A randomized controlled study on usefulness of vacuum-assisted closure therapy in the treatment of open fractures

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ABSTRACT:

OBJECTIVE: Vacuum-assisted closure (VAC) is an interventional, proactive injury treatment technique that exposes the wound bed to localized sub-atmospheric pressure, drains fluid from the extracellular space, enhances circulation, and promotes the growth of granulation tissue. The study goal is to determine how frequently wounds become infected, how long it takes to prepare a wound for skin-covering procedures, and how long it takes for a uniform granulation tissue bed to form in wounds that are being treated with vacuum-aided closure after main fracture fixation.

METHODS: This prospective randomized controlled study included patients between the ages of 18 and 60. The fracture was treated with primary internal fixation as quickly as feasible, and then VAC was used. Cases' functional results were documented throughout each follow-up.

RESULTS: After primary internal restoration with VAC, 30 patients with both leg bone open fractures were reported in this research. Following VAC treatment, the effective reduction in wound size (mean ± standard deviation) was 9.97± 9.59 cm2, with a P-value of 0.0481. With the use of this approach, wound size, infection, and functional outcomes have all been significantly reduced.

CONCLUSIONS: The main benefit of VAC has been identified as accelerating the formation of gingiva on injuries with accessible tendons and bones, open implants, exposed raw regions, and wounds. This helps with recovery times and soft tissue problem repair techniques.

KEYWORDS: vacuum-assisted closure, open fracture, injury, wound

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INTRODUCTION: The treating surgeons are challenged by the complex musculoskeletal injuries caused by auto accidents in terms of bone reconstruction, coverage, and wound healing. Substantial soft tissue deficiencies from these open both-bone leg fractures prevent cure through primary closings, deferred primary closings, or secondary intention. Despite advances in treatment to speed up the healing process through various types of treatment regimens, including different kinds of wound dressing, hyperbaric oxygen treatment, various types of antiseptic agents, skin grafts, or local flaps, the doctor is faced with challenges when trying to treat these open fractures with soft tissue injuries. [1] The use of negative pressure

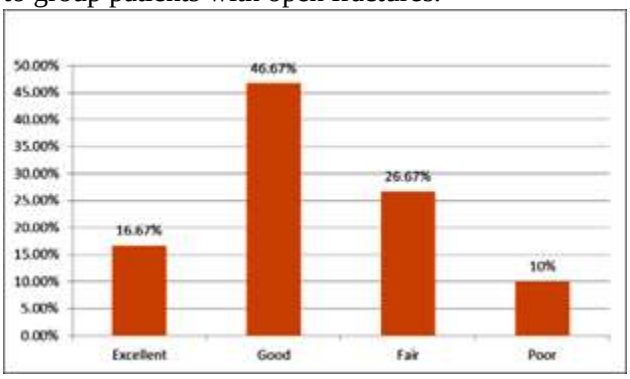
to generate a vacuum force, allowing the wounds drainage and suction, as a way of quickening wound healing, has been well-documented in a variety of different sorts of literature. [2]

Traditional methods of treating difficult soft injury situations, such as debridement, frequent dressing, saline or dry dressing, etc., were used up until recently. The disadvantages of these conventional methods include an infection incidence rate of 59%. [3,4] This prospective interventional study's goals are to assess the rates of wound infection, length of hospital stay, time needed to create a uniform new tissue bed in the wound, and soft tissue injury recovery rate in Gustilo Anderson compound fractures of both bone legs handled with vacuum-aided closure after primary fracture stabilization.

