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Review Article

Ayurvedic remedies for healing of wounds: A Review

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ABSTRACT

Healing of wounds, whether from accidental injury or surgical invention, involves the activity of an intricate network of blood cells, tissue types, cytokines, and growth factor. The traditional Indian medicine - Ayurveda, describes various herbs, fats, oils and minerals with anti-aging as well as wound healing properties. Wound healing can be defined as a complex dynamic process results in the restoration of anatomic continuity and function. Various phyto-active compounds and plant products have been used in treatment of wounds over the years. Wound healing herbal extracts promote blood clotting, fight infection, and accelerate the healing of wounds. Hence in the current review a list of the plants used in traditional medicine for the treatment of wounds were screened. It is a beneficial work for researchers to provide many details about the wound healing herbs and development of safe and effective and globally accepted herbal drugs for cuts and wounds.

1. Introduction

Research on wound healing agents is one of the developing areas in modern biomedical sciences. Many of the synthetic drugs currently used for the treatment of wounds are not only expensive but also pose problems such as allergy, drug resistance etc. and this situation has forced scientists to seek alternative drugs . In spite of tremendous development in the field of synthetic drugs during recent era, they are found to have some or other side effects, whereas plants still hold their own unique place, by the way of having no side effects**[1]**.

Plants have bear the basis of many traditional medicines throughout the world for thousands of years and continue to provide new remedies to mankind**[2]**. Correct knowledge of such crude drugs is very important aspect in preparation, safety and efficacy of the herbal products. Pharmacognosy is a simple and reliable tool, by which complete information of the crude drugs can be obtained**[3].**

Wound

Wounds are major case of physical disabilities**[4].** A wound which is disturbed state of tissue caused by physical, chemical, microbial (or) immunological insults (or) typically associated with loss function. According to the wound healing society wounds are physical injuries that results in an opening (or) break of the skin that cause disturbance in the normal skin anatomy and function**[5].**

Wound healing is the dynamic process take place by regeneration or repair of broken tissue**[6].** A lot of research has been envisaged to develop the better healing agents. The rapidity of wound healing depends to a considerable extent on the contraction that begins a few days after injury and continues for several weeks**[7].**

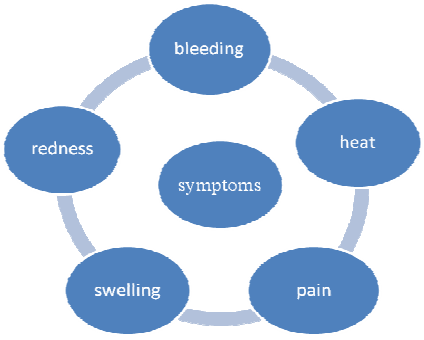

Figure No. 1: Representation of symptoms of wound

Causes

A pin, nail or any sharp object with a penetrating point can cause a puncture. When skin gets rubbed against any rough surface like a pavement, blood vessels maybe ruptured and blood oozes out, though the outer skin layer may not be completely broken. Sharp instruments with a smooth edge probably razor, blade, broken glass or a knife can cause a cut. Bleeding maybe profuse and nerves, muscles and tendons may be damaged if the cut is deep.

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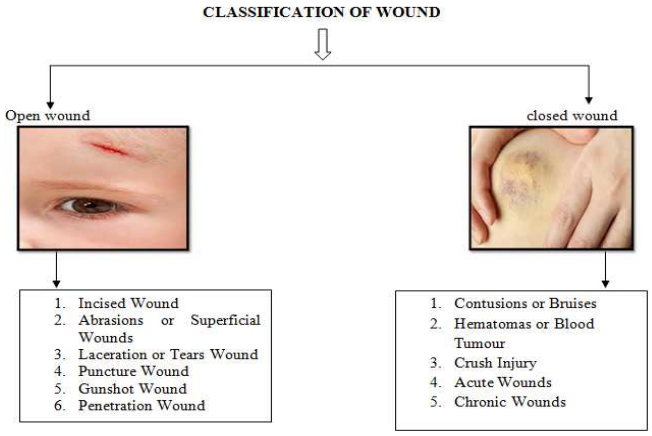

Figure No.2: Representation of classification of wound**[8]**

- **Open Wound**

Though an open wound blood escapes the body and bleeding is clearly visible. Open wound is further classified ii various types according to the object that occur the wound**[9].**

- **Incised Wound**

It is an injury with no tissue loss and minimal tissue damage. It is caused by a sharp object such as knife. Bleeding in such cases can be profuse, so immediate action should be taken.

