

Prospective Study to Evaluate the Clinical and Functional Outcome of Negative Pressure Wound Therapy in Management of Compound Fractures of Lower Limb

Pranav Kothiyal^{1*}, Mohd. Shifa Hasan², Arpit Vishnoi³, Vijay Gangwar⁴

¹Professor, Department of Orthopaedics, Sri Guru Ram Rai Institute of Medical and Health Sciences, Dehradun, India.

²Associate Professor, Department of Orthopaedics, Sri Guru Ram Rai Institute of Medical and Health Sciences, Dehradun, India.

³Assistant Professor, Department of Orthopaedics, Sri Guru Ram Rai Institute of Medical and Health Sciences, Dehradun, India.

⁴Junior Resident, Department of Orthopaedics, Sri Guru Ram Rai Institute of Medical and Health Sciences, Dehradun, India.

*Corresponding Author: Pranav Kothiyal, Professor, Department of Orthopaedics, Sri Guru Ram Rai Institute of Medical and Health Sciences, Dehradun, India.

<https://doi.org/10.58624/SVOAOR.2026.06.032>

Received: September 15, 2026

Published: October 26, 2026

Citation: Kothiyal P, Hasan MS, Vishnoi A, Gangwar V. Prospective Study to Evaluate the Clinical and Functional Outcome of Negative Pressure Wound Therapy in Management of Compound Fractures of Lower Limb. *SVOA Orthopaedics* 2026; 6:5, 242-251. doi: 10.58624/SVOAOR.2026.06.032

Abstract

Background: Compound fractures of the lower limb are frequently associated with extensive soft-tissue damage, contamination, and a high risk of infection and delayed wound healing. Negative pressure wound therapy (NPWT) has emerged as an effective adjunct in the management of complex traumatic wounds. This study aimed to evaluate the clinical and functional outcomes of NPWT in the management of compound fractures of the lower limb.

Methods: A prospective study was conducted at SGRR medical institute, Dehradun, India on patients presenting with compound fractures of the lower limb who were managed with standard fracture stabilization, wound debridement, and NPWT. Clinical outcomes were assessed in terms of wound healing, infection, requirement for secondary procedures or flap coverage, duration of hospital stay, and time to definitive wound closure. Functional outcome was evaluated using Long beach wound scoring system during follow-up.

Results: NPWT resulted in progressive wound improvement, reduction in wound size and exudate, and development of healthy granulation tissue. Most wounds could be successfully prepared for delayed primary closure or definitive soft-tissue coverage. The incidence of wound-related complications was low, and progressive improvement in functional outcomes was observed during follow-up.

Conclusion: NPWT is a useful adjunct in the management of compound fractures of the lower limb. It facilitates wound bed preparation, promotes granulation tissue formation, reduces wound complications, and may help achieve earlier definitive wound coverage with satisfactory functional outcomes.

Keywords: Compound Fractures, Negative Pressure Wound Therapy

Introduction

Traumatic injuries to the lower extremity constitute a major cause of disability and health-care utilisation worldwide. Over the past two decades, management paradigms have evolved from purely skeletal reconstruction towards an integrated approach that treats the bone and the soft-tissue envelope as a functional unit.

Within this context, negative pressure wound therapy (NPWT) has emerged as an important adjunct in the staged management of complex lower limb trauma.

Subsequent prospective and randomised studies in patients with severe open fractures of the lower limb have evaluated NPWT as part of comprehensive trauma care pathways, reporting potential benefits in wound healing, infection control, and disability outcomes when compared with conventional dressings. These developments have positioned NPWT as a key component of multimodal lower extremity trauma management, particularly in high energy injuries with significant soft-tissue compromise. (1,2)

This prospective hospital-based study was conducted to assess the clinical and functional outcomes of Negative Pressure Wound Therapy (NPWT) in the management of compound fractures of the lower limb.

Aim and Objectives

To evaluate the clinical and functional outcome of negative pressure wound therapy in management of compound fractures of lower limb. To evaluate the efficacy of NPWT in wound healing, decreasing and patient morbidity. The study was conducted at the Department of Orthopaedics, Shri Guru Ram Rai Institute of Medical after obtaining approval from the Institutional Ethics Committee. A written and informed consent was obtained from all patients.

