ISSN: 2456-9909 (Online)

International Journal of Research in AYUSH and Pharmaceutical Sciences

Review Article

Bridging the Gap: A Review of Ayurvedic Principles and Therapies for Integration into Contemporary Wound Care

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ARTICLE INFO

Article history:

Received: 01-02-2025

Accepted: 11-03-2025

Published: 02-04-2025

Keywords:

Ayurvedic wound care. *Vrana Chikitsa.* Integrative medicine. Chronic wound.

ABSTRACT

particularly in the face of rising antimicrobial resistance. While modern wound care employs evidence-based strategies such as debridement, infection control, and advanced dressings, challenges persist-especially in resource-limited settings. Ayurveda, the ancient Indian system of medicine, offers a time-tested, holistic approach to wound management ("Vrana Chikitsa"), emphasizing individualized care and natural remedies.

This review examines the potential for integrating Ayurvedic wound healing practices with contemporary medical approaches. Ayurvedic herbal formulations like honey, ghee, turmeric, Triphala, neem, and guggul exhibit scientifically validated antimicrobial, anti-inflammatory, antioxidant, and regenerative properties. Conceptual overlaps-such as between "Dushta Vrana" and chronic wounds-demonstrate a shared understanding of pathophysiology and the importance of systemic factors in healing.

Although challenges remain, including standardization, regulatory acceptance, and the need for robust clinical trials, integration offers promising opportunities. These include low-cost, accessible care, reduced dependence on antibiotics, and personalized treatment through Ayurveda's Prakriti-based approach. A collaborative, evidence-driven model combining both systems can lead to more effective, holistic, and sustainable wound care solutions.

INTRODUCTION

Historical Context of Wound Care

Wound management boasts a rich history across diverse cultures. In ancient India, the Vedas (specifically the Rigveda), dating back to around 1500–1200 BC, contain early descriptions of advanced medical practices, including accounts of limb replacement (such as the legend of the Ashwini Kumaras replacing the leg of Vishpala with an iron one) and the use of natural remedies for inflammation and healing[1,2].

Access this article online

Quick Response Code

https://doi.org/10.47070/ijraps.v9i3.206

Later, foundational Ayurvedic texts like the Sushruta Samhita (circa 6th century B.C.) extensively detailed "Vrana" (wound) and its comprehensive management, laying a robust foundation for both surgical and medicinal approaches to wound care[3,4].

Concurrently, Western medicine evolved. Hippocrates (5th century B.C.) advocated for natural dressings, utilizing substances like water, wine, and honey to promote healing[5]. Aulus Cornelius Celsus (1st century A.D.) systematically studied wounds and famously described the four cardinal signs of inflammation: *rubor* (redness), *tumor* (swelling), *calor* (heat), and *dolor* (pain)[6,7]. A major paradigm shift occurred around the 11th century A.D., moving away from the erroneous belief that pus was a healthy sign in wounds, towards modern principles of debridement and antisepsis[8]. In the 16th century,

Dr. Ambroise Paré revolutionized gunshot wound treatment by replacing the traditional, painful cauterization with a more humane approach involving a healing balm and developing vessel ligation to control bleeding, marking a significant step into the modern era of surgery[9,10]. The 19th and 20th centuries saw further breakthroughs with Louis Pasteur's discovery of wound-infecting organisms, leading to an understanding of asepsis, and the subsequent introduction of antibiotics like Penicillin, which dramatically altered wound management[11,12].

Significance of Wound Healing as a Global Health Challenge

Despite modern advancements, wound healing remains a significant global health challenge. Chronic wounds, such as diabetic foot ulcers, pressure ulcers, and venous leg ulcers, impose a substantial burden on healthcare systems worldwide, affecting millions and incurring significant costs[13,14]. They severely impact patient quality of life, leading to pain, decreased mobility, social isolation, and financial strain[14]. Complications like cellulitis, osteomyelitis, sepsis, and amputations are common and life-threatening[15]. The rising threat of antibiotic-resistant bacteria further complicates wound management, making traditional treatments less effective and necessitating alternative strategies[16,17].

