Original Article

Vacuum Assisted Closure Therapy: Role in Modern Plastic Surgery

Muhammad Ahmad, Saleem A Malik

ABSTRACT

OBJECTIVE: To share the experience of vacuum assisted closure therapy in private setup.
DESIGN: Descriptive
SETTING: A private clinic for Aesthetic Plastic Surgery, Rawalpindi - Pakistan.
STUDY PERIOD: June 2005 to June 2008
MATERIALS AND METHODS: The vacuum assisted closure (VAC) therapy was used in 35 patients suffering from the open wound involving various anatomical areas. All the wounds had failed to heal after treatment with multiple wound dressings and debridement. Before the application of VAC, surgical debridement was performed to remove all the devitalized necrotic tissues, and the wound was packed with povodine/iodine (Pyodine®). VAC was applied after 24 to 48 hours. Tissue cultures for micro-organisms were obtained before the application of VAC and at the end of VAC therapy. Wound dimensions were noted prior to and at the end of VAC, before the definitive treatment using skin graft or flap was performed.
RESULTS: Thirty-five patients were included in this study withmale to female ratio of 1.7:1. Majority (40%) of the patients were 31-40 years of age. Road traffic accident was the commonest cause (31.4%) followed by diabetic ulcers (17.1%). Leg was most commonly effected area (31.4%). There were 28.6% diabetics, 22.9% smokers and 20% hypertensives among study subjects. Mean wound size decreased from 12.64x9.68-cm to 10.4x8.32-cm in non-diabetics, and from 10.5x8.7-cm to 9.0x6.4-cm in diabetic patients. Mean hospital stay was 24.4 days in non-diabetics as compared to 42.6 days in diabetics. Average 11.6 VACs were performed in diabetics, and 6.9 in non-diabetics.
CONCLUSION: VAC is a useful adjunct to the standard treatment of chronic wounds. It is an extremely simple modality and does not require expensive equipment.

KEYWORDS: Vacuum assisted closure, Wounds, Negative pressure therapy, Plastic surgery, Granulation tissue.

INTRODUCTION

The vacuum assisted closure (VAC) therapy was first reported in 1990s[1]. It has revolutionized the clinical management of the wounds [2-5]. It has been successfully used in the setting of wounds complicated by burns, infection, poor circulation, exposed bone or artificial implants and dehiscence [6-8]. An open cell sponge is placed in the wound, sealed with an adherent drape, and attached to a tube through which subatmospheric pressure is applied [9] (Fig.1). It is reported that the negative pressure facilitates healing by improving the rate of angiogenesis, endothelial proliferation, the integrity of the capillary basement membrane, capillary blood flow, capillary caliber, and by decreasing interstitial oedema and bacterial burden within the wound [10-12]. This technique has also been shown to effectively stimulate healing by secondary intention [1,9]. Although VAC is in use at many institutions of Pakistan but the clinical studies are limited and more so from private setup. In this study we present our experience of vacuum assisted closure therapy.

MATERIALS AND METHODS

The study was conducted in private clinic of Aesthetic Plastic Surgery, Rawalpindi-Pakistan from June 2005 to June 2008. The VAC therapy was used in 35 patients (22 males and 13 females) having the open wound from diverse etiology and involving different anatomical areas. All the wounds had failed to heal after treatment with wound dressings and debridements. Five (14.3%) patients had application of an external fixator for open tibial fractures. In each case, 24-48 hours before VAC application, surgical debridements were done to remove all the devitalized necrotic tissues, and the wound was packed with povodine/iodine (Pyodine®). Swab cultures for micro-organisms were obtained before and at the end of VAC therapy. All patients were followed until satisfactory wound healing was achieved, indicated by the formation of healthy granulation tissue. At each visit wound dimensions were recorded and clinical photographs were obtained to objectively evaluate wound shrinkage and formation of granulation tissue. At the end of treatment, the wound coverage using skin graft or flap was performed.

