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Original Research Article

Role of vacuum assisted closer therapy in various types of musculoskeletal injuries.

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ABSTRACT

INTRODUCTION : In wound care for a wide variety of causes all around the world, reconstructive surgeons now include vacuum-assisted closure, often known as VAC, as part of their arsenal of treatment options. This beneficial device is attributed with expediting wound healing by reducing bacterial burden and increasing granulation tissue. This can, in certain instances, make the requirement for a flap obsolete, which is especially true in wounds that were caused by trauma. This is especially helpful in low-income nations, where certain surgical treatments require specialized equipment that is not readily available, and when patients do not have the financial resources to pay for costly procedures.**MATERIAL AND METHODS** : As a time-bound trial, musculoskeletal injuries that satisfied the inclusion criteria from January 2020 to August 2021 were considered for the study. The study required a minimum of 76 patients, randomized using a simple random selection approach, with 40 patients assigned to the VAC group and 36 assigned to the CONTROL group. The VAC group received a placebo. Recordings were made of the length of time that vacuum-assisted closure was utilized, the final wound closure outcome, the costs in comparison to those of standard dressing changes or free flaps, and a list of any and all complications. **RESULTS** : The VAC group had a considerably shorter therapy time (7.85±2.29) compared to the control group (22.06±8.16). The VAC group showed a considerably larger mean wound size decrease (cm2) (2.78±2.70) compared to the control group (0.36±0.54). The VAC group had a considerably greater mean granulation rate (93.86±11.15%) compared to the control group (47.96±19.25). The VAC group showed a substantially larger mean improvement in wound bed score (14.63±2.00) compared to the control group (9.83±1.90).Flap surgery, secondary closure, secondary intention, and skin grafting outcome were 32.50%, 17.50%, 10.00%, and 40.00% in the VAC group and 50.00%, 16.67%, 5.56%, and 33.33% in the control group. Based on outcomes, both groups showed no significant differences. **CONCLUSION:** The use of vacuum assisted closure dressing has been proven to be completely risk-free. Therefore, in the case of acute musculoskeletal injury, vacuum assisted closure dressing can be considered an improved option for wound treatment.

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KEYWORDS : Fractures, Wounds, Vacuum-assisted closure

INTRODUCTION

Wound healing is a complex and dynamic process that includes an immediate sequence of cell migration leading to repair and closure. This sequence starts with the removal of debris, control of infection, clearance of inflammation, angiogenesis, deposition of granulation tissue, contraction, remodeling of the connective tissue matrix, and maturation. When a wound fails to undergo this sequence of events, a chronic open wound without anatomical or functional integrity results occurs [1]

High-energy open fractures require both adequate soft tissue coverage and skeletal stability. In these types of injuries, debridement of all dead tissue can produce significant soft tissue defects precluding healing through primary intension, delayed primary intension, or secondary intention [2]. To obtain wound coverage in these difficult situations by various surgical methods. These include musculo-cutaneous or fascio-cutaneous tissue transfers, skin grafts, and local rotation flaps. Although skin grafts are readily obtainable, they are dependent on the vascularity of their recipient bed and maybe contraindicated when exposed bone, cartilage, tendons, or surgical implants exist [3].

In such type situation, a local rotation flap may be needed. When the soft-tissue defect prevents local coverage [4], free tissue transfers are usually required, but the transfer may produce donor site morbidity and require late revisions due to the size of the muscle flap [5].

Although non-operative modalities, such as hyperbaric oxygen, have been used to enhance wound coverage, these type devices may not be available to all patients and may not be adequate for use in patients presenting with high-velocity injuries due to edema, retraction of the skin, and soft tissue, wound size, or loss of available local coverage [6]. Attempts have been made to identify an alternative treatment of wound management in these patients. Clinically, chronic wounds may be associated with diabetes, pressure sore, venous insufficiency, trauma, prolonged immobilization, or vascular disease. The treatment of open, chronic wounds is variable and costly, demanding lengthy hospital stays or specialized home care requiring skilled nursing and costly supplies. Rapid healing of chronic wounds could result in decreased hospitalization and an earlier return of function. A method that improves the healing process could greatly decrease the risk of infection, amputation, and length of hospital stay and result in an estimated potential annual savings of billions of rupees of healthcare cost [1]. Initially developed in the early1990s, for the management of large, chronically infected wounds that could not be closed in extremely debilitated patients, the use of vacuum-assisted closure (VAC) has been more recently used in the treatment of traumatic wounds [7]. The purpose of this study is to evaluate the results of this therapy for the management of patients presenting with open musculoskeletal injuries.

