Original Article

Therapeutic Effects of Rosemary *(Rosmarinus Officinalis)* in Wound Healing: Evidence and Relevance to Pakistan. A Narrative Review

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Abstract

Wound healing is a major challenge globally, especially in lower and middle income countries including Pakistan, where diabetes and post-surgical infections are very common and may have a negative impact on daily life. *Rosmarinus officinalis* is an evergreen, aromatic shrub, of the Lamiaceae family, and is widely grown and used in Pakistan. Rosemary contains many natural compounds including carnosic acid, rosmarinic acid, ursolic acid, and essential oils which are commonly considered to be the major contributors of its anti-inflammatory and antioxidant effects. This narrative review will help to collect the preclinical and clinical data to understand how rosemary may help in wound healing and discuss its possible uses in the healthcare system of Pakistan. Overall findings suggest that rosemary could be helpful in the healing of wounds, but further clinical studies on the utilization of rosemary in modern wound care treatment in Pakistan are required to confirm its benefits.

Keywords: Therapeutic effects, rosemary, rosmarinus officinalis , wound healing

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Introduction

The process of wound healing is a highly structured and complex biological process that is divided into four stages such as hemostasis, inflammation, proliferation, and remodeling, and all these stages are coordinated through specific cellular and molecular interactions to regain normal tissue structure and function.[1] Many factors can disturb this normal process of wound healing which includes infection, poor nutrition, poor blood supply to the area, smoking, exposure to radiation and weak immunity.[2] Globally around $148.65 billion was spent on wound care in 2022 which highlights the burden on the economy associated with chronic wounds.[3] Over the past two decades, the problem of diabetic foot ulcers has increased in Pakistan which was 4.5% in early 2000s but increased to 19.5% from 2011 to 2022, that is why people with diabetes face more wound complications and slower wound healing as compared to people without diabetes.[4,5]

Rosmarinus officinalis (rosemary) is a member of the Lamiaceae family and it is well known for its pharmacological action, particularly its high anti-inflammatory, antioxidant, and antimicrobial effects.[6] Diterpenes from rosemary, especially carnosic acid, carnosol, and rosmanol, have also been identified as having anti-cancer activity by modulating inflammation, oxidative damage and cellular proliferation.[7] Although there are studies which prove wound healing through rosemary, there is little to no data so far that brings all the evidence together or discusses how it applies specifically to wound care in Pakistan.

The aim of this narrative review is to (i) summarize the bioactive compounds of rosemary relevant to wound healing, (ii) review preclinical and clinical evidence for the wound healing efficacy of rosemary, (iii) outline the proposed mechanisms of action, and (iv) contextualize the evidence within Pakistani epidemiological, therapeutic, and regulatory realities.

Review Methodology

The approach used in this study is a narrative review approach. The literature was searched on platforms like PubMed/MEDLINE, Scopus, Web of Science, Google Scholar, and Pakistani Journals Online and HEC Digital Library covering studies published up to January 2026. Keywords like '*Rosmarinus offici-*

nalis', 'wound healing', 'anti-inflammatory' and 'Pakistan' were used to find relevant studies. Articles in English only, including original research and systematic reviews which report chemical and pharmacological properties of rosemary, along with experimental studies on animals, were used. Studies in languages other than English and those that do not have an abstract were excluded.

Phytochemistry of Rosmarinus officinalis

Rosemary contains various bioactive compounds, including glycosides, terpenoids, phenols, alkaloids and tannins (Table-1), which exhibit strong antioxidant activity and mild antimicrobial activity against *Staphylococcus aureus*. Rosemary oil hydrogel is proven to accelerate wound contraction and reduce inflammation due to these bioactive compounds.[8] Carnosic acid and carnosol are the abundant and main bioactive compounds present in rosemary which possess strong antioxidant and anti-inflammatory effects and activate transient receptor potential ankyrin 1 (TRPA1) nociceptor to enhance tissue repair.[9] Rosmarinic acid present in rosemary decreases levels of inflammatory markers such as cyclooxygenase-2 (COX-2), prostaglandin E2 (PGE-2), interleukin 1 beta (IL-1β) and matrix metallopeptidase-2 (MMP-2).[10] The volatile compounds present in essential oil of rosemary such as 1,8-cineole (eucalyptol), camphor, α-pinene, camphene, borneol, and limonene help in antimicrobial activity against gram-positive and gram-negative bacteria.[11] Flavonoids present in rosemary provide additional anti-inflammatory and antioxidant activity and inhibit generation of free radicals and prevent oxidative damage.[12]

Mechanisms Underlying Wound Healing Activity

Antimicrobial Effects

The pathogenic bacteria like *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli*, and *Candida albicans* delay healing of the wound and prolong inflammation. Rosemary essential oil preparations loaded in nanostructured lipid carriers (NCLs) increase the healing of infected wound and decrease the bacterial colonization and inflammatory period.[13] Studies have shown that rosemary essential oil is rich in carvacrol and γ-terpinene which can effectively eliminate gram negative bacteria including *E. coli* with minimum inhibitory concentration (MICs) values of 0.025 µL/mL to 0.78 µL/mL.[14] Rosemary oil has also been studied for drug resistant infections and is proved to be useful in counteracting gram positive bacterial, fungal infection, and drug resistant infections.[15]