- **Abrasions or Superficial Wounds**

It is caused by sliding fall onto a rough surface. During abrasion the topmost layer of the skin i.e. epidermis is scraped off that exposes nerve ending resulting in a painful injury. Blood loss similar to a burn can result from serious abrasions.

- **Laceration Wound or Tears Wounds**

This is the nonsurgical injury in conjunction with some type of trauma, resulting in tissue injury and damage.

- **Puncture Wounds**

They are caused by some object puncturing the skin, such as needle or nail. Chances of injection in them are common because dirt can enter into the depth of wound.

- **Gunshot Wounds**

They are caused by a bullet or similar driving into or through the body.

- **Penetration Wounds**

Penetration wounds are caused by an object such as a knife entering and coming out from the skin.

- **Closed Wound**

In closed wounds blood escapes the circulating system but remain in the body. It includes Contusion or bruises, haematomas or blood tumour, Crush injury etc**[9].**

- **Contusions or bruises**

Bruises are caused by a blunt force trauma that damage tissue under the skin.

- **Hematomas or blood tumor**

They are caused by damage to a blood vessel that consequently causes blood to collect under the skin.

- **Crush injury**

Crush injury is caused when great or extreme amount of force is applied on the skin over long period of time.

- **Acute Wounds**

Acute wound is a tissue injury that normally proceeds through an orderly and timely reparative process that results in sustained restoration of anatomic and functional integrity. Acute wounds are usually caused by cuts or surgical incisions and complete the wound healing process within the expected time frame**[10].**

- **Chronic Wounds**

Chronic wounds are wounds that have failed to progress through the normal stages of healing and therefore enter a state of pathologic inflammation chronic wounds either require a prolonged time to heal or recur frequently. Local infection, hypoxia, trauma, foreign bodies and systemic problems such as diabetes mellitus, Malnutrition, immunodeficiency or medications are the most frequent causes of chronic wounds**[11,12]**.

Pathology of wounds

Wounds are physical injuries that result in an opening or break of the skin. Proper healing of wounds is essential for the restoration of disrupted anatomical continuity and disturbed functional status of the skin. Healing is a complex and intricate process initiated in response to an injury that restores the function and integrity of damaged tissues. Wound healing involves continuous cell–cell and cell–matrix interactions that allow the process to proceed in three overlapping phase's viz. inflammation (0–3 days), cellular proliferation (3–12 days) and remodeling (3–6 months). Healing requires the collaborative efforts of many different tissues and cell lineages. It involves platelet aggregation and blood clotting, formation of fibrin, an inflammatory response to injury, alteration in the ground substances, angiogenesis and re-epithelialization. Healing is not complete until the disrupted surfaces are firmly knit by collagen. The basic principle of optimal wound healing is to minimize tissue damage and provide adequate tissue perfusion and oxygenation, proper nutrition and moist wound healing environment to restore the anatomical continuity and function of the affected part. Cutaneous wound repair is accompanied by an ordered and definable sequence of biological events starting with wound closure and progressing to the repair and remodeling of damaged tissue. In spite of tremendous advances in the pharmaceutical drug industry, the availability of drugs capable of stimulating the process of wound repair is still limited. Moreover, the management of chronic wounds is another major problem due to the high cost of therapy and the presence of unwanted side effects. It is consented that reactive oxygen species (ROS) are deleterious to wound healing process due to the harmful effects on cells and tissues. Absorbable synthetic biomaterials are considered to be degraded via ROS. Free-radical-scavenging enzymes (FRSE) are a cytoprotective enzymatic group that has an essential role in the reduction, de-activation and removal of ROS as well as wound healing process. Inflammation, which constitutes a part

of the acute response, results in a coordinated influx of neutrophils at the wound site. These cells, through their characteristic "respiratory burst" activity, produce free radicals. Wound related non-phagocytic cells also generate free radicals by involving non-phagocytic NAD(P)H oxidase mechanism. Thus, the wound site is rich in both oxygen and nitrogen centered reactive species along with their derivatives. The presence of these radicals will result in oxidative stress leading to lipid peroxidation, DNA breakage, and enzyme inactivation, including free-radical scavengerenzymes. Evidence for the role of oxidants in the pathogenesis of many diseases suggests that antioxidants may be of therapeutic use in these conditions. Topical applications of compounds with free-radical-scavenging properties in patients have shownto improve significantly wound healing and protect tissues from oxidative damage**[13-26].**

