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Effectiveness of Vacuum-assisted Closure (VAC) Therapy for Open Musculoskeletal Injuries: A Cross-Sectional Study

Waseem Ahmed[1], Sher Baz Khan[2], Bader Mohammed H Alqarni[3], Ahmed Elkhashab[4], Niaz Hussain Keerio[5], Hamza Fareed[6]

[1]Assistant Professor Orthopaedics, Muhammad Medical College and Hospital Mirpurkhas Pakistan; [2]Consultant Orthopaedic Surgeon, PHQ Hospital Gilgit Pakistan; [3]Resident in Orthopaedic Surgery, King Abdul Aziz Hospital, Mecca, Saudi Arabia; [4]Registrar Orthopaedics, King Abdul Aziz Hospital, Mecca, Saudi Arabia; [5]Assistant Professor Orthopaedics, Muhammad Medical College and Hospital Mirpurkhas Pakistan; [6]Assistant Professor Orthopaedics, Fauji Foundation Hospital, Rawalpindi Pakistan.

ABSTRACT

Introduction: Treatment of wounds is a crucial process that requires an event of cell migration to control blood perfusion and repair in a short time period. The series of cell migration involves debris removal, infection control, reducing inflammation, formation of granulation tissue.

Aim: To examine the effectiveness of vacuum-assisted closure therapy for open musculoskeletal injuries.

Methodology: All the patients underwent the standard radiological assessment. We performed a routine hematological investigation. We gently placed the open-pore foam (35 PPI density and 33 mm thick) dressing into the cavity of the wound. We used 400–600 microns size polyurethane open-pore foam because these foams are effective at transmitting mechanical forces across the wound also assist wound healing by applying pressure on the entire wound. The drape was used to seal the wound site. Study design: A cross-sectional study. Place and Duration: This study was conducted at Muhammad Medical College and Hospital Mirpurkhas, PHQ Hospital Gilgit, Fauji Foundation Hospital, Rawalpindi Pakistan from June 2020 to June 2021.

Results: For this study, we recruited 30 patients with a mean age of 39 ± 18 years. All the selected patients had acute trauma. We observed 13.33% cases with decreased wound size greater than 25mm over 8 days however no significant difference was found between 0 to 8 days. The overall mean difference of wound size was reported as 13.24 ± 8.48 with a significant p-value of 0.0001 which depicts a significant shrink in wound size over time. Regarding bacterial growth, we observed that at day 0 all patients reported bacterial growth which reduces to 40% cases at day 8.

Conclusion: Outcomes of our study revealed that vacuum-assisted closure therapy is an effective method for managing open musculoskeletal injuries. Sub atmospheric pressure reduces blood perfusion, increases the formation of granulation tissue, and also minimizes tissue bacterial growth.

Key Words: Open musculoskeletal injuries, Vacuum Assisted wound closure, Adults, atmospheric pressure, Treatment, Debridement

INTRODUCTION

Treatment of wounds is a crucial process that requires an event of cell migration to control blood perfusion and repair in a short time period. The series of cell migration involves debris removal, infection control, reducing inflammation, formation of granulation tissue. However, disruption to this sequence may result in the chronic open wound without anatomical or functional integrity results.[1] Soft tissue coverage and skeletal stability are the basic requirements of high-end injuries. In these injuries, soft tissue defects may be caused by debridement during primary healing.[2] In the past various surgical methods are widely used to obtain coverage. These methods include skin grafts, local rotation flaps.[3] Skin grafts are widely used for coverage but are highly dependent on vascularity. Instead of skin grafts, local flap rotation is needed in case of exposed bone, cartilage, tendons, or surgical implants.[4] Furthermore, the free tissue transfers method is also used in cases of soft tissue defects which prevents the coverage. However, this method may produce donor site morbidity.[5] On the other side, many non-surgical methods are also used to obtain coverage but these methods are insufficient to

Corresponding Author:
Waseem Ahmed, Assistant Professor Orthopaedics, Muhammad Medical College and Hospital Mirpurkhas Pakistan.
Email: dr.waseemzubair@ymail.com

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handle high-end injuries. Patients with bigger wound sizes require an alternative method for managing their injuries.[6] In case of poor management, the risk of chronic wounds increases. These chronic wounds cause immobilization and are associated with venous insufficiency, diabetes, and traumas. The management of chronic wounds requires prolonged hospital stays and costly treatment.[1] A method that enhances the healing process can also decrease lengthy hospital stays and minimize the infection risk. Since the 1990s, vacuum-assisted closure (VAC) therapy is used to manage large wound sizes and chronic wounds.[7] We designed this study to examine the effectiveness of vacuum-assisted closure (VAC) therapy for patients with open musculoskeletal injuries.

