaves, latex	Aloe-emodin, barbaloin.	Wound Healing
2	Artemisia pallens (Davana, Davanum)	Asteraceae	Whole plant	Davanone, davan ether, davana, furanand linalool.	Cuts & wounds
3	Lawsonia alba (Heena)	Lythraceae	Leaf	Lawsonecoumarins, xanthonones, flavonoids, naphthoquinones, steroids, fatty acid.	Wounds

4	<i>Pterocarpus santalinus</i> (Lal Chandan)	Fabaceae	Leaf, stem	Phenols, anthocyanin, saponin, triterpenoids, flavonoids, tannins, glycerides, glycosides,	Cuts, wounds, boils, inflammation
5	<i>Morinda citrifolia</i> (Indian mulberry)	Rubiaceae	Leaves	Scopoletin, catechin, beta- sitosterol, damnacanthal, alkaloids, lignans	Wounds
6	<i>Sesamum indicum</i> (Til)	Pedaliaceae	Roots	Sesame seeds (up to 60% oil), 30% protein, vitamin E, B-complex vitamins (niacin), folic acid, magnesium, phosphorous, calcium,	Wounds
7	<i>Acalypha langiana</i> (Khokali)	Euphorbiaceae	Leaves	Acalyphine and triacetoneamine, cyanogenic glucosides, and alkaloids.	On external wounds
8	<i>Vernonia arborea</i> (Karana, Sadagai)	Asteraceae	Leaves, bark	Alpha-amyrin acetate, beta- amyrin, lupeol, stigmaterol, beta- sitosterol	Wounds
9	<i>Cassia fistula</i> (bendra, lathi)	Fabaceae	Leaves	Anthraquinones, fistulic acid, rhein, rheinglucoside, sennosides A and B, phlobaphenes, lupeol, emodin, chrysophanic acid, beta-sitosterol and hexacosanol, fistulic acid.	Wounds
10	<i>Abrus precatorius</i> (Gunchi, gunja)	Fabaceae	Leaves	Glycyrrhizin, Triterpene glycosides, pinitol, and alkaloids such as asabrine, hepaphotone, choline and precatorine	Cuts & wounds
11	<i>Tragia involucrate</i> (bichchuti)	Euphorbiaceae	Roots	Tannins, flavanoids, alkaloids, saponins	Pain, wounds, swellings, Eczema
12	<i>Alternanthera sessilis</i> (chanchi)	Amaranthaceae	Leaves	Stigmaterol, campesterol, B- sitosterol, a-	Antibacterial, wound healing

				stigmasteanol and also contain 5-a-stigmasta-7-enol.	
13	Allium cepa (onion)	Liliaceae	Bulb	Kampferol, β -sitosterol, ferulic acid, myritic acid, prostaglandins.	Enhanced wound healing and Antibacterial property
14	Curcuma longa (Turmeric, Haldi)	Zingiberaceae	Rhizomes	Curcumin (diferuloylmethane), turmeric oil or turmerol & 1, 7-bis, 6-hepta-diene-3, 5-Dione	wound healing and regeneration
15	Mimusops Elengi (Bakul)	Sapotaceae	Barks	taraxerol, taraxerone, ursolic acid, betulinic acid, V-spinosterol, W-sitosterol, lupeol, alkaloid isoretronecyl tiglate & mixture of triterpenoid saponins	Stimulated wound contraction; increase the tensile strength of incision

VI. EVIDENCE FROM EXPERIMENTAL AND CLINICAL STUDIES

- Aloe vera gel accelerated wound contraction and epithelialization in rat excision models.^[6]
- Turmeric ointment showed faster healing in burns and chronic ulcers compared to placebo.
- Centella asiatica extract improved tensile strength in incision wound models and is used clinically for scar management.
- Neem extract exhibited strong antimicrobial activity against Staphylococcus aureus and Escherichia coli, preventing infection.^[8]

VII. HERBAL FORMULATIONS AND MODERN ADVANCES

- Traditional formulations: Jatyadi taila (Ayurvedic oil), Panchavalka kwath.
- Modern dosage forms: Herbal hydrogels (Aloe vera), nanocurcumin, Centella-loaded nanofibers.
- Herbal wound dressings impregnated with Neem and Turmeric extracts.

VIII. CHALLENGES AND LIMITATIONS

- Variability in phytoconstituents due to soil, season, and extraction.^[8]
- Lack of standardization across formulations.^[6]

- Limited clinical trials; most studies are animal-based.
- Stability and shelf-life issues of extracts.
- Regulatory hurdles for herbal drugs.^[8]

IX. FUTURE PERSPECTIVES

- Integration with nanotechnology (nanogels, liposomes, nanoparticles).
- Development of standardized polyherbal formulations.
- Clinical validation in diabetic ulcers, burns, and chronic wounds.
- Herbal wound dressings combining antimicrobial and healing activity.

Natural products and herbal remedies have been investigated all over the world. At the fundamental and clinical trial levels, several institutes are focusing on the development of herbal medicines in the drug delivery system. The only requirement is to develop more effective methods for delivering such pharmaceuticals to specific locations and throughout the body in doses that do not interfere with present treatment. Something that not only reduces toxicity and hypersensitive reactions but also improves the patient's internal strength is highly desirable. The idea of using herbal nanoparticles to deliver cancer treatments may pique the interest of certain future research

organizations, leading to potentially eye-catching results.

X. CONCLUSION

Wound healing is a process that begins with trauma and concludes with the formation of scars. Medicinal plants play a significant role in wound healing due to their diverse pharmacological activities. Medicinal plants play a crucial role in wound healing through antimicrobial, anti-inflammatory, antioxidant, and collagen-enhancing effects. Their integration with modern pharmaceutical technology offers promising, safe, and economical alternatives to synthetic agents. With rigorous clinical trials and quality standardization, herbal medicines can emerge as mainstream wound healing therapies.

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