The use of intramedullary nails or plates to treat tibia bone fractures is a common practice in trauma orthopedic surgery. Despite improvements in antibiotics and new surgical methods, treating soft tissue infections after surgery is still difficult and expensive. Conventional management entails irrigation, debridement, the removal of hardware, the destruction of dead space, and intravenous antibiotics. [5] These traditional treatments for soft tissue infections may not be effective. We have experimented with other techniques over the last fifteen years, including our antibacterial cement, external fixators, negative pressure-aided closure, and novel flap options for the procedure. Compound fractures with high energy have a higher risk of infection and soft tissue loss, necessitating immediate debridement and saline irrigation. In the treatment of these open injuries, wound healing was considered to be the main and most clinically significant factor. Conventional wound dressing had low patient compliance and required lengthy periods, recurrent debridement, and greater damage to granulation tissue. VAC therapy creates a hygienic, advantageous environment that supports both closed and open wound healing while maintaining sterility, cleanliness, and moisture levels. [6]

METHODS: A prospective interventional research design was used. The patients' fully informed written permission was also obtained. Our research comprised patients who were older than 18 years old, had open musculoskeletal injuries to the leg (Gustilo Anderson 2, 3A, and 3B), and were in stable hemodynamic condition. [7] Patients with diabetes, cancer, peripheral vascular disease, pre-existing septic arthritis in the bone, peripheral nerve deficiency in the damaged limb, and pre-existing osteomyelitis were excluded from the research.

At the time of admission, a thorough medical history was obtained, including information on the patient's manner of injury, in addition to generic data such as name, age, sex, employment, and residence. The patient's vital signs were all checked. The Gustilo Anderson classification for complex fractures was used to group patients with open fractures.



Function outcome using Johner and Wruh criteria

Open fractures of types 2, 3A and 3B were treated after the necessary radiographs were taken. Sutures were inserted after the wound was treated with several normal salines and hydrogen peroxide (a topical antiseptic). The skin around the incision was then coated with povidone-iodine. After that, the limb was immobilized until a permanent attachment was made. [8] Fractures of Gustilo Anderson type 3C were excluded from this investigation. Once the patients' overall health was stabilized and the swelling had

reduced, all patients had surgery as soon as feasible. The fracture was treated with primary internal fixation as quickly as feasible, and then VAC was used.

VACUUM-ASSISTED WOUND CARE: Before irrigation with ordinary saline to treat the wound, a culture swab was collected for microbiology. The vacuum-aided closure's mechanism of action is still not fully understood. [9] But the following has been noted:

a. Boosted blood circulation

b. Increased granulation tissue production

c. Bacterial removal - Applying sub-atmospheric pressure to wounds increases local oxygen levels by increasing blood flow. As a result, anaerobic organism growth is slowed or prevented, which has been linked to slower healing rates. Furthermore, neutrophils have access to more oxygen for the oxidative bursts that destroy germs.

d. Physiologic basis: Both a mechanical mechanism and a fluid-based mechanism have been put up as basic reasons for the wounds treated with the vacuum-aided closure technique healing more quickly. Due to the pressure gradient produced, applying a regulated vacuum to the injury interface makes it easier to remove the extra interstitial fluid. As a consequence, the interstitial pressure decreases and drops underneath the capillary forces. The capillaries reopen, restoring flow to the surrounding tissue. All soluble substances that are not bonded will be carried away by the fluid. This comprises both the impediments to and the facilitators of wound healing.

Because the skin is viscoelastic, like the majority of tissues, the mechanical force causes it to gently deform over time. [10,11] The stresses exerted to cause the extracellular matrix to distort, as well as the cells that are connected to it. Numerous chemical reactions are brought on by cell deformation, including changes in ionic strength, an increase in the availability of mitochondrial membrane channels, the discharge of second messengers, the stimulation of molecular mechanisms, and changes in gene expression that promote mitosis. In this process, tissue development and osteogenic displacement are founded. [12,13,14] Tissues at the wound/sponge contact as well as around the wound are deformed by vacuum-aided closure. When the vacuum is applied near the wound, the sponge collapses, bringing the margins of the wound closer together. When suction is used, tissues around the incision are also stretched. These peri-wound regions may nevertheless experience an elevated mitotic rate as a consequence of this remote strain.