Rationale for Exploring Integration

Given these complexities, there's growing interest in integrating traditional medical systems like Ayurveda. Ayurveda offers a rich repository of knowledge and natural remedies, some of which are conceptually aligned with modern evidence-based approaches and exhibit potent biological activities[18,19]. This exploration seeks complementary strategies to enhance healing outcomes, reduce healthcare costs, and improve patient well-being, particularly in resource-limited settings where access to advanced modern wound care may be limited[19,20].

Purpose and Scope of the Review Article

This review analyzes Ayurvedic wound healing principles alongside contemporary wound care, highlighting areas of convergence and potential for synergistic integration. It explores scientific evidence supporting various Ayurvedic interventions and addresses the challenges and opportunities in bridging these paradigms for a more holistic, patient-centered approach to wound management.

Foundations of Wound Care: A Comparative Analysis

Contemporary Wound Care Principles

Modern wound care follows a systematic, evidence-based framework for optimal healing and complication prevention[21,22]. This includes thorough assessment, meticulous cleaning and debridement, effective infection prevention, appropriate dressing selection, and comprehensive systemic support[21,23].

Assessment involves evaluating wound characteristics such as size, depth, tissue type (e.g., granulation, slough, necrotic), and exudate, along with pain assessment. Crucially, systemic factors like diabetes, peripheral vascular disease, obesity, immune dysfunction, and malnutrition are evaluated, as they can significantly impede healing[14,21].

Cleaning and Debridement are fundamental steps. Cleaning removes debris, bacteria, and exudate, typically with sterile solutions like normal saline. Debridement, the removal of nonviable, necrotic tissue, is essential for chronic wounds to progress to healing[15]. Techniques include:

- Surgical (Sharp) Debridement: Precise removal with scalpels or scissors for rapid tissue removal[15].
- Autolytic Debridement: The body's own enzymes break down necrotic tissue, often enhanced by moist dressings[22].
- Biological Debridement (Larval Therapy): Sterile fly larvae selectively dissolve necrotic tissue and ingest bacteria[15].
- Enzymatic Debridement: Application of topical chemical enzymes to slough off necrotic tissue[22].
- Mechanical Debridement: Uses physical force, such as irrigation or wet-to-dry dressings, to remove unwanted tissue[22].

Infection Prevention is paramount. Strategies include strict sterile technique during dressing changes, rigorous hand hygiene, and the judicious use of topical antimicrobials or systemic antibiotics for high-risk or infected wounds[23].

Moist Wound Healing is a widely accepted principle. Maintaining a moist environment accelerates healing, reduces scarring, promotes cell proliferation and migration (fibroblasts, keratinocytes), prevents scab formation, and minimizes pain[22,24].

Dressing Selection plays a critical role in protecting the wound, managing exudate, and supporting the healing process[23]. Advanced dressings include hydrogels (for moisture donation), alginates (for high absorbency), foams (for protection and moderate absorbency), and hydrocolloids (for moisture retention and adhesion)[22]. Compression therapy is vital for venous leg ulcers to aid blood flow and prevent fluid buildup[25].

Systemic Support is vital, including adequate nutrition (especially protein and Vitamin C), hydration, and management of underlying comorbidities. Patient education and psychological

counseling are also integrated to promote holistic recovery[21,23].

Ayurvedic Concepts of Vrana (Wound)

Ayurveda offers a highly detailed understanding of "Vrana" (wound), defined as a breach or discontinuity of body tissue. Acharya Sushruta noted that wound scars leave a lifelong imprint, emphasizing the importance of proper healing[3].

Classifications of Vrana:

- **According to Etiology**
  - Nija Vrana (Endogenous): Arise from internal imbalances of the Doshas (Vataja, Pittaja, Kaphaja, Raktaja, and combinations thereof), reflecting systemic health issues[26,27].
  - Agantuja Vrana (Exogenous): Traumatic wounds resulting from external factors like striking, falling, bites, fire, or weapons. Examples include *Chhinna* (cut), *Bhinna* (ruptured), *Viddha* (punctured), *Kshata* (lacerated), *Picchita* (crushed), and *Ghrishta* (abraded)[26,27].
- **According to Clinical Features:**
  - *Shuddha Vrana* (Clean/Healthy Wound): Characterized by the absence of Tridosha vitiation, healthy dark brown edges, good granulation tissue, minimal or no pain, and clear exudation[26].
  - *Ruhyamana Vrana* (Healing Wound): A wound progressing towards healing, devoid of slough, exhibiting a pigeon-grey color, with dryness and firmly adhering skin scales[26].
  - *Rudha Vrana* (Healed Wound): A completely healed wound with the absence of pathology (e.g., nodules, swelling, pain, discoloration), and the surface and color matching the surrounding skin[26].
  - *Dushta Vrana* (Unhealthy/Complicated Wound): A degraded wound that refuses to heal or heals very slowly despite efforts. It is characterized by varied appearances, foul-smelling pus, severe pain, burning sensation, and chronicity, closely mirroring the modern concept of chronic wounds[26,27].
- **According to Prognosis (*Sadhyasadhyata*)**
  - *Sukhsadhya Vrana* (Easily Curable): Wounds found in young, strong individuals, or on specific, less complex body parts[26].
  - *Krichhasadhya Vrana* (Difficult to Cure): Wounds in old, emaciated, or timid individuals, or affecting vital areas (like eyes, joints), or associated with systemic diseases such as diabetes, and often presenting with frothy discharge or foreign matter[26].
  - *Yapya Vrana* (Palliative Treatment Needed): Wounds in chronic conditions requiring lifelong management, where complete cure might not be achievable[26].
  - *Asadhya Vrana* (Incurable): Wounds in very weak individuals, exuding fat, marrow, or brain matter, or proving incurable due to severe humoral imbalances and successive tissue invasion[26].

Traditional Examination Methods: Ayurveda employs Trividha Pariksha (Darshan - Inspection, Sparshana - Palpation, Prashna - Interrogation) and Shadvidha Pariksha (adding Shabda - crepitus, Roopa - external features, Gandha - smell, Rasa - taste, Sparsha - touch) for detailed assessment[27]. Sushruta specifically emphasized Pancha Lakshana for local wound examination: *Gandha* (Smell), *Varna* (Colors), *Srava* (Discharge), *Vedana* (Pain), and *Akriti* (Shape)[26].

Vrana Vastu (Sites of Wound Involvement): Vrana can affect various body components, including *Tvak* (skin), *Mamsa* (muscles), *Sira* (blood vessels), *Snayu* (ligaments/tendons), *Asthi* (bones), *Sandhi* (joints), *Koshta* (viscera), and *Marma* (vital parts)[26].

Ayurvedic Stages and Signs of Wound Healing and Recurrence: Ayurvedic texts describe distinct signs for unripe, ripening, and ripe wounds, guiding management[26]. A healed ulcer can re-open due to vitiation of Doshas, excessive physical exercise, trauma, indigestion, or emotional factors, indicating a holistic understanding of relapse[27].

A significant conceptual overlap exists between "Dushta Vrana" and the modern concept of "chronic wounds"[27]. Both systems recognize a persistent, problematic wound that deviates from normal healing. Ayurveda's detailed "Pancha Lakshana" and prognostic classifications offer a holistic assessment framework that complements modern wound assessment approaches by considering both local and systemic factors[21,27]. Both systems also share a common understanding that wound healing is profoundly influenced by the body's internal state and external stressors[14,27].

Integrating Ayurvedic Therapies into Contemporary Wound Management

Ayurveda offers diverse therapeutic modalities, including herbal formulations and parasurgical procedures, many of which align with modern wound healing objectives.

Ayurvedic Herbal Formulations and Topical Applications

Ayurveda utilizes a wide array of natural products with scientifically validated properties relevant to

wound healing, including antimicrobial, anti-inflammatory, antioxidant, and tissue-regenerating effects[18,28]. Many exhibit multi-targeted action, supporting various stages of healing and potentially reducing the need for multiple single-action agents.

Honey (*Madhu*)

Honey is widely recognized for its antioxidant, anti-inflammatory, and broad-spectrum antibacterial effects[18,29]. Its high sugar content creates an osmotic effect, inhibiting bacterial growth, while its low pH reduces protease activity and stimulates healing cells. Additionally, it promotes autolytic debridement, angiogenesis, granulation, and epithelialization[29]. Clinical trials and systematic reviews show promising results in various wound types, including burns, infected surgical wounds, diabetic foot ulcers, and pressure ulcers, demonstrating accelerated healing and reduced infection rates[29,30].