The management of open fractures requires addressing the soft tissue component in addition to the management of fractures. In the past few decades, there has been tremendous research in this area. Yet, there is no standard protocol that can be implemented while managing open musculoskeletal injuries.

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The annual incidence of open fractures of long bones has been estimated to be 11.5 per 100,000 persons [8] with 40% incidence in the lower limb. These injuries still represent a major challenge for the treating surgeon and frequently demand a series of soft tissue and bone procedures to achieve undisturbed healing of the wound with adequate limb function. However, despite improvement in operative techniques and antibiotic therapy, septic complications still occur in severe open fractures. Delayed wound healing is a significant health problem, particularly in older patients and the ones with co-morbidities like diabetes and peripheral vascular disease. In addition to the pain and suffering, failure of the wound to heal also imposes a social and financial burden.

The management of an open fracture is often difficult. The mainstay of treatment involves timely initial debridement and irrigation of the wound. This is repeated every 48 to 72 hours until no further contamination or necrotic tissue remains in the wound. Traditional instruction has been to leave at least the traumatic portion of the wound open, to allow for fluid and bacterial egress from the wound bed. When the wound shows no further signs of tissue necrosis, definitive soft tissue coverage can be performed. This can be achieved with delay. Primary closure of the wound, split-thickness skin graft over a vascularized bed, and for the more severe injuries, rotational flap or microvascular tissue transfers.

The vacuum-assisted closure was pioneered by Dr. Louis Argenta and Dr. Michael Morykwas [9]. It is a development from the standard surgical procedure, which uses vacuum-assisted drainage to remove blood or serous fluid from an operation site to provide a drier surgical field and control blood flow (Thomas 2001). In VAC therapy, the application of topical negative pressure removes blood and serous fluid, reduces infection rates, and increases localized blood flow, thereby supplying the wound with oxygen and nutrition to promote accelerated healing. Alternative names for VAC include topical negative pressure, sub atmospheric pressure, sealed surface wound suction, vacuum sealing, and foam suction dressing.

So we have conducted a prospective study with the question: does vacuum-assisted closer therapy for various types of musculoskeletal injuries give a better functional outcome?

MATERIAL AND METHOD

To compare the efficacy of Vacuum Assisted Closure Therapy with Conventional dressing in terms of wound management in open musculoskeletal injuries based on following parameters -

1. Duration of therapy (in days)
2. Decrease in wound surface area (cm 2)
3. Rate of granulation tissue formation (%)

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4. Improvement in Wound Bed Score.

SOURCE OF DATA

His study is hospital based INTERVENTIONAL study , conducted in department of orthopaedics, UPUMS, Saifai , Etawah . A clearance from ethical committee of institute was obtained. Written informed consent was taken from all the patients or their family for participation in the study. The study conducted from January 2020 to august 2021.

STUDY DESIGN

Hospital based, comparative type of Prospective interventional randomized (single blinding) controlled study

STUDY PERIOD

Duration of study was from Jan 2020 to Aug 2021.

SAMPLE SIZE

All the patient admitted in Orthopaedic department of U.P.U.M.S. with Musculo-skeletal injury full filling inclusion criteria from Jan 2020 to Aug 2021 were considered for study as time bound study with a aim of min no of 76 patients, 40 in VAC group and 36 in CONTROL group randomized using simple random sampling method.

METHOD OF DATA COLLECTION

Patients admitted in orthopaedics department of U.P.U.M.S. SAIFAI with musculoskeletal injury between January 2020 to August 202 after following inclusion criteria .

Following inclusion and exclusion criteria were used for recruitment of patients in study :-

INCLUSION CRITERIA

1. Adults (>18years of age)
2. Both sex
3. Musculocutaneous injuries in extremities that required coverage procedures/acute traumatic soft tissue

   defects/infected soft tissue defect/traumatic ulcers

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4. Open fracture Gustillo Anderson Type 2,3a and 3b

EXCLUSION CRITERIA

1. Pre-existing osteomyelitis in wounds.
2. Neurovascular deficit in injured limb Patients with peripheral vascular disease.
3. Malignancy.
4. Patients not willing to participate in the study.

