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Comparison of vacuum assisted closure (VAC) and standard therapy in compound fractures

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Abstract
Background: A bone fracture is a medical condition where the continuity of the bone is broken. Open fractures usually are high-energy injuries. This, along with the exposure of bone and deep tissue to the environment, leads to increased risk of infection, wound complications, and non-union [1, 2]. Antibiotics, surgical debridement, and internal fixation have improved outcomes of open fracture management in important ways, and it includes primary asepsis, adequate debridement, immobilization, and protection of wounds against disturbance and reinfection [3, 4]. Wound healing is a complex and dynamic process that includes an immediate sequence of cell migration leading to repair and closure. This sequence begins with removal of debris, control of infection, clearance of inflammation, angiogenesis, deposition of granulation tissue, contraction, remodeling of the connective tissue matrix and maturation. When wound fails to undergo this sequence of events, a chronic open wound without anatomical or functional integrity results. Vacuum assisted closure (VAC) is relatively a new technique which hastens granulation tissue formation by speeding up all these parameters [5].
Materials and Methods: The present study was Hospital based Prospective comparative study carried out from July 2016 to October 2018, on 90 cases satisfying the inclusion criteria following complete assessment. Patients were assessed by efficacy of both procedures was measured by the time taken by wound be optimal for skin grafting/flap, whether slough and discharge present or not, rate of decrease in size of wound (%) and whether flap is needed or avoided by use of VAC dressing
Result: Both group are compare on the basis of type of fracture as per Gustillo and Anderson classification, duration of receiving treatment from initial injury, slough was comparable on day 0 and day 4, frequency of discharge, granulation tissue and size of wound.
Conclusion: VAC therapy show final cessation of slow earlier than those treated by standard therapy for fracture management. VAC therapy shows earlier control of discharge, earlier appearance granulation tissue and earlier decrease in size of wound compare to standard therapy. Rate of healing is faster in VAC therapy compared to standard therapy. Earlier optimized covering of wound can be obtained by VAC therapy. Requirement of skin grafting is less in subjects treated with VAC therapy. Minimal complications with complete healing possible with VAC therapy in compound fractures of lower limb.

Keywords: VAC therapy and standard wound therapy

1. Introduction
According to the global burden of disease study of 2010, injury accounted for 10% of deaths worldwide and 11.2% of all disability-adjusted life years (DALYs). A bone fracture is a medical condition where the continuity of the bone is broken.Open fractures represent a spectrum of injuries sharing the common feature of fractures that have communication with the environment [1, 2]. Open fractures usually are high-energy injuries. This, along with the exposure of bone and deep tissue to the environment, leads to increased risk of infection, wound complications, and non-union [3, 4]. Antibiotics, surgical débridement, and internal fixation have improved outcomes of open fracture management in important ways, but the underlying principles for treating open fractures have remained the same since World War I: primary asepsis, adequate debridement, immobilization, and protection of wounds against disturbance and reinfection [3, 4]. Wound healing is a complex and dynamic process that includes an immediate sequence of cell migration leading to repair and closure. This sequence begins with removal of debris, control of infection, clearance of inflammation, angiogenesis, deposition of granulation tissue, contraction, remodelling of the connective tissue matrix and maturation.

When wound fails to undergo this sequence of events, a chronic open wound without anatomical or functional integrity results. Topical negative pressure therapy (TNP) was developed by Fleischmann in 1993 and was popularized in 1995 as Vacuum assisted closure (VAC) system (kinetic Concepts Inc, San Antonio, Texas, USA).[8] It is known by many pseudonyms—TNP (topical negative pressure), SPD (sub-atmospheric pressure), VST (vacuum sealing technique) and SSS (sealed surface wound suction). It is hypothesized that VAC therapy if used in precise indications hastens wound healing by decreasing tissue edema, reducing tissue bacterial levels, increasing blood flow to the wound and hence hastens granulation tissue formation and results in early wound closure[5].This study is intended to assess the outcome of wound healing in Compound fractures by VAC therapy and Standard wound therapy

2. Materials and method

This was Hospital based Prospective comparative conducted in Dr. Bhim Rao Ambedkar Memorial Hospital, Raipur, Chhattisgarh between July 2016 and October 2018.The study included 90 patients where 30 patient presenting with lower limb compound fractures Managed by VAC closure treatment and another of 60 patients group 2 (receiving standard wound therapy)

