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ORIGINAL ARTICLE

Outcome of Vacuum Assisted Dressing in Open Comminuted Tibial Fracture with Primary Fixation

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Abstract

Background/Aim: Wound management of the compound open tibia (Gustilo-Anderson grade 2, 3a, 3b) is complicated by a higher infection and the problem of adequate soft tissue coverage is significant. Primary wound closure is not easily advisable in these types of compound open tibial fractures. Early tissue flap or graft procedure might increase the complication rate due to temporary graft rejection and wound infections. The aim of this study was to analyse the duration required for formation of healthy granulation tissue, duration required for making wound fit for skin cover procedure and duration of hospital stay in compound open tibia fracture treated with vacuum assisted closure (VAC).

Methods: A prospective interventional study of 22 patients aged 18 to 60 years was done. After assessing the size of the wound, primary bone fixation and wound debridement were carried out as soon as possible and then VAC was applied. Assessment of VAC therapy was based on mean decreases in wound size and "modified Johner and Wruh's criteria", used for assessment of the functional outcome of tibial shaft fracture was recorded during each follow-up.

Results: Twenty two patients suffered comminuted open fractures of tibia-fibula. Primary fixation of bone were done with vacuum dressing. During follow-up, the good decrease in wound size considering vacuum dressing remedy was once 18.75 ± 18.36 cm^2 ($p = 0.001$). Six patients achieved excellent results according to "modified Johner and Wruh's criteria" of tibial shaft fracture.

Conclusion: This technique effectively reduced wound size, accelerated the formation of healthy granulation tissue of wound with open fracture bone and provided a better functional outcome. The VAC treatment had suggestively increased wound closure rate, decreased morbidity and costs for patients.

Key words: Vacuum Assisted closure (VAC); Gustilo-Anderson classification; Open fracture; Soft tissue injury; Road Traffic Accident; Advanced Trauma Life Support (ATLS).

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Introduction

The subcutaneous location of the anterior-medial tibial surface is responsible for the high proportion of open diaphyseal fractures. Approximately 4 % of these fractures are open.[1] Road traffic accidents (RTA) account for more than 50 % of all open fractures, with the majority of other modes being caused by falls, sports-related injuries and direct blows.[1] The type 3 open fracture discovered is a mere 60 %.[2] The high number of open fractures continues to be a difficult problem for surgeons. The initial evaluation should adhere to the Advanced Trauma Life Support (ATLS) protocol guidelines. Following initial resuscitation, the focus shifts to

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the mechanism of injury and general examination of the afflicted limb. Special consideration should be given to neuro-vascular evaluation, compartment status and the involvement of soft tissue injuries and wound contaminations.

The decision must then be made as to whether the wound should be closed by primary or secondary, suture or reconstructive surgery. These include various types of dressings, hyperbaric oxygen treatment, various antiseptic agents, skin grafts or local flaps.[3] The ultimate soft tissue covering should be applied as soon as possible, ideally during the first 72 h following trauma.[4] The therapy of tibia bone fractures with locking plates or intra-medullary inter-locking nails is well established in trauma orthopaedic surgery. However, it can be very difficult and expensive to cure soft tissue infections after surgery. Studies have suggested delaying initial wound closure[5] to avoid flap rejection, deep infections and delayed bone union. Conventional wound dressing needs a longer duration, recurrent debridement and is followed with more damage to healthy tissue and non-compliance to patients.[6]

Vacuum assisted closure (VAC) (Kinche, Concepts, Inc, San Antonio, TX, USA) treatment provides a good environment that allows for both open and closed treatment, better wound healing procedures under moist, hygienic, sterile conditions.[7] Primary closure is important temporary prevention of the exposed vital structure from bacterial contamination, as well as to induce a locally normal circulatory stimulation and proliferation of wound granulation tissues. The VAC is a new modality system for the treatment of open fracture wounds. VAC therapies offer a more sterile, comfortable environment that benefits from both open and closed treatment and ultimately speeds up the process of wound healing under moist, sterile and clean circumstances. Important characteristics of a wound include: sufficient blood flow, the absence of a deep infection and adequate debridement of the wound. Individuals who respond well to VAC treatment are those who are well-nourished and in good health overall.

Negative pressure therapy (NPWT) "soothes the wound environment, reduces wound oedema/bacterial load, progresses tissue perfusion and stimulates granulation tissue and angiogenesis". All this progresses the possibility of primary closure of wounds and reduces the need for plastic procedures. VAC dressing is a non-invasive, dynamic-wound treatment, technique that increases blood circulation, exposes wound to local sub-atmospheric pressure, drains oedema from the extra-vascular space and enhances the growth of healthy granulation tissue.[8]

The mechanism of action of vacuum aided wound treatment is not fully understood at this time.[9] However, with this method, enhanced circulation increases wound healing. When a negative pressure of 125 mm Hg is applied to the wound, granulation tissues form faster. The number of bacteria per gram tissue decreases. After four to five days, the wound is treated using a vacuum-aided closure method.[10]

This study objective was to study the duration required for formation of healthy granulation tissue, duration required for making the wound fit for skin cover procedure and the duration of hospital stay in compound open tibia fracture treated with VAC.