All patients for wound management will be subjected to

1. Standard radiological assessment of the injury wound.
2. Routine haematological investigation, for example complete blood count, ESR, blood sugar, HIV, HCV and HBsAg, Gram stain and culture.
3. A total number of 50 cases were included in the study which were randomly divided into groups-

Group A- It included 40 patients belonging to the “Study group where wound was managed by VAC Therapy.
Group B- It included 36 patients belonging to the “Control group” where wound was managed by Conventional treatment.

All these cases were treated with tetanus prophylaxis, standard antibiotics, appropriate analgesics and other supportive measures.

The evaluation of results was based on the following parameters:

1. Percentage of granulation tissue formation
2. Improvement in the wound bed score and
3. Preparedness of the wound bed for secondary procedures for soft tissues coverage like split skin grafting and flap
   surgeries.

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The data was analyzed statistically using Student T test/ Chi square test.

Conventional Dressing Regime-

- Wound preparation: Any dressing from the wound is removed and discarded. A culture swab for microbiology is taken before wound irrigation with normal saline.
- All the cases of open injuries are thoroughly irrigated with copious amount of normal saline so as to remove the contamination of foreign bodies.

Thereafter, the surgical debridement of wound is done to get rid of necrotic and devitalized tissues and adequate haemostasis is achieved.

A moistened dressing is applied to the wound, and allowed to dry. With removal of the dry dressing. necrotic tissue is removed with the dressing Dry dressings can be applied over wounds with more exudate.

Such saline wet-to-dry gauze dressing of the wound is done daily in a strict aseptic manner.

Technique of VAC Therapy:

1. Wound Preparation
Any dressings from the wound are removed and discarded. If required, a culture swab for microbiology should be taken before

wound irrigation with normal saline. Surface slough or necrotic tissue should be surgically removed (surgical debridement) and adequate haemostasis achieved. Prior to application of the drape, it is essential to prepare the peri-wound skin and ensure that it is dry.

2. Placement of Foam
Sterile, open-cell foam dressing is gently placed into the wound cavity. Open-pore, reticulated medical-grade foams (pore size 400 to 600 μ) are used as they are the most effective at transmitting mechanical forces across the wound and provide an even
distribution of negative pressure over the entire wound bed to aid in wound healing. Embedded in the foam is a fenestrated evacuation tube, which is connected to a computer-controlled vacuum pump that contains a fluid collection canister.

3. Sealing with Drapes
The site is then sealed with an adhesive drape which is included in the commercially available VACTM dressings. Drapes should the foam and tubing and at least 3-5 cm of surrounding healthy tissue to ensure a good seal.

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4. The Application of Negative Pressure

Controlled pressure is uniformly applied to all tissues on the inner surface of the wound. The foam dressing should compress in response to the negative pressure. The pump can deliver either continuous or intermittent negative pressures, ranging from -50 to -125 mmHg (adjustable up to 200 mmHg). Intermittent delivery consisting of a seven-minute cycle of five minutes on and two minutes off is an optimum setting. The ideal negative pressure setting is -125mmHg. The negative pressure is set to continuous mode for the first 48 hours, when there is more exudates build up and the pressure is changed as required thereafter.

Assessment

Details of cases were recorded including patient particulars, history and wound characteristics. Routine investigations and radiological assessment were done. A thorough wound irrigation followed by debridement of the devitalized tissue was don e in both the VAC and the Conventional treatment groups. Broad spectrum antibiotics tetanus prophylaxis and other supportive measures were implemented in all the cases.

The assessment of results is based on following parameters utilized to com pare the efficacy of VAC therapy with respect to
Conventional dressing in our study -

1. Improvement in the Wound Bed Score.
2. Rate of Granulation (in %).
3. Time duration required for formation of healthy granulation tissue.
4. Mean Decrease in Wound Surface Area (incm 2).

1. Wound Bed Score -

It is a classification system consisting of 8 parameters. Each parameter receives a score from 0 (worst score) to 2 (best score), and all the parameter scores are added for a total score. Thus, each wound can have a maximum score of 16 (the best score possible), to a minimum score of 0 (the worst score possible)

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2. Rate of Granulation -

The length of granulation tissue (a), multiplied by breadth of granulation tissue (b), divided by length of wound (c), multiplied by breadth of wound (d) and whole multiplied by 100, gives the rate of granulation tissue in percentage (%).

