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Original Article

Modified Negative Pressure Wound Therapy Using a Romovac Drain in Resource-Limited Settings: An Economical Technical Alternative for Complex Wound Management

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ABSTRACT

Background: Negative pressure wound therapy (NPWT) has emerged as an effective adjunct in the management of acute and chronic wounds by promoting angiogenesis, reducing edema, decreasing bacterial colonization, and accelerating granulation tissue formation. However, the widespread adoption of commercially available NPWT systems remains limited in low- and middle-income countries because of their high acquisition and maintenance costs. Cost-effective indigenous alternatives are therefore of considerable clinical interest.
Technical Report: We describe a simplified NPWT technique utilizing a standard Romovac closed-suction drainage system, sterile polyurethane foam, and transparent adhesive film to create an airtight negative pressure environment. The technique employs materials routinely available in general surgical practice and can be assembled without specialized equipment. Illustrative clinical photographs from patients treated at our institution demonstrate practical application of the method in extensive lower-limb soft tissue defects.
Discussion: The modified system reproduces the essential principles of conventional NPWT while substantially reducing procedural costs. Its simplicity and accessibility make it particularly attractive for public hospitals and resource-constrained healthcare settings. Existing evidence supporting NPWT suggests that controlled negative pressure enhances wound healing through macrodeformation, microdeformation, exudate removal, improved tissue perfusion, and stimulation of granulation tissue formation.
Conclusions: A Romovac-based NPWT dressing represents a practical and economical alternative when commercial vacuum-assisted closure devices are unavailable or unaffordable. Although encouraging from a technical standpoint, prospective comparative studies are required to evaluate clinical outcomes and establish equivalence with commercially available systems.

Keywords: *Negative pressure wound therapy, vacuum-assisted closure, Romovac drain, wound healing, low-cost innovation, resource-limited settings, chronic wounds.*

INTRODUCTION

Complex wounds remain a major challenge in contemporary surgical practice, particularly in developing countries where delayed presentation, high-energy trauma, diabetic foot disease, chronic infections, and socioeconomic barriers frequently complicate management. Extensive soft tissue defects resulting from trauma, surgical debridement, or chronic ulceration often expose deep structures such as tendon, bone, or neurovascular bundles, necessitating prolonged wound bed preparation before definitive closure can be attempted. Diabetic foot ulceration in particular constitutes one of the most common indications for advanced wound care, with a substantial proportion of affected patients remaining at risk of limb loss in the absence of timely and effective intervention.[1] Large soft tissue defects often require repeated dressing changes, prolonged hospitalization, and delayed definitive reconstruction, increasing both healthcare expenditure and patient morbidity, and placing considerable strain on nursing and surgical resources in already resource-constrained hospitals.

Since its introduction by Argenta and Morykwas, negative pressure wound therapy (NPWT) has transformed the management of acute and chronic wounds by providing controlled subatmospheric pressure to the wound environment.[2] Their original animal studies established the basic physiological foundation for the technique, demonstrating that continuous or intermittent negative pressure applied through an open-cell foam interface accelerates granulation tissue formation and improves the rate of wound contraction.[3] Subsequent mechanistic investigations, including systematic reviews of the molecular pathways involved, have clarified that these benefits arise from two complementary biomechanical effects: macrodeformation, in which the foam and overlying negative pressure draw wound edges together and reduce overall wound volume, and microdeformation, in which localized mechanical strain at the cellular level stimulates fibroblast proliferation, extracellular matrix synthesis, and capillary ingrowth.[4-8]

Beyond these mechanical effects, negative pressure has been shown to reduce interstitial edema, enhance local tissue perfusion, and continuously evacuate wound exudate, thereby lowering the concentration of inflammatory mediators and reducing bacterial bioburden within the wound bed.[9-11] Vacuum-assisted closure has further been shown to promote angiogenesis and to create a moist, protected wound environment that is comparatively resistant to exogenous contamination, an effect of particular relevance in heavily colonized or high-risk wounds.[12]

Over the past two decades, the clinical indications for NPWT have expanded considerably beyond its original description. It is now used routinely in the management of traumatic soft tissue injuries and degloving wounds, diabetic foot ulcers, fasciotomy wounds following compartment syndrome, burns, skin graft stabilization, closed surgical incisions at high risk of dehiscence, and wounds healing by secondary intention.[13-17] Systematic reviews and meta-analyses, including a Cochrane review addressing pressure ulcers, have generally reported favorable outcomes for NPWT compared with conventional dressings in terms of wound bed preparation and healing, although the certainty of evidence varies considerably across wound types and study designs, and many included trials remain small or methodologically heterogeneous.[13,14,18-21]

