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Review Article

Jalaukavacharana in Venous Congestion and Reconstructive Surgery: Mechanisms, Clinical Applications, and Safety Concerns

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Abstract

Venous congestion can destroy otherwise viable tissue after digital replantation, flap transfer, or composite tissue reattachment. When a correctable obstruction is found, surgical exploration is the treatment of choice. In some patients, however, venous repair is not technically possible, thromboses again after revision, or fails to provide adequate outflow despite satisfactory arterial

inflow. Medicinal leeches may then be used to drain congested blood for a limited period while new venous connections develop. In Ayurveda, therapeutic leech application is described as *Jalaukavacharana*, a gentle form of *Raktamokshana*. This narrative review brings together the classical description of the procedure and current evidence from reconstructive surgery, vascular physiology, and studies of leech saliva. The immediate benefit comes from removal of pooled blood; continued oozing after detachment prolongs the drainage. Salivary substances such as hirudin, calin, saratin, destabilase, and hyaluronidase may support this effect through anticoagulant, antiplatelet, fibrin-modifying, and tissue-spreading actions. Clinical experience is strongest in congested replanted digits and compromised flaps, although most published evidence comes from case series, retrospective studies, and heterogeneous reviews. Treatment is appropriate only when arterial inflow is present, the tissue is still viable, and mechanical causes have been corrected or cannot be corrected. Infection with Aeromonas species, cumulative blood loss, anemia, prolonged bleeding, and patient anxiety are the main practical concerns. Safe use therefore depends on certified single-use leeches, antimicrobial prophylaxis based on local susceptibility, close flap observation, serial hematological monitoring, and clear criteria for stopping treatment. *Jalaukavacharana* is best regarded as an adjunct to reconstructive care and not as a replacement for indicated vascular revision.

Keywords: *Jalaukavacharana*; medicinal leech therapy; venous congestion; reconstructive surgery; microsurgery; flap salvage; hirudin; *Raktamokshana*

1. Introduction

A reconstructed tissue survives only when arterial inflow and venous drainage remain in balance. Venous compromise may first appear as a dusky or violaceous colour, increasing swelling, dark bleeding on pin-prick testing, and a tense flap or replanted part. As pressure rises within the venous and capillary beds, fluid moves into the interstitium and edema worsens. Capillary flow becomes sluggish, oxygen diffusion falls, and endothelial injury encourages inflammation and microthrombus formation. The process may advance quickly, which is why venous congestion is treated as a reconstructive emergency.

Management begins with a search for a reversible cause. Thrombosis at the venous anastomosis, a kinked pedicle, hematoma, tight dressings, external pressure, excessive inset tension, and technical failure should be corrected without delay. Yet there are situations in which no suitable vein is available, the repaired vein repeatedly thromboses, or diffuse congestion continues after revision. Medicinal leeches have a limited but useful role in such cases. They remove venous blood directly and leave behind salivary substances that keep the bite site bleeding for several hours. Much of the clinical support for this practice comes from accumulated surgical experience rather than controlled trials [1-4].

Ayurvedic surgical texts describe this procedure as *Jalaukavacharana* and place it under *Raktamokshana*. Sushruta recommended it for delicate sites and for patients in whom more traumatic methods of bloodletting were unsuitable [5]. Its long history is relevant, but historical use alone is not evidence of present-day efficacy. Modern reconstructive practice relies on observable changes in venous pressure, tissue perfusion, and bleeding, together with experimental knowledge of leech salivary molecules [1,6,7]. For that reason, *Rakta*, *Pitta*, and *Rakta Dushti* should be discussed in their own Ayurvedic context rather than presented as direct synonyms for thrombosis or microvascular inflammation. This article reviews where *Jalaukavacharana* may help, how the treatment works, what the available evidence actually shows, and how complications can be reduced. The clinical position is straightforward: leeches may serve as a temporary bridge when arterial inflow is satisfactory but venous outflow cannot be restored promptly. They should never postpone re-exploration when a surgically correctable problem is suspected.