Study Population:

All patients satisfying the inclusion criteria who were admitted in Shri Mahant Indires Hospital, Dehradun.

A total of 160 patients were included in the study.

Inclusion Criteria

Patients were admitted with history of trauma and were diagnosed with soft tissue injury to lower limb with or without fracture.

All patients were aged > 10 years.

Compound fractures were classified as Gustilo-Anderson type 2 and type 3a, 3b and Tscherne grade 2 and grade 3.

Exclusion Criteria

- Age < 10 years.
- Gustilo-Anderson type 1.
- Pathological fracture with open wound.
- Patients with malignancy or on anticoagulants, chemotherapy, and corticosteroids.
- Patients having pre-existing osteomyelitis in the wound.
- Fractures with neurovascular injury.

Methodolgy

Patients were admitted from the Department of Orthopaedics OPD and Emergency of Shri Mahant Indires Hospital. Classification of wounds was done by Gustilo-Anderson and Tscherne classification. Informed consent was taken and PAC was done.

Wounds were washed with normal saline, hydrogen peroxide and betadine. Debridement was done in minor / major OT along with fixation for fracture if required. VAC application was done as follows:-

- The wound was covered with surgical foam sponge.
- It was sealed with cling drape and a hole was created.
- The tract pad was applied over the hole.
- The tract pad was connected with the NPWT machine.

Adjustment of pressure was done differently for, acute traumatic wounds

– 130 mmHg and chronic wounds

– 200 mmHg. 12-hourly monitoring for collection of secretion was done and the following parameters were noted

–Amount of secretion.

Colour of secretion.

Nature of secretion.

Foam dressing was exchanged every 3 days and at the time of exchange, evaluation was done for

–Size of the wound

– Progressive decrease/consolidation in wound size

Granulation tissue:

Colour: Whether the wound bed appeared pink/red due to the presence of new blood vessels or yellow/whitish due to slough.

Texture: Whether the wound bed had a granular texture classically described as “beefy” or “fleshy”.

Moisture Level: Evaluation of the granulation tissue to see if it was moist but not excessively wet or covered with secretions.

Surface Area: If the granulation covered the wound bed evenly, indicating progressive healing.

Vascularity: If the wound bed had a good or poor blood supply.

Presence of exudate: It was noted whether there was some exudate or excessive discharge.

At every dressing change the wound assessment scoring was done by Long Beach Wound Score

Criteria for wound healing was assessed in terms of Decrease in wound size, new healthy Granulation tissue formation, Epithelialization at margins, Absence of exudates, Resolution of inflammation and Decreased pain.

Once the wound is deemed healthy as evidenced by long beach wound score further management was done by either closure of wound if possible or partial thickness skin graft application.



Case 1. Compound fracture femur shaft(Gustilo Anderson type 3a). Patient managed by thorough washing and debridement of wound followed by external fixator and VAC application. Secondary closure of wound done after VAC removal.



Case 2. Patient presented with compound fracture distal femur shaft (Gustilo Anderson type 3a). Patient managed by debridement and VAC application. 1 week later vac is removed followed by closure of wound.



Case 3. Patient with compound fracture of proximal tibia shaft (Gustilo Anderson type 3a). clinical pic showing wound over anteromedial aspect of leg with bone exposed. Patient managed by debridement, external fixator and VAC application. Wound finally managed by patial thickness skin graft after VAC removal.

Table 1. Injury characteristics and severity profile of lower-limb compound injuries managed with NPWT (n = 160)

Variable	Category	n
Mode of trauma	RTA (Two-wheeler)	128
	Fall from height	24
	Occupational injury	8
Fracture site	Tibia–Fibula	72
	Tibia alone	38
	Femur	22
	Ankle (Pilon/Malleolar)	28
Gustilo–Anderson type	Type II	54
	Type IIIA	54
	Type IIIB	52
Tscherne grade	Grade 2	92
	Grade 3	68

Table 2. NPWT delivery profile and treatment characteristics stratified by Gustilo–Anderson type (n = 160).