All of the wound's tissue surface was subjected to regulated, uniform pressure. A-VAC dressing typically lasts 4 to 5 days. 125 mmHg of intermittently negative pressure was administered. Although this is not completely understood, it has been seen that periodic negative pressure seems to be more beneficial than constant negative pressure. The cells may relax and get ready for the next cycle with the help of intermittent negative pressure. Before performing a 4-6 mm punch biopsy, obtaining samples for histology and culture, and clinically evaluating the wounds for indications of infection, a culture swab for microbiology was collected.

It would be noted if there was drainage, edema, erythema, visible bone, or exposed tendon. It would also be reported whether vacuum-aided closure treatment had any side effects. Day 0, Day 4, and Day 8 would be the times when these measures and results would be recorded. Inflammatory cells, excessive collagen production, arterioles, bacteria, proliferative fibroblasts, and fibrosis would all be noticed and measured by the pathologist in the biopsy samples. A shorter hospital stay, increased patient comfort, a decrease in the number of germs in the blood, the separation of interstitial fluid to facilitate tissue decompression, and the creation of a moist, closed wound healing environment are all benefits of VAC treatment. At each follow-up, the functional outcomes of patients were recorded using the modified Johner and Wruh's criteria (Table 1).

RESULTS: The 60 open-leg fracture patients included in this research include both bone legs. In every instance, vacuum-assisted closure treatment was used. The research was done between February 2019 and December 2022. With a mean age of 42.2 years and patient ages ranging from 18 to 62, fractures were more

common in the third and fourth decades. Table 2 displays various demographic information about our investigation. Application of VAC dressings: The following table displays the total count of VAC dressings administered after fixation treatments up until a second procedure was necessary (Table 3).
Based on the mean reduction in wound size and modified Johner and Wruh's (1983) criteria, VAC treatment is evaluated (Tables 4 and 5). Following the administration of all VAC dressings, a final secondary operation was performed to close the wound (Table 6).

Table 1: Johner & Wruh's modified criteria

	Criteria	**Poor**	**Fair**	**Good**	**Excellent**
	Infection/Nonunion	Yes	None	None	None
	Neurovascular injury	Severe	Moderate	Minimum	None
Mobility	**Gait**	Significant limp	Mild limp	Normal	Normal
	Pain	Severe	Moderate	Occasional	None
	Ankle	less than 50%	75% to 50%	More than 75%	Full
	Knee	less than 75%	90% to75%	More than 90%	Full
Deformity	**Shortening**	More than 20 mm	11-20 mm	6-10 mm	0-5 mm
	Posterior/ Anterior	More than 200	11-200	6-100	0-50
	valgus/ Varus	More than 100	6-100	Feb-50	None

Table 2: Patients' demographics and other details

Variables		**N (%)**
Gender	Female	18(30)
	Male	42(70)
Side	Left	20(33.33)
	Right	40(66.67)
Injury Mode	Fall from height	10(16.67)
	RTA	50(83.33)
Injury Type	Interlocking nail	48(80)
	III- B	20(33.33)
	III- A	32(53.33)
	II	8(13.33)
Internal fixation Type	LRS	2(3.33)
	Plate	10(16.67)

Table 3: Amount of VAC dressings used overall following fixing

VAC dressing (N)	**N (%)**
>5	10 (16.67%)

5	22 (36.67%)
4	28 (46.67%)
Total	60 (100%)

Table 4: After VAC treatment, the average changes in wound size

	Mean	**SD**	**t-value**
VAC Therapy Initiation Wound Size	45	22.85	2.034
VAC Therapy Cessation Wound Size	35.45	21.8	
Wound Size reduction due to VAC Therapy	9.97	9.59	
Percentage Decrease	21.22		

Table 5: Johner & Wruh's modified criteria

Criteria	**POOR**	**FAIR**	**GOOD**	**Excellent**
N	6	16	28	10

Table 6: Secondary actions that must be taken after applying the VAC dressing

Secondary procedure	**N (%)**
Secondary intention	2 (3.33&)
Direct closure	8 (80%)
Split skin graft	38 (6.67%)
Tissue transfer	4 (6.67%)
Debridement and secondary closure	6 (10%)
Total	60 (100%)