2. Aim and Objectives

The aim was to examine *Jalaukavacharana* as an adjunct for venous congestion by considering its classical Ayurvedic basis alongside current knowledge of reconstructive surgery, vascular physiology, leech salivary biology, clinical outcomes, and procedural safety. The specific objectives are to:

- summarize the classical Ayurvedic basis and procedural logic of *Jalaukavacharana*;
- describe the pathophysiology and clinical recognition of venous congestion in reconstructed tissues;
- explain the mechanical and biochemical actions of medicinal leeches;
- appraise the main reconstructive indications and the quality of supporting evidence;
- outline patient selection, monitoring, complications, contraindications, and risk mitigation; and
- propose practical elements for standardization and future research.

3. Review Methodology

A narrative review was undertaken. The classical account of *Jalaukavacharana*, including *Raktamokshana*, selection of leeches, application, observation, removal, and aftercare, was studied mainly from the Sushruta Samhita and supported by relevant later Ayurvedic literature. Contemporary publications were identified through PubMed, Scopus, Web of Science, Google Scholar, and ScienceDirect. Search terms included "*Jalaukavacharana*," "medicinal leech," "hirudotherapy," "venous congestion," "flap salvage," "digital replantation," "microsurgery," "hirudin," "leech saliva," "Aeromonas," and "reconstructive surgery," used singly and in combination.

Systematic reviews, clinically relevant reviews, surgical case series, retrospective and prospective studies, experimental work on salivary constituents, and practical treatment recommendations were given priority.

Randomized trials from non-reconstructive indications were considered only when they helped explain biological or symptomatic effects. Duplicate publications, conference abstracts without full reports, and papers unrelated to therapeutic leech use were excluded. The studies differed substantially in indication, protocol, and outcome reporting; therefore, the findings are presented as a critical narrative synthesis rather than a formal systematic review or clinical guideline.

4. Classical Ayurvedic Basis of *Jalaukavacharana*

The Sushruta Samhita contains one of the earliest detailed accounts of medicinal leech therapy. *Jalaukavacharana* is described under *Raktamokshana* as a localized and comparatively gentle method of removing blood. The indications include local changes in colour, swelling, burning, and pain associated with disturbance of *Rakta* and *Pitta*, particularly in delicate patients or sensitive anatomical sites [5]. The classical procedure involves more than placing a leech on the skin. It includes choosing an appropriate leech, preparing the site, observing attachment and feeding, removing the leech safely, caring for the bite, and managing the leech after use.

Sushruta distinguishes *Nirvisha* leeches considered suitable for treatment from *Savisha* varieties that should be avoided. The classical classification belongs to its own ecological and toxicological framework, but the underlying concern is still practical: the organism used for treatment must be appropriate, healthy, and safely sourced. In present-day practice, this means certified medicinal species, controlled storage, traceable supply, single-patient use, and disposal according to biomedical-waste regulations.

Ayurvedic texts explain the benefit as the controlled removal of vitiated *Rakta*, followed by relief of swelling, discoloration, burning, and pain. Reconstructive physiology describes a different mechanism: venous pressure falls, pooled blood escapes, and capillary perfusion is given time to recover. The two accounts can be discussed together because both describe improvement after localized blood removal. They should not, however, be treated as interchangeable explanations or as proof that classical terms have direct molecular equivalents.

5. Venous Congestion in Reconstructive Surgery

5.1 Pathophysiology

Venous congestion develops when arterial blood continues to enter a tissue but venous return is inadequate. Pressure rises in venules and capillaries, blood transit slows, and fluid leaks into the interstitial space. The resulting edema compresses small vessels and lymphatics. At the same time, stagnant blood favours endothelial dysfunction, leukocyte adhesion, platelet activation, and microthrombus formation. Oxygen extraction may be maintained briefly, but effective perfusion eventually falls. Untreated congestion therefore becomes a combined problem of pressure, edema, inflammation, hypoxia, and thrombosis.

The usual mechanical causes are venous anastomotic thrombosis, pedicle twisting or kinking, a tight tunnel, external pressure, hematoma, poor flap inset, and marked postoperative edema. Congestion may also occur when veins are absent or too small for repair, after severe crush or avulsion injury, or when the available venous territory is inadequate. This distinction guides treatment. A correctable obstruction calls for surgery; leeches are considered when revision is impossible, incomplete, or unable to provide sufficient drainage.