The technology itself has continued to evolve substantially since its introduction. Contemporary commercial platforms now include canister-free and single-use disposable systems, portable battery-operated devices suitable for ambulatory use, negative pressure wound therapy with instillation and dwell time for heavily contaminated or infected wounds,[22] and, more recently, systems incorporating smart sensors for continuous monitoring of pressure delivery and exudate volume.[23-25] These innovations have improved convenience and expanded the clinical scope of NPWT in well-resourced settings.

Despite these advances, commercial NPWT systems remain prohibitively expensive for many institutions in low- and middle-income countries. The recurring costs associated with proprietary foam dressings, dedicated vacuum pumps, disposable canisters, and single-use consumables frequently exceed the financial capacity of both public hospitals and individual patients, effectively excluding a large proportion of patients who might otherwise benefit from this therapy.[20] This disparity has driven growing interest in locally assembled alternatives capable of reproducing the essential biological principles of NPWT using materials already stocked in general surgical practice, without reliance on proprietary consumables or dedicated capital equipment.

Several investigators have therefore explored indigenous modifications constructed from routinely available hospital supplies, typically combining an open-cell foam dressing, an occlusive adhesive film, and a suction source capable of generating and maintaining subatmospheric pressure. One such modification incorporates a Romovac closed-suction drainage device, a system already familiar to most surgeons and readily available in operating theatres, into an improvised NPWT assembly. Because this device requires no additional procurement, specialized training, or dedicated infrastructure, it offers a potentially scalable solution for institutions where commercial vacuum-assisted closure systems are unavailable or unaffordable.

This technical report describes the construction and application of a Romovac-based NPWT dressing and discusses its potential role as an economical alternative in resource-constrained healthcare environments.

MATERIALS AND METHODS

Materials Required

The dressing assembly requires only materials that are routinely available in most operating theatres, obviating the need for specialized or proprietary equipment:

- Sterile polyurethane foam
- Romovac closed-suction drainage system
- Transparent adhesive occlusive film
- Sterile gauze
- Sterile scissors
- Skin preparation solution
- Adhesive strips, if additional reinforcement of the seal is required

No dedicated vacuum machine, canister, or proprietary consumable is required for assembly or operation of the system.

Surgical Technique

Following thorough wound assessment, adequate surgical debridement is performed until all devitalized tissue has been removed and healthy, bleeding wound margins are achieved.

Sterile polyurethane foam is then fashioned to conform to the dimensions and contour of the wound and gently placed over the wound bed. The fenestrated segment of the Romovac drain is positioned within or immediately above the foam so as to permit uniform suction across the entire dressing.

Transparent adhesive film is applied circumferentially over the foam and the adjacent intact skin to establish an airtight seal, and the external drain tubing is connected to the Romovac suction reservoir to generate continuous negative pressure across the wound surface.

Seal integrity should be verified immediately after application, and exudate output should be monitored throughout the course of therapy. Dressings may subsequently be changed according to individual wound characteristics and institutional protocol.

Biological Basis of Negative Pressure Wound Therapy

The beneficial effects of NPWT arise from multiple physiological mechanisms.

Reduction of Tissue Edema

Continuous removal of interstitial fluid lowers tissue pressure, thereby improving capillary perfusion and oxygen delivery.

Enhancement of Granulation Tissue Formation

Mechanical microdeformation stimulates fibroblast proliferation, extracellular matrix production, and angiogenesis, resulting in accelerated granulation tissue development.

Improved Local Blood Flow

Experimental studies have demonstrated increased perfusion surrounding wounds subjected to controlled negative pressure, facilitating nutrient delivery and tissue repair.

Reduction of Wound Exudate

Continuous evacuation of exudate prevents fluid accumulation while reducing concentrations of inflammatory mediators.

Mechanical Wound Contraction

Macrodeformation generated by negative pressure approximates wound edges and contributes to reduction in wound dimensions.

Optimization for Definitive Reconstruction

NPWT frequently produces a healthier wound bed suitable for split-thickness skin grafting or flap reconstruction.