		Type II (n=54)	Type IIIA (n=54)	Type IIIB (n=52)
Fixation method	External fixator	54	54	52
NPWT duration (days)	Mean ± SD	9.5 ± 3.9	13.5 ± 3.7	12.1 ± 4
Number of dressing changes (count)	Mean ± SD	2.3 ± 1.8	3.5 ± 1.6	3 ± 1.8

Table 3. Exudate volume trend during NPWT (12-hourly collection) over the first 3 days stratified by Gustilo–Anderson type (n = 160).

12-hour exudate volume	Type II (n=54) Mean ± SD (mL)	Type IIIA (n=54) Mean ± SD (mL)	Type IIIB (n=52) Mean ± SD (mL)
Day 1	38 ± 16	45 ± 16	49 ± 13
Day 2	24 ± 13	28 ± 14	29 ± 12
Day 3	12.5 ± 11.6	16.7 ± 12	17 ± 10

Table 4. Time to healthy granulation and definitive wound closure stratified by Gustilo–Anderson type in NPWT-treated lower-limb compound injuries (n = 160).

	Type II (n=54) Mean ± SD	Type IIIA (n=54) Mean ± SD	Type IIIB (n=26) Mean ± SD
Time to healthy granulation (days)	6 ± 2	7.5 ± 2	8.5 ± 2.5
Time to definitive closure (days post injury)	8.2 ± 2	13.5 ± 3	24.5 ± 1.5

Table 5. Infection status stratified by Gustilo–Anderson type in NPWT-managed lower-limb compound injuries (n = 160)

Gustilo Anderson type	No infection n (%)	Superficial infection n (%)	Deep infection n (%)
Type II (n=54)	50 (92.5%)	4(7.4%)	0
Type IIIA (n=54)	47 (87%)	3(5.5%)	4(7.4%)
Type IIIB (n=52)	42 (77.7%)	4(7.6%)	8(15.3%)
Total (N=160)	139 (86.8%)	11(6.8%)	12(7.5%)

Table 6. Culture isolate profile in NPWT-managed lower-limb compound injuries.

Culture isolate organism	Frequency of occurrence(n)
MSSA	12 (37.5%)
MRSA	10 (31.25%)
Pseudomonas	4 (12.5%)
Enterobacteriaceae	4 (12.5%)
Polymicrobial growth	2 (6.2%)

Table 7. Definitive wound closure methods and time to closure by modality in NPWT-managed lower-limb compound injuries.

Closure method	n	Time to closure (days post-injury) Mean $\pm$ SD
Delayed primary closure	68 (42.5%)	8.5 $\pm$ 2
Split-thickness skin graft (STSG)	80 (50%)	13.2 $\pm$ 3.5
Flap coverage	12 (7.5%)	24.7 $\pm$ 1.5

Table 8. Six-month clinical outcome, stratified by Gustilo–Anderson type in NPWT-managed lower limb compound injuries (n = 160).

Variable	Category	Type II (n=54)	Type IIIA (n=54)	Type IIIB (n=52)	Total (N=160)
Final outcome at 6 months	Complete healing	54	49	45	148 (92.5%)
	Flap marginal necrosis (revised)	0	2	3	5 (3%)
	Partial graft loss (<20%)	0	3	4	7 (4.5%)
Hospital stay(days)	Mean $\pm$ SD	14 $\pm$ 5	18 $\pm$ 4	19 $\pm$ 6.5	

Table 9. NPWT-related complications observed during therapy in lower-limb compound injuries (n = 160).

