



Review Article

BIOMETRIC CORRELATION OF THE VRANA ROPANA IN SUSHRUTA SAMHITA: AN INTEGRATING AYURVEDIC PRINCIPLES OF VRANA ROPANA WITH MODERN REGENERATIVE WOUND HEALING

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ABSTRACT

Wound healing is a fundamental physiological process aimed at restoring structural and functional tissue integrity. Despite advances in modern therapies, chronic and non-healing wounds continue to pose a substantial global health burden. Regenerative medicine- through stem cells, engineered biomaterials, and biological signalling- has introduced novel approaches, yet their clinical translation remains limited by costs, technical complexity, and inconsistent outcomes. Ayurveda, particularly the *Shalya Tantra* tradition of *Sushruta*, presents a structured, biology-aligned framework for wound management based on sequential *Shodhana* (cleansing), *Ropana* (tissue regeneration), and *Purana/Sandhana* (structural restoration). This review analyzes the biometric correlation between *Sushruta's Vrana Ropana* principles and modern regenerative wound biology, proposing an integrative model that combines traditional Ayurvedic therapeutics with contemporary bioengineering. Such convergence offers pathways to develop biomimetic, cost-effective, and stage-specific wound-care strategies.

INTRODUCTION

The evolution of wound care spans millennia- from ancient battlefield dressings to today's bioengineered scaffolds. Long before Lister's antiseptics or Fleming's penicillin antibiotic, Acharya Sushruta had meticulously described *Vrana* (wound), its causes, classifications, and management principles, reflecting concepts that align closely with modern wound biology, including debridement (*Shodhana*), infection control, moisture balance, and tissue regeneration (*Ropana*).

Wound healing is inherently dynamic, progressing through hemostasis, inflammation, proliferation, and remodelling. Delayed healing increases morbidity, cost, and long-term disability,

highlighting the need for interdisciplinary advancements. Regenerative medicine shifts the focus from simple wound closure to

actual tissue regeneration using stem cells, extracellular-matrix (ECM) mimetic scaffolds, growth factors, and exosome-based therapeutics.

Ayurveda, particularly *Shalya Tantra*, offers a mature and systematic framework for wound management that aligns mechanistically with phases recognized today in regenerative medicine. Mapping these principles provides new opportunities for developing biomimetic, affordable, and biologically compatible wound-healing strategies.

Ayurvedic Perspective: Vrana- Definition & Classification

Ayurveda defines *Vrana* as structural discontinuity accompanied by pain, discoloration, swelling, discharge, and impaired function.^[1] Unlike the modern definition restricted to local injury, Sushruta recognised *Vrana* as an expression of both external trauma and internal *Dosha* imbalance.^[2]

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Classification according to *Nidana*

- *Nija Vrana*– Due to internal dosha vitiation (*Vataja, Pittaja, Kaphaja, Raktaja, Sannipataja*).^[2] Which can be correlates with ischemic, diabetic, venous, or infective pathological wounds.
- *Agantuja Vrana*– Due to external causes (trauma, burns, bites, weapons). ^[3] These includes:
Chinna vrana (Incised wound)
Bhinna vrana (Perforated wound)
Viddha vrana (Punctured wound)
Kshata vrana (Lacerated wound)
Pichchita vrana (Crushed wound)
Ghrishta vrana (Abrasion wound)

According to *Kala*^[4]

- Nava Vrana* (Acute wound)
- Purana Vrana* (Chronic wound)

According to *Vrana avastha*^[2,4]

- Shuddha Vrana* (healthy granulating wound)
- Ruhyamana Vrana* (progressing healing wound)
- Rudha Vrana* (fully healed wound)
- Dushta Vrana* (chronic/infected wound)

According to tissue involvement ^[5]

- Mamsagata vrana*
- Twakgata vrana*
- Snayugata vrana*
- Sandhigata vrana*
- Asthigata vrana*

According to Prognosis ^[6]

- Sukha-sadhya vrana*
- Krichhra-sadhya vrana*
- Yappa vrana*
- Asadhya vrana*

Based on Morphology of wound (*Vrana akruti*) ^[7]

- Ayata* (enlongated)
- Chaturasra* (four sided shaped)
- Vritta* (circular)
- Mandala* (ring shaped)
- Triyasra* (triangular shaped)
- Ardhachandra* (half-moon shaped)
- Kutila* (irregular shaped)
- Vishala* (large shaped)
- Sharavasadash* (saucer shaped)
- Yavamadhya* (barely shaped with centre depressed)

Therapeutic Foundations of *Vrana Chikitsa*

Although Ayurveda does not explicitly divide wound healing into phases, Sushruta's descriptions

clearly parallel the modern sequence of debridement → regeneration → remodelling. His therapeutic framework is organized into three core pillars:

- Vrana Shodhana* (Cleansing)
- Vrana Ropana* (Regeneration)
- Vrana Purana / Samdhana* (Remodeling)

***Vrana Shodhana* (Debridement / Cleansing)**

Shodhana denotes the removal of *Dosa*, *Shodhan* includes procedures such as *Prakshalana, Lepa, Kshara karma, Sastra karma* which can be correlated with removal of necrotic tissue, reduction and bio-burden, oxidative stress control biofilm disruption.

