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ORIGINAL RESEARCH

Outcome Of Negative Pressure Wound Therapy For Open Fracture Of Lower Limb: Experience From A Tertiary Care Centre

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Abstract

Background: Gustilo-Anderson grade IIIb open fractures of the lower limb present significant management challenges. This study evaluated the outcomes of negative pressure wound therapy (NPWT) for these complex injuries at a tertiary care center in Tripura, India.

Methods: This prospective observational study included 20 adult patients with Gustilo-Anderson grade IIIb open lower limb fractures treated between May 2020-April 2021. All patients received initial trauma management, wound debridement, and external fixation followed by NPWT. Outcomes assessed included time to granulation tissue formation, infection rates, and time to definitive surgery.

Results: The mean age was 31.6 ± 9.4 years, with a male predominance. Road traffic accidents caused 90% of injuries. Healthy granulation tissue developed in 90% of patients within 72 hours of NPWT initiation. The mean time to complete granulation coverage was 14.4 ± 4.7 days. Superficial infection rates decreased from 7 pre-NPWT to 3 post-NPWT. Most patients (84.2%) were ready for definitive surgery by 5 weeks post-external fixation.

Conclusion: NPWT appears effective in promoting wound healing, controlling infections, and optimizing the wound bed for definitive surgery in Gustilo-Anderson grade IIIb open lower limb fractures. However, larger trials are needed to establish standardized protocols and long-term outcomes.

Key-words: Gustilo Anderson grade IIIb, negative pressure wound therapy, open fractures,wound infection, wound healing

Introduction

Gustilo-Anderson grade IIIb open fractures of lower limb are complex injuries that present significant challenges in orthopedic and reconstructive management. Traditionally, these fractures have been managed with extensive initial wound debridement, stabilization using external fixation, and delayed wound closure.[1,2] However, this conventional approach has been associated with a high incidence of complications, including deep infections, malunion, and nonunion.[3–5] While stable fracture fixation can often be achieved using internal plating in the early stages, soft tissue reconstruction—particularly in severe open fractures—frequently necessitates flap coverage to ensure adequate wound closure and promote functional recovery. Inadequate soft tissue management may result in serious consequences such as infection, prolonged morbidity, or even limb amputation.[6–8]

Historically, sterile gauze dressings were the standard for temporary wound coverage. However, there has been a paradigm shift with the increasing use of Negative Pressure Wound Therapy (NPWT), a technique that applies continuous or intermittent sub-atmospheric pressure to the wound bed. NPWT has been shown to facilitate wound healing, reduce

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bacterial colonization, and promote granulation tissue formation.[9–13] Systematic reviews, including those by Cochrane, suggest that NPWT may lower the risk of surgical site infections and wound dehiscence compared to conventional dressings.[5,14–16] Nonetheless, the overall quality of evidence remains low to moderate, and further robust, large-scale trials are needed to validate these findings and inform standardized treatment protocols.

Despite the growing global evidence supporting NPWT, there is limited research from the Indian context, particularly from the northeastern region. Therefore, the present study was undertaken to evaluate the clinical outcomes of NPWT in the management of Gustilo-Anderson grade IIIb open lower limb fractures at a tertiary care center in Tripura, India.

Material and Methodology

This prospective observational study was conducted in the Department of Orthopaedics at Agartala Government Medical College and Govinda Ballabh Pant Hospital (AGMC & GBPH), Agartala, Tripura, over a period spanning from May 2020 to April 2021. The study included all adult patients (aged ≥18 years) presenting with Gustilo-Anderson Grade IIIb open fractures of the lower limb who attended the Orthopaedics Department during the study period. Patients with uncontrolled diabetes mellitus, those who were critically ill, or those unwilling to provide informed consent were excluded. Based on the defined inclusion and exclusion criteria, a total of 20 patients were considered as the final sample.

