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LEECH THERAPY IN PLASTIC AND RECONSTRUCTIVE SURGERY: A REVIEW ARTICLE

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ABSTRACT

Medicinal leech therapy (hirudotherapy) has re-emerged over the past five decades as an important adjunct in plastic and reconstructive surgery, chiefly for the salvage of flaps and replanted or revascularised tissue compromised by venous congestion. The medicinal leech (Hirudo medicinalis and related species) secretes a complex mixture of bioactive salivary compounds — including hirudin, calin, hyaluronidase, destabilase, apyrase, eglins and bdellins — that produce local anticoagulation, vasodilatation, controlled decongestive bleeding and anti-inflammatory effects, thereby providing temporary venous outflow until spontaneous neovascularisation (inosculation) restores physiological drainage. Leeches have been used in the salvage of free and pedicled flaps, digit replantation and revascularisation, and replantation of the ear, nose, lip, scalp and other composite tissues, and were approved by the United States Food and Drug Administration as a medical device for this indication in 2004. Pooled data from systematic reviews report tissue salvage rates ranging from approximately 61% to 88%, though outcomes vary considerably by tissue type, with pedicled flaps generally salvaged more successfully than free flaps or digital replants. The principal risks of leech therapy are blood loss requiring transfusion and infection with Aeromonas species harboured in the leech gut, which necessitates antibiotic prophylaxis, though rising antimicrobial resistance among Aeromonas isolates is an emerging concern. This review summarises the biology and mechanism of action of medicinal leeches, their indications and technique of application in plastic and reconstructive surgery, the evidence for efficacy, associated complications and their management, contraindications, alternative techniques, and the direction of future research.

KEYWORDS: Hirudotherapy, Medicinal leech, Hirudo medicinalis, Flap salvage, Venous congestion, Replantation, Plastic and reconstructive surgery, Hirudin.

INTRODUCTION

Medicinal leeches have a documented history in medicine spanning more than two millennia, having been used historically in Ayurvedic, Greek, Roman, Egyptian, and later European medical traditions, predominantly for bloodletting.[1,2] With the decline of humoral theories of disease in the nineteenth century, leech use fell into disfavour, only to re-emerge in the mid-twentieth century when Derganc and Zdravic first reported its modern surgical application in the salvage of congested skin flaps in 1960.[3] Since then, leech therapy has become firmly established in reconstructive microsurgery, and medicinal leeches were formally approved by the United States Food and Drug Administration as a medical device for use in plastic and reconstructive surgery in July 2004.[2]

The single most important application of medicinal leeches in contemporary plastic surgery is the management of venous congestion in flaps and replanted tissue, a complication that can progress to partial or complete tissue necrosis within as little as three hours if untreated.[4]

Free and pedicled flap reconstruction is now routine in oncological, traumatic, and congenital reconstructive surgery, but remains vulnerable to microvascular compromise; postoperative venous thrombosis is widely regarded as the most common and rapidly damaging vascular event affecting flap viability.[5] When surgical re-exploration and revision of the venous anastomosis are not feasible or fail to relieve congestion, hirudotherapy offers a practical, low-cost, non-surgical means of providing temporary venous outflow until spontaneous inosculation and neovascularisation restore physiological drainage.[4,6] Notably, this modern surgical application draws directly on a therapeutic tradition first systematically documented in classical Ayurvedic surgery, where leech application (Jalaukavacharana) was already described as a distinct and preferred method of controlled bloodletting nearly two millennia before its adoption into Western reconstructive microsurgery.[1,43] This review synthesises current evidence on the classical Ayurvedic foundations, biology, indications, technique, efficacy, complications, and alternatives of medicinal leech therapy as applied to plastic and reconstructive surgery.