Ayurvedic remedies for healing of wounds

Ayurveda, the Indian traditional system of medicine, is based on empirical knowledge of the observations and the experience over millennia. More than 1200 diseases are mentioned in different classical Ayurvedic texts. Management in various forms of these diseases is made with more than 1000 medicinal plants (89.93%); 58 minerals, metals, or ores (5.24%); and 54 animal and marine products (4.86%). Healing of wounds is one of the important areas of clinical medicines explained in many Ayurvedic texts under the heading "Vranaropaka". The wound as a medical problem was first discussed by Maharshi Agnibesha in Agnibesha Samhita (later known as Charaka Samhita) as "Vrana" Maharshi Sushruta in Sushruta Samhita elaborated on the same and also gave some more details about wound and its healing. According to the Ayurveda, Vrana(wounds or ulcers) is the discontinuation of lining membrane that after healing leaves a scar for life closely resembling the modern definition. Similarly, inflammation is considered to be an early phase in the pathogenesis of wounds termed Vranashotha. Different types of wounds as mentioned in Ayurveda may be endogenous in origin due to a defect in human functional units, such as Vata (nerve impulses), Pitta (enzymes and hormones), and Kapha(body fluids), or exogenous due to trauma, such as Chinna(cut wound), Bhinna (perforated wound), Viddha (punctured wound), Kshata (lacerated wound), Picchita (contusion), and Ghrista (abrasion wound). These steps have striking similarities with wounds described in modern medicine (FIG-3). Classical management of wounds according to Sushruta Samhita follows 60 therapeutic steps, starting with an aseptic dressing of the affected part and ending with the rehabilitation of the normal structure and function. These therapeutic measures were aimed not only to accelerate the healing process but also to maintain the quality and aesthetics of the healing. As described in different Ayurvedic classics like Charaka Samhita (ca. 5000 b.c.), Sushruta Samhita(ca. 1000 b.c.), Astamga Hridaya (ca. a.d. 600), Bhavaprakash Nighantu (ca. a.d. 1500), Dhanwantari Nighantu (ca. a.d. 1800), and Ayurveda Siksha (a.d. 20th century), it has been estimated that 70% of the wound healing Ayurvedic drugs are of plant origin, 20% of mineral origin, and the remaining 10% consisting of animal products. These drugs are stated to be effective in different conditions such as Vrana (wounds or ulcers), Nadivrana (sinuses), Vidradhi (abscess), Visarpa (erysipelas), Upadamsha (syphilitic ulcers), Vranajakrimi(maggots in wounds), Dustavrana(septic wounds), Vranashotha (inflammatory changes of wounds), Vranavisha (cellulitis), Ugravrana (purulative ulcer), Netravrana (hordeolum or stye sepsis), Pramehapidaka (diabetic carbuncle), and Bhagandara (fistula-in-ano). Scientific investigations have been carriedout to assess the wound healing properties of some these drugs**[27].**