Ghee (*Goghrita*)

Ghee, or clarified butter, is valued for its moisturizing, emollient, anti-inflammatory, and natural disinfectant properties[31,32]. It creates a moist wound environment crucial for healing, and its butyrate content can reduce inflammation. Rich in fat-soluble vitamins (A and E) and essential fatty acids, it supports cell formation, tissue regeneration, and vascularity[31]. Clinical experience and animal studies demonstrate its bacteriostatic action, desloughing properties, rapid granulation, deodorizing effects, pain reduction, and promotion of wound contraction with soft epithelization and reduced scarring[31,32].

Turmeric (*Haridra*/Curcumin)

Turmeric's active compound, curcumin, is a powerful anti-inflammatory, antimicrobial, and antioxidant agent[33,34]. It reduces inflammation by inhibiting pro-inflammatory cytokines, combats various bacteria including *S. aureus* and *P. aeruginosa*, and enhances fibroblast proliferation and collagen production, crucial for wound repair[33,34]. Preclinical and clinical studies show it enhances granulation tissue formation, collagen deposition, wound contraction, and accelerates re-epithelialization, making it effective even in challenging conditions like diabetic wounds[33,34].

***Neem* (*Azadirachta indica*)**

Neem is a multi-potent herb with documented antibacterial, antifungal, antiviral, antiseptic, anti-inflammatory, and antioxidant properties[19,35]. Its compounds inhibit common wound pathogens and modulate cytokine production, enhance collagen synthesis, and promote epithelialization[35,36]. Animal studies show significant reductions in wound size, improved tensile strength, and accelerated re-epithelialization, comparable to conventional antiseptic agents[36]. A clinical trial found neem-based mouthwash effective in controlling pain, swelling, and improving wound healing after oral surgery[37].

Triphala

Triphala, a preparation of three fruits (*Amalaki*, *Bibhitaki*, *Haritaki*), is known for its antioxidant, anti-inflammatory, and antibacterial effects[38,39]. It promotes collagen formation, helps rebuild skin protein, retains skin moisture, and reduces bacterial load[38]. In-vitro studies demonstrate its antimicrobial activity against common wound pathogens like *S. aureus* and *P. aeruginosa*[39]. Animal studies using Triphala-incorporated collagen sponges show increased wound contraction, tissue regeneration, and collagen turnover, particularly beneficial for infected dermal wounds and diabetic wounds[38,40].

***Guggul* (*Commiphora wightii*)**

Guggul, an oleo-gum resin, possesses significant anti-inflammatory, bactericidal, and anti-arthritic properties[41,42]. It is traditionally used to strengthen bones and aid fracture healing. Experimental studies have shown that herbal ointments containing *Commiphora wightii* can significantly promote wound contraction, accelerate healing, and exert potent anti-inflammatory activity, supporting its traditional use in wound management[41].

***Lepanam* (Topical Herbal Applications)**

Lepanam refers to the application of herbal pastes, ointments, or oils onto affected skin areas. These topical applications, incorporating various herbs like turmeric, neem, or specific formulations like *Jatyadi* oil or *Panchavalkala*, are integral to Ayurvedic wound management[43,44]. They are traditionally used for pain relief, reducing swelling, promoting skin renewal, detoxification, and accelerating healing in wounds and ulcers[43]. While direct large-scale clinical trials on "*Lepanam*" as a general procedure are scarce, systematic reviews confirm that Lepa (topical application) is a recognized procedure in Ayurvedic wound healing, and numerous studies support the effectiveness of various Ayurvedic topical medications for wound care, demonstrating properties like anti-inflammatory, antiseptic, and tissue-regenerative effects[44,45]. These Ayurvedic topical applications align with the modern principle of moist wound healing, as many formulations like Ghee and Honey effectively maintain a moist environment[32,46]. The documented antimicrobial properties of several Ayurvedic herbs offer a promising avenue for combating antibiotic-resistant wound infections, aligning with modern challenges[18].