THE AYURVEDIC PERSPECTIVE: JALAUKAVACHARANA

Long before its incorporation into Western reconstructive microsurgery, leech therapy occupied a well-defined place in classical Ayurvedic surgery under the name Jalaukavacharana — literally, the 'application (avacharana) of the water-dwelling creature (jalauka)'.[43] Acharya Sushruta, traditionally regarded as the father of surgery and dated to approximately the sixth to seventh century BCE, devoted an entire chapter of the Sutrasthana of the Sushruta Samhita (the Jalaukavacharaniya Adhyaya) to the selection, classification, and clinical use of medicinal leeches, describing Jalaukavacharana as the most refined and least invasive of the recognised methods of Raktamokshana, or therapeutic bloodletting.[36,43]

Sushruta classified leeches into twelve varieties, divided equally into six poisonous (Savisha) and six non-poisonous (Nirvisha) types, distinguished by their breeding habitat, physical appearance, and behaviour; leeches bred in clean, fresh water bodies rooted with lotus and water-lily were considered Nirvisha and fit for therapeutic use, whereas those from stagnant, contaminated, or decomposing water were classified as Savisha and explicitly proscribed for clinical application because of the systemic toxicity — swelling, itching, fainting, and burning — that their bite could produce.[36,37,43] This classical requirement to positively identify and select only clean, medically suitable leeches, and to reject those from contaminated sources, anticipates by many centuries the modern practice of sourcing certified, laboratory-reared Hirudo medicinalis for clinical use and of screening leech holding-tank water for pathogenic organisms such as Aeromonas before treatment.[36]

In Ayurvedic pathophysiology, chronic non-healing wounds, venous stasis, and related inflammatory conditions are understood as manifestations of vitiated Rakta (blood tissue) frequently complicated by aggravated Pitta and Kapha dosha; Jalaukavacharana was specifically indicated where blood vitiated by Pitta required removal, since the leech — being cold in potency and naturally adapted to water — was considered ideally suited to draw out Pitta-dominant vitiated blood without the systemic disturbance of more aggressive bloodletting techniques such as Siravedha (venesection).[38,41] Classical texts recommend Jalaukavacharana across a range of surgical and medical conditions attributed to Rakta Dushti, including Vidradhi (abscess), Gulma (abdominal lump/mass), Arsha (haemorrhoids), Kushtha (skin disorders), and Vata-Rakta (a condition with clinical parallels to gout and peripheral vascular disease), several of which correspond closely to the venous congestion,

inflammatory skin conditions, and vascular insufficiency states for which hirudotherapy is used today.[38.41]

Sushruta further noted that Jalaukavacharana was the gentlest and most convenient mode of bloodletting, and for this reason was specifically recommended for patients least able to tolerate more invasive procedures — kings and the wealthy, children, the elderly, the timid, the debilitated, women, and those of delicate constitution.[36] This classical emphasis on a minimally invasive, well-tolerated technique for vulnerable patients mirrors the rationale for using leech therapy in modern reconstructive surgery, where it is similarly reserved for clinical situations — surgically uncorrectable venous congestion in a compromised flap or a delicate replanted digit — in which further invasive intervention would carry disproportionate risk.[26,43] The prolonged discontinuity of this tradition following the rise of antibiotics and mid-twentieth-century Western medicine, and its subsequent independent rediscovery by reconstructive surgeons from the 1960s onward, is increasingly recognised in the literature as a re-convergence with, rather than an entirely novel departure from, principles already established in the Sushruta Samhita.[43]

BIOLOGY OF THE MEDICINAL LEECH AND MECHANISM OF ACTION

The medicinal leech, most commonly Hirudo medicinalis (with Hirudinaria species also used in South Asia), is a haematophagous annelid that, during feeding, makes a characteristic Y-shaped incision using three jaws lined with fine teeth, and can ingest up to several times its own body weight in blood over a single feeding session lasting approximately 20 to 60 minutes.[7] The therapeutic effect of the leech arises not primarily from the volume of blood removed by active sucking, but from the pharmacologically active substances secreted in its saliva during feeding and from continued oozing of blood from the bite site for several hours after the leech has spontaneously detached.[8,9]