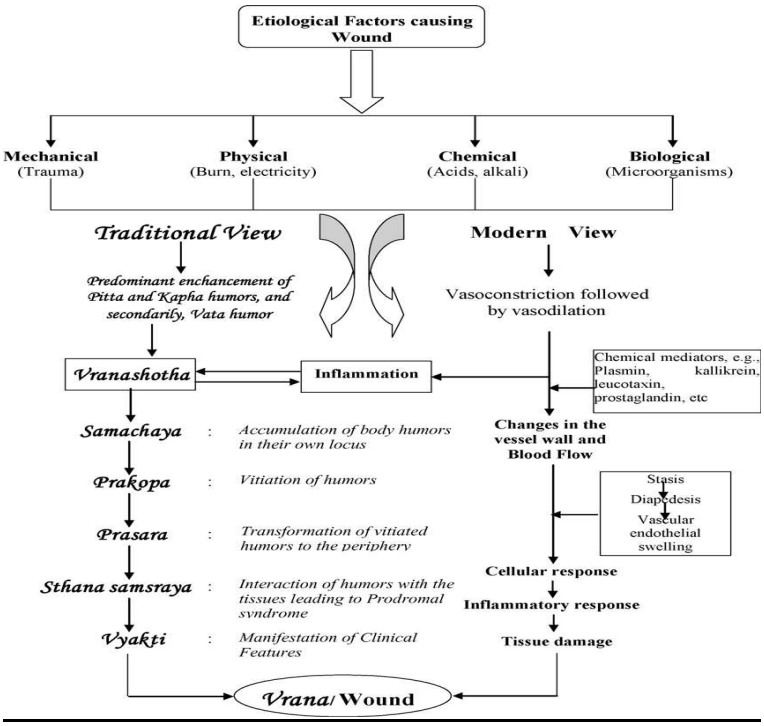

Figure No. 3: Representation of etiological factors causing wound

A. The Inflammatory Phase

The inflammatory phase starts immediately after the injury that usually last between 24 and 48 hrs and may persist for up to 2 weeks in some cases. The inflammatory phase launches the haemostatic mechanisms to immediately stop blood loss from the wound site. Clinically recognizable cardinal sign of inflammation, rubor, calor, tumor, dolor and function-laesa appear as the consequence. This phase is characterized by vasoconstriction and platelet aggregation to induce blood clotting and subsequently vasodilatation and phagocytosis to produce inflammation at the wound site[28].

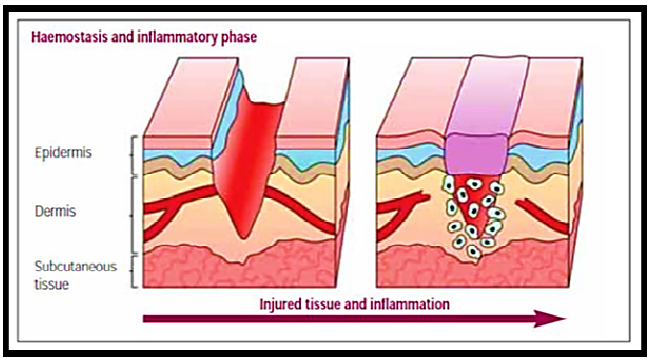

Figure No. 4: Structure of haemostasis and inflammatory phase

B. The Fibroplastic Phase

The second phase of wound healing is the fibroplastic phase that lasts up to 2 days to 3 weeks after the inflammatory phase. This phase comprises of three steps viz., granulation, contraction and epithelialisation. In the granulation step fibroblasts form a bed of collagen and new capillaries are produced. Fibroblast produces a variety of substances essential for wound repair including glycosamino glycans and collagen. Under the step of contraction wound edges pull together to reduces the defects in the third step epithelial tissues are formed over the wound site[29].

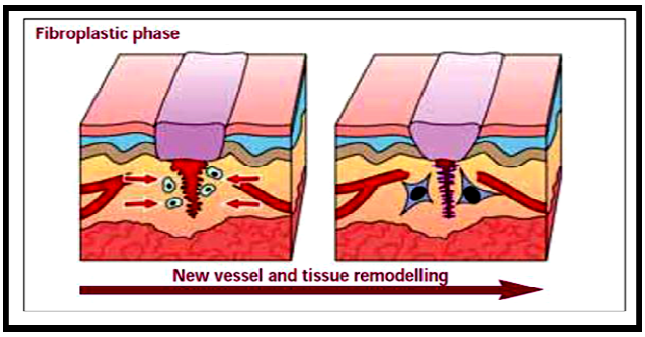

Figure No. 5: Structure of fibroplastic phase

C. The Remodelling Phase

This phase last for 3 weeks to 2 years. New collagen is formed in this phase. Tissue tensile strength is increased due to intermolecular cross-linking of collagen via vitamin-C dependent hydroxylation. The scar flattens and scar tissues become 80% as strong as the original[30,31]. The wound healing activities of plants have since been explored in folklore. Many Ayurvedic herbal plants have a very important role in the process of wound healing. Plants are more potent healers because they promote the repair mechanisms in the natural way. Extensive research has been carried out in the area of wound healing management through medicinal plants. Herbal medicines in wound management involve disinfection, debridement and providing a moist environment to encourage the establishment of the suitable environment for natural healing process[32].