METHODOLOGY:

Ethical considerations were obtained from the research committees of different hospitals. We only recruited patients aged above 18 years old with open musculoskeletal injuries required coverage procedure. All the patients with pre-existing wounds osteomyelitis, neurovascular deficit, and malignancies were excluded. Diabetic patients with any vascular disease were also not entertained in this study. All the patients underwent the standard radiological assessment. We performed a routine hematological investigation.[8] These investigations included complete blood count, ESR, blood sugar, Gram stain and culture. We provided zinc and multivitamin supplements to the patients daily. The procedure of vacuum-assisted wound therapy was initiated after the removal of dressing from the wound. With the help of normal saline, a culture swab was taken before wound irrigation. We surgically removed the necrotic tissues and achieved adequate hemostasis. Before the application of the drape physicians assured about the dryness of the wound and prepare skin accordingly. We gently placed the open-pore foam (35 PPI density and 33 mm thick) dressing into the cavity of the wound. We used 400–600 microns size polyurethane open-pore foam because these foams are effective at transmitting mechanical forces across the wound and also assist wound healing by applying pressure on the entire wound. The drape was used to seal the wound site. We uniformly applied controlled pressure of 125 mmHg to all the tissues present on the inner surface of the wound. The total time of the cycle was 7 minutes among the pump was on for 5 minutes.

We performed statistical analysis by using a statistical package for the social sciences software version 23.0. Kolmogorov-Smirnov test and unpaired t-test were used to check the normality of our data. Quantitative variables were represented in mean and standard deviations while qualitative variables were measured by Chi-square test and Wilcoxon signed ranks test. Wilcoxon signed ranks test was applied to analyze the histological parameters and ranked them as grade 3-severe, 2 as moderate, 1 as mild, and 0 as absent.

RESULTS

For this study, we recruited 30 patients with a mean age of 39 ± 18 years. All the selected cases had acute trauma. We observed that road accidents were a major mechanism of injury in 22 (73.33%) cases. A total of 5 (16.66%) patients had machine injuries while 3(10%) had height injuries. We observed that 3 patients had IIIa injury, 16 patients had grade IIIb injury, 7 cases had grade IIIc, and 4 cases had II injury (As shown in Table 1). We observed 13.33% cases with decreased wound size greater than 25mm over 8 days however no significant difference was found between 0 to 8 days. The overall mean difference of wound size was reported as 13.24 ± 8.48 with a significant p-value of 0.0001 which depicts a significant shrink in wound size over time (As shown in Table 2). Regarding bacterial growth, we observed that at day 0 all patients reported bacterial growth which reduces to 40% cases at day 8 (As shown in Table 3). Findings revealed inflammation in many patients with a significant p-value of 0.003 (As shown in Table 4).

Table 1: Demographic information of the study participants

Demographic variables	
Mean age (Years)	39 ± 18
Mechanism of injury	
Road accidents	22 (73.33%)
Machine injury	5 (16.6%)
Fall from height	3 (10%)
Gustilo Anderson classification	
II	4 (13.3%)
IIIa	3 (10%)
IIIb	16 (53.3%)
IIIc	7 (23.3%)

Table 2: Wound size of study participants

Wound size	Total patients (N=30)	Chi-square	P-value
>25	4 (13.33%)	14.4	0.013
20–24.9	2 (6.66%)		
15–19.9	6 (20%)		
10–14.9	8 (26.66%)		
5–9.9	2 (6.66%)		
1–4.9	8 (26.66%)		
Mean difference (mm)	13.24 ± 8.48		0.0001 (C.I: 95%= 11.053 - 15.327)

Table 3: Bacterial growth from Day 0 to Day 8

Bacterial growth	Day 0	Day 4	Day 8
Absent	0	6 (20%)	18 (60%)
Present	30 (100%)	24 (80%)	12 (40%)

Table 4: Histological ranking of Wound healing

Wound healing stages	Positive (ranks of day 0 < ranks of day 8)	Negative (ranks of day 0 >ranks of day 8)	Equal (ranks of day in which results of day 8 is equal to ranks of day 0)	p-value
Fibrosis	30	0	0	0.001
Inflammatory cells	2	24	4	0.003
Collagen formation	30	0	0	0.001
Proliferative fibroblasts	30	0	0	0.001