We studied 90 adult patients of compound lower limb fracture of which most of the patients were brought to the causality or admitted through outpatient department basis, clinical history was elicited. Careful clinical examination of skeletal system and soft tissue injuries was recorded. Radiographs were done. Limb was immobilized in a above knee slab. once patient's general condition stabilized then we planned operative fixation done than in post operative period VAC therapy or Standard wound therapy use

2.1.1 Inclusion criteria

- Patients with age group above 18 years.
- Type IIIA, IIIB compound fractures (Gustilo and Anderson classification.)
- Late (more than 2 weeks) presentation of Type II compound fractures (Gustilo and Anderson classification.)
- Traumatic Amputation.

2.1.2 Exclusion criteria

- Pathological fractures with osteomyelitis
- Compound fracture of Type I and Type IIIC (Gustilo and Anderson)
- Wounds associated with diabetes, osteomyelitis, malignancies and peripheral vascular disease.
- Patient with raised PT/INR
- Haemophiliacs.

2.2 Methodology

2.2.1 Wound Preparation for VAC.

Any dressings from the wound was removed and discarded. A culture swab was taken and wound was thoroughly irrigated with normal saline. All the necrotic tissues wwre surgically debrided and adequate homeostasis was achieved. Peri-wound skin was thoroughly dried and prepared. Sterile, open-pore foam dressing was then gently placed into the wound cavity. The foam was then sealed with an adhesive drape (loban /opsite) covering the foam and the tubing with at least three to five centimeters of surrounding healthy tissue to ensure a seal. Connecting tube was then applied after making a small opening (3-4 mm) on the drape. Controlled pressure was then uniformly applied to all the tissue on the inner surface of the wound through connecting tube connected to the negative pressure central suction delivering an intermittent negative pressure of -125mmHg. The dressing was changed every 4thday.

Fig 1: wound preparation for VAC

Fig 2: VAC machine and it's component

2.2.2 Wound Preparation for Standard wound therapy

Any dressing from the wound was removed and discarded. A culture swab was taken and wound was thoroughly irrigated with normal saline. All the necrotic tissues were surgically removed and surgical debridement will be done. Daily dressings was done by conventional methods, that is, cleaning with Hydrogen peroxide and Betadine Normal saline and then dressing the wound with povidone iodine (5%) or Neosporin ointment.

2.2.3 Outcome record: Results were made on the basis of the analysis of the following between the two groups:-

- The efficacy of both procedures was measured by the time taken by wound be optimal for skin grafting/flap cover of
- Whether slough and discharge present or not.
- Rate of decrease in size of wound (%).
- Whether flap is needed or avoided by use of VAC dressing.

3. Results

Comparison of type of fracture (Gustillo and Anderson classification) between study groups was performed between two study groups using chi square test. No significant difference was detected between two groups indicating that both groups were matched for distribution of type of fracture.