5.2 Clinical Recognition and Monitoring

A congested flap or replanted part commonly becomes dark red, bluish, or violaceous, with progressive swelling and firmness. Pin-prick testing may produce rapid dark bleeding, while capillary refill becomes abnormal and tissue tension increases. Temperature can remain normal early and fall as compromise advances. Repeated bedside examination is still the foundation of monitoring. Doppler assessment, near-infrared spectroscopy, laser Doppler imaging, indocyanine-green angiography, thermography, or hyperspectral imaging may add useful information, but none should delay surgical review when the clinical picture is concerning.

In practice, the sequence is to confirm arterial inflow, remove external compression, obtain urgent microsurgical assessment, and re-explore whenever a technical cause is likely. Leech therapy is considered only after this decision has been made. It has little chance of success when arterial perfusion is absent or when irreversible ischemia and necrosis are already established.

6. Mechanisms of Medicinal Leech Therapy

6.1 Mechanical Decompression and Sustained Drainage

A medicinal leech makes a small tri-radiate bite and consumes a limited amount of congested blood. Much of the decompressive effect occurs after the leech detaches, when anticoagulant and antiplatelet activity at the bite allows continued oozing. Repeated applications can thus create a temporary external route for venous drainage until native veins or new vascular connections become functional [2-4]. Treatment should be guided by the tissue response rather than by a fixed number of leeches. Improvement in colour, softness, capillary refill, bleeding characteristics, and stability between applications is more informative than a predetermined dose.

The same continued bleeding that relieves congestion can also produce clinically important blood loss. The number and frequency of applications must be adjusted to the size of the affected tissue, severity of congestion, circulating blood volume, response to treatment, and change in hemoglobin. Extra caution is required in children, frail patients, and those with large flaps.

6.2 Salivary Constituents and Biological Actions

Leech saliva is not a single drug. It contains a mixture of proteins, peptides, enzymes, and smaller molecules that affect hemostasis, extracellular-matrix permeability, inflammation, and local vascular tone [8-11].

Composition varies among species and also depends on the method used to collect and analyse the secretion. Identification of a molecule in saliva does not automatically prove that it reaches a therapeutic concentration in human tissue; biochemical evidence and clinical effect should therefore be separated clearly.

Hirudin, the best studied component, directly inhibits thrombin. Calin and related substances interfere with collagen-dependent platelet adhesion and help maintain post-bite bleeding. Saratin acts on the interaction between collagen and von Willebrand factor. Destabilase shows fibrin-modifying and fibrinolytic activity in experimental systems, while hyaluronidase helps other salivary components spread through the extracellular matrix. Bdellins and eglins inhibit selected proteases involved in inflammation and tissue injury. Histamine-like substances and other vasodilatory molecules may influence local flow. These actions support the mechanical drainage produced by the bite; they do not replace it [8-13].

Table 1. Principal Constituents of Medicinal Leech Saliva and Their Clinically Relevant Actions

Constituent/Group	Principal Experimental Action	Potential Relevance in Venous Congestion	Interpretive Caution
Hirudin	Direct inhibition of thrombin	Limits fibrin formation and thrombin-mediated platelet activation	Clinical effect occurs within a complex salivary mixture
Calin and related platelet inhibitors	Inhibition of collagen-dependent platelet adhesion	Supports prolonged post-detachment bleeding	Magnitude varies with species and local conditions
Saratin	Interference with collagen-von Willebrand factor interaction	May reduce platelet adhesion at the bite and microvascular injury sites	Mostly supported by biochemical evidence
Destabilase	Fibrin-modifying/fibrinolytic activity in experimental systems	May assist microvascular patency	Should not be described as proven systemic thrombolysis
Hyaluronidase	Degradation of extracellular-matrix hyaluronic acid	Facilitates local spread of salivary substances	Also has theoretical implications for spread of microorganisms
Bdellins and eglins	Inhibition of selected serine proteases	May reduce protease-mediated inflammation and tissue damage	Clinical contribution is difficult to isolate

Constituent/Group	Principal Experimental Action	Potential Relevance in Venous Congestion	Interpretive Caution
Histamine-like and vasodilatory substances	Local vasodilatation	May improve local blood flow around viable congested tissue	Increased inflow is useful only when decompression is adequate

7. Integrative Interpretation

A useful integrative discussion starts with what can be observed clinically. Ayurveda describes local discoloration, swelling, burning, pain, and disturbance of *Rakta*. Reconstructive science describes venous hypertension, edema, hypoxia, endothelial injury, inflammation, and microthrombosis. Both approaches may lead to controlled removal of blood from viable congested tissue, but they arrive there through different concepts and methods of validation.