DISCUSSION

Interaction of cells, extracellular matrix molecules, and biochemical mediators are the fundamentals of the healing process which leads to functional restoration of injured sites by replacing the tissue defect, reduce the blood loss.[9] Restoration of an intact epithelial barrier is the primary goal of wound healing.[10] Vascular supply, new capillaries formation, and matrix molecules limit the rate of the wound healing process.[11] However, these events are influenced by the locally acting growth factors which disturb the process of proliferation, angiogenesis, chemotaxis and migration, gene expression, proteinases, and protein production. Disturbance of growth factors badly affects the healing process and results in a chronic or nonhealing wound.[12-14] The sub-atmospheric pressure on the wound enhances the blood flow and reduces the bacterial colonization of wound tissues. Increased blood circulation to the wound site may prevent bacterial growth.[15] A dated study of Robson et al reported a successful correlation between surgical intervention and tissue bacterial counts of less than 10^5 organisms per gram of tissue.[16] Many other studies reported a positive correlation between increased blood flow and oxidative bursts that kill bacteria.[17-19]

In our study, we observed that 20% of patients had no bacterial growth at day 4. However, on day 8, the absence of bacterial growth was observed in 60% of cases. Our results are in correspondence to the previous studies of Argenta,[7] Banwell et al.[20] and Morykwas[21] in which they reported that the VAC process aid in the clearance of bacterial growth. However, the results of Weed et al are in contradiction in which he revealed 10^4–10^6 bacterial growth during negative pressure wound therapy.[22] The negative pressure of VAC therapy exerts uniform force towards the center of the wound by mechanically stretching the cells and decreasing the wound size.[23,24] In our study, 26.6% of patients reported a decrease in wound size of 1 to 4.9 mm, 46.66% of patients' wound size decreased from 10 to 19.9 mm, and 13.33% reported a decrease in wound size of more than 25mm from day 0 to day 8. These results are comparable with the previous studies of Argenta,[7] Joseph,[1] and Morykwas et al.[21] in which they also observed a shrinking in wound size by using VAC therapy.

We also observed an increase in vascularity rate and formation of granulation tissue along with healthy tissue growth. We observed a reduced inflammation rate. The increased formation of granulation tissue was achieved due to uniform pressure applied to the wound site. Currently, mitotic rates can be achieved by applying mechanical stress to the tissue using the Ilizarov technique and soft tissue expanders.[25, 26] Very limited literature has been produced using VAC to compound injuries. Studies reported a high rate of nonunion and infection in open musculoskeletal injuries.[27,28] In open musculoskeletal injuries, neurovascular structures are crucial due to repeated demand for debridements.[29] We observed effective outcomes of VAC therapy in terms of minimizing the risk of infection, especially for open musculoskeletal injuries.

CONCLUSION

Outcomes of our study revealed that vacuum-assisted closure therapy is an effective method for managing open musculoskeletal injuries. Sub atmospheric pressure reduces blood perfusion, increases the formation of granulation tissue, and also minimizes tissue bacterial growth. However, still there is a need for soft tissue reconstruction to obtain adequate coverage.

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Conflict of interest:

None

Permission

It was taken from the ethical review committee of the institute

REFERENCES

1. Joseph E, Hamori CA, Bergman S, Roaf E,. A prospective randomized trial of vacuum-assisted closure versus standard therapy of chronic nonhealing wounds. Wounds. 2000; 12 (3): 60–67.
2. Yaremchuk MJ, BurgessA. R, BrumbackR. J, Concepts in soft tissue management, in Lower Extremity Salvage and Recon-

