Indian Journal of Orthopaedics Surgery 2022;8(2):141–147

Content available at: https://www.ipinnovative.com/open-access-journals

Indian Journal of Orthopaedics Surgery

Journal homepage: https://www.ijos.co.in/

Original Research Article

To evaluate the role of VAC therapy in open fractures after primary fixation in term of faster and more effective wound healing

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ARTICLE INFO

Article history:
Received 31-03-2022
Accepted 24-05-2022
Available online 15-06-2022

Keywords:
Vacuum assisted closure
Musculoskeletal injury
Wound healing
Gustilo anderson classification

ABSTRACT

Background: Vacuum-assisted closure (VAC) is a noninvasive, active wound management system that exposes a wound bed to local sub atmospheric pressure, removes fluid from the extravascular space, improves circulation, and enhances the proliferation of granulation tissue. The purpose of this study is to know the rate of wound infection, number of days required for making the wound fit for skin cover procedures, number of days required for formation of uniform granulation tissue bed in the wound healing treated by Vacuum Assisted Closure after primary fixation of fracture.
Methodology: Patients between 18 to 60 years were included in this prospective randomized controlled trial. Primary internal Fixation of fracture was done as soon as possible followed by VAC application. Functional outcome of cases recorded during each follow up according to Johner and Wruh's (1983).
Result: According to this study, 30 patients with open fractures of both bone leg after primary internal fixation with VAC application. During follow up effective decrease (mean ± SD) in wound size after VAC therapy was 9.97±9.59 cm2 with P-value 0.0481. This technique has resulted in the effective decrease in wound size, infection and give a better functional outcome.
Conclusion: The greatest advantage of VAC was found to facilitate rapid formation of granulation tissue on wounds with exposed tendons, bones, raw area wounds and exposed implants hence decrease healing time and minimize soft tissue defect coverage procedures.

1. Introduction

Compound musculoskeletal trauma due to road traffic accident poses difficulty to the treating surgeons regarding bone reconstruction, coverage and wound healing. These open both bone leg fracture produce significant soft tissue defects precluding healing through primary closures, delayed primary closures, or secondary intention. Despite the advances in treatment to expedite wound healing by several types of treatment regimen including different types of dressings, hyperbaric oxygen therapy, several types of antiseptic agents, skin grafts or local flaps, treatment to these open fracture with soft tissue injuries presents dilemma to the surgeon.[1] In various literatures, it is well documented that use of negative pressure to create a vacuum force, enabling the drainage and suction of wounds is promote wound healing.[2]

Previously complex soft injuries were treated by conventional techniques like wound debridement, regular dressing, saline or dry dressing etc and disadvantages of these conventional methods according to a study by caudle and stern[3] are incidence of infection was 59% similar

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https://doi.org/10.18231/j.ijos.2022.025

studies by Cierny et al.[4] The purpose of this prospective interventional study is to evaluate the rate of wound infection, number of days required for making the wound fit for skin cover procedures, number of days required for formation of uniform granulation tissue bed in the wound, number of days of hospital stay and healing of soft tissue injury in Gustilo Anderson compound fracture both bone leg treated by Vacuum Assisted Closure after primary stabilization of fracture.

In trauma orthopaedics surgery, the management of the tibia bone fractures with plates or intramedullary nails is widely accepted. However, the postoperative treatment of soft tissue infections are remains challenging and expensive to treat, despite advances in antibiotics and new operative techniques. The traditional management includes irrigation and debridement, obliteration of dead space, intravenous antibiotics, and removal of the hardware.[5] These conventional methods may not be efficient for the soft tissue infections. In the past fifteen years, we have been trying additional methods including self-made antibiotic cement, negative pressure assisted closure, external fixators, and new flap choices for the treatment. High energy compound fractures have more chance of loss of soft tissue and infection and required urgent debridement and irrigation with normal saline. Wound healing was regarded as the primary and most clinically relevant in management of these open injuries. Conventional wound dressing required prolonged period, repeated debridement, more injuries to granulation tissue and had poor patient compliance. VAC therapy facilitate a sterile, favourable environment that provide the benefit of both open and closed treatment and wound healing progress under moist, clean and sterile conditions.[6]

2. Methodology

Study design was prospective interventional study. Informed written consent from the patients were also taken. Patients included in our study were above 18 years of age, patients with open musculoskeletal injuries in leg (Gustilo Anderson 2, 3A and 3B) and haemodynamically stable patients. Patients with pre-existing osteomyelitis in the bone, neurovascular deficit in the injured limb, diabetes, malignancy, peripheral vascular disease were excluded from the study.

