

Negative Pressure Wound Therapy with Partial Closure for Surgical Site Infections Following Spinal Surgery: A Prospective Case Series

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ABSTRACT

Background: Deep surgical site infections (SSIs) following spinal surgery remain a major postoperative challenge, particularly when associated with instrumentation and extensive soft-tissue dissection. Negative Pressure Wound Therapy (NPWT) has shown promise in managing complex wounds, but evidence on its use combined with partial wound closure in spinal SSIs is limited. This study evaluates the effectiveness of NPWT with partial closure and identifies factors influencing wound healing duration.

Methods: A prospective observational study was conducted at a tertiary care centre from July 2016 to April 2022. Sixteen patients (16–70 years) with deep SSIs and wound gaping after thoracic or lumbar open spinal surgery were included. All patients underwent surgical debridement, partial wound closure, and NPWT at -125 mmHg with dressing changes every 5–7 days. Demographic variables, wound characteristics, NPWT duration, number of dressing changes and healing time were recorded. The primary outcome was time to complete wound healing. Statistical significance was set at $p \leq 0.05$.

Results: The mean patient age was 51.1 ± 12.6 years, with males comprising 69%. The mean healing time was 10.2 ± 2.8 weeks. Patients with comorbidities had significantly longer healing durations (11.4 ± 2.9 vs. 9.0 ± 1.7 weeks; $p = 0.027$). Larger wound size was also associated with delayed healing ($p = 0.035$). No major NPWT-related complications were observed.

Conclusion: NPWT with partial wound closure is a safe and effective strategy for managing deep SSIs after spinal surgery. Comorbidities and larger wound size significantly prolong healing, emphasizing the need for individualized wound management strategies.

KEYWORDS: Spinal surgery, Surgical site infection, Negative pressure wound therapy, Partial wound closure, Wound healing, Debridement.

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INTRODUCTION

Surgical site infections (SSIs) remain a significant postoperative complication following spinal surgeries, increasing patient morbidity and healthcare costs. Despite advancements in perioperative care, including prophylactic antibiotics and strict aseptic techniques, the incidence of SSIs remains concerning high, sometimes necessitating reoperation and extended antibiotic regimens.¹ Complex wound infections after spinal procedures present a challenge owing to the involvement of orthopaedic implants and extensive soft tissue dissection.

Negative Pressure Wound Therapy (NPWT) has emerged as a valuable modality for managing complex wounds, promoting granulation tissue formation, reducing edema and enhancing wound healing.² Its application in orthopaedic surgery, particularly for high-risk surgical wounds, has gained increasing support.² However, studies focusing specifically on NPWT combined with partial wound closure in spinal surgical site infections are limited.

This study aims to assess the efficacy of NPWT with partial closure in managing deep SSIs after spinal surgery and to identify patient and wound factors influencing wound healing duration.

MATERIAL AND METHODS

This prospective observational study was conducted at a single tertiary care center from July 2016 to April 2022. Patients aged 16 to 70 years who developed deep surgical site infections with wound gaping following open thoracic or lumbar spinal surgeries for degenerative or traumatic conditions were included. Cases with superficial infections without instrumentation, prior spinal infections and minimally invasive procedures were excluded. All patients underwent thorough surgical debridement and irrigation under aseptic conditions (Figure – 1). Following debridement, partial wound closure was performed based on wound size and clinical judgment and NPWT was applied using a vacuum-assisted closure device (VAC®, KCI) with continuous negative

pressure set at 125 mmHg. Dressings were changed every 5 to 7 days under sterile conditions and NPWT was continued until the wound depth reduced to less than 2 cm, at which point complete wound closure was executed (Figure – 2).

Demographic and clinical data including age, gender, body mass index, smoking status and presence of comorbidities such as diabetes mellitus and hypertension were recorded. Wound characteristics including location, size, duration of NPWT, number of dressing changes and overall healing time (defined as complete epithelialization suitable for discontinuing dressings) were documented. The primary endpoint was time to wound healing. Secondary assessments included analysis of associations between healing time and patient factors including comorbid conditions and wound size, as well as NPWT-related complications.

Data analysis was performed using R software (version 4.0.4) and Microsoft Excel 2019. Continuous variables were expressed as mean \pm standard deviation when normally distributed and median with range for skewed data. Categorical variables were presented as frequencies and percentages. Inferential statistics included Student's t-test or Mann-Whitney U test for continuous variables and chi-square test for categorical variables. A p-value of ≤ 0.05 was considered statistically significant.