struction. Orthopaedic and Plastic Surgical Management, 1989: 95–106.
3. Haller JA, Billingham RE. Studies of the origin of the vasculature in free skin grafts. Annals of Surgery. 1967; 166(6): 896–901.
4. Geishauser M, Staudenmaier RW, Biemer E. Donor-site morbidity of the segmental rectus abdominis muscle flap. **Br. J. Plast. Surg**. 1998; 51 (8): 603–607.
5. Kelly MB, Searle. Improving the donor site cosmesis of the latissimus dorsi flap. Annals of Plastic Surgery. 1998; 41 (6): 629–632.
6. Heng MCY. Topical hyperbaric therapy for problem skin wounds. **J** Dermatol Surg. 1993; 19 (8): 784–793.
7. Morykwas MJ, Argenta LC. Vacuum-assisted closure: a new method for wound control and treatment: clinical experience. Annals of Plastic Surgery. 1997; 38 (6):563–577.
8. Sinha K, Vijendra D. Chauhan, Maheshwari R, Chauhan N, Rajan M, Agrawal A. Vacuum Assisted Closure Therapy versus Standard Wound Therapy for Open Musculoskeletal Injuries. Advances in Orthopedics. 2013; 2013: 8.
9. Clarke RA, Henson PM. The Molecular and Cellular Biology of Wound Repair. Plenum Press, New York, NY, USA.1988.
10. Cohen IK, Diegelmann RF, Lindblad WJ. Wound Healing: Biochemical and Clinical Aspects. WB Saunders, Philadelphia, Pa, USA. 1992.
11. Hunt TK, Barbul A, Caldwell M. D, Eaglstein W. H. Vascular factors govern healing in chronic wounds. in Clinical and Experimental Approach to Dermal and Epidermal Repair: Normal and Chronic Wounds, pp. 1–17, Wiley & Leiss, New York, NY, USA, 1991.
12. Pierce GF, Vande Berg J, Rudolph R, Tarpley J, Mustoe TA. Platelet-derived growth factor-BB and transforming growth factor beta1 selectively modulate glycosaminoglycans, collagen, and myofibroblasts in excisional wounds. **Am. J. Pathol**. 1991; 138 (3): 629–646.
13. Laiho M, Keski OJ. Growth factors in the regulation of pericellular proteolysis: a review," Cancer Research. 1989; 49 (10): 2533–2553.
14. Whitby DJ, Ferguson MW, LongakerN. S. M. T. Immunohistological studies of the extracellular matrix and soluble growth factors in fetal and adult wound healing in Fetal Wound Healing, pp. 161–177, Elsevier Science, New York, NY, USA. 1992.
15. Hunt TK. The physiology of wound healing. Annals of Emergency Medicine. 1988; 17(12): 1265–1273.
16. Kucan JO, Robson MC, Heggers JP. Comparison of silver sulfadiazine, povidone-iodine and physiologic saline in the treatment of chronic pressure ulcers. **J** Am Geriatr Soc. 1981; 29 (5): 232–235.
17. Seiler WO, Stahelin HB, Sonabend W. Einflus aerobe und anaerober keime auf den heilungsverlauf von dekubitalulzera. Schweizerische Medizinische Wochenschrift. 1979; 109: 1595–1599.
18. Daltrey DC, Rhodes B, Chattwood JG. Investigation into the microbial flora of healing and non-healing decubitus ulcers. **J. Clin. Pathol**. 1981; 34(7): 701–705.
19. Ryan TJ. Microcirculation in psoriasis: blood vessels, lymphatics and tissue fluid," Pharmacology and Therapeutics. 1980; 10 (1): 27–64.
20. Banwell P, Withey S, Holten I. The use of negative pressure to promote healing," **Br. J. Plast. Surg**. 1998; 51(1): 79–82.
21. Morykwas MJ, Argenta LC, Shelton-Brown EI, McGuirt W. Vacuum-assisted closure: a new method for wound control and treatment: animal studies and basic foundation. Annals of Plastic Surgery. 1997; 38 (6): 553–562.
22. Weed T, Ratliff C, Drake DB,. Quantifying bacterial bioburden during negative pressure wound therapy: does the wound VAC enhance bacterial clearance? Annals of Plastic Surgery. 2004; 52 (3): 276–280.
23. Thoma R. Ueber die histomechanik des gefasssystems und die pathogens der angioskeleroose. Virchows Archiv für Pathologische Anatomie und Physiologie und für Klinische Medizin. 1911; 204 (1): 1–74.
24. Philbeck TE, Whittington KT, Millsap MH, Briones RB, Wight DG, Schroeder WJ. The clinical and cost effectiveness of externally applied negative pressure wound therapy in the treatment of wounds in home healthcare Medicare patients. Ostomy/Wound Management. 1999; 45 (11): 41–50.
25. Ilizarov GA. The tension-stress effect on the genesis and growth of tissues. Part I. The influence of stability of fixation and soft-tissue preservation. Clinical Orthopaedics and Related Research. 1989; 238: 249–281.
26. Hall GD, Van Way WC, Fei' Tau Kung K, Compton-Allen M. Peripheral nerve elongation with tissue expansion techniques. **J Trauma**. 1993; 34 (3): 401–405.
27. Akin Yoola AL, Ako-Nai AK, Dosumu O, Aboderin AO, Kassim O. Microbial isolates in early swabs of open musculoskeletal injuries. **Niger. Postgrad. Med. J**. 2006; 13 (3): 176–181.
28. Fleischmann W, Strecker W, Bombelli M, Kinzl L. Vacuum sealing for treatment of soft tissue injury in open fractures. Unfallchirurg. 1993; 96 (9): 488–492.
29. Jones SM, Banwell PE, Shakespeare PG. Advances in wound healing: topical negative pressure therapy. **Postgrad. Med. J**. 2005; 81 (956): 353–357.