It is therefore misleading to translate *Rakta Dushti* as venous thrombosis or to describe *Pitta* as a cytokine pathway. A safer interpretation is that *Jalaukavacharana* produces measurable effects: removal of blood, prolonged drainage, reduced tissue tension, and changes in local hemostasis. These outcomes can be studied without changing the meaning of the Ayurvedic terms or claiming a molecular equivalence that has not been demonstrated.

Table 2. Interpretive Relationship Between Classical Descriptions and Modern Clinical Observations

Classical Clinical Description	Modern Observable Process	Shared Therapeutic Observation	Limitation of Correlation
Localized Rakta disturbance with discoloration and swelling	Venous hypertension, blood pooling, and edema	Controlled blood removal may reduce tissue tension	The terms are not pathophysiological synonyms
Raktamokshana by Jalaukavacharana	External decompression with sustained local bleeding	Congested blood is evacuated from viable tissue	Modern use requires vascular diagnosis and monitoring
Relief of burning and pain	Reduced pressure, inflammation, and ischemic discomfort	Symptoms may improve after decompression	Analgesia is multifactorial and indication-dependent
Use in delicate sites/persons	Minimally traumatic localized intervention	Small bite sites may be preferable to repeated scarification	Blood loss can still be clinically important
Selection of Nirvisha leeches	Certified species, controlled breeding, and infection control	Safety depends on correct biological sourcing	Classical and modern classifications use different criteria

8. Clinical Applications in Reconstructive Surgery

8.1 Digital and Fingertip Replantation

Replanted digits and distal fingertips are among the clearest indications for leech therapy. In very distal amputations or severe crush and avulsion injuries, arterial repair may be possible even when no vein can be anastomosed. Once arterial inflow is restored, the digit becomes cyanotic and tense unless an alternative route for venous drainage is provided. Leeches can offer that route until new venous channels form. Early reports, later clinical series, and recent retrospective studies show that salvage is possible, particularly when congestion is recognized early and the tissue remains viable [14-16].

Repeated application is often needed, with close observation of colour, turgor, capillary refill, and the nature of bleeding. Delayed treatment, proximal or avulsion injury, extensive crush damage, poor arterial inflow, and established necrosis are associated with failure. An accessible congested surface or viable nail

bed may make application easier, but the protocol must be adapted to the individual digit.

8.2 Free and Pedicled Flaps

Venous compromise in a free flap usually requires urgent return to the operating room. Leeches are considered only after thrombosis, kinking, compression, or technical failure has been corrected, or when no further venous reconstruction is possible. They may also help with persistent peripheral congestion despite a patent arterial anastomosis. Reviews and institutional series report useful salvage, although results differ widely according to flap type, timing, severity, and treatment protocol [3,4,17-19].

Local and pedicled flaps may become congested because of rotation, tight sutures, pressure, hematoma, edema, or partial impairment of venous return. Releasing a dressing, correcting the inset, evacuating a hematoma, or relieving pedicle pressure comes first. If congestion persists, a leech can reduce local venous pressure while the flap adapts. Thin cutaneous and fasciocutaneous flaps are generally more suitable than bulky muscle or adipose flaps, because superficial bites may not decompress the deeper part of a large tissue mass.

8.3 Auricular, Nasal, Lip, Scalp, and Head-and-Neck Reconstruction

Reattachment of the ear, nose, lip, or scalp presents a recurring technical problem: arterial inflow may be restored, but the veins can be too small or too damaged for reliable repair. In such cases, leeches have been used as a temporary substitute for venous drainage while neovascularization occurs. Early treatment is especially important in facial structures, where tissue loss has major functional and cosmetic consequences. Case series describe successful salvage when arterial perfusion is maintained and congestion is treated promptly [20].