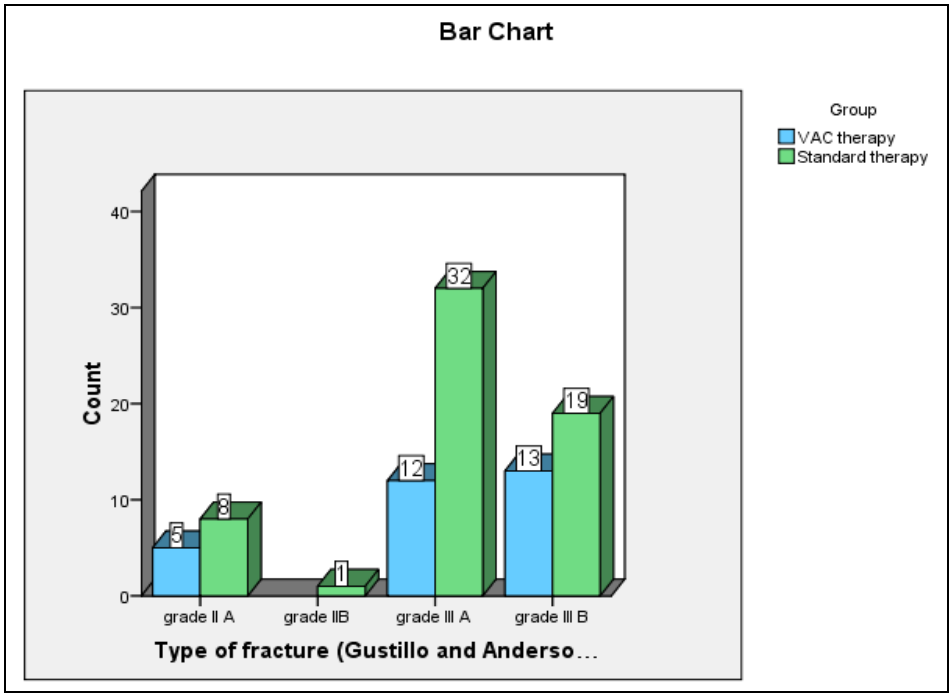

Fig 3: Comparison of type of fracture

Comparison of Duration between Injury and VAC/SWT application was performed using student's t test. No significant difference was observed between mean values of duration indicating that both groups were matched for the parameters.

Table 1: Comparison of Duration between Injury and VAC/SWT application

	Group	N	Mean	Std. Deviation	Std. Error Mean	t	Significance
Duration Between Injury and VAC/SWT application	VAC therapy	30	5.1667	3.24923	.59322	.216	.830
	Standard therapy	60	5.0667	1.10264	.14235		

Comparison of slough at different interval from surgery between two study groups was performed using Chi-square test. No significant difference in frequency distribution was present at day 0, and day 4 but slough was found to be significantly higher at say 8 in VAC therapy group. Further frequency of Slough was found to be lower in VAC therapy at 12th day though difference failed to reach statistical significance

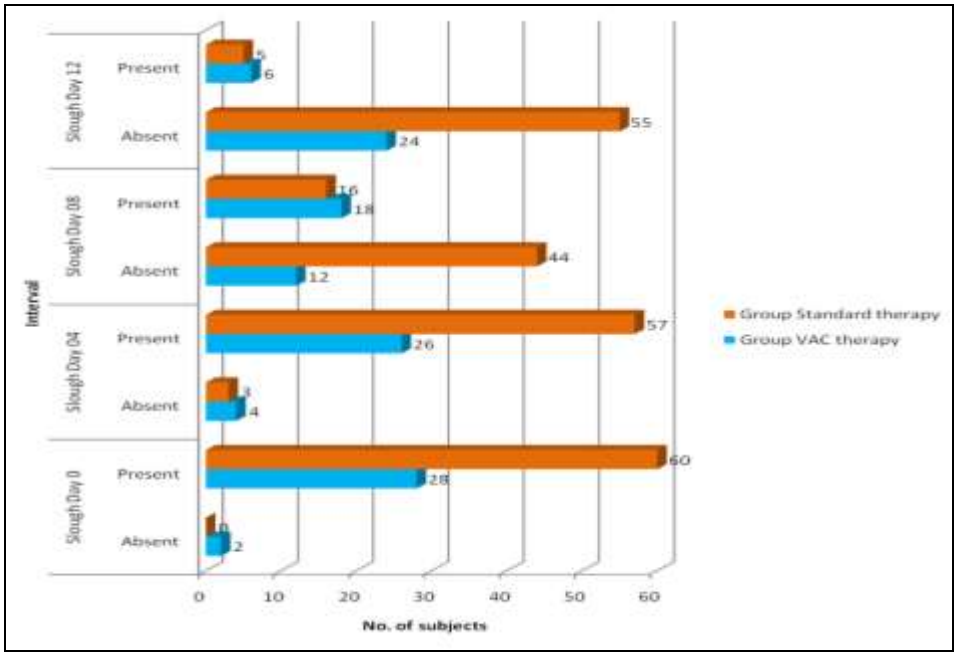

Fig 4: Comparison of slough at different interval from surgery between two study groups

Comparison of Discharge at different interval from day of surgery between study groups was performed using Chi square test. Frequency of discharge was found to be significantly lower in VAC therapy group at day 0, day 4 but on day 8 and day 12 discharge was found to be significantly lower in standard therapy group.