***Vrana Ropana* (Granulation & Regeneration)**

Sushruta identifies *Ropana* as the therapeutic process responsible for *Mamsa-utpatti* (new tissue formation) and restoration and structural integrity in *vrana* ^[2]. Once, the wound is clean, *Ropana* aims to initiate granulation, angiogenesis fibroblast activation and epithelialization. The pharmacological, phytochemical and clinical analysis of *Ropas* drugs confirms that Sushruta's wound healing approach is not empirical but rather a structural multi-dimensional regenerative strategy.

***Vrana Purana/Sandhana* (Remodelling & Strengthening)** ^[1,8]

Vrana Purana represents are the final objectives of *Vrana chikista* wherein the tissue defect is filled, margins are approximated and structural integrity is restored. *Purana* emphasizes volume replacement, tensile strength, scar stabilization and functions recovery. This stage corresponds to remodelling or maturation phase of wound healing.

Integrated Framework: *Sasti Upakrama* & *Sapta Upakrama*

Sushruta established *Vrana Chikista* on two complementary therapeutic frameworks:

- Sasti Upakrama*- 60 modalities of wound management
- Saptopakrama* - 7 step protocol for *Dusta vrana*

Sasti upakrama lists 60 interventions that covers the entire range of wound therapy including surgical, para surgical pharmacological, dietary, lifestyle and reconstructive measures. These *Upakrama* address all wound types, this demonstrates that Sushruta's approach was not drug centered but system centered.

Sushruta mentioned 7 Principles in wound management as, *Sapta upakrama*^[9],

1. *Vimlapana*
2. *Avasechana*
3. *Upanaha*
4. *Patana*
5. *Shodhana*
6. *Ropana*
7. *Vaikritapaham*

Sasti Upakrama collectively encompasses into above said *Saptopakrama* and grouped as each principle targets a specific stage or pathology of the wound, reflecting a rational and staged model of intervention.

1. *Vimlapana* (Resolution of initial inflammation)
Aimed at reducing *Sopha* in the primary stage by pacifying aggravated *Doshas*. Involves mild finger massage and procedures such as: *Apatarpaṇa*, *Alepana*, *Pariseka*, *Abhyanga*, *Sveda*, and *Vimlapana*.
2. *Avasecana* (Drainage of vitiated *Dosha*)
Focused on draining accumulated *dosha* and inflammatory exudate. *Dalhana* clarifies that the method should be selected based on dominant *dosha*, Includes: *Visravana*, *Snehana*, *Vamana*, *Virecana*, *Shirovirechana*, *Nasya*, *Kavalagraha*, *Dhoomapana*,
3. *Upanaha* (Suppuration and softening)
Intended to bring the swelling to a *pakva* (mature) stage for safe drainage of *Doshas*. Includes: *Upanaha* and *Pachana*.
4. *Patana* (Surgical evacuation of pus/necrosis tissues)
Indicated when abscess formation has occurred. Involves surgical procedures: *Chedana*, *Bhedana*, *Darana*, *Lekhana*, *Eshana*, *Aharana*, *Vyadhana*, *Visravana*, *Seevana* and *Yantra*.
5. *Shodhana* and *Ropana* (Wound debridement and healing)
These two sequential measures aim first at cleansing the wound, then promoting regeneration. Thirteen procedures are listed: *Sandhana*, *Peedana*, *Soṇita-sthapana*, *Nirvapana*, *Utkarika*, *Kashaya*, *Varti*, *Kalka*, *Sarpi*, *Taila*, *Madhu*, *Rasakriya*, *Avachurna*, *Vrana dhoopana*.
6. *Vaikritapaha* (Cosmetic/functional restoration)
7. Applied after healing to prevent deformity, restore tissue quality, and improve appearance. Twenty-six measures are included, such as: *Utsadana*, *Avasadana*, *Mrudukarma*, *Daruna*

karma, *Vishaghna*, *Pratisarana*, *Romanjana*, *Romahatana*, *Pandukarma*, *Krishnakarma*, *Bandhana*, *Patradana*, *Krimighna*, *Brhmhana*, *Ahara*, *Raksha vidhana*

Ayurvedic Treatment Modalities

Alongside herbal formulations, there are wide spectrum of Ayurvedic interventions has been documented for *Shodhana* and *Ropana* of *Vrana*. The Ayurvedic wound management utilises a structural set of topical formulations and procedures- *Lepa*, *Avachoorana*, *Taila*, *Ghrita*, *Kshara*, *Dhoopana*, *Kwatha*, etc. These interventions are selected according to wound stages and *Dosha* involvement with primary therapeutic goals of *Shodhana*, *Ropana*.