Application of VAC:

The VAC device consisted of a double layer of ½ inch thick open cell foam into which was embedded an evacuation tube of 16 or 18 Fr°. The tube was connected to a 5-ml syringe. The tube from collection container of vacuum pump was placed inside the syringe. The foam was soaked with Pyodine® and trimmed to fit the dimensions of the wound, and was applied in direct contact with the base of the wound. Pre-op drapes (Opsite®) were used extending 3-5 cm beyond the margins of the wound to create an airtight seal (Fig. 2). For 1st 24 hours, 125-150 mmHg of continuous negative pressure was applied and then continued with intermittent pressure cycles of 20 minutes ON and 40 minutes OFF for the next 24 hours. After 48 hours, the VAC dressing was changed. The wound was washed thoroughly with normal saline and VAC was re-applied in most cases at bedside. The same routine was continued until a satisfactory clean, granulating wound bed was obtained for the definitive procedure (skin graft or flap).

Data were collected using a pre-designed proforma. Demographic information collected includes age, sex and co-morbid condition. Information noted for wound includes size before and after application of VAC, site and etiology of the wound. Mean, frequency, ratio and percentages were calculated and data were inferenced also in the form of tables using Microsoft Excel®.

RESULTS

A total of 35 patients were included in the study with 22 (62.9%) males and 13 (37.1%) females. The male to female ratio was 1.7:1. The mean age of male patients was 39.6 years (range 19–73 years) as compared to 39.4 years (range 27-50 years) for female patients. Majority of the patients (40%) were in their 3rd decade of life. Road traffic accident was the commonest cause found in 31.4% followed by diabetic ulcers in 17.1% **(Table I)**. Leg (31.4%) was the most commonly affected area **(Table II)**. There were 28.6% diabetics, 22.9% smokers and 20% hypertensives among study subjects. Wound size decreased from 12.64×9.68-cm to 10.4×8.32-cm in non-diabetics, and from 10.5×8.7-cm to 9.0×6.4-cm in diabetic patients **(Table III)**. The mean hospital stay was 24.4 days in non-diabetics as compared to 42.6 days in diabetics. The average number of VACs applied in diabetics was 11.6 as compared to 6.9 in non-diabetics.

Case 1:

A 50 years old male presented with a non-healing wound on anterior tibia for last one month. He had a tibial fracture that was fixed by external fixator by an orthopaedic surgeon (**Figure 3a).** The VACs were applied, resulting in granulation tissue formation **(Figure 3b & 3c)**. The wound was finally skin grafted **(Figure 3d)**.

Case 2: A 73 years old male was referred from a urologist with a Fournier's gangrene involving the lower abdomen, scrotum and perineum. The testes were exposed. There was minimal scrotal skin. The penile shaft was also devoid of any skin **(Figure 4a)**. The systemic antibiotics were given according to the culture and sensitivity report. Daily dressing and surgical debridements were initiated **(Figure 4b)**. Later on VAC was started **(Figure 4c)**. The VAC treatment resulted in a good granulation tissue formation (Figure 4d). The wounds were later skin grafted **(Figure 4e)**.

Case 3: A 50 years old female presented with a non-healing 9×6-cm wound over left leg after a road traffic accident. The wound did not respond to conventional treatment and was referred for management **(Figure 5a)**. She was non-diabetic and was not willing for any coverage with the flap, so VAC therapy was initiated. After VAC therapy, the healthy granulating wound obtained that was covered with split-thickness skin graft harvested from left thigh **(Figure 5b)**. The post operative period was satisfactory with no long term complication **(Figure 5c)**.

TABLE I: ETIOLOGY OF THE WOUNDS (n = 35)

Cause	Male	Female
Road Traffic Accident	9 (25.7%)	2 (5.7%)
Diabetic Ulcer	3 (8.6%)	3 (8.6%)
Burn	1 (2.9%)	1 (2.9%)
Workplace Accident	3 (8.6%)	-
Domestic Accidents	-	3 (8.6%)
Firearm injury	1 (8.9%)	-
Earthquake	2 (5.7%)	2 (5.7%)
Infection	3 (8.6%)	2 (5.7%)

TABLE II: ANATOMICAL DISTRIBUTION (n=35)

Area	No. of Patients	%
Abdomen ± perineum	4	11.4
Chest	1	2.9
Back	3	8.6
Forearm	3	8.6
Arm	1	2.9
Hand	2	5.7
Thigh	5	14.3
Leg	11	31.4
Foot	5	14.3