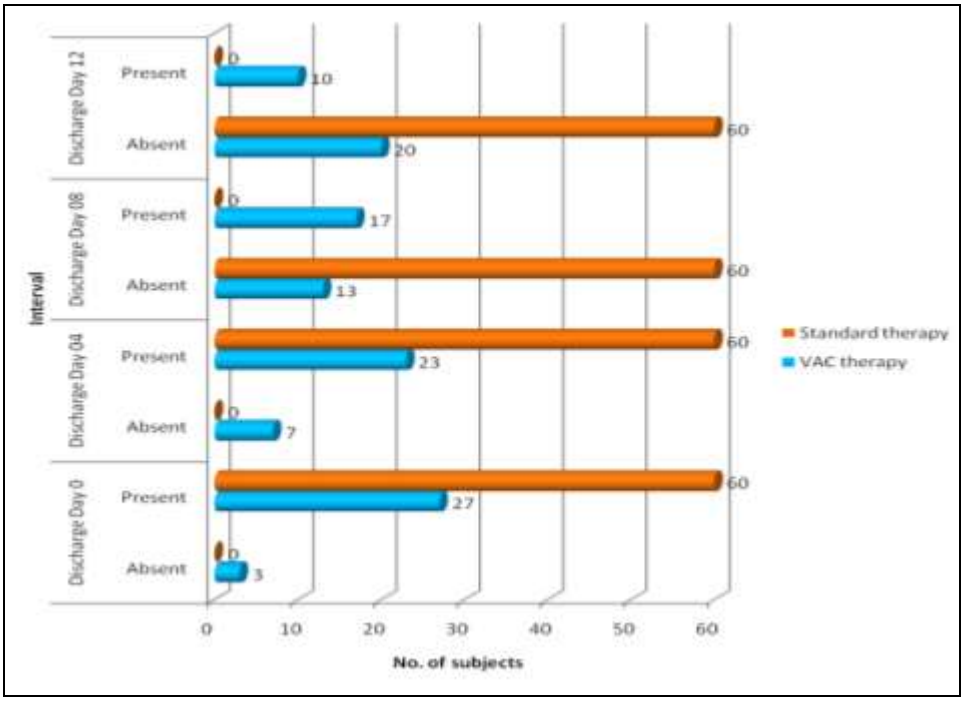

Fig 5: Comparison of Discharge at different interval from day of surgery between study groups.

Comparison of granulation tissue at different interval from day of surgery between study groups was performed using Chi square test. While granulation tissue was not significantly different at day 0 between two study groups, significantly higher Frequency of granulation tissue was noted at day 4 but on day 8 and day 12 in VAC group.