Head-and-neck free flaps may also require leeches after conventional salvage measures have failed. These patients need particularly careful supervision. Repeated treatment over several days can cause substantial blood loss, and placement near mucosa or the airway raises concerns about migration, aspiration, and containment. Clear nursing protocols and ready access to the reconstructive team are essential.

8.4 Breast Reconstruction and Large-Volume Flaps

Experience in breast reconstruction is less predictable than in digits or small composite tissues. A superficial bite may not drain a large flap adequately, while repeated applications can lead to considerable blood loss. A systematic review found that selected breast tissues could be salvaged, but the evidence was based mainly on case reports and small series and complications were common [21]. The decision should weigh the chance of salvage against transfusion requirements, infection risk, and available surgical alternatives.

8.5 Pediatric Reconstruction

Children may benefit after digital replantation, auricular reattachment, scalp injury, or congenital reconstruction, but their smaller blood volume leaves much less room for cumulative loss. Fewer leeches, shorter intervals of reassessment, frequent hemoglobin measurement, careful fluid balance, and early escalation are therefore necessary. Describing *Jalaukavacharana* as gentle does not remove the need to measure blood loss and watch for hemodynamic deterioration.

8.6 Chronic Venous and Musculoskeletal Conditions

Leech therapy has also been used for chronic venous disease and painful musculoskeletal conditions. Randomized trials and a meta-analysis suggest short-term benefit in knee osteoarthritis, and one randomized trial reported improvement in lateral epicondylitis [22-24]. These studies support possible analgesic and anti-inflammatory effects, but they answer a different clinical question from flap salvage, where the immediate goal is venous decompression. The findings should not be extended to diabetic ulcers or ischemic wounds without careful vascular and infection assessment; in such patients, indiscriminate use may do more harm than good.

Table 3. Main Clinical Applications and Strength of Supporting Evidence

Clinical Situation	Therapeutic Role	Evidence Profile	Key Qualification
Replanted digit or fingertip without adequate venous repair	Temporary external venous outflow	Multiple series; systematic and retrospective evidence	Preserved arterial inflow and early treatment are essential
Free-flap venous congestion after revision is impossible or incomplete	Bridge until collateral drainage develops	Systematic reviews and institutional series	Must not delay indicated surgical exploration
Pedicled/local flap congestion	Reduction of venous pressure and edema	Case series and clinical experience	Correct compression, hematoma, or inset problems first
Ear, nose, lip, and scalp reattachment	Substitute for absent small-calibre venous drainage	Case reports and series	Requires intensive monitoring and infection prophylaxis

Clinical Situation	Therapeutic Role	Evidence Profile	Key Qualification
Breast or other large-volume flap	Selected superficial territory salvage	Limited, heterogeneous evidence	High blood-loss burden and incomplete deep decompression
Pediatric reconstructive congestion	Same physiological bridge as in adults	Case-based evidence	Small blood volume substantially increases anemia risk
Osteoarthritis/lateral epicondylitis	Short-term symptom modulation	Randomized trials; meta-analysis for knee osteoarthritis	Different clinical objective from reconstructive salvage

9. Critical Appraisal of the Clinical Evidence

The reconstructive literature is encouraging, but it has important limitations. A systematic review of 277 reported cases found a salvage rate of about 78%, and later reviews commonly reported rates between 65% and 85% in selected patients [3,4]. These percentages are not a universal treatment effect. The reports differ in anatomy, flap type, severity, timing, previous revision, number of leeches, antibiotic policy, and definition of success. Publication bias is also likely, because unusual and successful cases are more readily reported than failures.

Randomized trials are difficult to conduct in an emergency salvage setting, especially when withholding a plausible treatment may lead to tissue loss. Better evidence will probably come from prospective multicentre registries, common definitions, and carefully designed observational studies that account for timing and severity. Reports should distinguish complete from partial survival and should include debridement, transfusion, infection, treatment duration, function, cosmetic outcome, and the burden experienced by the patient.

Mechanistic evidence also varies in strength. Direct thrombin inhibition and effects on platelet adhesion are well established, whereas the clinical contribution of individual protease inhibitors, vasodilators, and antimicrobial peptides is harder to separate. Claims about specific salivary molecules should therefore state whether the evidence is biochemical, experimental, or clinical. The most secure explanation of benefit remains direct blood removal followed by sustained local drainage.