Wound Assessment in the VAC Group

- Pre-VAC Assessment of the Wound –

After thorough irrigation and debridement of the wound, the wound of the patient is assessed by measuring the maximum length and maximum width of the wound. Thus, the initial wound surface area is calculated.

Also, the initial Wound Bed Score of the wound is recorded.

- Post -VAC Assessment of the Wound –

Subsequently, when the VAC dressing is removed after an adequate time, the maximum length and the maximum width of the wound is measured again and the final wound surface area is calculated. Hence, the decrease in the wound surface area is calculated by subtracting the initial wound surface area from the final area. Also, the Wound Bed Score of the wound is recorded again and thus,

The improvement in Wound Bed Score is calculated by subtracting the initial WBS from the final WBS.

On removal of VAC dressing, the maximum length and breadth of the healthy beefy red granulation tissue covering the wound is also measured. Thus, the Rate of Granulation tissue formation is calculated using the above mentioned formula.

Wound Assessment in the Control Group -

Similar to the VAC group, the initial wound surface area and the initial Wound Bed Score is recorded in every control case. Thereafter, wound surface area and Wound Bed Score is recorded on Day 7 after daily dressing of the wound by conventional methods for one week. In this way, the decrease in the wound surface area and the improvement in the WBS is calculated for the control group. Also, the maximum length and breadth of the healthy beefy red granulation tissue covering the wound is measured on Day 7. Similarly, the Rate of Granulation tissue formation on Day 7 is calculated using the above mentioned formula.

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RESULTS

In our study of total 76patients, mean age of patients is 34.71 years. The maximum number of patients belonged to the age group of 21 -30 years i.e. 25 out of 76 patients (32.89%) followed by the age group of 31 -40 years i.e. 18 out of 76patients (23.68 %). This suggests that these two age groups are most susceptible to acute musculoskeletal trauma. Out of 76 patient 60 (78.94)% patients are males and 10 (21.05)% patients are females showing male preponderance because of travelling and working in agriculture fields and factories. The most common mode of injury was found out to be Road Traffic Accident (79%). Other cases of trauma were Railway accident (6.5%), fall from height (6.5%), and machine injury (8%). Out of 76 patients, 12 (16%) patients belong to type 2, 17(22%) patients belongs to type 3A while 47(62%) patients belongs to type 3B. Table and Figure show the comparisons duration of therapy (days) in VAC group and control group. The mean duration of therapy was significantly lower in VAC group (7.85±2.29) as compared to control group (22.06±8.16).

Table 1 show the comparisons decrease in wound size (cm2) in VAC group and control group. The mean decrease in wound size (cm2) was significantly higher in VAC group (2.78±2.70) as compared to control group (0.36±0.54).

	VAC group (n=40)		**Control group (n=36)**		**t**	**1 p-value**
	Mean	**±SD**	**Mean**	**±SD**		
Decrease in wound size (cm2)	2.78	2.70	0.36	0.54	5.26	<0.001*

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Table 2 : Comparisons of mean rate of granulation (%) in VACgroup and control group

The mean rate of granulation (%) was significantly higher in VAC group (93.86±11.15) as compared to control group (47.96±19.25).

	VAC group (n=40)		Control group (n=36)		t	[1] pvalue
	Mean	±SD	Mean	±SD		
Rate of granulation (%)	93.86	11.15	47.96	19.25	12.88	<0.001*

Table 3 show the comparisons of mean Improvement in wound bed score in VAC group and control group.

The mean Improvement in wound bed score was significantly higher in VAC group (14.63±2.00) as compared to control group (9.83±1.90).