Complication variable	Yes n(%)	No n (%)
Peri-wound maceration	16 (10%)	144 (90%)
Bleeding during NPWT/ dressing	38 (23.8%)	122 (76.2%)
Foam adherence	10 (6.2%)	150 (93.8%)
Tubing blockage	4 (2.5%)	156 (97.5%)

Discussion

The present study entitled “Prospective study to evaluate the clinical and functional outcome of negative pressure wound therapy in management of compound fractures of lower limb” was conducted as a prospective hospital-based investigation in the Department of Orthopaedics, Shri Guru Ram Rai Institute of Medical and Health Sciences. The work focused on assessing clinical and functional recovery following negative pressure wound therapy in patients with compound fractures of the lower limb and examining its effectiveness in enhancing wound healing while reducing morbidity. The evaluation further addressed wound progression parameters, infection status, requirement of definitive soft-tissue coverage, and restoration of limb function after NPWT-assisted management of open lower-extremity injuries.

The mean age was 34.2 ± 13.1 years (18–70), with 56.3% in the 21–40 year group and males constituting 72.5%. The largest socio-economic group was lower-middle class (43.8%). A similar young-adult predominance has been reported by Kumaar (2024) [3], where the mean age was 37.06 ± 10.34 years in severe open fractures treated with NPWT. Suriyakumar (2021) [4] also noted a mean age of 30 years with male predominance in Grade IIIC compound injuries. These comparable demographics reflect the higher 101 exposure of young males to high-energy limb trauma.

Road-traffic accidents accounted for 80.0% of injuries, with tibia–fibula fractures most frequent (45.0%), followed by tibia (23.8%), ankle (17.5%) and femur (13.8%). Gustilo–Anderson types II, IIIA and IIIB were nearly equal (33.8%, 33.8%, 32.5%), with Tscherne grade 2 in 57.5% and grade 3 in 42.5% (Table 1). Mean time to debridement was 7.21 ± 3.43 hours. Similar dominance of traffic trauma has been described by Gottipati (2024) [5], where 82.35% injuries resulted from road accidents and the leg was most commonly involved. Kumaar (2024) [3] likewise focused on Gustilo IIIA/IIIB fractures, and Singh (2020) [34] evaluated Grade IIIB/IIIC tibial injuries, confirming the predominance of severe tibial trauma patterns. Early debridement within hours of injury aligns with principles outlined by Lok (2025) [6], emphasizing prompt wound clearance in complex limb trauma. No major contrasting epidemiological pattern was identified among comparable trauma studies.

All fractures were stabilized with external fixation (100% across Gustilo types). Mean NPWT duration was 11.8 ± 4.17 days overall, being longest in type IIIa (13.5 ± 3.7 days), followed by type IIIB (12.08 ± 4.19) and type II (9.5 ± 3.9). Mean number of dressing changes were 4 ± 2 overall, highest in type IIIa (3.5 ± 1.6) (Table 2). Similar use of external fixation with NPWT in severe open fractures has been reported by Singh (2020) [7], where all Grade IIIB/IIIC tibial injuries underwent fixation with soft-tissue management. Gottipati (2024) [5] also reported VAC use alongside fracture stabilization with a mean treatment duration of 10.5 days and 3.3 dressing changes, closely comparable to the overall NPWT duration and dressing frequency observed. Kumaar (2024) [3] likewise applied NPWT after fixation in Gustilo IIIA/IIIB fractures, supporting the combined fixation-NPWT approach across severity grades.

Exudate volume showed a progressive decline across all Gustilo types, with overall mean 44.0 mL on day 1, 27.0 mL on day 2 and 15.4 mL on day 3. Higher initial exudate in type IIIB (49 ± 13.6 mL) compared with type II (38 ± 16 mL) reflects increasing soft-tissue severity (Table 3). Progressive reduction in wound exudate under NPWT aligns with mechanisms described by Lok [6], where NPWT controls fluid and promotes granulation in complex limb trauma. Comparable wound-bed improvement with VAC has been described by Gottipati [5], who reported measurable wound reduction and healthy granulation within 10.5 days. Kumaar [3] also demonstrated significant wound-area reduction after NPWT, reflecting similar fluid control and tissue response.