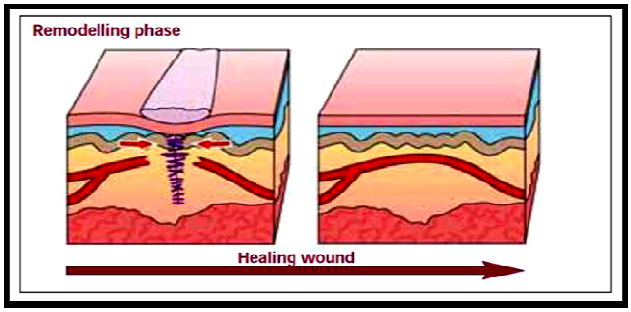

Figure No. 6: Structure of remodelling phase

Factor Affecting Wound Healing

- Improper diet
- Infection at the wound site
- Insufficient oxygen supply and tissue perfusion to the wound area
- Drugs
- Elderly age
- Diabetes and other diseases conditions

Wound healing is normal biological process in the human body. Many factors can adversely affect this process and lead to improper and impaired wound healing. A thought understanding of these factors and their influence on wound healing is essential for better therapeutic option for wound treatment[33].

1. Improper Diet

Wound healing is anabolic process that requires both energy and nutritive substrates. It is reported that serum albumin level

of 3.5gm/dl or more is necessary for proper wound healing[34]. Protein is essential for collagen synthesis on wound site. A state malnutrition may provide an inadequate amount of protein and this can decreased the rate of collagen synthesis wound tensile strength or increased chance of infection[35,36].

2. Infection at the Wound Site

Wound infection is probably the most common reason of impaired wound healing. Streptococcus aeurous, streptococcus pyrogenes, Escherichia coli and pseudomonas, aeruginosa[37,38].

3. Insufficient Oxygen Supply and Tissue Perfusion to the Wound Area

Adequate blood supply and tissue perfusion is extremely important for wound healing. Excessive pain, cold and anxiety can cause local vasoconstriction and increased healing time. Smoking and use of tobacco decreased tissue perfusion and oxygen tension in wound[39,40].

4. Drugs

Many drugs are known to impair wound healing. Chemotherapeutic drugs are used in cancer are the largest group well known to delay wound repair**[41]**. Systemic glucocorticoids interfere normal healing by reducing collagen synthesis and fibroblast proliferation.

5. Elderly Age

Elderly age is found to associate with delay wound healing. It is reported that the fibroblast growth and activity diminishes and collagen production, wound contraction is slow in older individuals**[42].**

6. Diabetes and Other Diseases Conditions

Diabetic patients are more susceptible to wound healing. In study wound infection rate was found 11% higher in diabetic patients than in general patient's population**[43].** Acute and chronic liver diseases also associated with delay wound healing. Patients with altered immune faction have an increased susceptibility to wound infection.

3. Nutrition

Nutrition deficiency or imbalance may have an important influence on metabolic processes and can be reflected in healing as follows:

- **Vit. A deficiency:** This vitamin is concerned, inter alia, with the integrity of epithelium and, if deficient, epithelialization is retarted.
- **Vit. C** is vital to the formation of collagen; deficiency causes poor scar tissue formation. It plays important role in wound repair and activate metabolism.
- **Vit. E** aids the formation of new capillaries which are necessary for wound restoration.
- **Vit. K** the antihaemorrhagic vitamin helps to preserve the normal state of capillaries and deficiency causes petechiae, echymoses and delayed clotting time. It has a strong influence on the maturation of collagen and the development of tensile strength in wounds.
- **Protein deficiency**: as fibrin and collagen are proteins, wound healing is retarded during protein deficiency and subsequent disruptions common**[44].**

Role of phytopharmaceuticals in wound healing

Tannins

Result revealed that tannins are one of the important phytoconstituents responsible for wound healing mainly due to their astringent and antimicrobial property**[45].**

Role of herbal medicines in wound healing and regeneration

The following factors influence wound healing:

1. Vascularity

Wounds in very vascular parts of the body heal quickly due to well supplied blood.