RESULTS

A total of 16 patients met the inclusion criteria, with a mean age of 51.1 ± 12.6 years. The cohort comprised 69% males and 31% females. Comorbidities were present in 56% of patients, including diabetes mellitus and hypertension. Wounds were predominantly located in the lumbar region (75%) with the remainder in the thoracic region (25%), as shown in Table – 1. Of the comorbidities present, alcoholism was the most predominant (50%), and type 2 diabetes mellitus (31%) and the least being heart disease (6%), as shown in Table – 2. The mean wound size measured at the initial presentation was 3.4 cm. The average duration required for complete wound healing post-NPWT and partial closure was 10.2 ± 2.8 weeks. Patients with comorbidities experienced significantly longer healing times (11.4 ± 2.9 weeks) compared to those without comorbidities (9.0 ± 1.7 weeks; $p = 0.027$). Similarly, larger wound size correlated with prolonged healing time ($p = 0.035$). No significant difference in healing time was observed between males and females ($p = 0.45$). The mean number of NPWT dressing changes per patient was 4.2 ± 1.8 (Table – 3). No major complications related to NPWT, such as skin necrosis or device malfunction were reported. Minor adverse events included transient skin irritation in two patients, which resolved without intervention.

DISCUSSION

This prospective study reinforces the growing body of evidence that NPWT combined with partial wound closure provides meaningful benefits for deep SSIs after spinal surgery. Our finding of an average wound healing duration of 10.2 weeks is consistent with recent meta-analyses and systematic reviews that confirm NPWT accelerates healing in complex wounds versus conventional therapy, reducing wound area and expediting granulation tissue formation.^{2,3} Several studies by Reyes et al, Ramcharan et al, Chen et al and Desai et al have suggested that, in addition to lowering infection rates, NPWT optimizes the wound microenvironment by controlling exudate, reducing tissue edema, and improving local perfusion, all of which are critical in spinal wounds vulnerable to prolonged healing.^{4,5,6,7}

The demographic profile of our study population showed a male predominance of 69%, which is consistent with findings reported in other spinal SSI cohorts.⁸ This may reflect gender-related differences in exposure to risk factors or health-seeking behaviour. Importantly, our analysis revealed no statistically significant difference in healing times between males and females ($p=0.45$), which agrees with previous research suggesting that sex does not significantly influence SSI healing outcomes.⁹

Comorbidities were present in 56% of our patients and were associated with significantly prolonged wound healing times (mean 11.4 weeks versus 9.0 weeks in patients without comorbidities, $p=0.027$). This finding concurs with established literature indicating that conditions such as diabetes mellitus and hypertension adversely affect wound healing through mechanisms such as impaired microcirculation and immune function.^{2,10,11} It highlights the necessity for aggressive management of comorbidities in spinal surgery patients to optimize postoperative infection control and healing.

Wound size demonstrated a significant positive correlation with healing duration ($\rho = 0.62$, $p=0.035$), aligning with prior research by Wang et al, indicating that larger wounds inherently demand more time for granulation and epithelialization.^{6,12} The application of partial wound closure combined with NPWT in our protocol may have contributed to reduced bacterial colonization and improved wound healing dynamics, though further comparative studies are needed to establish the superiority of this approach over NPWT alone. Our findings suggest that wound management strategies should consider wound dimensions as a critical factor influencing healing prognosis, particularly in complex spinal SSIs, similar to Ren et al.¹³

The safety profile of NPWT in our cohort was favourable, with no major complications observed. Minor transient skin irritations were reported in two patients, which resolved without intervention. These findings are consistent with previous studies by Hegde et al, that have documented the safety of NPWT when applied correctly in orthopaedic and spinal surgeries.^{2,13,14} The low complication rate reinforces NPWT's suitability as an adjunctive therapy for managing deep spinal surgical wounds, though vigilance is required to prevent device-related issues such as skin maceration or pressure injuries in susceptible patients.

This study's limitations include its single-center design and relatively small sample size, which limited the ability to perform multivariate analyses and control for potential confounders. Additionally, the lack of a control group receiving standard wound care without NPWT or partial closure restricts direct comparisons and causal inferences. The absence of detailed microbiological profiling also limits understanding of pathogen-specific responses. Future multi-centre randomized controlled trials with larger

cohorts and comprehensive microbiological assessments are needed to validate our findings and further optimize treatment protocols for spinal surgical site infections.

CONCLUSION

Negative Pressure Wound Therapy combined with partial wound closure is an effective and safe strategy for managing deep surgical site infections following spinal surgery. In this prospective cohort, the technique facilitated reliable wound healing with a low rate of complications and demonstrated particular benefit in patients with larger wounds. Comorbidities such as diabetes mellitus and hypertension were associated with delayed healing, underscoring the importance of optimizing systemic health in infected spinal surgery patients. While these findings support NPWT with partial closure as a valuable adjunct in complex spinal wound management, larger comparative studies are warranted to refine patient selection criteria and establish standardized treatment protocols.