The nature of exudate coming in the collection canister changed to serosanguinous instead of becoming watery or purulent in majority of cases. The progressive dominance of serosanguinous fluid indicates transition toward healthy granulating wound bed. Similar descriptions of the nature of exudate reflecting NPWT promoting granulation and controlled exudate have been noted by Robert [8], who highlighted increased vascularity and reduced wound fluid under negative pressure. Kaushik [9] also reported improved wound condition and readiness for closure with NPWT compared with gauze dressings, consistent with the improving exudate profile observed.

Wound area changed from 28.9 ± 22.9 cm² at baseline to 34.6 ± 25.6 cm² on day 3, followed by progressive reduction to 23.3 ± 17.6 cm² on day 6, 16.0 ± 12.4 cm² on day 9 and 8.91 ± 7.44 cm² pre-closure. This overall reduction pattern with NPWT is comparable to Kumaar [3], who reported a decrease in mean wound area from 66.05 cm² to 27.97 cm² after VAC in Gustilo III fractures.

Gottipati [5] also observed measurable wound size reduction with VAC therapy alongside formation of a healthy granulation bed. Kaushik [9] similarly reported accelerated wound closure time and improved wound condition with NPWT compared with gauze dressings. The transient increase in mean wound area at day 3 before reduction represents a unique early debridement-related expansion phase not quantified in the compared NPWT series.

Long Beach Wound Score improved significantly across all domains, with total score rising from 5.225 ± 1.488 at baseline to 7.981 ± 1.256 at discharge.

Appearance, size, depth, infection and perfusion domains all showed statistically significant improvement. This multidomain wound improvement with NPWT is consistent with mechanisms described by Robert [8], where NPWT enhances vascularity, granulation and wound-bed quality. Gottipati [5] also reported development of uniform healthy granulation and readiness for closure after VAC, reflecting similar composite wound improvement. Kumaar [8] demonstrated significant infection reduction and wound-area decrease after NPWT, aligning with LBWS infection and size domain gains.

Time to healthy granulation averaged 7.20 ± 2.45 days overall, increasing with severity from type II (6.00 ± 2.39) to IIIA (7.5 ± 2) and IIIB (8.5 ± 2.5) (Table 4). Mean time to definitive closure was 13 ± 5 days overall, with clear prolongation by severity. The time for closure was as follows, 8.2 ± 2 in type II, 13.5 ± 3 in IIIA, 24.5 ± 1.5 in IIIB (Table 4). Similar rapid granulation under VAC has been reported by Gottipati [5], where a healthy granulation bed suitable for grafting formed at a mean of 10.5 days. Kumaar [8] also noted improved wound healing dynamics and earlier closure after NPWT in type III fractures. Singh [7] reported successful soft-tissue coverage in 106 severe IIIB/C injuries with acceptable healing timelines after aggressive management. The clear gradation of granulation and closure time by Gustilo severity provides a quantified severity-response pattern not specifically stratified in the compared studies.

Infection outcomes showed absence of infection in 86.8%, superficial infection in 2.5% and deep infection in 7.5% overall. By severity, infection free status was highest in type II (92.5.0%), followed by type IIIA (87%), while type IIIB showed lower infection-free rate (77%) with deep infection of 15.4%. Low infection rates with NPWT are comparable to Kumaar (2024) [3], who reported reduction in infection prevalence from 80.6% pre-VAC to 19.4% post-VAC in Gustilo III fractures. Bhat (2019) [10] also observed only 7.4% deep infection after VAC use in open lower limb fractures, closely aligning with the overall deep infection rate of 7.5%. Singh (2020) [7] reported deep infection in 12.1% of severe IIIB/C tibial injuries after aggressive management, consistent with higher infection in severe grades. In contrast, Costa (2020) [1] found no significant reduction in deep infection with incisional NPWT (5.84% vs 6.68%), suggesting limited prophylactic benefit in closed surgical incisions compared with open fracture wounds.