Illustrative Clinical Examples

The present report includes representative clinical photographs demonstrating application of the Romovac-based NPWT technique.

Case Series:

Example 1

A 22-year-old male presented with an extensive soft tissue defect involving the dorsum of the foot following surgical debridement. Clinical photographs demonstrate a clean wound bed with healthy granulation tissue prior to application of the modified dressing.

Subsequent images illustrate construction of the indigenous NPWT system using polyurethane foam covered by transparent adhesive film and connected to a Romovac suction drain to establish continuous negative pressure.
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Fig 1.

Fig 2

Fig 3

Example 2

An additional lower-limb wound is presented to demonstrate reproducibility of the technique across varying wound configurations. The photograph highlights secure sealing of the dressing and integration of the Romovac drainage system using routinely available surgical materials.

These images are included solely for technical illustration and should not be interpreted as evidence of efficacy beyond the individual casesdepicted.

RESULTS

The Romovac-based negative pressure wound therapy assembly was successfully constructed and applied in both illustrative cases using only materials routinely available in general surgical practice, without the need for a dedicated vacuum pump or proprietary consumables. Sterile polyurethane foam could be trimmed and fitted to each wound bed without difficulty, and the fenestrated segment of the Romovac drain was consistently positioned to permit uniform suction across the foam interface.

An airtight seal was achieved and maintained using standard transparent adhesive film in both cases, including the extensive dorsal foot defect in Example 1 and the lower-limb wound in Example 2, despite differences in wound location, contour, and surface area. Once connected to the Romovac suction reservoir, continuous negative pressure was generated and sustained throughout the period of dressing wear, with no loss of seal integrity or reservoir malfunction observed during application.

The technique proved reproducible across two anatomically distinct wound types, supporting its adaptability to varying wound configurations encountered in routine surgical practice. Assembly required no additional specialized training beyond familiarity with standard closed-suction drainage systems, and no equipment beyond that already stocked in the operating theatre was necessary.

Because this report is descriptive and technical in nature, formal quantitative outcome measures such as time to complete granulation, percentage reduction in wound area, infection rates, or requirement for subsequent reconstructive procedures were not systematically recorded and therefore fall outside the scope of the present results. These parameters, together with direct outcome comparisons against commercially available NPWT systems, are identified as priorities for future prospective evaluation, as discussed below.

Advantages of the Romovac-Based Modification

The proposed technique offers several practical advantages.

- Considerably lower cost compared with commercial NPWT systems.
- Readily available materials in most district and tertiary hospitals.
- Minimal additional training required for assembly.
- Easy adaptation into routine surgical practice.
- Potential reduction in frequency of conventional dressing changes.
- Applicability to traumatic wounds, diabetic foot ulcers, fasciotomy wounds, and post-debridement defects.
- Particularly valuable in government hospitals and economically constrained settings.

DISCUSSION

Negative pressure wound therapy has become an integral component of modern wound management because of its ability to optimize the wound microenvironment through continuous removal of exudate, reduction of tissue edema, mechanical stabilization of the wound bed, and promotion of angiogenesis and granulation tissue formation. Experimental and clinical investigations have demonstrated that controlled subatmospheric pressure induces both macrodeformation and microdeformation, resulting in enhanced cellular proliferation and extracellular matrix remodeling that collectively accelerate wound healing.

Recent reviews have further emphasized that NPWT is no longer restricted to chronic wounds but is now routinely employed for traumatic soft tissue injuries, diabetic foot ulcers, fasciotomy wounds, skin graft stabilization, burns, and management of complex postoperative wounds. Technological advances have expanded the availability of canister-free systems, portable devices, instillation therapy, and smart monitoring technologies, illustrating the continuing evolution of NPWT platforms.

Despite these advances, the cost of commercial systems remains a major obstacle in many low- and middle-income countries. Expenditure related to dedicated vacuum pumps, proprietary polyurethane foams, disposable canisters, and maintenance often exceeds the financial capacity of both healthcare institutions and patients. Consequently, surgeons working in resource-constrained environments have increasingly explored locally assembled alternatives intended to reproduce the biological principles of NPWT using readily available hospital supplies.

The Romovac-based modification described in this report follows the same fundamental therapeutic concept. By combining sterile polyurethane foam, an occlusive adhesive dressing, and a standard closed-suction drainage reservoir, the system creates a sealed environment capable of delivering sustained negative pressure without dependence on specialized equipment. Because Romovac drains are routinely stocked in most operating theatres, implementation requires minimal additional infrastructure or procurement.