Challenges and Opportunities for Integration

Challenges

Integrating Ayurvedic wound healing into mainstream contemporary care faces several significant challenges. Standardization of Ayurvedic formulations is a primary concern, as traditional preparation methods often lack consistent quality control, precise dosage, and detailed chemical characterization, which are critical for modern medical acceptance[52,53]. There is a need for more rigorous, high-quality clinical trials (Randomized Controlled Trials - RCTs) to establish definitive efficacy and compare outcomes against conventional treatments, providing the robust evidence base required by modern medicine[30,52]. Regulatory hurdles are considerable, requiring clear guidelines for product approval, manufacturing standards, and practitioner licensing to ensure safety and quality[53,54]. Bridging the philosophical differences between Ayurveda's holistic, individualized approach and modern medicine's reductionist, disease-specific focus requires mutual understanding and open dialogue[54]. Finally, practitioner training and education are crucial for both Ayurvedic and modern medical professionals to facilitate safe, ethical, and effective collaborative practice[52].

Opportunities

Despite these challenges, integration offers significant opportunities. The inherent antimicrobial properties of many Ayurvedic herbs (e.g., honey, neem, turmeric, Triphala) offer a valuable resource against the rising threat of antibiotic-resistant infections, a major global health crisis in wound care[16,18]. The cost-effectiveness of natural remedies can significantly improve access to wound care, especially in resource-limited settings and developing countries, offering sustainable solutions where advanced care is inaccessible[19,55]. Ayurveda's emphasis on holistic patient care aligns with the growing modern recognition of managing comorbidities, diet, lifestyle, and overall well-being for optimal healing outcomes, moving beyond just treating the wound itself[21,56]. The Ayurvedic concept of "Prakriti" (individual constitution) offers a unique framework for personalized medicine approaches, allowing for tailored treatments based on an individual's unique physiological and psychological profile, a concept gaining traction in modern healthcare[57,58]. Natural remedies may also offer a lower risk of adverse effects compared to some synthetic drugs, contributing to improved patient safety and compliance[30].

CONCLUSION

Summary of Potential Benefits

This review highlights significant conceptual and functional overlaps between Ayurvedic and contemporary wound care. Ayurveda's holistic framework for understanding wound etiology and prognosis, particularly the concept of "Dushta Vrana," directly corresponds to the modern understanding of chronic wounds. Both systems recognize the profound influence of systemic factors and patient individuality on the healing process.

Ayurvedic therapeutic modalities, including diverse herbal formulations (honey, ghee, turmeric, neem, Triphala, and various Lepanam applications) and parasurgical procedures (Raktamokshana, Agnikarma), demonstrate promising properties. These remedies offer antimicrobial, anti-inflammatory, antioxidant, and tissue-regenerative effects, supporting the principles of moist wound healing and offering viable solutions to combat antibiotic resistance. Existing scientific evidence, though varied in rigor, suggests that these traditional practices can contribute valuable insights, particularly in infection control, pain management, and addressing systemic factors that impede healing.

Call for Further Research and Collaboration

To fully realize the potential of this integration, more rigorous, well-designed randomized controlled clinical trials (RCTs) are urgently needed. Future research should prioritize standardizing Ayurvedic formulations, elucidating precise molecular mechanisms of action, and conducting comparative effectiveness research against conventional treatments. This will provide the strong evidence base necessary for broader acceptance and seamless integration into modern clinical guidelines.

Future Outlook for Integrative Wound Care

A collaborative, interdisciplinary approach, combining the ancient wisdom of Ayurveda with modern scientific inquiry, holds immense promise. Such integration could lead to more effective, holistic, and patient-centered strategies, especially for chronic and complex wounds that remain challenging despite modern advancements. By leveraging the strengths of both systems—Ayurveda's individualized, holistic perspective and natural pharmacopeia, alongside modern medicine's diagnostic precision and advanced technologies—healthcare providers can offer truly comprehensive care. This synergistic approach represents a progressive step towards a truly integrative wound management paradigm that improves patient outcomes, enhances quality of life, and effectively

addresses current healthcare challenges, including the global threat of antimicrobial resistance.

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Cite this article as:
Sanket Chandrashekhar Rawekar, Priyanka Jaipalsingh Bandwal, Yusuf Ahemad Latif A. Ansari. Bridging the Gap: A Review of Ayurvedic Principles and Therapies for Integration into Contemporary Wound Care. International Journal of Research in AYUSH and Pharmaceutical Sciences, 2025;9(3):1-8.
https://doi.org/10.47070/ijraps.v9i3.206
Source of support: Nil, Conflict of interest: None Declared

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