Wound Healing Activity of Herbal Gel Using Excision Wound Model in Rats

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ABSTRACT

Wound healing is a complex and dynamic biological process that involves a sequence of events including hemostasis, inflammation, proliferation, and tissue remodeling to restore the structural and functional integrity of damaged tissues. Effective wound management is essential to prevent infection, reduce healing time, and promote proper tissue regeneration. Conventional wound healing therapies such as antibiotics, antiseptics, and anti-inflammatory agents are widely used; however, their prolonged use may lead to adverse effects including skin irritation, delayed healing, and microbial resistance. Therefore, the development of safer and more effective alternative therapies has gained considerable attention in recent years.

Herbal medicines have been traditionally used in the treatment of wounds due to their antimicrobial, antioxidant, and anti-inflammatory properties. Medicinal plants contain bioactive phytoconstituents such as flavonoids, tannins, alkaloids, and phenolic compounds that contribute to enhanced collagen synthesis, fibroblast proliferation, and tissue regeneration. Herbal gel formulations offer advantages such as improved topical drug delivery, better spreadability, enhanced skin penetration, and prolonged retention at the wound site.

The present review focuses on the wound healing activity of herbal gel formulations evaluated using the excision wound model in albino rats. Parameters such as wound contraction, epithelialization period, and histopathological changes are commonly used to assess healing efficacy. Findings from various studies indicate that herbal gel formulations significantly accelerate wound healing and represent a promising therapeutic approach for wound management.

Keywords: Wound Healing, Herbal Gel, Excision Wound Model, Albino Rats, Tissue Regeneration, Wound Contraction, Epithelialization, Medicinal Plants, Topical Drug Delivery, Anti-inflammatory Activity, Antioxidant Activity, Skin Repair.

INTRODUCTION

Wound healing is a complex biological process that restores the structural and functional integrity of damaged tissues following injury. The healing process occurs through a series of overlapping phases including **hemostasis, inflammation, proliferation, and remodeling**, which collectively contribute to tissue repair and regeneration. During these phases, several cellular and biochemical events take place such as fibroblast proliferation, collagen synthesis, angiogenesis, and epithelialization that promote wound closure and restoration of tissue strength [1,2].

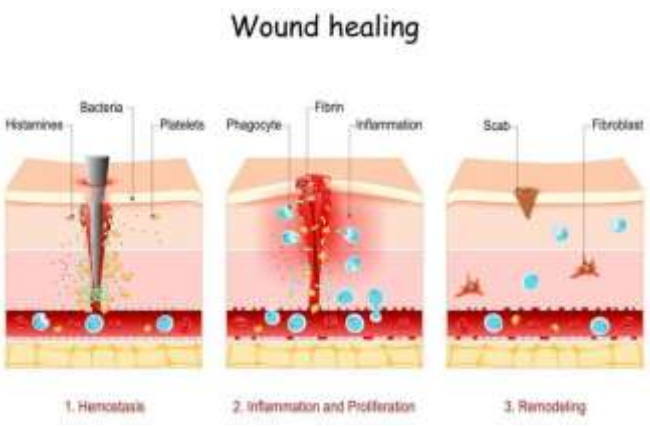

Image 1: Phases of Wound Healing

A wound is defined as a disruption in the normal anatomical structure and physiological function of the skin caused by trauma, burns, surgical procedures, infections, or chronic diseases such as diabetes mellitus. Acute wounds typically heal within a predictable period, whereas chronic wounds such as diabetic ulcers, pressure ulcers, and venous ulcers often exhibit delayed healing due to impaired cellular activity and poor blood circulation. Delayed wound healing can lead to complications including infection, chronic inflammation, and excessive scar formation, making wound management a significant healthcare challenge [3–5].

Conventional wound treatment approaches involve the use of **antibiotics, antiseptics, anti-inflammatory drugs, and synthetic topical formulations** designed to prevent infection and accelerate tissue repair. Although these treatments are widely used in clinical practice, prolonged use may result in adverse effects such as skin irritation, allergic reactions, cytotoxicity, and development of microbial resistance [6].

In recent years, herbal medicines have gained increasing attention as alternative therapeutic agents for wound management. Medicinal plants contain various bioactive phytochemicals such as **flavonoids, tannins, alkaloids, terpenoids, and phenolic compounds**, which exhibit antimicrobial, antioxidant, and anti-inflammatory activities. These compounds enhance wound healing by stimulating collagen synthesis, promoting fibroblast proliferation, improving angiogenesis, and protecting tissues from oxidative stress [7–9].