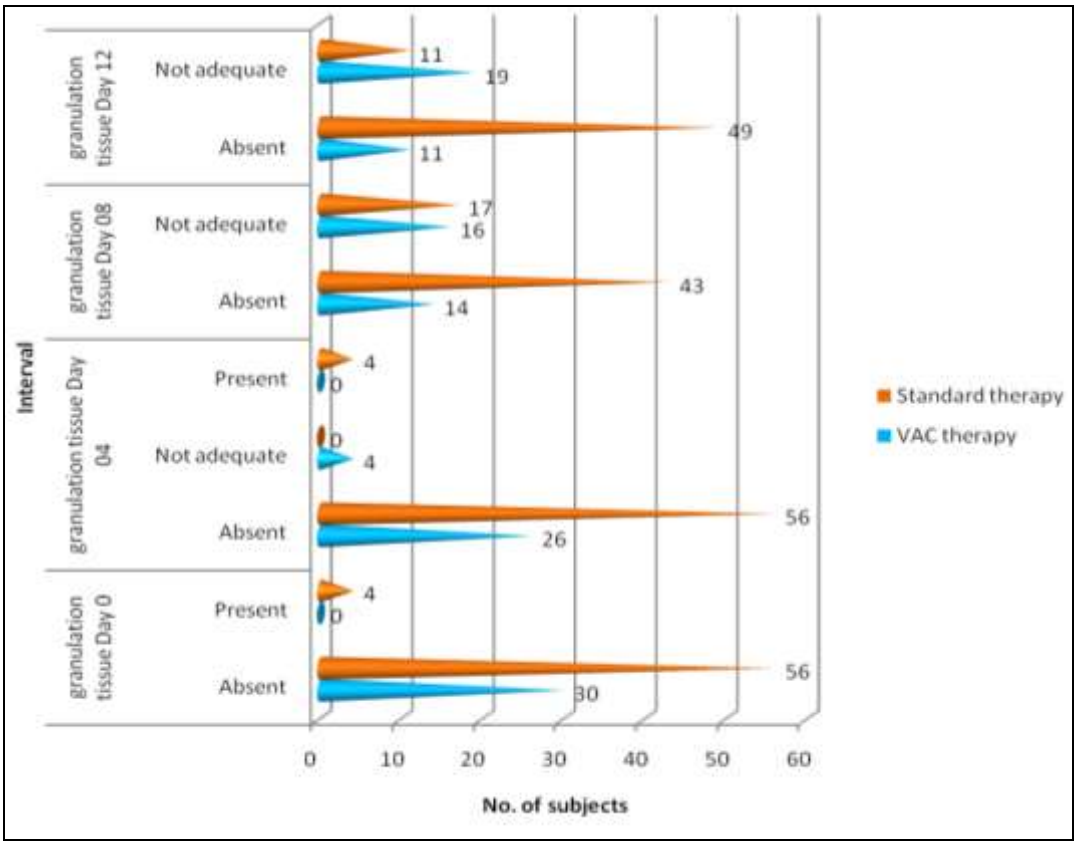

Fig 6: Comparison of granulation tissue at different interval from day of surgery between study groups.

Comparison of size of wound at different interval from day of surgery between study groups was performed size of wound was found to be significantly smaller in VAC group at day 0, day 4, day 8 and day 12 compared to that in standard therapy group.

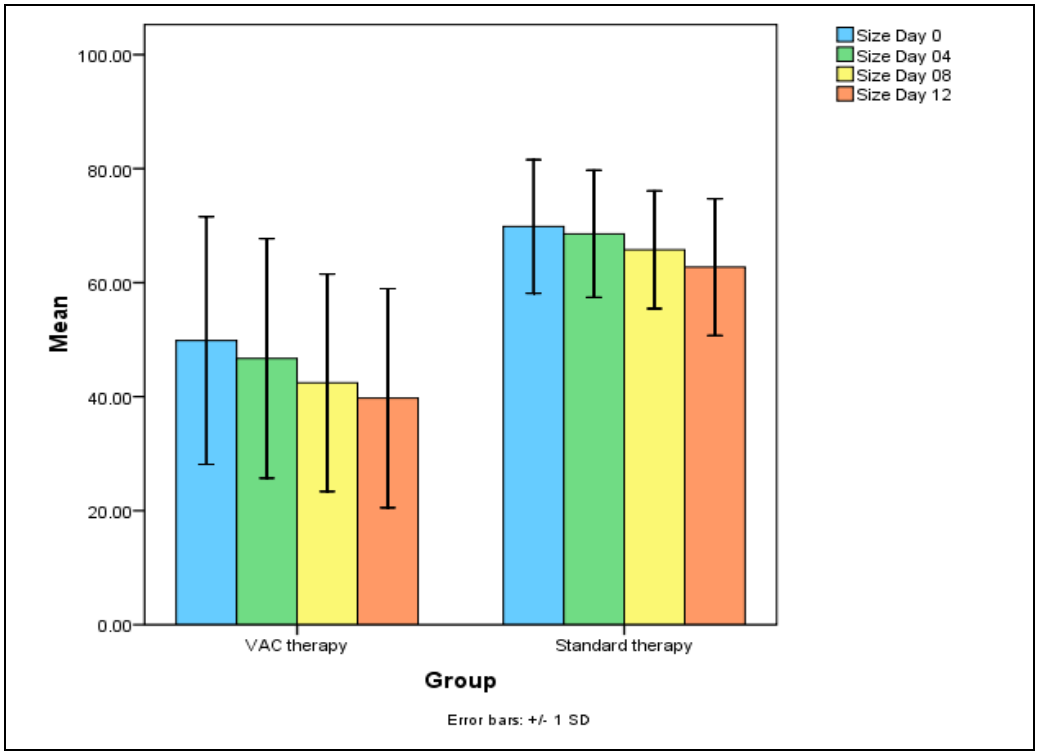

Fig 7: Comparison of granulation tissue at different interval from day of surgery between study groups**.**

Result after vac application

Fig 8: After vac application followed by grafting

4. Discussion

Our two study groups VAC and Standard therapy were matched for age distribution as well as gender distribution. These findings indicate that study groups were comparable at baseline as per basic demographic status.