Table 1: *Key Bioactive Components of Rosmarinus Officinalis and their Relevance in Wound Healing*

Constituent	Class	Primary Bioactivity	Wound Healing Relevance
Carnosic acid	Diterpene phenol	Antioxidant, anti-inflammatory	Reduces oxidative stress; activate TRPA 1
Rosmarinic acid	Phenolic ester	Antimicrobial, anti-inflammatory	Inhibits COX-2, PGE-2, IL-1β, MMP2
Carnosol	Diterpene phenol	Antioxidant, pro-apoptotic in cancer	Scavenges reactive oxygen species
1,8-Cineole (eucalyptol)	Monoterpenoid	Antimicrobial	Effective against *Pseudomonas aeruginosa* and *Staphylococcus aureus*
Camphor	Monoterpenoid	Antimicrobial	Inhibits ***S. aureus*** biofilm formation
Flavanone aglycones	Flavonoid	Anti-inflammatory, antioxidant	Inhibit generation of metal related free radicals

TRPA: transient receptor potential ankyrin ; COX-2: cyclooxygenase-2; PGE-2: prostaglandin E2 ; IL-1β: interleukin 1 beta; MMP2: matrix metallopeptidase 2.

Anti-inflammatory Modulation

Excessive or increased inflammation is a main sign of non-healing wounds. Rosemary essential oil containing eucalyptol, α-pinene and camphor exhibits anti-inflammatory effects by inhibition of protein breakdown.[16] Rosmarinic acid and carnosic acid suppress

MMP-9 expression by downregulating NF-κB, hence reducing pro-inflammatory cytokines.[17] In another study an ethanolic extract of *Rosmarinus officinalis* in a rat model of neuropathic pain reduced the levels of inflammatory markers including cyclooxygenase-2 (COX2), prostaglandin E2 (PGE-2), interleukin 1 beta (IL-1β), matrix metallopeptidase 2 (MMP2).[10]

Antioxidant Effects

Oxidative stress has a dual role in healing of wounds, it serves as beneficial biological signal at normal levels, but when excessive reactive oxygen species are produced, it impairs cell function and slows tissue repair.[18] The bioactive components of rosemary, which include phenolic diterpenes and phenolic acids, particularly carnosic acid, carnosol, and rosmarinic acid are widely known as the primary contributors to its antioxidant activity.[19] The antioxidant activity of carnosol and ursolic acid reduces oxidative stress and scavenge free radicals therefore protecting cells from oxidative damage and facilitating tissue repair.[20]

Proliferation and Re-epithelialization

In an in vivo study, the group treated with rosemary essential oils showed notable improvements in wound healing, angiogenesis, and granulation tissue formation compared to the control group.[21] Another study demonstrated that skin wounds treated with rosemary cream display faster re-epithelialization than control mice and carnosic acid present in rosemary stimulates the transient receptor potential ankyrin 1 (TRPA1) nociceptor present in sensory neurons and therefore promotes tissue regeneration.[22] Rosemary essential oil also enhances fibroblast proliferation and extracellular matrix deposition in cutaneous lesion in mice, resulting in regeneration of granulation tissue in treated wound.[23] Angiogenic effects mediated by vascular endothelial growth factor (VEGF) have also been studied in rosemary essential oil, which showed healing effects in diabetic wound.[24]

Preclinical Evidence

Most of the evidence showing that rosemary helps in wound healing comes from studies done on animals. Khezri K et al. [13] reported that the rosemary essential oil exerted a significant effect on the wound closure time of skin excisional wound models on wistar rats by increasing the rate of epithelial cell turnover and enhancing the process of re-epithelialization. According to one study, the inactivation of macrophage infiltration and fibroblast proliferation at the wound site was also reported to occur when 4 percent rosemary was used, enhancing TGF-α and TGF-β, indicating that it does not only inhibit the healing process due to its anti-inflammatory effect but also stimulates the activity of fibroblasts and hence tissue repair.[25] Additionally, Yilmaz R et al. [26] documented that rosemary extracts promote wound contraction through enhanced myofibroblast differentiation, increase collagen content, and improved tissue tensile strength. In a comparative study, Uritu CM et al.[27] documented that rosemary possesses anti-inflammatory and analgesic properties and its ethanolic extract inhibits acetic acid induced pain in mice. A recent study by Rapp E et al.[22] in an adult mouse skin wound model reported that an ethanol based rosemary extract accelerates the healing of the wound. No significant harmful effects were observed in the animal study reviewed, which suggests that topical application of rosemary extract is safe.