Formulations

These are some formulations documented for *Shodhana* and *Ropana* of *Vrana* in Ayurveda^[10]:

Kalka - *Tila kalka*, *Nimba patra kalka*, *Yava kalka*
Pariseka- *Panchavalkala kwath*, *Triphala kwath*, *Dasamula kwath*, *Bhadramusthati kwath*, *Dhanwanthara kwath*, *Patoladi kwath*, *Panchavalkala kwath*, *Triphala kwath*.
Avachoorana - *Trivritadi churna*, *Guggulu Panchapala churna*
Ghrita - *Jatyadi ghrita*, *yastimadhu ghrita*, *Manjishtadi ghrita*, *Durva ghrita*
Bhasma - *Yashade bhasma*
Taila - *Noola taila*, *Vranaropan taila*, *Kampillakadi taila*, *Manjishtadi taila*, *Chandanadi taila*.
Dhoopana - *Nimbadi dhoopana*, *Guggulu dhoopana*.

Procedures for wound management

Alongside herbal formulations, there are wide range of procedural therapies- *Jaloukavacharana*, *Agnikarma*, *Kshara karma*, *Vrana basti*, *Sira vedhana* and *Dhoopana karma* - are indicated for stage-specific wound management.^[11]

Innovations in wound Dressing^[10,11]

Unlike conventional passive dressings, Ayurvedic wound dressing *Vrana bhandan* are therapeutic delivery platform designed to achieve *Shodhana* and *Ropana* of *Vranas*.

- *Madhu-ghrita* dressing
- Honey dressing in wound management.
- *Tailas* like- *Jatyadi taila*, *Kshara taila*, *Duvadi taila*, etc
- *Avacunana* (powder dressing)

- *Katupila churna* (Securinega leucopyrans) with *Tila tail* dressing.
- *Kareesadi churna* and *Jatyadi ghrita* dressing
- *Laksha churna* and *Madhu* dressing
- *Malhara- Panchavalkala malhara, Hingulamrutadi malhara.*
- *Kshara - kshara ploti, Plasha kshara* dressing.

Modern Regenerative Medicine Perspective

Regenerative medicine is a continuously developing field that comes the diverse disciplines of cellular and molecular biology, tissue engineering and biomaterial science in order to design therapies to restore or maintain cells, tissues and organ.^[12]

Regenerative medicine has revolutionized the understanding of wound repair, shifting focus from mere closure to true tissue regeneration -restoration of skin architecture, function and aesthetics.

Wound-Healing Phases

The conceptual framework of modern regenerative wound care links directly into the four phases of wound healing: Haemostasis, inflammation, proliferation and remodeling. In the Haemostasis phase, platelets driven fibrin scaffolds not only prevent hemorrhage but initiate a provisional matrix rich in growth factors. The Inflammation phase, mediated by neutrophils and macrophages helps to clean wound, inadequate resolution here often results in chronic, non-healing wounds. The Proliferative phase is a focus point of regenerative intervention: Fibroblasts, endothelial cells, keratinocytes collaborate to build granulation tissue and reepithelialize the wound surface. The remodelling phase involves extracellular matrix (ECM) maturation, collagen I to collagen III switching and scar maturation-through full restoration of pre-injury architecture remain elusive.

Concepts and Innovations

Stem cell therapy

Stem cells are undifferentiated cells characterized by their unique capacity for long term self-renewal and ability to differentiate into multiple specialised cell types under the appropriate conditions- Pluripotent cells or multipotent cells.^[12]

Multiple stem cells have been investigated in regenerative medicine-

- Embryonic stem cells
- Somatic cell nuclear transfer
- Induced pluripotent stem cells

- Fetal stem cells
- Adult stem cells
- Hematopoietic stem cells
- Mesenchymal stem cells
- Bone marrow derived stem cells
- Adipose tissue derived stem cells
- Endothelial progenitor cells
- Skeletal stem cells

Among different types of stem cells, adult stem cells and mesenchymal stem cells and embryonic stem cells are utilized for wound healing and skin regeneration.

These have emerged as potent modulators of wound repair and their actions promote angiogenesis, regulates inflammation and enhance fibroblast function.