Methods

This study was designed as a prospective interventional study. Purposive sampling, satisfying the inclusion criteria was performed in Karnataka Institute of Medical Sciences (KIMS), Hubli, Karnataka, India. The patient's permission was also obtained for the study. Study was performed from January 2021 to January 2022. Ethical clearance was obtained from the Ethical Committee of the institution (Karnataka Institute of Medical Sciences Ethics Committee, Decision No 728/2020-21).

Patients clinically diagnosed with open complex tibial fracture (Gustilo-Anderson grade, 2, 3a, 3b)[11] were included in the study at Karnataka Institute of Medical Science Hubli. Patients with pre-existing osteomyelitis in the bone, neurovascular deficiency in the wounded limb, tumour, paediatrics fracture and vascular injury were not included in the study. The patient were without comorbidities, such as diabetes, hypertension, coagulation problems, etc.

Follow-up period was 6 months (20-24 weeks) and included following up the average time until definitive wound closure surgery, such as split thickness skin graft (SSG), flap surgery or

Table 1: Modification of Johner and Wruh's criteria

Criteria	Excellent	Good	Fair	Poor
Non-union/infection	none	none	none	yes
Neurovascular injury	none	minimum	moderate	severe
Deformity				
Varus/valgus (°)	none	2-5	6-10	> 10
Shortening (°)	0-5 mm	6-10 mm	11-20 mm	> 20 mm
Anterior/posterior (°)	0-5 mm	6-10 mm	11-20 mm	> 20 mm
Movements				
Knee joint (%)	full	> 90 %	90-75 %	< 75 %
Ankle joint (%)	full	> 75 %	75-50 %	< 50 %
Pain	none	occasional	moderate	severe
Gait	normal	normal	mild limp	significant limp

secondary suture was achieved. All the fractures were caused by high-energy trauma and the partially poly-traumatised patients were treated according to ATLS guidelines. The complex open tibia fractures were categorised using the Gustilo-Anderson classification.

Types 2, 3A and 3B fractures were treated with radical debridement, wound cleaning with copious amounts of saline (0.9 % NaCl), peroxide and betadine solutions (topical anti-septic), skin painting with povidone-iodine, compartment decompression and primary immobilisation of the fracture with external skeletal fixation. In addition, the rate of infection, fracture union (at least 3 cortical continuities of Bridging callus) in AP / lateral X-rays, length of VAC administration and complication development were also assessed.

Application of VAC dressing

After external fixation stabilised the fracture, regular wound debridement and effective haemostasis were obtained, a standard saline dressing on the first day was applied. On the second day, sterile granufoam (black poly urethane) was cut to fit the contour of the wound and applied over it. A fenestrated tube was introduced into the foam after the wound was properly sealed with adhesive tape. A fluid collecting container and vacuum pump were attached to the fenestrated tube. The device intermittently produced suction between 100 and 125 mm Hg. Every third day, after assessing the size of the wound VAC dressings were replaced. Assessment of VAC therapy was based on mean decrease in wound size and "modified Johner and Wruh's criteria".[12] Assessment of the functional outcome of tibial shaft fracture was recorded during each follow-up (Table 1).

SPSS for Windows 20 was used for statistical analysis. The t-test and the Mann-Whitney U-test were used to evaluate parametric and non-parametric variables, while categorical data were compared using the Chi-square test. $P < 0.05$ was considered statistically significant.

Results

Patients aged from 18 to 60 years, mean age of 40.2 years. Table 2 shows basic characteristics of patients as well as type and nature of the injury.

Table 2: Characteristics of injuries and participants

Variables	N	%
Gender		
Male	14	70.00
Female	8	30.00
Leg side		
Right	15	66.68
Left	7	33.32
Nature of injury		
RTA	16	84.33
Other	6	15.67
Gustilo-Anderson grade		
2	4	18.67
3a	11	49.38
3b	7	31.95
Types of fixation		
External fixation	16	72.72
Nails	6	27.28

RTA: road traffic accident;

Table 3 shows the necessary procedures after the fixing technique until the definitive secondary procedure were required (total number of VAC dressing applications).

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Table 3: Total number of vacuum assisted closure (VAC) application after primary fixation

Number of VAC dressing	N	%
Four	9	42.80
Five	7	32.40
> Five	6	24.80
Total	**22**	**100.00**

Figure 1-3 shows clinical outcome of compound open tibial fracture with primary fixation by Ilizarov, followed by VAC dressing.