More than twenty distinct bioactive compounds have been identified in leech saliva, broadly grouped by their pharmacological actions.[9,10]

- Hirudin — a 65 to 66 amino acid polypeptide and the most potent naturally occurring direct thrombin inhibitor known, which prevents fibrinogen conversion to fibrin and has also been shown experimentally to promote angiogenesis and neovascularisation in congested flap tissue by upregulating vascular endothelial growth factor expression.[9,11,12]
- Calin — inhibits von Willebrand factor–mediated platelet adhesion to collagen, thereby suppressing platelet aggregation at the site of vascular injury.[13]

- Hyaluronidase — a spreading factor that increases the permeability of connective tissue, facilitating diffusion of other salivary components into surrounding tissue.[9]
- Destabilase — possesses fibrinolytic (thrombolytic) glycosidase activity, dissolving early fibrin clots.[9,10]
- Apyrase — a non-specific inhibitor of platelet aggregation.[9]
- Eglins and bdellins — small protease inhibitors with anti-inflammatory activity, inhibiting trypsin, plasmin, chymotrypsin, and neutrophil elastase.[9,10]
- Hirustasin, guamerin, and related antistasin-type inhibitors — additional serine-protease inhibitors contributing to the anticoagulant and anti-inflammatory profile of leech saliva.[10,14]
- Vasodilatory and anaesthetic substances, including histamine-like compounds and acetylcholine, which promote local vasodilatation and account for the characteristically painless nature of the leech bite.[9,10]

Collectively, these compounds decongest stagnant venous blood, inhibit local thrombus propagation, increase local blood flow, and reduce inflammatory tissue injury, providing a temporary physiological substitute for venous drainage in tissue where surgical venous outflow has failed or cannot be re-established.[9,10] Continued passive oozing from the bite site after leech detachment — rather than the leech's active blood meal alone — is considered a major contributor to sustained decongestion of the flap over the following hours.[8] In Ayurvedic terms, this biochemically mediated removal of stagnant, 'vitiated' blood and the accompanying resolution of local swelling and discolouration can be seen as a physiological restatement of the classical rationale for Jalaukavacharana in conditions of Rakta Dushti, even though the underlying molecular mechanisms were, naturally, unknown to the classical authors.[38,43]

INDICATIONS IN PLASTIC AND RECONSTRUCTIVE SURGERY

Salvage of Free and Pedicled Flaps with Venous Congestion

Prevention of flap necrosis secondary to venous congestion is the most frequent indication for hirudotherapy in plastic surgery.[6] Clinical signs of venous congestion include a cyanotic or dusky discolouration of the flap, increased tissue turgor, a cool tactile temperature paradoxically accompanied by brisk and dark capillary refill, and rapid, dark dermal bleeding on pinprick testing.[6] When venous obstruction cannot be corrected surgically — for example, when re-exploration of the anastomosis is not possible or has already failed —

leech therapy can serve as a bridge therapy until inosculation and collateral venous outflow are established.[4,15] Leech application has been reported across a wide range of flap types and reconstructive sites, including lower and upper extremity flaps, head and neck reconstruction, breast reconstruction, and trunk reconstruction.[16]

Digit Replantation and Revascularisation

The use of leeches in distal digit replantation, where venous anastomosis is often technically difficult or impossible owing to the small calibre of digital veins, was described as early as 1991 and remains a well-established indication.[17] Leech therapy provides temporary venous drainage for the replanted digit until neovascularisation occurs, and is used both in complete replantation and in revascularisation of partially amputated or devascularised digits.[16,18]

Replantation of the Ear, Nose, Lip, Scalp, and Other Composite Tissues

Leech therapy has also been documented in the salvage of replanted or revascularised composite tissues where venous repair is technically limited, including microsurgical ear replantation (in some cases performed with a single arterial anastomosis and leeches substituting entirely for venous anastomosis), nasal tip and total nose replantation, lip replantation, and salvage of partial facial soft-tissue avulsions.[19,22] Isolated reports also describe its use for congested nipple-areolar reconstructions and other small composite grafts.[6]