Out of 160 patients 32 grew organisms from the samples taken at the time of dressings during VAC change. The organisms grown were identified as MSSA in 37.5%, MRSA in 31.25%, Pseudomonas in 12.5%, Enterobacteriaceae also in 12.5% and polymicrobial growth in 6.2% of all cultures that grew any organism. Predominance of Staphylococcus species in open fracture wounds is consistent with infection patterns reported in orthopaedic trauma literature summarized by Lok [6], highlighting Gram-positive organisms as common pathogens in lower-limb trauma wounds. Comparable mixed flora including Staphylococcus and Pseudomonas has also been described in contaminated orthopaedic wounds treated with NPWT by Chaudhary [11]. Detailed organism-wise distribution in NPWT-treated fractures, as quantified here, is not specifically reported in most NPWT fracture outcome series.

Definitive closure was achieved by delayed primary closure in 42.5%, split thickness skin graft in 50.0% and flap coverage in 7.5%, with mean closure times 8.5 ± 2 , 13.2 ± 3.5 and 24.7 ± 1.5 days respectively. Predominance of graft-based closure after NPWT is comparable to Chaudhary [11], where 67.8% wounds required skin grafting and 32.2% secondary suturing after NPWT. Gottipati [5] also reported readiness for definitive coverage with graft or flap after VAC therapy, consistent with staged closure patterns. Singh [7] described flap based reconstruction in severe IIIB/C injuries with longer healing timelines, aligning with the prolonged closure time seen for flap coverage.

Six-month outcomes showed complete healing in 92.5% overall (almost 90% in type IIIA and IIIA; 100.0% in II). Complications of flap marginal necrosis and partial graft loss was seen in 3% and 4.5% respectively. High healing rates after NPWT are comparable to Gottipati [5], where 15 of 17 patients achieved successful wound healing after VAC. Singh [7] also reported union and acceptable outcomes in severe IIIB/C fractures after staged management, supporting high final healing proportions.

Chaudhary [11] documented substantial wound improvement and closure in all NPWT-treated cases with a mean hospital stay of 14.05 days, similar to the ~17-day stay observed in our study.

Complications during NPWT included peri-wound maceration in 10.0%, bleeding during therapy/dressing in 23.8%, foam adherence in 6.3%, and no tubing blockage, with any NPWT-related complication recorded in 55.0%. Minor local complications such as maceration and bleeding have been described with VAC use in orthopaedic wounds by Robert[12], who noted that NPWT dressings may cause peri-wound moisture changes and bleeding from granulating tissue. Similar technical issues during NPWT application have also been reported by Chaudhary[11] in low-cost NPWT systems, where dressing-related adjustments were required during therapy. Absence of major device failure or blockage aligns with feasibility observations by Dingemans [2], who reported NPWT device feasibility with few failures.

Correlation analysis showed strong positive correlation between NPWT duration and dressing changes and between NPWT duration and LBWS discharge score. Other wound severity and functional variables showed weak or non-significant correlations with granulation time, closure time, hospital stay, and lower extremity functional score. Similar association of NPWT duration with wound improvement has been implied by Kaushik[9], who showed fewer dressings and faster closure with NPWT compared with gauze therapy. Robert [8] also emphasized that sustained NPWT exposure improves wound-bed quality and granulation.

Progressive reduction in wound area, significant improvement in Long Beach Wound Score domains, declining exudate volume, and low infection incidence across Gustilo grades collectively demonstrate enhanced local healing response under NPWT. Similar wound contraction, granulation development, and infection control reported by Kumaar [3] and Gottipati [5] support the observed clinical improvement trajectory. The high proportion of definitive closure achieved through delayed primary suturing or grafting with minimal flap requirement, together with short granulation intervals, further indicates that NPWT optimized conditions for reconstruction and reduced wound morbidity in open fractures. Functional recovery outcomes were favorable, with satisfactory LEFS scores, timely weight-bearing, and return-to-work periods across severity categories. Determinant analysis showed that infection, increasing age, and larger initial wound size adversely influenced function, aligning with 116 prognostic patterns in severe limb trauma described by Singh [7] and Azoury [12]. Early debridement and effective NPWT-mediated wound control appeared to mitigate severity-related complications, reflected by high six-month healing rates and low adverse outcomes. Overall, the evidence supports the study hypothesis that NPWT enhances wound healing dynamics, facilitates definitive closure, and contributes to improved clinical and functional outcomes in lower-limb compound fractures.