On admission detailed history of patients was elicited regarding mode of injury and general information like name, age, sex, occupation and address were noted. All vitals of the patients were examined. Patients with open fractures were divided according to the Gustilo Anderson classification for compound fractures.

After obtaining the necessary radiographs, Type 2, 3A and 3B open fractures were treated by cleaning of the wound with copious amount of normal saline, and hydrogen peroxide[7] (topical antiseptic) followed by painting of the skin around the wound with povidone iodine and suturing done. The limb was then immobilized till definite fixation was done. Gustilo Anderson type 3C fractures were not included in this study. All patients were operated as early as possible once the general condition of the patients was stable and swelling subsided. Primary internal Fixation of fracture was done as soon as possible followed by VAC application.

2.1. Vacuum assisted wound therapy

A culture swab for microbiology was taken before wound irrigation with normal saline. Mechanism of action of the vacuum assisted closure is not completely nderstood yet.[8] However the following have been observed-

1. Increased blood flow
2. Increased formation of granulation tissue- Morykwas et al in his study found that wounds filled significantly faster with granulation tissue when a negative pressure of 125mmHg was applied to wounds compared with 25mmHg and 500mmHg.[9]
3. Bacterial clearance- Morykwas et al reported a significant decrease in the number of organisms per gram tissue after 4 to 5 days treatment of wounds with vacuum assisted closure system.[10]
   The application of sub atmospheric pressure to wounds causes increased blood flow and therefore increased local oxygen levels. This reduces or eliminates the growth of anaerobic organisms the presence of which has been correlated to decreased healing rates. In addition greater amount of oxygen is available to neutrophils for the oxidative bursts that kill bacteria.
4. Physiologic basis- Two broad mechanisms have been proposed to account for the increased rate of healing for the wounds treated with the vacuum assisted closure system a fluid based mechanism and a mechanical mechanism. Application of a controlled vacuum to the wound interface facilitates the removal of excess interstitial fluid because of the pressure gradient created. This results in a decrease in the interstitial pressure, which falls below the capillary pressure. The capillaries re-open and flow to periwound tissue is restored. All non bound soluble factors will be removed with the fluid. This includes both the factors that inhibit and those that promote wound healing.

The skin (and most tissues) is viscoelastic; it was deform slowly over time when mechanical force is applied to it.[11] The applied forces deform the extracellular matrix and therefore the cells which are anchored to it. Cell deformation causes a wide variety of molecular responses including ion concentration changes and increase permeability of membrane ion channels, release of second messengers, molecular pathways stimulation and changes in

gene expression and therefore increased mitosis. This effect is the basis of tissue expansion and osteogenic distraction.[12]

Vacuum assisted closure causes deformation of tissues at the wound/sponge interface and also in the periwound area. At the site of the wound, application of vacuum causes collapse of the sponge, drawing the wound edges together. Tissues in the periwound area also stretched when vacuum is applied. This distant strain may still result in an increased mitotic rate in these periwound areas.

Uniform controlled pressure was applied to all tissue surface of the wound. Average duration of a VAC dressing is 4 to 5 days. The pressure applied an intermittent negative pressure of 125 mmHg. It is observed that intermittent negative pressure appears more effective than continuous negative pressure, although this is not fully understood. Two possible explanations were advanced by Philbeck et al.[13] They suggested that intermittent negative pressure results in rhythmic perfusion of the tissue which is maintained due to process of capillary autoregulation is not activated. Intermittent negative pressure allows the cells time to rest and prepare for the next cycle. A culture swab for microbiology was taken before we also clinically assesses the wounds for signs of infection and obtain 4–6 mm punch biopsy, samples for histology and culture.

The presence of drainage, edema, erythema, exposed bone, or exposed tendon would be documented. Any complications associated with vacuum assisted closure therapy would be also documented. Such measurements and findings would be recorded on day zero, day four, and day eight. The pathologist would be noted and quantified the presence of inflammatory cells, bacteria, arterioles, proliferative fibroblasts, excessive collagen formation, and fibrosis in the biopsy samples. Advantages of VAC therapy include reduced frequency of dressing changes, thus reducing nursing time for wound, increasing patient comfort, reduced hospital length of stay, reduced bacterial cell count, removal of interstitial fluid to allow tissue decompression and provision of a closed, moist wound healing environment. Functional outcome of cases recorded during each follow up according to Johner and Wruh's (1983) criteria with modification[14] (Table 1).