Hematoma and Other Post-Reconstructive Indications

Beyond frank venous congestion, leech therapy has been used to manage localised hematoma and early signs of flap-tip compromise following reconstructive procedures. In a single-centre retrospective series of 23 consecutive cases in which leeches were used after plastic reconstructive surgery, the leading indications were venous congestion (52%) and hematoma (39%), with a smaller proportion of cases (9%) treated for incipient necrosis at the flap tip.[23]

CLINICAL PROTOCOL AND TECHNIQUE OF APPLICATION

Although the literature on leech therapy is heterogeneous and no universally standardised protocol exists, several recurring elements characterise its clinical use in plastic and reconstructive surgery.[24]

- Selection of medically certified, laboratory-reared leeches (typically Hirudo medicinalis), stored and transported under controlled, hygienic conditions.

- Cleaning of the congested area and application of one or more leeches directly to the most congested portion of the flap or replanted tissue, allowing the leech to attach and feed until spontaneous detachment, generally over 20 minutes to several hours.
- The number of leeches applied per session is generally titrated to the size and degree of congestion of the flap, and the frequency of application commonly ranges from every two to eight hours during the acute phase of congestion.
- Treatment is typically continued for four to ten days, or until clinical signs of congestion resolve and neovascularisation is judged to be established, after which therapy is tapered and discontinued.[24,25]
- Leeches must never be forcibly removed (for example, by pulling or applying salt), as this can induce regurgitation of gut contents into the bite wound and increase the risk of bacterial infection; spontaneous detachment following completion of the blood meal is the recommended method.[9]
- Each leech is used on a single patient only and is subsequently destroyed according to institutional biomedical waste protocols; leeches are never reused between patients.[9,24]

Close clinical and haematological monitoring is essential throughout the treatment course. Historical protocols recommend clinical and blood-count review as frequently as every four hours during active leeching, given the risk of substantial cumulative blood loss from both the leech bite and continued post-detachment oozing.[9,26]

EVIDENCE OF EFFICACY

Reported tissue salvage rates following leech therapy vary considerably across published case series, systematic reviews, and institutional retrospective studies, reflecting differences in tissue type, indication, protocol, and definition of 'success'. A systematic review of 277 clinical cases in plastic and reconstructive surgery reported an overall tissue salvage rate of 77.98%, with the remaining tissue ultimately requiring surgical resection.[27] A subsequent literature review pooling ten studies and 298 patients found that 60.73% of flaps were entirely or partially salvaged following leech therapy, 16.77% were lost entirely, and outcomes were not clearly reported for the remainder.[4] Table 1 summarises salvage outcomes reported across several representative studies.

Table 1: Representative Reported Outcomes of Leech Therapy for Flap and Replant Salvage.

Study / Author(s)	Setting / Tissue	N	Reported Salvage Outcome
Whitaker et al., 2012[27]	Plastic & reconstructive surgery, systematic review	277	77.98% overall salvage rate
Herlin et al., 2017[24]	Systematic review, 1960–2015 (41 studies analysed)	43 (subset)	~84% total/partial salvage; 16% loss
Cornejo et al., 2017[16]	Single institution, mixed flap sites (extremity, head/neck, trunk)	87	60.9% total/partial salvage (51.7% total + 9.2% partial); 39.1% loss
Butt et al., 2016[28]	Flaps and digital replants/revascularisations, 2-year regional review	20 tissues / 18 pts	65% overall salvage; pedicled flaps 100% (6/6); free flaps 0/2; digital revascularisation 67%; digital replants 25%
Nguyen et al., 2012[29]	Institutional flap salvage series	10 (in pooled analysis)	100% salvage reported in this series
Chepeha et al., 2002[30]	Surgically unsalvageable venous obstruction after free tissue transfer	8	Complete tissue survival without Aeromonas infection using dual antibiotic prophylaxis