Several medicinal plants including **Aloe vera, Azadirachta indica, Curcuma longa, Centella asiatica, and Ocimum sanctum** have demonstrated significant wound healing properties in experimental studies. These plants help reduce inflammation, prevent microbial infection, and stimulate tissue regeneration [10–12].

Topical drug delivery systems such as **herbal gel formulations** are widely used in wound treatment because they provide better spreadability, improved skin penetration, and controlled release of active constituents at the wound site. Gel formulations also create a moist environment that facilitates faster wound contraction and tissue regeneration [13].

Experimental animal models are commonly employed to evaluate the wound healing potential of pharmaceutical formulations. Among these, the **excision wound model in albino rats** is widely used for assessing wound healing activity by measuring parameters such as percentage wound contraction, epithelialization period, and histopathological changes [14,15].

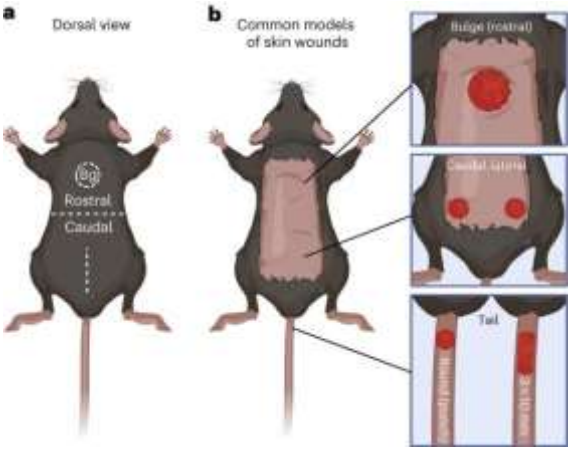

Image 2: Excision Wound Model in Rats

Therefore, herbal gel formulations represent a promising therapeutic approach for enhancing wound healing and improving tissue regeneration.

MATERIALS AND METHODS

Materials

The herbal gel formulation was prepared using selected medicinal plant extracts known for their wound healing activity. The materials used in the formulation included **herbal extract (Aloe vera / Neem / Turmeric), Carbopol 940 as a gelling agent, propylene glycol as a penetration enhancer, triethanolamine for pH adjustment, methyl paraben and propyl paraben as preservatives, and distilled water as the vehicle**. All chemicals and reagents used in the formulation were of **analytical grade** and obtained from standard pharmaceutical suppliers [16,17].

Selection of Herbal Extract

Herbal extracts possessing antimicrobial, antioxidant, and anti-inflammatory properties were selected for the preparation of the herbal gel formulation. Medicinal plants such as **Aloe vera, Azadirachta indica (Neem), Curcuma longa (Turmeric), and Centella asiatica** have been widely reported to exhibit significant wound healing activity due to the presence of bioactive phytochemicals including flavonoids, tannins, and phenolic compounds [18,19].

Preparation of Herbal Gel

The herbal gel formulation was prepared using the **Carbopol gel base method**. **Procedure**

1. Carbopol 940 was accurately weighed and dispersed in distilled water with continuous stirring.
2. The mixture was allowed to hydrate and swell to form a uniform gel base.
3. The herbal extract was dissolved in propylene glycol and incorporated into the gel base with continuous stirring.
4. Preservatives such as methyl paraben and propyl paraben were added to improve stability.
5. Triethanolamine was added dropwise to adjust the pH and obtain a smooth gel formulation.
6. The prepared gel was stored in airtight containers for further evaluation [20].

Table 1: Composition of Herbal Gel Formulation

Ingredient	Quantity	Function
Herbal extract	1–2 %	Active wound healing agent
Carbopol 940	1 %	Gelling agent
Propylene glycol	10 %	Penetration enhancer
Methyl paraben	0.2 %	Preservative
Propyl paraben	0.1 %	Preservative
Triethanolamine	q.s.	pH adjustment
Distilled water	q.s.	Vehicle

Experimental Animals

Healthy **albino rats weighing approximately 150–200 g** were used to evaluate the wound healing activity of the herbal gel formulation. The animals were housed under standard laboratory conditions with controlled temperature, humidity, and a 12-hour light–dark cycle. They were provided with standard laboratory diet and water ad libitum.

All experimental procedures involving animals were conducted according to the **guidelines of the Institutional Animal Ethics Committee and standard laboratory animal care protocols** [21].

Excision Wound Model

The **excision wound model** was used to evaluate the wound healing activity of the herbal gel formulation.

Procedure

1. Albino rats were anesthetized using a suitable anesthetic agent.
2. The dorsal region of the animal was shaved and disinfected.
3. A circular full-thickness wound of approximately **500 mm² area** was created using sterile surgical instruments.
4. The animals were divided into experimental groups for evaluation of wound healing activity [22].