10. Patient Selection and Proposed Clinical Protocol

10.1 Indications and Prerequisites

The most suitable patient has viable but clearly congested reconstructed tissue, demonstrable arterial inflow, and venous drainage that cannot be corrected promptly or remains inadequate after revision. Before treatment, the reconstructive team should record the likely cause, anatomical extent, vascular findings, and intended role of the leeches. Consent should cover the visible use of a living organism, prolonged bleeding, Aeromonas infection, anemia, transfusion, incomplete salvage, and the possibility of further surgery.

10.2 Preparation

Baseline evaluation should include a complete blood count, platelet count, relevant coagulation tests, medication review, allergy history, infection risk, and clinical photographs. Antiplatelet and anticoagulant medicines should be reviewed in relation to the reconstructive indication rather than stopped automatically. Leeches should come from an approved supplier, be stored under the recommended conditions, and be traceable by batch. Each leech should be used for one patient and one application only.

10.3 Application and Monitoring

The site is cleaned gently with sterile saline. Residual antiseptic may prevent attachment, so strongly scented agents should not be left on the skin. A small container or barrier can keep the leech over the congested area, and a sterile needle prick may be used to encourage attachment. The leech is normally allowed to feed and detach on its own. Forced removal is avoided unless necessary because rough handling may injure the tissue or provoke regurgitation. After detachment, a sterile absorbent dressing is applied without immediately stopping the desired oozing.

Monitoring should include flap colour, temperature, softness, capillary refill, Doppler findings where relevant, the amount and character of bleeding, vital signs, fluid balance, and the cumulative number of leeches used. The interval between hemoglobin measurements depends on treatment intensity and patient vulnerability; high-intensity therapy may require testing more than once a day. Transfusion decisions should reflect symptoms, hemodynamics, comorbidity, ongoing blood loss, and the reconstructive objective rather than a single fixed hemoglobin value.

10.4 Reapplication and Termination

A leech is reapplied when congestion returns and the previous application produced a useful response. Published schedules vary considerably, from applications every few hours to longer intervals, and treatment often continues for several days [4,25]. Therapy can be tapered

or stopped when colour, tissue tension, capillary refill, and perfusion remain stable between applications. It should be stopped or escalated when arterial inflow worsens, necrosis becomes established, bleeding cannot be controlled, infection is suspected, anemia becomes unsafe, or the surgical team judges that further salvage is unlikely.

Table 4. Proposed Standardized Workflow for Medicinal Leech Therapy

Stage	Required Action	Documentation/ Endpoint
Immediate assessment	Confirm venous congestion, assess arterial inflow, remove external compression, and obtain urgent microsurgical review	Cause, severity, photographs, vascular findings, decision regarding re-exploration
Eligibility	Use only when tissue is viable and venous repair is impossible, incomplete, or unsuccessful	Written indication and expected bridge duration
Baseline safety	CBC, platelets, relevant coagulation profile, medication/allergy review, infection-risk assessment	Baseline values and monitoring frequency
Consent	Discuss bleeding, anemia/transfusion, Aeromonas infection, distress, failure, and possible further surgery	Written informed consent
Biological product	Certified medicinal species; correct storage; single use; traceable batch	Supplier, batch/lot, number used, disposal record
Application	Saline-cleaned site, confined placement, spontaneous feeding/detachment, sterile absorbent dressing	Time of attachment/detachment and bite location
Ongoing monitoring	Serial flap examination, vitals, bleeding, cumulative leeches, fluid balance, hemoglobin	Standard chart at predefined intervals
Antimicrobial prevention	Agent active against local Aeromonas isolates, guided by policy and susceptibility data	Drug, dose, duration, cultures if infection suspected
Stopping/escalation	Stop after sustained resolution; escalate for arterial failure, necrosis, infection, unsafe bleeding, or non-response	Explicit termination reason and reconstructive outcome

11. Safety Concerns, Complications, and Contraindications

11.1 Aeromonas Infection

Aeromonas species normally live in the medicinal leech gut and are the infection most closely associated with treatment. They may cause cellulitis, flap infection, abscess, bacteremia, or sepsis. *Aeromonas hydrophila* and *Aeromonas veronii* are often reported, but susceptibility patterns are not uniform [25-27]. Antibiotic

prophylaxis active against locally encountered isolates is therefore standard practice. No single drug should be described as universally reliable; the institutional regimen should be agreed with microbiology and antimicrobial-stewardship teams, and cultures should be obtained promptly when infection is suspected.