Table 7: After VAC therapy complications

Complication	**N (%)**
Exposed implant	2 (3.33%)
Deep infection	6 (10%)
Knee joint pain	14 (23.33%)
Knee and Ankle joint stiffness	10 (16.67%)

As with any wound management, clinicians, patients, and carers should routinely examine the patient's wound, peri-wound tissue, and exudates for signs of infection, signs that the infection is becoming worse, or signs of other issues. Because the foam was applied incorrectly to the wound, four of the patients experienced discomfort during VAC treatment. This pain was relieved by painkillers and a modification in the VAC foam. Six of the patients had minor skin infections, which were managed with regular bandages and the proper drugs after pus culture and sensitivity. However, Table 7 indicated more issues.

DISCUSSIONS: VAC has been promoted as a cutting-edge approach to wound healing and infection management. VAC is becoming a staple of contemporary wound therapy since it is generally well tolerated, has fewer contraindications, and causes fewer problems. Consequently, we wanted to use VAC to treat the

wound and speed up the healing of the open fracture in both bone legs. The present study's objective was to determine how well the vacuum-assisted closure device worked to heal open fractures in both bone legs after initial internal repair reduced the size of the incision. Our research showed that these injuries typically affect people between the ages of 42.2 and 62.2 (18 to 62), with fractures being most common in people between the ages of 30 and 40 due to outdoor activity.

Due to high-velocity trauma, both bones in the legs most often suffer from long bone fractures in adults. Adults most often sustain tibial shaft fractures, which are typically treated with interlocking nailing. [15,16,17] Locking plate osteosynthesis, however, is similarly successful and has fewer side effects in tibial shaft fractures, according to several studies. [18] In our institution, we choose nails over plates and screws. We have reduced the patient's iatrogenic trauma during the nailing technique. In this research, the majority of the 48 patients (80%) had intramedullary nails, while the remaining 10 patients (16.67%) preferred plates, and 2 patients (3.33%) received LRS.

Restoring the contour and speeding up the regeneration of the soft tissue is the major challenge in treating complex musculoskeletal injuries. In comparison to conventional wound coverings, VAC proved successful in reducing the widths of wounds over time, according to prior research. [19,29] The wound size reduction achieved by VAC treatment in the current research varied from 2.8 to 25 cm2, with a mean reduction of 9.97 with an SD of 9.59 (21.22%) cm2. In type III compound tibial fractures, a multistage approach to treatment seems to be more effective in minimizing complications and producing the best outcomes. Out of 60 patients, 10 patients in our research had great results, 28 patients had acceptable results, 16 patients had medium results, and 6 patients had bad results.

According to research, all open tibial shaft fractures may be treated with unreamed tibial nails (excluding type IIIC). Additionally, they stated that type IIIB open fractures had a 13% infection incidence whereas type I, II, and IIIA open fractures had a 4% overall chronic infection rate. Infection was the second most frequent consequence, occurring in 10% of study participants after joint stiffness (16.67%). 20 With the early introduction of exercises for knee and ankle mobilization, this incidence may be further decreased.

CONCLUSIONS: After initial fixation and subsequent VAC administration, all patients underwent clinical evaluations for 12 months of follow-up. Starting on the second postoperative day, VAC dressings were applied every 4 to 5 days. Throughout the VAC treatment, there was no need for ongoing surgical debridement. Primary internal fixation with VAC treatment in open fractures of both bone legs would propose newer treatment mobility based on the examination of the data gathered in the current investigation. This method has effectively reduced wound size, reduced infections, and improved the results. The most significant benefit of VAC was discovered to be the acceleration of the production of granulation tissue on raw area wounds and wounds with exposed bones, which reduced additional soft tissue covering treatments and sped up wound healing.

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