	VAC group (n=40)		Control group (n=36)		t	[1] pvalue
	Mean	±SD	Mean	±SD		
Improvement in wound bed score	14.63	2.00	9.83	1.90	10.68	<0.001*

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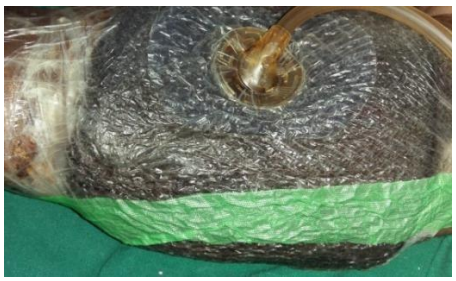
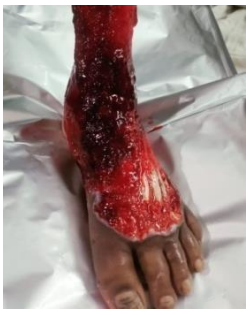
Table 4 show the distribution of study population according to outcome in groups. The percentage of Flap surgery, Sec closure, Sec intention, and Skin grafting outcome were 32.50%, 17.50%, 10.00%, and 40.00% in VAC group and 50.00%, 16.67%, 5.56%, and 33.33% in control group, respectively. On the basis of Outcome, the both groups were not significantly different.

Outcome	**VAC group (n=40)**		**Control group (n=36)**		**Chi Sq.**	**[1]p-value**
	n	**%**	**n**	**%**		
Flap surgery	13	32.50	18	50.00	2.07	0.558
Sec closure	7	17.50	6	16.67		
Sec intention	4	10.00	2	5.56		
Skin grafting	16	40.00	12	33.33		

Figure 1 shows the clinical picture of a 28 year young male with crush foot managed by VAC.





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DISCUSSION

In the study by Ondieki et al [91], the healing time of 8.1 days in the VAC group is comparable to our study group while that of the control group (i.e. 8.4 days) is inconsistent with the healing time of our control group probably because, he included only acute traumatic wounds with soft tissue loss without any compound fractures. Thus, traumatic wounds without any bony component take lesser time to heal in comparison to those that have open fractures when the wound management is by conventional dressing. On the other hand, there is not much difference in the healing time when the wound management is by VAC therapy.

In yet another study by Sandhya et al[93], the average time taken for granulation tissue formation in VAC therapy group (i.e. 13.71 days) was found out to be longer compared to our study group probably because, this study included large wounds having chronic etiologies like diabetic ulcers, cellulitis, etc. while on the other hand, the duration of therapy in the control group (i.e. 24.35 days) was comparable to our control group. This shows that VAC therapy takes longer time for healing of chronic wounds as compared to wounds due to acute trauma while there is not much difference in the healing potential when such wounds are managed by conventional dressing.

The mean duration of VAC therapy was at a higher side in the study by Venu et al [94] (i.e. 10.5 days) when compared to our study probably because, his study exclusively consisted of patients belonging to Type 3b Gustillo Anderson classification unlike our present study where, only 41.8 % of cases belong to Type 3b.

The mean time taken for final wound closure was lesser in both VAC group (6.7 days) and the control group (16.1 days) in the study by Yang et al [84]as compared to our study because, while we included patients with higher grade open musculoskeletal injuries, Yang had only the surgical fasciotomy wounds in his study.

The time taken to achieve full granulation by VAC therapy in the study by Bollero et al [86], was much longer (i.e. 22 days) compared to our current study, mainly due to the complex nature of wounds involved in his study as 86% cases had exposed bone. While in another study by Wanderaetal[79], the median time for full granulation using VAC therapy was slightly longer (i.e. 12 days) as compared to our current study. This could be due to the larger starting average wound surface area of 335.8 cm 2 in Wandera's study versus 224.6cm 2 in our study.

The mean reduction in wound size in the VAC group was found out to be 2.78cm ^{2}while in the control group it was 0.36cm ^{2}. The mean decrease in wound size found in the study by Venu et al [94](i.e. 1.5 cm 2) was much less compared to our study because, all the patients in his study belonged to Gustillo Anderson type 3b while in our current study only 11 out of 34 patients managed by VAC therapy belong to type 3b.

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In the study by Ondiekiet al [91], the mean reduction in wound size in the VAC group (3.7cm 2) is comparable to our study group while it is inconsistent with respect to the reduction in wound size in the control group (3.6 cm 2). This is probably because, this study consisted of acute trauma with only soft tissue loss and no compound fractures while our study includes high grade open musculoskeletal injuries with 62.0% cases being Type 3b injuries.. Thus, the presence of open fracture has no detrimental effect in the reduction of wound size when the wound management is by VAC therapy. On the other hand, the presence of open fracture definitely leads to lesser reduction in wound size when the wound management is by conventional dressing.