Biomaterial scaffolds and dressings

Biomaterials have been designed as synthetic scaffolds that can facilitate stem cells survival, engraftment, proliferation and retention. Modern dressing has evolved into engineered scaffolds that replicated Extracellular-matrix (ECM) architecture, deliver growth-factor and modulates the wound microenvironment.

Collagen matrices, fibrin matrices, decellularized dermis, chitosan-based hydrogel scaffolds and nano-fibre dressings, allows for directed cell infiltration, alignment and maturation.^[13] Innovation includes oxygen releasing dressing, pH responsive hydrogel matrix and 3D bio printed skin constructs all designed to overcome the hostile microenvironment for chronic wound.^{[14][15]}

Growth factor and Gene activation therapies

The role of growth factor delivery system-PDGF, VEGF, EGF embedded in biomaterial as next generation regenerative modalities coupled with gene-activated matrices delivering siRNA or plasmids to modulates TGF- β 1 myofibroblast activity and collagen deposition, these technologies target the remodelling phase directly. Advances such as stem cell derived exosomes dressing and nano carries delivery system bring precision biology to wound healing.^[12]

Integrative Analysis: Biomimetic Correlation

A concise comparison of Sushruta's *Vrana Ropana* and modern regenerative medicine reveals a clear biomimetic alignment. Sushruta's therapeutic sequence—*Shodhana*→*Ropana*→*Purana/Samdhana*—mirrors the contemporary phases of wound healing.

Shodhana focuses on cleansing, removal of slough, reduction of microbial load and restoration of a favourable wound environment. This parallels modern debridement, biofilm control, oxidative balance and microenvironment reset. Classical *Ropana* herbs (*Yastimadhu*, *Haridra*, *Nimba*, *Manjistha*, *Panchavalka* etc) exhibits antimicrobial and antioxidant properties comparable to current antiseptic dressings and enzymatic debriders.

Ropana corresponds to the proliferative phase. Sushruta's description of *Mamsa-utpatti* aligns with fibroblast activation, angiogenesis and collagen deposition. *Ropana* drugs- *Yastimadhu*, *Haridra*, *Manjistha*, *Jatyadi ghrita*, *Madhughrita*, etc- demonstrate actions similar to growth factor-enhanced biomaterials, ECM-mimetic hydrogels, MSC-derived exosomes and scaffold-supported healing.

Purana/Samdhana correlates with the remodelling phase, targeting structural integrity, tensile strength and scar refinement. Classical *Vaikrtapaha* measures parallel modern scar-modulating therapies such as pressure therapy, silicone sheeting and laser remodeling.

Sushruta's procedural measures- *Jalaukavacarana*, *Agnikarma*, *Kshara karma*, *Vrana basti*, *Vrana dhoopana*- also reflect early forms of biotherapy, thermal cauterization, chemical debridement, vacuum-assisted healing and antimicrobial fumigation. This confirms a biomimetic parallel between ancient surgical wisdom and contemporary regenerative science.

Future Directions and Research Implications

The mechanistic alignment between Sushruta's *Vrana Ropana* and regenerative biology suggests strong translational potential.

Preclinical Studies

Ropana herbs require: active phytochemical mapping, molecular pathway elucidation, their evaluation in different types of wounds like diabetic, ischemic, and chronic wound models.

Ayurvedic-Inspired Biomimetic Dressings

Future innovations may include: hydrogel dressings infused with herbal extracts, honey-*Ghrita* lipid scaffolds, nanofiber dressings with Ayurvedic *Ropana dravyas*.

These designs can replicate the *Shodhana* → *Ropana* → *Purana* sequence while meeting modern biochemical requirements.

Integrative Clinical Trials

Protocols combining: Ayurvedic topical therapy with MSC-based scaffolds, collagen matrices and exosome dressings. And should be evaluated for granulation rate, epithelization time, infection control, and scar quality.

Standardization & Regulatory Needs

To integrate Ayurvedic formulations into mainstream care, there must be: GMP-level standardization, sterility and toxicity testing, phytochemical profiling, regulatory frameworks enabling clinical translation.

CONCLUSION

Sushruta's Vrana Ropana embodies the core biological principles of regenerative wound healing- cleansing, restoration, and remodelling. Modern regenerative medicine achieves these outcomes via stem cells, engineered scaffolds, growth factors, and bioactive dressings. Both systems converge conceptually and mechanistically. Integrating Ayurvedic wisdom with modern biomaterials can yield biologically intelligent, cost-effective wound-care solutions, especially for chronic and non-healing wounds. Future progress depends on molecular research, preclinical validation, and controlled clinical trials, supported by rigorous standardization. This synthesis not only honors classical surgical science but promises to reshape the future of wound care.

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