Aging affects the inflammatory response during fracture healing through senescence of the immune response and increased systemic pro-inflammatory status. Important cells of the inflammatory response, macrophages, T cells, mesenchymal stem cells, have demonstrated intrinsic age-related changes that could impact fracture healing. Additionally, vascularization and angiogenesis are impaired in fracture healing of the elderly. Finally, osteochondral cells and their progenitors demonstrate decreased activity and quantity within the callus. Age-related changes affect many of the biologic processes involved in fracture healing. However, the contributions of such changes do not fully explain the poorer healing outcomes and increased morbidity reported in elderly patients [8].

Clinically, gender and stability affect bone defect healing simultaneously. It is unclear whether gender and stability interact in some synergistic or deleterious way. Knowledge of synergistic or independent effects of these factors might suggest a gender-related modification in the stability of clinical fracture devices that could possibly improve bone healing outcome. Clinically, gender and stability of fracture fixation have been reported to independently influence bone regeneration but it remains unclear whether these factors interact in a deleterious or synergistic way. Therefore, the purposes of the present pilot study were to generate research questions by comparing bone defect healing between middle-aged male and female rats under the influence of variable fixation stability using analysis from (1) mechanical properties of the callus at 6 weeks; (2) bony bridging of the defect; (3) *in vivo* callus development over time as well as (4) to determine callus mineralization, size, geometry, and microstructure [9].

Though classically known fact that female are at higher risk of low bone density, fractures are seen at higher bone density in males. Further healing process as is dependent on bone mineral density, is slower in females comparably [10].

No significant difference was detected between two groups regarding type of fracture (Gustillo and Anderson classification) between study groups indicating that both groups were matched for distribution of type of fracture. Also No significant difference was observed between mean values of duration for start of therapy indicating that both groups were matched for duration of start of therapy from trauma.

Gustilo-Anderson classification that has become the most commonly used system for classifying open fractures. Like many classification systems, the purpose of the Gustilo-Anderson schema is to provide a prognostic framework that guides treatment and facilitates communication among surgeons and clinician-scientists. Decades of research correlating the Gustilo-Anderson type with infection risk have helped refine surgical protocols, change antibiotic recommendations, and determine appropriate timing for interventions including débridement, internal fixation, and soft tissue coverage. As a widely known and relatively straightforward system, which has become the standard of

classifying open fractures, the Gustilo-Anderson classification also is useful for education of residents and other trainees in the treatment of patients with orthopaedic trauma. Thus matching of groups with respect to these classes indicate that the bias of initial status of wound with possible varied outcome can be well taken care of. [11] When flow of slough was compared between subjects treated with VAC therapy and standard therapy, no significant difference in frequency distribution was present at day 0, and day 4 but slough was found to be significantly higher at day 8 in VAC therapy group. Further frequency of Slough was found to be lower in VAC therapy at 12th day though difference failed to reach statistical significance. Thus it was observed in our study that though there is momentary increase in slough at one week post op, the slough decreases later on in comparison to standard therapy and slough regression is faster in VAC therapy [12].

Frequency of discharge was found to be significantly lower in VAC therapy group at day 0, day 4 but on day 8 and day 12 discharge was found to be significantly lower in standard therapy group. This indicates that in VAC therapy, discharge is less in initial days as compared to standard therapy. Further the discharge is though rapidly controlled in VAC therapy, final decrease in discharge is found in standard therapy.

In our study granulation tissue was not significantly different at day 0 indicating that at baseline these two groups were comparable. Though significantly higher Frequency of granulation tissue was noted at day 4 in standard therapy, on day 8 and day 12 granulation tissue frequency was higher in VAC group though the granulation tissue was not found to be adequate. This indicates that initial healing was with appearance of granulation tissue was faster in standard therapy, but VAC therapy shows increased healing potential in later stages at day 8 and day 12.

In our study Comparison of size of wound at different interval from day of surgery between study groups was performed size of wound was found to be significantly smaller in VAC group at day 0, day 4, day 8 and day 12 compared to that in standard therapy group. As the baseline size of wound was smaller in VAC groups it is a source of bias which can be said to be following the same expected trends in further progression of wound during treatment.