Conclusion

After our study we concluded that negative pressure wound therapy is an effective adjunct in the management of compound fractures of the lower limb by enhancing wound bed preparation, promoting granulation, and enabling timely definitive closure. All the integrated clinical, microbiological, and functional evidence in the study substantiated that NPWT enhances wound healing dynamics, facilitates reliable soft-tissue reconstruction, reduces patient morbidity and helps in restoration of limb function in compound fractures of the lower extremity.

Conflict of Interest

The authors declare no conflicts of interest with respect to the research, authorship and/or publication of this article.

References

1. Costa ML, Achten J, Bruce J, Tutton E, Petrou S, Lamb SE, Parsons NR, UK WOLFF Collaboration. Effect of negative pressure wound therapy vs standard wound management on 12-month disability among adults with severe open fracture of the lower limb: the WOLFF randomized clinical trial. *Jama*. 2018 Jun 12;319(22):2280-8.
2. Dingemans SA, Birnie MF, Backes M, de Jong VM, Luitse JS, Carel Goslings J, Schepers T. Prophylactic negative pressure wound therapy after lower extremity fracture surgery: a pilot study. *International Orthopaedics*. 2018 Apr;42(4):747-53.

3. Kumaar A, Shanthappa AH, Hongaiah D, Sanjay N, Sharma A. Evaluation of Clinical Outcomes of Negative-Pressure Wound Therapy in Gustilo-Anderson Type IIIA/IIIB Open Fractures of Extremities. *Cureus*. 2024 Feb 7;16(2).
4. Suriyakumar S, Saluja SS, Ramanujam M, Mancheri MN, Jambu N. Management of Grade 3C Compound Injury of Lower Limb with Floating Knee–Salvage versus Amputation (Case Series). *Journal of Orthopaedic Case Reports*. 2021 Feb;11(2):119.
5. Gottipati S, Gowtham B, Chalimeda S, Ravipati S, Khullar K. Functional outcomes in orthopaedic open wounds treated with vacuum-assisted closure therapy: a prospective case series. *Cureus*. 2024 Feb 19;16(2).
6. Lok E, Oe T, Ng S. Lower Extremity Traumatic Wound Management: Relative Significance of Negative Pressure Wound Therapy in the Orthopedic Setting. *Advances in Wound Care*. 2025 Jul;14(7):327-43
7. Singh J, Dhillon MS, Dhatt SS. Single-stage “fix and flap” gives good outcomes in grade 3B/C open tibial fractures: a prospective study. *Malaysian orthopaedic journal*. 2020 Mar;14(1):61
8. Robert N. Negative pressure wound therapy in orthopaedic surgery. *Orthopaedics & Traumatology: Surgery & Research*. 2017 Feb 1;103(1):S99-103.
9. Kaushik D, Joshi N, Kumar R, Gaba S, Sapra R, Kumar K. Negative pressure wound therapy versus gauze dressings for the treatment of contaminated traumatic wounds. *Journal of wound care*. 2017 Oct 2;26(10):600-6.
10. Bhat TA, Ibrahim R, Bhat TA, Bhat AA. In-hospital low-cost custom made VAC: Effective method for reducing infection in late presenting Open lower limb fractures in overburdened Indian hospitals. *Journal of Clinical Orthopaedics and Trauma*. 2019 Jan 1;10(1):195-200.
11. Chaudhary S, Kumar V, Gandhi P, Koichade M, Mandal S. Low cost, modified negative pressure wound therapy in infected orthopaedic 128 wounds: can it be as effective as its costly counterparts?. *Journal of Clinical Orthopaedics and Trauma*. 2020 Oct 1;11:S876-82
12. Azoury SC, Stranix JT, Kovach SJ, Levin LS. Principles of orthoplastic surgery for lower extremity reconstruction: why is this 130 important?. *Journal of Reconstructive Microsurgery*. 2021 Jan;37(01):042-50

Copyright: © 2026 All rights reserved by Kothiyal P and other associated authors. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.