All patients received initial trauma assessment and emergency management per ATLS protocol. Following stabilization, orthopaedic evaluation included inspection for soft tissue damage, bone involvement, and contamination. Wounds were irrigated, debrided, and scored, then dressed with povidone-iodine gauze. Broad-spectrum IV antibiotics, tetanus prophylaxis, fluids, and analgesics were administered. Neurovascular status was assessed, and radiographs and routine labs were obtained. Temporary external fixators were applied as needed. Nonviable tissue was debrided, and wound swabs were collected for culture and sensitivity testing (CST).Once bleeding was controlled and clear tissue demarcation was evident, negative pressure wound therapy (NPWT) was initiated using VEL NeXT™kits (Datt Mediproducts Pvt. Ltd., India) operated at -125 mmHg continuous pressure for 72 hours. After 72 hours, NPWT dressings were removed, and granulation tissue formation and signs of superficial infection were documented. A wound swab was collected again for culture and sensitivity testing (CST), and antibiotics were adjusted according to the CST results.Dressing changes were performed every 2 to 3 days, and the time to complete wound coverage with healthy granulation tissue was documented. In the second week, or upon full granulation, wound swabs were sent for culture and sensitivity testing (CST) to guide definitive wound coverage. This standardized protocol was followed for all study participants. Patients were followed weekly for the first month and then monthly thereafter. At each visit, serial radiographs were obtained, and assessments included the presence of superficial infection and the duration required for the development and complete coverage of the wound with healthy granulation tissue.

Data were input into a Microsoft Excel spreadsheet and subsequently analyzed using SPSS (version 27.0) and R-Studio. Qualitative variables were represented as frequencies and percentages, whereas quantitative variables were summarized as means with standard deviations.

Results

Majority of the patients were below 30 years of age and majority were male (Table 1). Mean age was 31.6± 9.4 years. In our study, the majority of patients (18 individuals, 90.0%) sustained injuries as a result of road traffic accidents (RTA). Injuries due to falls from height and firearm-related trauma were each observed in 1 patient (5%). In our study, 6 patients (30%) sustained foot and ankle injuries involving the distal tibia and tarsal bones. Leg injuries, affecting the tibia, fibula, or both, were observed in 10 patients (50%). Additionally, isolated thigh injuries involving the femur were identified in 4 patients (20%).

Table 1: Basic characteristics of patients

Age-group (in years)	**Frequency**	**Percentage**
≤30	12	60
31-40	3	15
41-50	5	25
Gender	**Frequency**	**Percentage**
Female	2	10
Male	18	90
Total	20	100

Wound irrigation, debridement and external fixation were performed as initial treatment. The mean duration between trauma and initial treatment was 19.8± 8.0 (range 10-36 hr). Among the cases analyzed, the mean interval between external fixation (Ex-Fix) and the initiation of Negative Pressure Wound Therapy (NPWT) was

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5.9 ± 1.0 days. In 11 cases (55%), NPWT was initiated within 5 days or less, while the remaining 9 cases (45%) had an interval exceeding 5 days **(Figure 1)**.

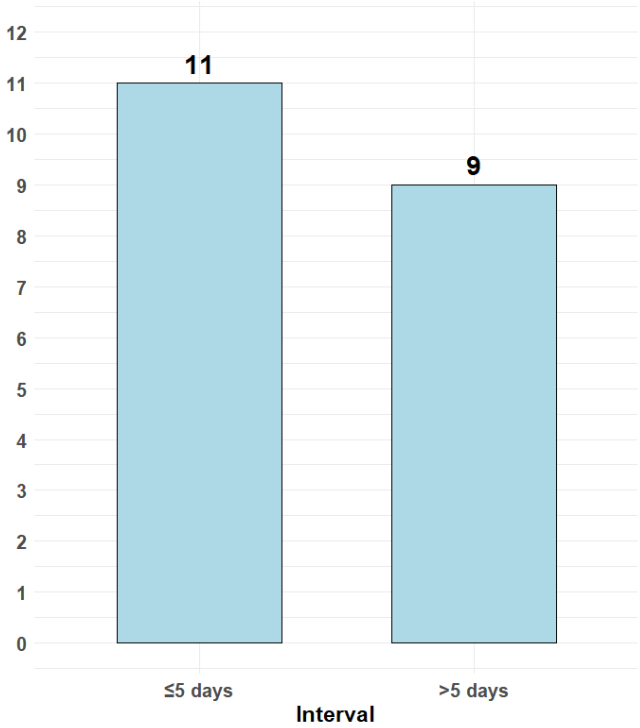

Figure 1: Interval between external fixation to NPWT

In our study, healthy granulation tissue was observed in 18 patients (90.0%) within 72 hours of initiating Negative Pressure Wound Therapy (NPWT)**(Figure 2)**. The mean duration to achieve complete granulation tissue coverage was 14.4 ± 4.7 days. Four patients received wound coverage using a local flap, another four patients underwent wound coverage through secondary repair, and eleven patients had split-thickness skin graft (SSG) wound coverage.