Significantly higher frequency of skin grafting was needed in standard therapy to close the wound compared to wounds treated by VAC therapy, though at least part of this can be attributed to larger mean size of wound in standard therapy group.

With these differences in intermediate observations where short term parameters were favoring standard therapy and intermediate term parameters were favoring VAC therapy, at the end of follow up, all fractures showed 100% healing with no complications observed.

Venu Madhav HV *et al*. carried out prospective 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, number of days of hospital stay and healing of soft tissue injury in Gustilo Anderson compound grade IIIB fractures treated by Vacuum Assisted Closure & by stabilization of fracture. Where in, only Gustilo Anderson compound grade IIIB fractures were included in the study. The time duration taken for formation of healthy granulation tissue was less as claimed by authors. But surprisingly, author have not used any control group in the study [13].

The results of our study was in line with this study showing appearance of granulation tissues earlier in VAC group though granulation tissue were not adequate. At 4th day though granulation tissue were found to be higher in standard therapy group. Later on in process VAC group took over.

The mechanism of VAC therapy is very simple. An open-cell structured foam is cut according to size and shape of the wound and then it is kept on the wound bed, a suction drain with perforations only in the end of the tube is laid on the foam. Then the entire wound is then sealed with an opposite or a transparent membrane which is adhesive then the other end of the suction tube is connected to a vacuum machine, once the wound is sealed and the machine is switched on the fluid from the wound is drawn through the foam into a canister which can be disposed subsequently. By this the edema from the wound is removed, new blood vessels are formed (angiogenesis) & hence leads to formation of healthy granulation bed & all this leads to earlier skin cover procedures of the wounds [14].

Gupta U *et al* performed a study to analyse and compare the results of vacuum assisted closure therapy and standard wound therapy in management of compound fractures. 30 patients having compound fractures upto grade IIIB (Gustilo and Anderson classification) were randomly treated either using SWT or VAC therapy. After initial wound debridement and provisional fracture fixation, therapy was started and continued till the wound got optimized for coverage either by split skin graft or flap. Author observed that time to optimized coverage in VAC group was shorter also the mean rate of decrease in wound size was higher in VAC therapy compared to standard wound therapy. But author have not mentioned anything about the significance of difference between two groups [15].

Though the significance is not mentioned the trends seen in this study by a large matched to those in our study. Our study is better only, owing to having achieved statistical significance.

Our results are again consistent with the findings of study done by Morykwas *et al.* Sinha *et al.* and Banwell *et al.* [16] who also found that VAC therapy helps in reducing the size of wound at much faster rate as compared to SWT when applied to wounds resulting from open fractures. Our results are again somewhat comparable with the findings of study done by Arti *et al.* who also found less time taken by wounds to get optimized for coverage treated by VAC therapy as compared to SWT [17].

Gupta K *et al.* also carried out prospective randomised study is to compare the rate of infection, primary wound coverage, hospital stay and healing of soft tissue injury associated with open musculoskeletal injuries. Thirty patients with open musculoskeletal injuries were included in this study. They were divided in two groups of 15 each, Group A (VAC) and Group B (sterile dressing group) .All these patients had undergone wound debridement and fracture fixation. This was followed by application of Vacuum Assisted Closure (VAC) for Group A and sterile dressings for group B patients. The infection rate of these two groups was analysed by clinical signs and symptoms. Authors noted that primary wound coverage can be done earlier in VAC group. Also, hospital stay was minimum in VAC Group and wound healing was also faster patients when compared to group with standard therapy [18].

5. Conclusion

Subjects who are treated by VAC therapy show final cessation of slow earlier than those treated by standard

therapy for fracture management. VAC therapy shows earlier control of discharge compared to standard therapy though final decrease in discharge is more in standard therapy. Granulation tissue appears early in standard therapy but sustained noticeable granulation tissue are favored by VAC therapy. VAC therapy leads to earlier decrease in size of wound. Rate of healing is faster in VAC therapy compared to standard therapy. Earlier optimized covering of wound can be obtained by VAC therapy. Requirement of skin grafting is less in subjects treated with VAC therapy. Minimal complications with complete healing possible with VAC therapy in compound fractures of lower limb.

6. Financial support and sponsorship: Nil.

7. Conflicts of interest: There are no conflicts of interest

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