Clinical Evidence

Human clinical trials using rosemary for wound healing are limited in number, and a significant gap exists that restricts the strength of recommendations. A randomized controlled trial (RCT) by Hadizadeh etal[28] involving 80 primiparous pregnant women applied rosemary based cream twice daily for 10 consecutive days postpartum. The rosemary group demonstrated significantly superior REEDA (Redness, Edema, Ecchymosis, Discharge, Approximation) scores at days 4 and 10. A pilot RCT study conducted by Parizi et al.[29] in patients with pressure ulcers admitted in an intensive care unit used rosemary cream once a day for seven consecutive days, and this resulted in prevention of progression of grade 1 pressure ulcer and facilitated healing. Another double blind randomized controlled trial by Dabaghzadeh[30] et al. was conducted in 50 healthy volunteers to investigate the effects of rosemary on acetyl cholinesterase (AChE) activity and oxidative stress biomarkers, and 1000mg of rosemary was given for 30 days which significantly decreased AChE activity and improved the antioxidant defense system. Rosemary extract is also used in oral cavity and periodontal applications for the treatment of oral wounds. In a study conducted by Chakraborty et al.[31] rosemary infused gelatin sponge was applied to

observe healing of palatal wound, and it served as a promising bioactive wound dressing for periodontal applications. Günther et al.[32] reported antimicrobial effects of rosemary on initial oral biofilms and demonstrated that rosemary extract has significant potential to eliminate microbial biofilms.

Relevance to Pakistan: Epidemiology, Availability, and Healthcare Context

In Pakistan, the burden of wound care is affected by multiple combined factors which increase the need for affordable and effective treatment. One of the major contributors in this burden is the high risk of diabetes. According to international diabetes federation, in 2024 in Pakistan, 31.4 % of adults are affected by diabetes and Pakistan has one of the highest diabetes rates globally. Due to this high prevalence, there are increased cases of diabetic foot ulcers which are associated with infections, delayed healing of wounds and an increased risk of amputation in areas where proper health care is not provided.[33] In addition to diabetic wounds, other causes of common wounds in Pakistan are burn injuries, infections from surgical sites, or other skin conditions. Rosemary (Urdu: "Akleel Kohistani") is cultivated all across Pakistan but usually in northern regions like Hunza and Gilgit Baltistan and is commercially available throughout the country.[34] Rosemary is also used to improve the quality of food and extend its shelf life, as well as it manages multiple health conditions like obesity, diabetes, inflammatory disorders and some neurological conditions.[35] The incorporation of rosemary in the locally prepared topical rosemary oil hydrogel significantly improves wound contraction and shows healing effects, proving that rosemary can potentially be used in wound dressings, hence providing cost effective and affordable alternative to expensive wound dressings.[8] However, despite availability and traditional use of rosemary, there is a lack of proper clinical and experimental studies in Pakistan which specifically evaluate its effectiveness in wound healing, highlighting an important gap in local research.

Formulation Considerations for Clinical Application

The wound healing property of rosemary is majorly affected by its formulation. Rosemary essential oil based preparations are highly effective against combating superficial wound infections but they may cause irritation if used at high concentration. In contrast, hydrocolloid dressings, which have gel for the production of new cells, accelerate the process of healing while delivering bioactive compounds at effective concentrations.[36] Nanoemulsions and nanoparticle encapsulation technologies have attracted the attention of scientists worldwide for research in wound healing due to their increased stability, excellent delivery and easy availability.[37] Solid lipid nanoparticles are also considered as an excellent topical carriers due to their high biocompatibility and their ability to encapsulate a wide range of both natural and semi-synthetic drugs. In addition, they are also suitable carriers to apply onto damaged and inflamed skin due to their lipid nature, which is an important factor in accelerating wound healing.[38]

Research Gaps and Recommendations

Although preclinical evidence is quite promising, there is still very limited clinical data to confirm the effectiveness of rosemary in wound healing. Major gaps include limited well designed randomized controlled trials in human subjects, limited dosage related studies, and lack of Pakistan specific clinical data. Future research should focus on well-designed RCTs in Pakistan, especially in patients with diabetic foot ulcers and surgical wounds, using standardized rosemary based creams or hydrogels. Also, to determine which bioactive compounds are the basis of herbal healing benefits, as well as to aid in improving the standardization of herbal products, comparative phytochemical analysis may be important. Studies should also include cost effectiveness evaluations which compare rosemary based wound dressings with the usual standard treatments, specifically within Pakistan's healthcare system.

Conclusion

Rosmarinus officinalis has high therapeutic potential to improve wound healing, microbial infection, oxidetive stress, impaired inflammation, and decreased cellular proliferation. Preclinical evidence is also consistent; although there are limited human trials, initial findings suggest that topical application of rosemary may help in the healing of post-surgical wounds and pressure ulcers. The high prevalence of diabetic wounds in Pakistan, combined with the local cultivation and accessibility of rosemary, its tradetional use in Unani medicine, and the need for cost effective wound treatments, provides strong justification for conducting thorough clinical research trials

in this area. Proper standardization of rosemary based topical preparations has the potential to be an accessible and affordable alternative to conventional wound care within Pakistan limited resource health-care system. However, strong evidence from well-designed randomized controlled trials (RCTs) is essential before these treatments can be widely adopted in clinical practice.

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MAA: Critical revisions for important intellectual content

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