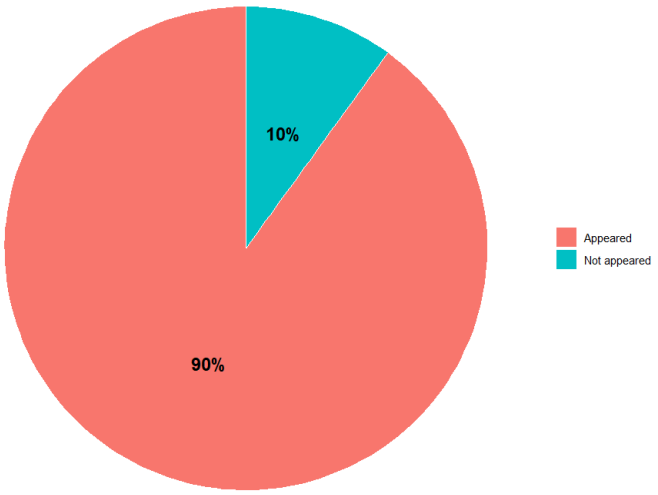

Figure 2: Status of appearance of granulation after 72 hours

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Figure 3a: Pre NPWT wound condition **Figure 3b: Post NPWT wound condition after 72 hours**

In our study, 7 patients (36.8%) reached the optimal stage for definitive surgery by the 4th week following external fixation. An additional 9 patients (47.4%) were ready by the 5th week, while 2 patients (10.5%) reached this stage by the 6th week. One patient (5.3%) was deemed suitable for definitive surgery by the 8th week post-external fixation. In the comparison of superficial infection status before and after the application of Negative Pressure Wound Therapy (NPWT), the number of patients with superficial infections decreased from 7 before NPWT to 3 after NPWT. This indicates a reduction in superficial infection prevalence following NPWT treatment**(Figure 4)**.Before NPWT, the bacterial isolates identified included three cases of *Staphylococcus aureus*, two cases of *Escherichia coli*, one case of *Proteus* species, and one case of *Pseudomonas* species. Following NPWT, the isolates included two cases of *Staphylococcus aureus* and one case of *Pseudomonas* species.