3. Observation and Results

The present study consists of 60 cases of open fracture of the both bone leg. Vacuum assisted closure therapy was applied in all the case. The study period was from November 2018 to September 2021. The age of the patients ranged from 18 to 62 years with the fracture being most common in the 3rd and 4th decade and an average age of 42.2 years. Various demographic details of our study are mentioned in Table 2.

Number of VAC dressing application- Total number of VAC dressing applied after fixation procedures till definitive secondary procedure required were shown in following table (Table 3).

3.1. Criteria for assessment

The assessment of VAC therapy is based on the mean decrease in wound size and Johner and Wruh's (1983) criteria with modification (Tables 4 and 5).

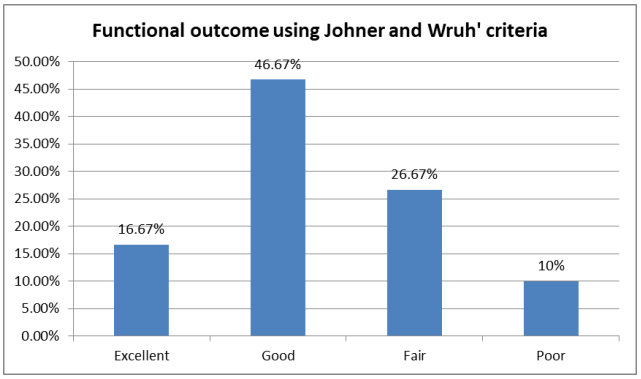

Fig. 1:

3.2. Definitive secondary procedure

After application of total number of VAC dressing definitive secondary surgery was done for closure (Table 6).

3.3. Complications

As with any wound treatment, clinicians and patients / care givers should frequently monitor the patient's wound, peri wound tissue and exudates for signs of infection, worsening infection or other complications. 4 of the patient developed pain during VAC therapy because foam are wrongly place on the wound which was subsided by pain killer and change in VAC foam. 6 of the patients developed superficial skin infections, which were treated with daily dressings and appropriate antibiotics after pus culture and sensitivity. However other complications were showing in Table 7.

4. Discusion

VAC has been advocated as novel method in the healing of wound and infection control. VAC is mostly well tolerated, with less contraindications and complications, is becoming a mainstay of modern wound management. Hence, we planned to use VAC for the treatment and fast healing of wound in open fracture both bone leg. The present study was undertaken to determine the efficacy of the vacuum assisted closure system in treatment of the open fractures of both bone leg after primary internal fixation gives decrease in wound size. Our study revealed the average age of patients with such injuries to be 42.2 years (18-62) in which fracture most common in a age group of 30 - 40^{th} decades of life because of outdoor activity.

The study conduct with 60 patient in which 42 (70%) patient male and 18 (30%) patient female showing male

Table 1: Johner and Wruh's (1983) criteria with modification

Criteria	Excellent	Good	Fair	Poor
Non union / infection	None	None	None	Yes
Neurovascular injury	None	Minimum	Moderate	Severe
Deformity				
Varus / valgus	None	$2\text{-}5^0$	$6\text{-}10^0$	$>10^0$
Anterior / Posterior	$0\text{-}5^0$	$6\text{-}10^0$	$11\text{-}20^0$	$>20^0$
Shortening	0-5 mm	6-10 mm	11-20 mm	>20 mm
Mobility				
Knee	Full	>90%	90 - 75%	<75%
Ankle	Full	>75%	75-50%	<50%
Pain	None	Occasional	Moderate	Severe
Gait	Normal	Normal	Mild limp	Significant limp

Table 2: Various details of our study

Variables		Number of patients	Percentage
Sex distribution	Male	42	70%
	Female	18	30%
Side distribution	Right	40	66.67
	Left	20	33.33%
Mode of injury	RTA	50	83.33%
	Fall from height	10	16.67%
Type of injury (gustilo Anderson)	II	8	13.33%
	III- A	32	53.33%
	III- B	20	33.33%
Type of internal fixation	Interlocking nail	48	80%
	Plate	10	16.67%
	LRS	2	3.33%

Table 3: Total number of VAC dressing applied after fixation

No. of VAC dressing	No. of patients	Percentage
4	28	46.67
5	22	36.67
>5	10	16.67
Total	60	100.00

Table 4: Mean changes in wound size after VAC therapy

	Wound size at theinitiation of vactherapy (in cm^2)	Wound size at thecessation of VACtherapy (in cm^2)	Decrease in woundsize attained by VACtherapy (in cm^2)	% decrease
Mean ±SD	45.00±22.85	35.45±21.80	9.97±9.59	21.22
t-value	2.034			