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FIGURES

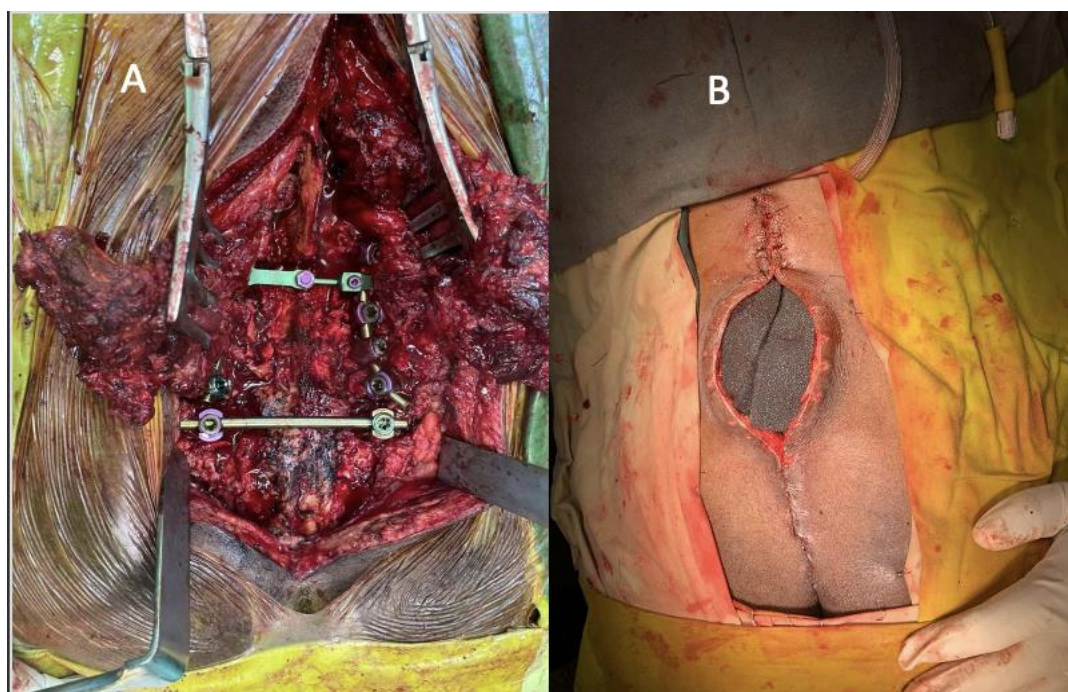


Figure – 1: Image (A) shows the extended debridement of the SSI without removal of implants. Image (B) shows the partial closure with VAC application.

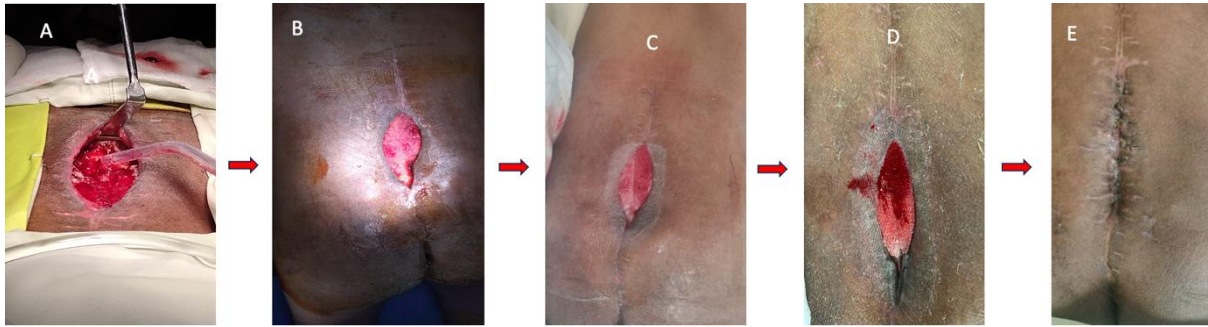


Figure – 2: Images (A) to (E) depict sequence of VAC applications with wound healing and wound closure.

TABLES

<u>VARIABLES</u>	<u>SUB CATEGORY</u>	<u>NUMBERS</u>
Age (years)	Mean	51.13 yrs
Gender	Female	31%
	Male	69%
Height (cm)	Mean	158.56 cm
Weight (Kg)	Mean	78.5 kg
BMI	Mean	31.27 kg/m ²
Comorbidities	No	43%
	Yes	56%

Table – 1: Demographics amongst patients infected with SSI after spinal surgeries.

<u>COMORBIDITIES</u>	<u>NUMBER OF SUBJECTS (%)</u>
Alcoholism	50
Heart Disease	6
Type 2 Diabetes Mellitus	31
Hypertension	12
Smoker	25
Hypothyroidism	13
None	44

Table – 2: Distribution of comorbid diseases amongst the infected patient cohort

<u>VARIABLES</u>	<u>SUB CATEGORY</u>	<u>NUMBERS</u>
Spinal Wound Infection	No	0%
	Yes	100%
Wound Size	Mean	3.4 cm
Number of Debridement	Mean	2.3
Average Number of NPWT application in each patient	Mean	7.6
Average length of incision	Mean	16.13

Average levels of stabilization	Mean	4.31 levels
Average time for complete wound healing (weeks)	Mean	10.2 ± 2.8
Average time for healing with comorbidities	Mean (p-Value – 0.027)	11.4 ± 2.9
Average time for healing without comorbidities		9 ± 1.7

Table – 3: Operative Interventions, NPWT Parameters and Healing Durations amongst the infected patient cohort.