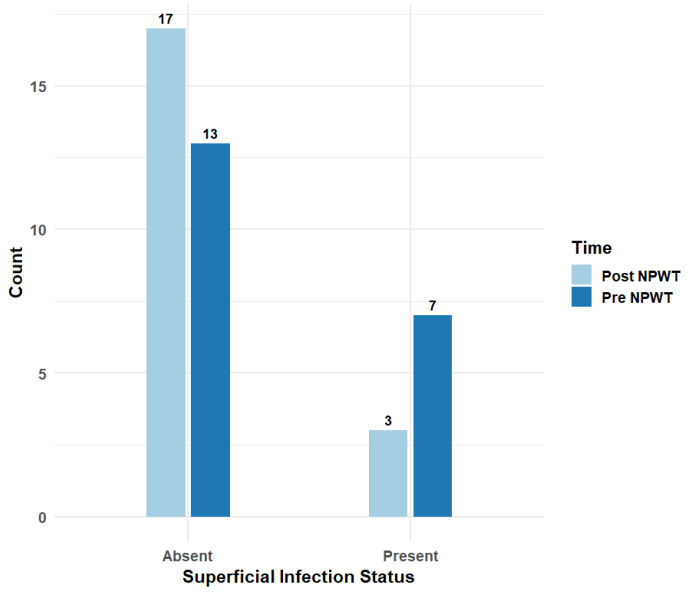

Figure 4: Distribution of Superficial infection pre and post NPWT

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Discussions

This study evaluated the outcomes of negative pressure wound therapy (NPWT) in managing Gustilo-Anderson grade IIIb open fractures of the lower limb. The majority of patients were under 30 years old, with a mean age of 31.6 ± 9.4 years. This finding aligns with Gopinathan et al., who reported that half of their study population was between 20-39 years old, with a mean age of 31 years.[17] However, the literature demonstrates a wide age distribution. For instance, Kumar et al. reported an average age of 37.06 ± 10.34 years, while Goel et al. observed a mean age of 44.5 years (range: 5-95 years) in their study, which included lower extremity injuries across all age groups.[18,19]The study population primarily comprised young males, with road traffic accidents accounting for 90% of the injuries. This demographic profile aligns with findings from other studies on open fractures, highlighting the increased risk of such injuries within this population group.[17–19]

Granulation tissue formation occurred rapidly in 90% of patients, with healthy tissue developing within 72 hours of NPWT initiation. The mean duration for complete granulation tissue coverage was 14.4 ± 4.7 days in this study. These findings align with previous research, such as Blum et al. (2012), who observed accelerated wound healing with NPWT in open tibial fractures.However, conflicting results have been reported in other studies. Kumaar et al. found a longer mean wound healing time of 18.47 ± 5.534 days.[18] Conversely, Virani et al. reported shorter durations, with an average of 8.3 days in the NPWT group and 9.3 days in the control group for complete wound coverage with healthy granulation tissue.[20] Sagy et al.'s prospective study demonstrated even more pronounced differences, with healthy granulations appearing after an average of 4 days in the NPWT group compared to 9.12 days in the traditional dressing group. Furthermore, they reported that full granulation tissue development required an average of 13 days in the NPWT group versus 22.04 days in the traditional dressing group.[21] Factors such as wound type, patient demographics, and study methodologies may contribute to the discrepancies observed across different research. Nevertheless, it demonstrated significant improvement over the traditional wound dressing method.

The implementation of Negative Pressure Wound Therapy (NPWT) demonstrated a reduction in superficial infections from 7 cases pre-intervention to 3 cases post-intervention. This finding aligns with existing literature highlighting the efficacy of NPWT in mitigating infection rates in open fractures. Stannard et al. (2009) reported significantly lower infection rates in patients treated with NPWT compared to those receiving standard dressings.[6] Similarly, Blum et al. (2012) observed a decreased rate of deep infection in the NPWT group compared to the conventional dressing group [8.4% (14/166) vs. 20.6% (13/63)].[22] Virani et al. reported that only 4.6% (2/43) of patients treated with NPWT developed infections, with a relative risk of 5.5 (95% confidence interval), suggesting that patients who received NPWT were 5.5 times less likely to develop infections compared to those who did not receive this treatment.[20]Prior to the initiation of Negative Pressure Wound Therapy (NPWT), bacterial isolates identified included *Staphylococcus aureus* in three cases, *Escherichia coli* in two cases, and one case each of *Proteus* species and *Pseudomonas* species. Following the application of NPWT, the isolates were limited to two cases of *Staphylococcus aureus* and one case of *Pseudomonas* species.These findings are consistent with those reported by Kumaar et al., who also identified *Staphylococcus aureus* as the predominant organism prior to Vacuum-Assisted Closure (VAC) therapy, and both *Staphylococcus aureus* and *Pseudomonas* species as the primary isolates in the post-VAC period.[18]

While the study presents promising results, it is crucial to acknowledge its limitations. The most significant limitation is the relatively small sample size, comprising only 20 cases, which may not suffice to draw robust conclusions. Additionally, the study was conducted at a single center, potentially limiting the generalizability of the findings. Conducting the study in a tertiary care hospital introduces the possibility of hospital-based selection bias. Furthermore, the ongoing COVID-19 pandemic and associated lockdown measures significantly impacted the study's progression and data collection. Future research could benefit from larger, randomized controlled trials to further validate these findings and compare NPWT directly with other wound management techniques in similar fracture patterns and settings.

Conclusion

This study adds to the growing body of evidence supporting the use of NPWT in the management of Gustilo-Anderson grade IIIb open fractures of the lower limb. The results are generally consistent with previous research, demonstrating that NPWT is effective in controlling infections, promoting wound healing, and optimizing the wound bed for definitive surgical intervention. However, further research is needed to establish standardized protocols and long-term outcomes of this treatment approach.

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