2. Infection

If the wound is not infected by microbial agents (bacteria, fungi etc.) the wound heals faster.

Flavanoids

Flavanoids show wound healing properties due to their antibacterial and antioxidant properties. Flavones, flavonoids and flavanols are phenolic structure with one carboxylic group. They are synthesized by plants in response to microbial infection and are often found effective in vitro as antimicrobial substance against a wide array of microorganisms**[46].** Tannins are polymeric phenolic substances possessing the astringent property. These compounds are soluble in water, alcohol and acetone and give precipitate with proteins. Coumarins are phenolic substances made of fused benzene and pyrone rings**[47].** They have a characteristic odor and several of them have antimicrobial properties.

Tragacanth mucilage

With respect to the wound healing mechanism of tragacanth mucilage, the exact mechanism could be proposed. However, the significant differences observed with the tragacanth mucilage-treated groups suggest that it could be affected on the proliferation and remodelling phases of wound healing. It is probably capable of stimulating the myofibroblast contraction, for a faster closure of the wound. Active ingredients of tragacanth mucilage, such as bassorin and tragacanthin, may contribute to the healing effects of tragacanth mucilage. Hydrolysis of tragacanth into arabinose and glucoronic acid may cause coagulation of surface proteins, and prevent wound infection that causes a faster wound healing**[48].**

Table No. 1: List of the Medicinal plants used for Wound healing[49-58]

Sr. No.	Botanical name	Vernacular name	Family	Parts used
1.	*Acacia catechu* Wild	Khair	Mimosaceae	Bark
2.	*Aegle marmelos*	Bael	Rutaceae	Root.
3.	*Aloe vera* (L.) Burm. f.	Korphad	Liliaceae	Leaf juice
4.	*Azadirachta indica* Juss	Neem	Meliaceae	Leaves
5.	*Calotropi sprocera* (Ait.)R. Br.	Rui	Asclepiadaceae	Leaves and Latex
6.	*Centella asiatica*	Brahmi	Umbelliferae	Flowers
7.	*Colocasia esculenta* (L.)Schott	Alu	Araceae	Leaf extract

8.	*Commiphora mukul* Hook	Guggule	Burseraceae	Whole Plant
9.	*Curcuma longa* L.	Halad	Zingiberaceae	Rhizome, Seeds
10.	*Dauca scarota* L.	Gajar	Apiaceae	Root
11.	*Eucalyptus globules*	Eucalyptus	Myrtaceae	Oil
12.	*Lawsonia innnermisalba* L.	Mehdi	Lythraceae	Leaves, Seeds, Bark and Flowers
13.	*Neumbo nuciera*	Kamal	Nymphacocese	Rhizomes
14.	*Ocimum sanctum* L.	Tulsi	Labiatae	Leaves
15.	*Phyllanthus embilica*	Amla	Euphorbiaceae	Fruit
16.	*Terminalia arjuna* (Roxb.) Wight &Arn	Arjun	Combretaceae	Bark
17.	*Terminala chebula*	Myrobalan harda	Combretoreceae	leaves & fruit
18.	*Trigonella foenum graecum* L.	Methi	Fabaceae	Seeds
19.	*Withania somnifera* Dunal.	Ashwagandha	AshwagandhaSolanaceae	Root, Seeds
20.	*Zingiber officinale* Rosc	Adrak	Zingiberaceae	Rhizome

2. Conclusion

Most of the natural plants in this review are those with wound healing potentials. Plants are more potent healers because they promote the repair mechanism in the natural way. The healing process can be physically monitored by assessing the rate of contraction of the wound, period of epithelization, tensile strength, histopathology, and weight of granuloma in different wound models. The healing tissue synthesizes more collagen to provide tensile strength. The demand of herbal drugs is increasing day by day in developed as well as developing countries because they are safer and well tolerated as

compared to those allopathic drugs. These plants should be subjected to animal and human studies to determine their effectiveness.

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