Outcomes are consistently better for pedicled flaps, where an intact arterial pedicle supports the tissue while leeches manage isolated venous outflow problems, than for free flaps or digital replants, where both arterial and venous supply may already be tenuous.[28] A comparative institutional study also found that patients requiring leech therapy for surgically uncorrectable venous congestion after free flap breast reconstruction had a numerically higher total flap loss rate than those whose congestion was managed surgically, although this difference did not reach statistical significance and was confounded by a markedly higher prevalence of obesity in the leech therapy group.[31] These findings reinforce that leech therapy functions best as an adjunct for otherwise unsalvageable congestion, rather than a substitute for meticulous microsurgical technique and, where feasible, surgical re-exploration.[4,24]

COMPLICATIONS AND RISK MANAGEMENT

Blood Loss and Anemia

Blood loss is an expected and, indeed, therapeutically intended consequence of leech therapy, but can be substantial when treatment is prolonged or numerous leeches are required.

Reported blood transfusion requirements vary widely across series, with some studies reporting that approximately half to all treated patients required transfusion, and packed red blood cell requirements ranging from as few as one to as many as twenty-eight units over a treatment course.[9] Regular clinical and haematological monitoring — historically recommended at four-hourly intervals during active leeching — is therefore essential, with transfusion generally indicated once haemoglobin falls below approximately 8 g/dL.[9,26]

Aeromonas Infection and Antibiotic Prophylaxis

The most significant infectious risk of leech therapy arises from Aeromonas species (principally Aeromonas hydrophila and Aeromonas veronii), which are natural symbionts residing in the leech gut and assist the leech in digesting its blood meal.[32,33] Reported infection rates following leech therapy range from approximately 2.4% to 20%, and infection can present acutely within the first 24 hours or in a delayed fashion up to several weeks after treatment; established infection frequently jeopardises flap or replant survival and can, in severe cases, progress to septicaemia.[9,33,34]

Fluoroquinolones (particularly ciprofloxacin), trimethoprim-sulfamethoxazole, and third-generation cephalosporins have historically been the most widely used prophylactic agents, and combined or dual-agent regimens (for example, ciprofloxacin with trimethoprim-sulfamethoxazole) have been proposed as offering the most reliable prophylaxis.[34,35]

However, an increasing number of case reports describe Aeromonas isolates resistant to ciprofloxacin, and, more recently, isolates demonstrating resistance to all three major first-line prophylactic antibiotic classes simultaneously, raising serious concern about the long-term reliability of empirical prophylaxis.[35,37] Proposed strategies to mitigate this risk include culturing water from leech holding tanks to identify local resistance patterns before treatment, using antibiotic-fed or otherwise decontaminated leech stocks, and closer institutional antimicrobial stewardship collaboration between surgeons and infectious disease specialists.[36,38] Because no antibiotic regimen can fully sterilise the leech gut, patient-directed systemic antibiotic prophylaxis for the duration of leech therapy — rather than reliance on leech decontamination alone — remains the primary infection control strategy.[9,38]

Other Complications

Less common complications reported in the literature include prerenal azotemia, intensive-care-unit psychosis, congestive cardiac decompensation from excessive blood loss, pneumonia, non-Aeromonas wound infection, decubitus ulceration from prolonged immobilisation, and hematoma at sites distant from the leech bite.[9] Patient and caregiver anxiety or aversion to the use of leeches is also a recognised, if underreported, barrier to acceptance and adherence in some settings.[6]

Contraindications

Recognised contraindications to hirudotherapy include patient refusal of leech therapy or of the potential need for subsequent blood transfusion, arterial inflow ischemia (since leech therapy addresses venous, not arterial, insufficiency), immunocompromised states such as advanced HIV infection (a recognised risk factor for Aeromonas infection), prior leech exposure with risk of anaphylaxis or known allergy, haemodynamic instability, haematological malignancy, severe anemia, decompensated hepatobiliary disease, cachexia, pregnancy and lactation, a predisposition to keloid scarring, and recent use of anticoagulant, immunosuppressive, or vasoactive medications.[9]