Prevention also depends on certified sourcing, single use, clean handling, avoidance of cross-contamination, appropriate dressings, and safe disposal. Antimicrobial peptides in leech saliva do not protect the patient from the Aeromonas organisms carried in the leech gut and are not a reason to omit prophylaxis.

11.2 Blood Loss, Anemia, and Prolonged Bleeding

Oozing from the bite is expected, but repeated applications can lead to major cumulative blood loss. Transfusion is common in intensive reconstructive protocols [3,4,18]. The risk is greater with large treatment areas, frequent applications, low baseline hemoglobin, pediatric or elderly patients, thrombocytopenia, coagulopathy, liver disease, and concurrent antithrombotic treatment. Nursing records should include the number of leeches, dressing saturation, visible bleeding, vital signs, and serial laboratory values.

When bleeding becomes unsafe, pressure is applied and anticoagulant use, platelet count, and coagulation status are reassessed. The reconstructive, anesthesia, and transfusion teams should be involved early. Hemostasis must be balanced against the possibility that closing the drainage route too soon will allow congestion to recur.

11.3 Other Adverse Effects

Other reported problems include pruritus, erythema, allergic reactions, scarring, migration to an unintended site, failure to attach, regurgitation, anxiety, and incomplete tissue salvage. Placement close to an airway or body cavity requires strict containment. Simple explanations, visual shielding when appropriate, and supportive counselling improve acceptance. Pain should be assessed and treated rather than assuming that every patient finds the bite painless.

11.4 Contraindications

Leech therapy is inappropriate when arterial inflow is absent, tissue is already non-viable, bleeding is uncontrolled, anemia is profound and cannot be corrected, severe thrombocytopenia or coagulopathy is present, or adequate monitoring cannot be provided. Previous severe hypersensitivity is another major contraindication. Severe immunosuppression, active infection, pregnancy, advanced peripheral arterial disease, and ongoing anticoagulation require individual assessment. Above all, leeches should not be used to delay urgent surgery for a correctable vascular obstruction.

Table 5. Major Risks and Risk-Mitigation Measures

Risk	Clinical Consequence	Prevention/ Monitoring	Response
Aeromonas infection	Cellulitis, flap infection, bacteremia, sepsis	Certified leeches, single use, active prophylaxis, local susceptibility surveillance	Culture promptly; targeted antimicrobial therapy; surgical review
Cumulative blood loss	Symptomatic anemia, hemodynamic instability, transfusion	Baseline and serial CBC, cumulative leech record, dressing/bleeding assessment	Reduce/stop therapy, resuscitate, transfuse when clinically indicated
Excessive prolonged bleeding	Local or systemic hemorrhagic risk	Coagulation/medication review and close observation	Pressure and hemostatic management balanced against recurrent congestion
Allergic reaction	Pruritus, urticaria, rarely severe hypersensitivity	History and observation	Stop exposure; treat according to severity
Migration/regurgitation	Unintended bite, contamination, airway/cavity risk	Physical containment and supervised application	Remove safely; assess exposure and infection risk

Risk	Clinical Consequence	Prevention/ Monitoring	Response
Treatment failure	Partial or complete tissue loss	Early diagnosis, correct indication, objective response assessment	Re-exploration, alternative salvage, debridement, or reconstruction
Psychological distress	Refusal, anxiety, poor cooperation	Pre-procedure counselling and visual shielding where suitable	Supportive communication; consider alternatives when feasible

12. Standardization, Ethics, and Future Research

Practice still varies widely between centres. Differences include the leech species used, application interval, treatment duration, antimicrobial policy, blood-test frequency, transfusion practice, and definition of success. Each institution that offers the treatment should have a written protocol covering indications, mandatory surgical assessment, traceable supply and storage, infection prevention, bedside monitoring, escalation, and disposal. Staff training should include recognition of arterial and venous compromise, safe attachment and containment, management of bleeding, and early signs of infection.