From a practical perspective, this modification offers several potential advantages. The assembly is simple, inexpensive, reproducible, and can be performed by surgeons familiar with standard closed-suction drainage systems. Such accessibility may facilitate earlier adoption of advanced wound management strategies in district hospitals and government institutions where commercial NPWT devices are unavailable.

However, several important limitations deserve consideration. Commercial NPWT systems provide calibrated pressure regulation, leak detection, programmable therapy modes, and continuous monitoring of vacuum delivery. In contrast, indigenous modifications may demonstrate variability in negative pressure generation and maintenance depending on drain characteristics, reservoir function, dressing integrity, and operator technique. Standardization therefore remains a challenge.

Systematic reviews evaluating NPWT have generally demonstrated favorable outcomes compared with conventional dressings for wound bed preparation and healing, although the certainty of evidence varies across wound types and many studies remain heterogeneous. Importantly, these data cannot be directly extrapolated to improvised systems because equivalent pressure delivery and clinical performance have not been comprehensively validated.

Accordingly, the present report should be interpreted as a description of a technically feasible and economically attractive alternative rather than evidence of therapeutic equivalence. The accompanying clinical photographs illustrate practical application of the technique but are not intended to establish efficacy. Future prospective studies should evaluate objective clinical endpoints including time to granulation tissue formation, reduction in wound dimensions, infection rates, requirement for reconstructive procedures, hospital length of stay, patient satisfaction, and overall treatment costs.

In resource-limited healthcare systems where financial constraints frequently delay or preclude access to commercial NPWT, low-cost adaptations such as the Romovac-based technique may represent an important bridge between conventional dressings and proprietary vacuum-assisted closure devices. Establishing standardized protocols and validating outcomes through controlled clinical research should be considered priorities for future investigation.

Amlani et al. conducted a prospective case series evaluating a low-cost negative pressure wound therapy device, constructed from an aquarium pump costing less than $100, for the management of musculoskeletal injuries at a hospital in Cameroon. Among patients with documented outcome data, the improvised system achieved successful wound closure in the majority of cases, and most treating providers rated the device as clinically beneficial, supporting the feasibility of low-cost NPWT alternatives in similarly resource-constrained settings. **(26)**

Knulst et al. designed and bench-tested the WOCA device, a portable, battery-powered negative pressure wound therapy system purpose-built for use in low- and middle-income countries, featuring adjustable pressure settings, overflow protection, and system-state alarms. Field prototypes were constructed and evaluated in Nepal, demonstrating that a safe, affordable, and user-friendly alternative to commercial NPWT platforms can be engineered specifically for resource-limited healthcare environments. **(27)**

Kodjo et al. reported a case of an immunocompromised child with an extensive septic thigh wound successfully managed using an improvised vacuum-assisted closure device in a resource-limited hospital setting in Ghana, highlighting the applicability of indigenous NPWT modifications even in complex pediatric and immunocompromised patients where commercial systems remain inaccessible. **(28)**

CONCLUSIONS

Commercial negative pressure wound therapy has become an indispensable component of modern wound management but remains inaccessible for many patients because of financial constraints.

The Romovac-based modified NPWT system described in this report offers a simple, reproducible, and economical alternative constructed from routinely available surgical materials. By preserving the core principles of vacuum-assisted wound therapy while significantly reducing expenditure, this technique may represent a valuable option for surgeons practicing in resource-limited environments.

Future prospective comparative studies are warranted to validate clinical outcomes and define its role within standardized wound care protocols.

Limitations

Although technically feasible, this modified system has inherent limitations.

Unlike commercial NPWT devices, precise regulation of negative pressure may not be consistently achievable. Variability in airtight sealing techniques and differences in locally available materials may influence performance. Furthermore, robust comparative clinical data remain limited.

Consequently, this technique should currently be regarded as an economical adaptation rather than a replacement for commercially engineered NPWT systems.

Declarations
Conflicts of Interest
The authors declare no competing interests.

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Ethics Statement
The illustrative clinical images included in this report were obtained with appropriate patient consent for academic publication. This technical report describes a surgical technique and does not present comparative clinical outcome data.

Author Contributions
All authors contributed to the conception, preparation, drafting, and critical revision of the manuscript and approved the final version.

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