Table 2: Experimental Animal Grouping

Group	Treatment
Group I	Control (untreated)
Group II	Standard drug (povidone iodine / marketed formulation)
Group III	Herbal gel formulation

Evaluation Parameters Percentage Wound Contraction

Wound contraction was measured by tracing the wound area on transparent paper at regular intervals.

$$\text{Percentage Wound Contraction} = \frac{\text{Initial wound area} - \text{Final wound area}}{\text{Initial wound area}} \times 100$$

Epithelialization Period

The epithelialization period was determined by recording the number of days required for **complete healing and falling of the scab without leaving a raw wound** [23].

Histopathological Study

At the end of the experimental period, tissue samples from the wound area were collected and examined microscopically to evaluate **collagen formation, fibroblast proliferation, angiogenesis, and epithelial regeneration**, which are important indicators of wound healing activity [24,25].

RESULTS AND DISCUSSION

Wound Contraction Study

The wound healing activity of the herbal gel formulation was evaluated using the **excision wound model in albino rats**. The wound area was measured at regular intervals, and the percentage wound contraction was calculated. The results indicated that the herbal gel-treated group showed a **significant reduction in wound area compared to the control group**.

Herbal extracts contain bioactive phytochemicals such as **flavonoids, tannins, and phenolic compounds**, which promote collagen synthesis, enhance fibroblast proliferation, and accelerate tissue regeneration. These compounds contribute to faster wound contraction and improved healing [26].

Table 3: Percentage Wound Contraction

Day	Control (%)	Standard (%)	Herbal Gel (%)
4	12	18	20
8	30	45	50
12	55	70	75
16	70	90	95

The results demonstrated that the **herbal gel formulation showed faster wound contraction compared to the untreated control group**, indicating significant wound healing activity.

Epithelialization Period

The epithelialization period refers to the time required for complete healing of the wound surface. The herbal gel-treated group showed **reduced epithelialization time compared to the control group**, indicating accelerated healing.

Table 4: Epithelialization Period

Treatment	Epithelialization Period (Days)
Control	20
Standard Drug	16
Herbal Gel	14

The faster epithelialization observed in the herbal gel-treated group may be attributed to the **presence of phytochemical compounds that promote cell proliferation and tissue regeneration** [27].

Histopathological Study

Histopathological examination of tissue samples from the wound area showed significant improvement in the herbal gel-treated group. Microscopic observations revealed **increased collagen deposition, fibroblast proliferation, angiogenesis,**

and epithelial regeneration, which are essential indicators of wound healing.

These findings confirm that the herbal gel formulation enhances the wound healing process by stimulating tissue regeneration and improving structural integrity of the skin [28].

Discussion

The results of the present study indicate that the herbal gel formulation possesses **significant wound healing activity** in the excision wound model in albino rats. The formulation promoted faster wound contraction, reduced epithelialization time, and improved collagen formation compared to the control group.

The wound healing effect of herbal formulations is primarily attributed to their **antimicrobial, antioxidant, and anti-inflammatory properties**. These properties help prevent microbial infection, reduce inflammation, and promote collagen synthesis, thereby accelerating tissue regeneration [29].

Furthermore, gel-based topical formulations provide advantages such as **better spreadability, improved drug penetration, and prolonged retention of active constituents at the wound site**, which enhances therapeutic effectiveness [30].

Therefore, the developed herbal gel formulation may serve as a **promising and safe alternative for wound management**.

CONCLUSION

The present study demonstrated that the developed **herbal gel formulation exhibited significant wound healing activity** when evaluated using the excision wound model in albino rats. The formulation showed enhanced wound contraction, reduced epithelialization time, and improved tissue regeneration compared to the untreated control group. The observed wound healing activity may be attributed to the presence of bioactive phytochemicals such as **flavonoids, tannins, phenolic compounds, and alkaloids**, which possess antimicrobial, antioxidant, and anti-inflammatory properties.

These phytoconstituents play a crucial role in stimulating **fibroblast proliferation, collagen synthesis, and angiogenesis**, which are essential processes involved in tissue repair and regeneration. The herbal gel formulation also provided advantages such as **better spreadability, improved skin penetration, and prolonged retention of active compounds at the wound site**, thereby enhancing therapeutic effectiveness.

Histopathological observations further confirmed improved collagen deposition and epithelial regeneration in the treated group. These findings suggest that herbal gel formulations can serve as a **safe, effective, and economical alternative to conventional synthetic wound healing agents**.

Therefore, the developed herbal gel formulation has promising potential for use in the management of wounds and skin injuries. However, further studies including **clinical trials and long-term stability evaluations** are necessary to confirm its safety and therapeutic efficacy in human subjects.

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