Consent should describe leech therapy honestly as an adjunctive salvage measure whose benefit cannot be guaranteed. Patients should be told what the treatment looks like and what bleeding, monitoring, antibiotics, transfusion, and further surgery may involve. When a patient lacks capacity, surrogate consent and, where appropriate, assent should follow local policy. Separate consent is required for identifiable photographs or publication. Unsupervised self-application has no place in the management of a compromised reconstructive flap.

Future research should favour prospective multicentre registries and protocols designed for specific indications. Near-infrared spectroscopy, laser Doppler methods, thermography, indocyanine-green angiography, and hyperspectral imaging may help define response and stopping criteria. Case reports of very large-scale treatment show what can be achieved, but also reveal the blood-loss, staffing, and infection-control burden [28]. Broader reviews of leech-derived compounds point to possible recombinant or synthetic therapies, while proteomic studies continue to identify salivary molecules that merit investigation [10,11,29]. Ayurveda-based research should state clearly whether classical concepts are being used as historical rationale, diagnostic criteria, or variables for treatment selection, and should link them to measurable clinical outcomes.

13. Discussion

Jalaukavacharana is an unusual example of a traditional procedure that has found a narrow, practical place in modern surgery. The relevant problem is specific: viable tissue continues to receive arterial blood but lacks adequate venous drainage. A leech opens an external route for that blood, and salivary anticoagulant and antiplatelet actions keep the route open after feeding. Systemic anticoagulation may reduce clot formation but does not remove pooled blood; scarification can drain blood but often less consistently. The combined mechanical and biochemical effect explains why leeches have remained useful despite advances in microsurgery [30].

Across the clinical literature, early recognition and correct selection matter more than any fixed schedule. Leeches cannot straighten a kinked pedicle, revise a thrombosed anastomosis, evacuate a compressive hematoma, or restore absent arterial inflow. Their value is greatest when a suitable vein does not exist or venous drainage remains inadequate after proper surgical management. Applying them indiscriminately exposes patients to infection and anemia; applying them too late may allow reversible congestion to progress to tissue loss. The procedure remains recognizably *Jalaukavacharana* because it uses a living leech for controlled local blood removal, with attention to the site and suitability of the patient. In a modern hospital, however, the same procedure also requires certified biological material, antibiotic prophylaxis, serial blood tests, nursing documentation, and reconstructive supervision. These perspectives can be presented together without converting Ayurvedic concepts into unproven molecular equivalents or relaxing current safety standards.

The evidence is weakened less by lack of experience than by inconsistent reporting. Many articles do not state how long congestion was present before treatment, whether re-exploration was attempted, how many leeches were used, how much blood was lost, which antibiotics were given, whether transfusion was required, or how much tissue ultimately survived. A minimum reporting set would make studies easier to compare and would support more realistic counselling. At present, medicinal leech therapy should be described as an evidence-supported adjunct based mainly on observational salvage data, not as a universally validated treatment with a single standard regimen.

14. Conclusion

Jalaukavacharana has a defensible role in carefully selected cases of venous congestion after replantation and

reconstructive surgery. Its main effect is simple and clinically visible: pooled venous blood is removed and the bite continues to drain after the leech detaches. Anticoagulant, antiplatelet, extracellular-matrix-modifying, and anti-inflammatory salivary actions may add to this effect. The best candidates have preserved arterial inflow, viable congested tissue, and venous outflow that cannot be restored promptly or remains inadequate after appropriate revision.

Leeches must not replace urgent vascular exploration when a correctable cause is present. Safe treatment requires certified single-use leeches, informed consent, prophylaxis directed against locally susceptible Aeromonas species, repeated clinical and hematological assessment, readiness to manage anemia and transfusion, and clear criteria for response and termination. Classical Ayurvedic reasoning and reconstructive physiology may be discussed side by side, provided that conceptual similarities are not presented as biological identity. The next step for the field is not broader indiscriminate use, but better protocols, prospective reporting, and multidisciplinary oversight.

Declarations

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