Figure 1: Compound open tibial fracture at presentation

Assessment of VAC therapy was based on mean decreases in wound size and "modified Johner and Wruh's criteria" was used and recorded for assessment of the functional outcome of tibial shaft fracture during each follow-up (Table 4 and 5).

Figure 2: Compound open tibial fracture after vacuum assisted closure (VAC) dressing

Figure 3: Compound open tibial fracture after tissue flap

Table 4: Mean changes in the wound size after vacuum assisted closure (VAC) therapy

Value	Before (cm³)	After (cm³)	Reduction (cm³)	%	p-value
Mean ± SD	48.00 ± 26.85	29.25 ± 25.80	18.75 ± 18.36	39.45	< 0.001

Before: Wound measurement before application of VAC dressing; After: Wound measurement after application of VAC dressing; Reduction: Reduction in wound measurement attained by VAC dressing; %: Percentage of reduction in wound measurement;

Following the administration of a total of 22 patients VAC dressings, surgery was performed to close the wound (Table 6).

Table 6: Definitive surgical procedure done after the end of vacuum assisted closure (VAC) application

Definitive secondary procedures	N	%
Secondary closure	2	9.10
Tissue flaps	7	31.81
Splint skin graft	12	54.54
Direct closure	1	4.55
Total	22	100.00

N: number of patients;

Patients were closely monitored for any complications. Any noted complications are presented in Table 7.

Table 7: Complications after vacuum assisted closure (VAC) therapy

Complication	N	%
Joint stiffness	6	27.27
Knee pain	13	59.09
Wound infection	2	9.09
Exposed implant	1	4.55

N: number of patients;

The average time between the trauma and the first debridement was 8-20 h (range from 2-23). The time it took to get to the union was 5.03 ± 1.58 months (range 3-8 months). The average decrease in wound dimensions was noted. The difference between pre and after VAC application was determined to be 39.45 % (20-60 %). Two of the 22 patients who had secondary closure developed a deep infection. However, one patient developed osteomyelitis and required surgical treatment. No statistically significant association was discovered between the size of the first wound and the development of infection ($p > 0.05$). There was no association discovered between the trauma type and the development of infections ($p > 0.05$).

Table 5: Assessment of functional outcome of tibial shaft fracture based on modified Johner and Wruh's criteria

Criteria	N	%
Excellent	6	27.27
Good	9	40.91
Fair	5	22.73
Poor	2	9.10

N: number of patients;

Discussion

The 4 criteria estimate the outcomes: severe soft tissue injuries, open fracture with reduced blood supply, wound contamination and fracture instability.[13] The studies deal with the management of open fractures and their delayed closure and healing. Stabilisation focuses on skeletal fixation and final wound closure. This research focuses on the wound healing process before final closure as well as temporary wound dressing. Similar to Sinha et al[14] in this study intermittent negative pressure of 100–125 mm Hg was applied. It was discovered that intermittent negative pressure was more efficient than continuous negative pressure in treating 30 open wounds using a vacuum dressing at 75-100 mm Hg.

In this study, the average time for debridement was 8 to 20 h, with a 39.45 % reduction in post-VAC treatment wound size. In Ramazan et al, the average time for trauma and surgery was 7.57 h. Wound measures taken after the most recent VAC administration revealed a mean reduction of 40.02 %.[15]

In presented investigation, the maximum time for wound healing was 8-12 days. Ghulam et al used VAC in 50 open compound tibial shaft fractures and observed that the maximum duration for wound healing was 15 to 20 days as opposed to 30 to 40 days with normal dressing.[16] The mean post-VAC treatment wound size decrease in this research was 39.45 %. The mean reduction in wound size between pre- and post-vacuum dressing was 43.06 %, according to Himanshu et al.[17] Vacuum dressing was used by Kila et al[18] to treat open wounds and they found that it reduced hospital stays and treatment costs. At institution where presented study was performed, the patient load is quite high and the availability of operation theatre and definitive surgery like flap is delayed. Therefore, the length of the patient's hospital stay was prolonged.

This study has limitations, including the small study population from a single centre. Additionally, there was no comparison group to act as a control. Future areas of research should prospectively investigate the utilisation of VAC to increase value in the treatment of open tibia fractures, perhaps by including it as a component of standardised clinical assessment and management plans.

Conclusion

Despite the modest number of patients used in the study, the results demonstrated the establishment of healthy granulation tissue required less time. The wound could be covered definitively using techniques like SSG and flap cover more quickly. The number of wound debridement was decreased. The granulation tissue that was created was homogeneous and healthy. By creating homogeneous granulation tissue, soft tissue flaws that resulted in an unsightly and uneven surface were prevented and the defects were covered. Applying VAC dressing in the presence of an external fixator presents technical challenges, but these issues were resolved by realigning the fixator, decreasing the need for secondary intervention and reducing donor site morbidity by reducing the graft size, when the wound was required to be closed.

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Conflict of interest

None.

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