Table 5: Johner and Wruh's(1983) criteria with modification

Criteria	No. of patients
Excellent	10
GOOD	28
FAIR	16
POOR	6

Table 6: Definitive secondary procedures required after application of VAC dressing

Definitive secondary procedure	No. of patients	Percentage
Debridement and secondary closure	6	10
Tissue transfer	4	6.67
Split skin graft	38	6.67
Direct closure	8	80.00
Secondary intention	2	3.33
Otal	60	100.00

Table 7: Complications after VAC therapy

Complication	No. of patients	Percentage
Ankle and knee joint stiffness	10	16.67
Knee joint pain	14	23.33
Deep infection	6	10
Exposed implant	2	3.33

Fig. 2: Pre operative wound condition presenting at emergency department

Fig. 3: Immediate post operative wound at the time of primary fixation procedure

predominance because of travelling, working in agriculture field and factories. Another study conducted by Tushar Ahluwalia et al[15] in this study they also shown that male predominace 94.12% of patients were males. Today in modern era the motor vehicle is most commonly use for transport and travelling and at this geographical area, road traffic accident are most often happen. In a study conducted by Kushagra Sinha et al[16] on 30 patients who had suffered an acute trauma. The number of dressing change according to the extent of the wound, presence of infection and wound healing time. Intermittent negative pressure was applied in all patients except in 4 patients. In 4 patient continuous negative pressure was applied. There was no need of repeat surgical debridement in 56 patients during the course of VAC therapy.

Open fracture both bone leg are most commonly long bone fracture in adult population due to high velocity trauma. Tibial shaft fractures are the most common long bone fractures in adults, commonly managed by

Fig. 4: Wound condition after 1^{st} VAC application

Fig. 5: Wound condition after 3^{rd} VAC therapy

interlocking nailing. However, several studies show that locking plate osteosynthesis is similar effective in tibial shaft fractures and are associated with less complications. In our institute we have preffer nail in comparison of plate and screw. In nailing procedure we have give lesser iotrogenic trauma to the patient .In this study we used intramedullary nail in most of the patient 48 (80%) and remaining preffered plate 10 (16.67%)patient and LRS in 2 (3.33%) patient.

The main issue dealing with compound musculoskeletal injury is to restore the outline and healing of the soft tissue as early as possible. The use of VAC to promote wound healing was first documented by Fleischman et

Fig. 6: Wound after 5 VAC therapy with nill infection and abundent granulation tissue which is ready for definitive secondary procedure (skin graft)

al.[17] Previous studies by Joseph et al., Morykwas and Argenta, and Morykwas et al[18] have shown that VAC was effective in shrinking the widths of wound over time compared to standard wound dressings. In the present study there was decrease in wound size attained by VAC therapy ranged from 2.8 to 25cm^2, with an average reduction of 9.97(SD9.59){ 21.22%} cm^2. Multistaged treatment option in type III compound tibial fractures seems to be a better method in reducing complications and achieving the best results. In our study we 10 patient had excellent, 28 patients had good, 16 patients had fair and 6 patient had poor result out of 60 patients.

Sanders et al.[19] indicated that unreamed tibial nailing was an acceptable technique for use in all open tibial shaft fractures (excluding type IIIC). They also reported that the overall chronic infection rate was 4%, with no infections in type I, II, and IIIA open fractures and a 13% rate in type IIIB open fractures. Joint stiffness was the common complication seen in 16.67% of the study participants which was followed by infection in 10% of them. This incidence can be further reduce with an early institution of knee and

ankle mobilization exercises.

5. Conclusion

All patients were clinically evaluated after the primary fixation and then VAC application, for period of follow up of 12 months. The frequency of VAC dressing application was 4 to 5 day per dressing from the second day of post-operative. There was no need of repeated surgical debridement during the course of VAC therapy. By the analysis of the data collected in the present study, Primary internal fixation with VAC application in open fracture both bone leg will suggest a newer treatment mobility. This technique has resulted in the effective decrease in wound size, decrease in infections and give a better functional outcome. The greatest advantage of VAC was found to increase formation of granulation tissue on wounds with exposed bones and raw area wounds hence shorten wound healing time and minimize secondary soft tissue coverage procedures.

6. Source of Funding

None.

7. Conflict of Interest

The authors declare no conflict of interest.

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Cite this article: Verma A, Patel J, Saroj AK, Kumar S, Agarwal S, Yadav A. To evaluate the role of VAC therapy in open fractures after primary fixation in term of faster and more effective wound healing. *Indian J Orthop Surg* 2022;8(2):141-147.