Lee et al [87]in a study of acute wounds treated with NPWT noted a greater average reduction of wound surface area i.e. about 24% as compared to our study. This could be due to longer duration of NPWT of about 18.4 days in his study compared to our present study where mean duration of VAC therapy was just 8 days. Thus, longer the duration of VAC therapy, more is the reduction in wound surface area

The rate of granulation in the VAC group was found out to be (93.86±11.15) % while in the control group it was (47.96±19.25) The uniform negative pressure delivered by the VAC therapy to the wound bed plays a significant role in formation of new healthy granulation tissue. In normal saline dressings, the gauze pad sticks to the dead tissue and while changing the dressings the dead tissue along with the new and delicate granulation tissue formed underneath is also removed along with the gauze pad and this causes mechanical damage to the formation of new granulation tissue in the wound bed.

The rate of granulation at the end of one week in the study by Chandrashekar et al [96] , was lower in both the VAC (68%) and the control group (40%) in comparison to our study probably because, his study included patients with acute, sub-acute as well as chronic open wounds of various etiologies like diabetic ulcer, venous ulcer, post - traumatic raw area, etc. while our study, exclusively included cases of acute musculoskeletal injuries. Thus, the rate of granulation tissue formation is slower in chronic wounds as compared to wounds due to acute trauma.

In the study by Dunn et al[89], the rate of granulation (i.e. 90% at the end of 12 days) was again slower in comparison to our study because this study included patients having traumatic, post -surgical as well as chronic wounds while our study exclusively consisted of acute musculoskeletal injuries. This further supports the view that the rate of granulation in wounds having chronic etiologies is slower incomparison to wounds due to acute trauma. The mean improvement in wound bed score in the VAC group was found out to be (14.63±2.00) while in the control group it was (9.83±1.90) . In the study by Chandrashekar et al[96], the improvement in the wound bed score was slower in both VAC (9.60 ± 2.16) as well as control group (5.12 ±1.99) probably because, this study included patients with acute, sub-acute as well as chronic open wounds of various etiologies like diabetic ulcer, venous ulcer, pressure sore, post- traumatic raw area, etc. while our present study, exclusively included cases of acute musculoskeletal injuries. Thus, the improvement in wound bed score is slower in chronic wounds as compared to acute traumatic wounds. Conventional wound dressing required prolonged period, repeated debridement, more trauma to granulation tissue and had poor patient compliance and long duration hospital stay

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The whole procedure of VAC application converts an open wound into a controlled and temporarily closed compartment with negative pressure uniformly applied over it. Thus, VAC therapy provides a sterile and controlled environment in which wound healing take place under moist, clean and sterile conditions so granulation and heeling rate is faster in comparision
conventionally dressing , due to this reson shorter hospital stay duration requir for patient. So VAC therapy ultimately is cost effective andcomfarmtable to patient.

The main limitation of VAC system is its higher cost of purchase or hire of a VAC unit.Thus, the high cost of vacuum system and the cost of vacuum dressing have discouraged many doctors from its application. But, when compared with saline dressings which take longer duration for wound healing, more number of debridement & more number of days of absence from work. When all these factors are compared with the cost of VAC therapy, the treatment expense of VAC is lesser compared to standard saline dressing along with better patient compliance and lesser morbidity to the patient.

CONCLUSION

Vacuum assisted closure therapy has been around for no longer than 20 years and has facilitated the wound healing process to a large extent. By reducing the healing time and being cost effective, NPWT dressing has made wound healing a more comfortable and cheaper process, as well as improving the quality of life and morbidity of the patients. It provides psychological, social and financial benefits to the patient by reducing the hospital stay and allowing early return to normal life.

Based on the parameters of reduction in wound size, rate of granulation and improvement in the wound bed score, it is concluded that wound healing is better with vacuum assisted closure therapy when compared to conventional dressing and it leads to early preparation of the wound bed for secondary closure, split skin grafting or flap rotation. Also, the compliance of the patient is good in vacuum assisted closure therapy.
Vacuum assisted closure dressing was found to be totally safe with no undue complications. Thus, vacuum assisted closure dressing can be considered as a superior option in the management of wounds in acute musculoskeletal injury.

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