CONTROVERSIES AND ALTERNATIVE TECHNIQUES

Despite decades of clinical use, the evidence base for medicinal leech therapy remains limited chiefly to case reports, case series, and retrospective institutional reviews; randomised controlled trials are lacking, and the true comparative efficacy of leech therapy versus surgical re-exploration, mechanical decongestion, or pharmacological anticoagulation for flap venous congestion remains incompletely defined.[6,24] This evidentiary gap, combined with the growing recognition of multidrug-resistant Aeromonas infections, has contributed to variable confidence and inconsistent adoption of hirudotherapy among plastic surgeons and trainees.[6]

Several alternative or complementary techniques for managing venous congestion have therefore been explored. Mechanical venous catheterisation (controlled bleeding through a small indwelling cannula) has been directly compared with leech therapy for sural flap congestion, with one study reporting fewer instances of flap necrosis, infection, and wound complications, together with greater patient and nursing satisfaction, using venous catheterisation, although at the cost of somewhat less blood removed per session compared with leeches.[39] Other adjuncts and thromboprophylactic strategies used in microsurgery —

including systemic or local heparin, low-molecular-weight heparin, aspirin, dextran-40, prostaglandin E1, and nitric oxide donors — target different points in the coagulation and inflammatory cascade and may be used alongside, rather than instead of, leech therapy in selected cases, though none has been shown definitively to improve flap survival over meticulous surgical technique alone.[24,40] Mechanical or 'artificial leech' devices, which apply controlled suction and local heparin infusion to mimic the decongestive effect of a biological leech without the associated infective risk, have also been described as an emerging alternative, though clinical experience remains limited.[6]

CURRENT EVIDENCE GAPS AND FUTURE DIRECTIONS

- Well-designed prospective and, where ethically and practically feasible, randomised comparative studies are needed to clarify the true incremental benefit of leech therapy over surgical re-exploration and other adjuncts for specific tissue types and clinical scenarios.
- Standardisation of leech application protocols — including number of leeches, frequency, and total duration of therapy — would improve comparability of future studies and support development of evidence-based clinical guidelines.
- Ongoing surveillance of Aeromonas antimicrobial resistance patterns, and development of updated, evidence-based prophylactic antibiotic recommendations, are urgently required given emerging multidrug resistance.
- Further research into recombinant and synthetic analogues of leech salivary compounds (for example, recombinant hirudin/lepirudin) may eventually allow the therapeutic benefits of hirudotherapy to be delivered without the infective and psychological drawbacks of live leech application.
- Comparative studies of mechanical decongestion devices and venous catheterisation against biological leech therapy would help define their respective roles in modern reconstructive practice.

CONCLUSION

Far from being a purely modern innovation, medicinal leech therapy in plastic and reconstructive surgery represents the clinical re-convergence of a technique first systematically codified in classical Ayurvedic surgery as Jalaukavacharana, with the biochemical and microsurgical understanding developed over the past century. Medicinal leech therapy remains a valuable, low-cost, and biologically plausible adjunct for the salvage

of flaps and replanted or revascularised tissue compromised by venous congestion in plastic and reconstructive surgery. Its efficacy is best supported for pedicled flaps and selected replantation scenarios where an intact arterial supply allows leech-mediated venous decongestion to bridge the gap until spontaneous neovascularisation restores physiological drainage; results in free flaps and complex digital replants are more variable. The principal risks — clinically significant blood loss and Aeromonas infection — are manageable with vigilant haematological monitoring and appropriate antibiotic prophylaxis, though rising antimicrobial resistance among Aeromonas isolates warrants continued surveillance and institutional protocol development. Given the current paucity of randomised controlled trials, further rigorously designed comparative research is needed to define optimal patient selection, standardised application protocols, and the comparative role of emerging mechanical and pharmacological alternatives, so that hirudotherapy can be applied with maximal benefit and minimal risk in modern reconstructive practice.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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