TABLE III: PATIENTS DETAILS

Case No.	Age	Sex	Size (cm)		Hospital Stay (days)	Co-morbid condition	No. of VACs
			Initial	At the End			
1	24	M	13×9	12×7	11	NIL	3
2	19	M	13×10	12×9	16	NIL	3
3	21	M	24×16	23×14	34	NIL	10
4	54	F	14×9	13×7	56	Diabetic + HTN	14
5	39	M	14×9	13×7	26	NIL	7
6	59	M	18×10	16×8	49	Diabetic + Smoker	13
7	27	F	19×11	18×10	28	NIL	8
8	56	M	20×11	17×9	105	Diabetic	24
9	21	M	12×7	10×5	61	Diabetic	19
10	26	M	14×7	12×6	26	NIL	5
11	61	M	12×9	11×8	34	HTN	7
12	50	F	9×6	9×5	17	HTN	4
13	36	M	16×11	14×9	28	NIL	7
14	62	M	24×18	20×16	34	Smoker	8
15	38	M	34×15	31×14	24	NIL	7
16	40	M	22×13	20×11	29	NIL	7
17	30	M	11×8	10×7	18	NIL	4
18	38	M	9×7	9×6	17	Diabetic	3
19	32	M	11×7	11×6	28	NIL	4
20	36	F	7×5	5×4	24	NIL	6
21	41	F	10×7	8×6	32	Diabetic	8
22	34	F	10×8	9×7	19	Smoker	6
23	32	F	5×6	3×4	24	NIL	7
24	34	M	12×6	11×5	24	Smoker	7
25	40	M	4×14	4×12	18	Smoker + HTN	6
26	45	M	5×6	4×3	22	Diabetic	6
27	34	F	4×10	3×9	20	NIL	7
28	50	M	7×12	5×9	29	HTN	11
29	48	M	4×7	4×5	27	HTN	10
30	29	F	8×13	7×11	24	Diabetic	9
31	38	F	9×11	7×9	30	HTN	12
32	40	F	5×6	4×3	17	Smoker	5
33	41	M	8×14	6×10	26	Smoker	8
34	50	F	5×6	4×4	24	Diabetic	7
35	47	F	4×7	3×5	36	Diabetic	13

HTN= Hypertensive

FIGURE I: MECHANISM OF VAC

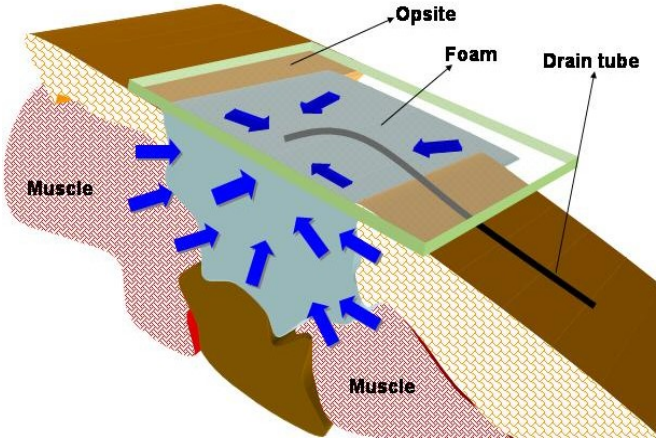


FIGURE II: FUNCTIONING OF VAC

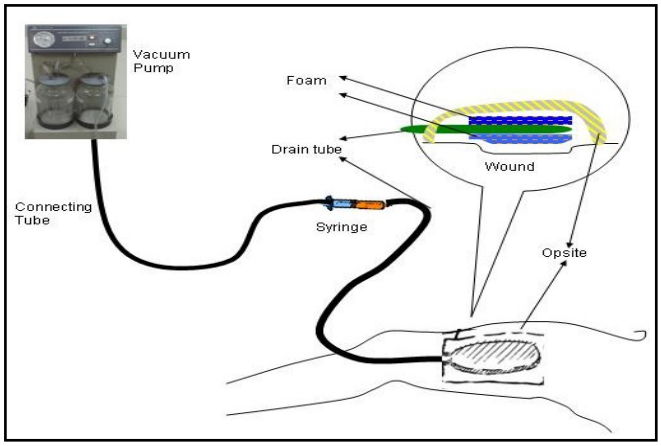
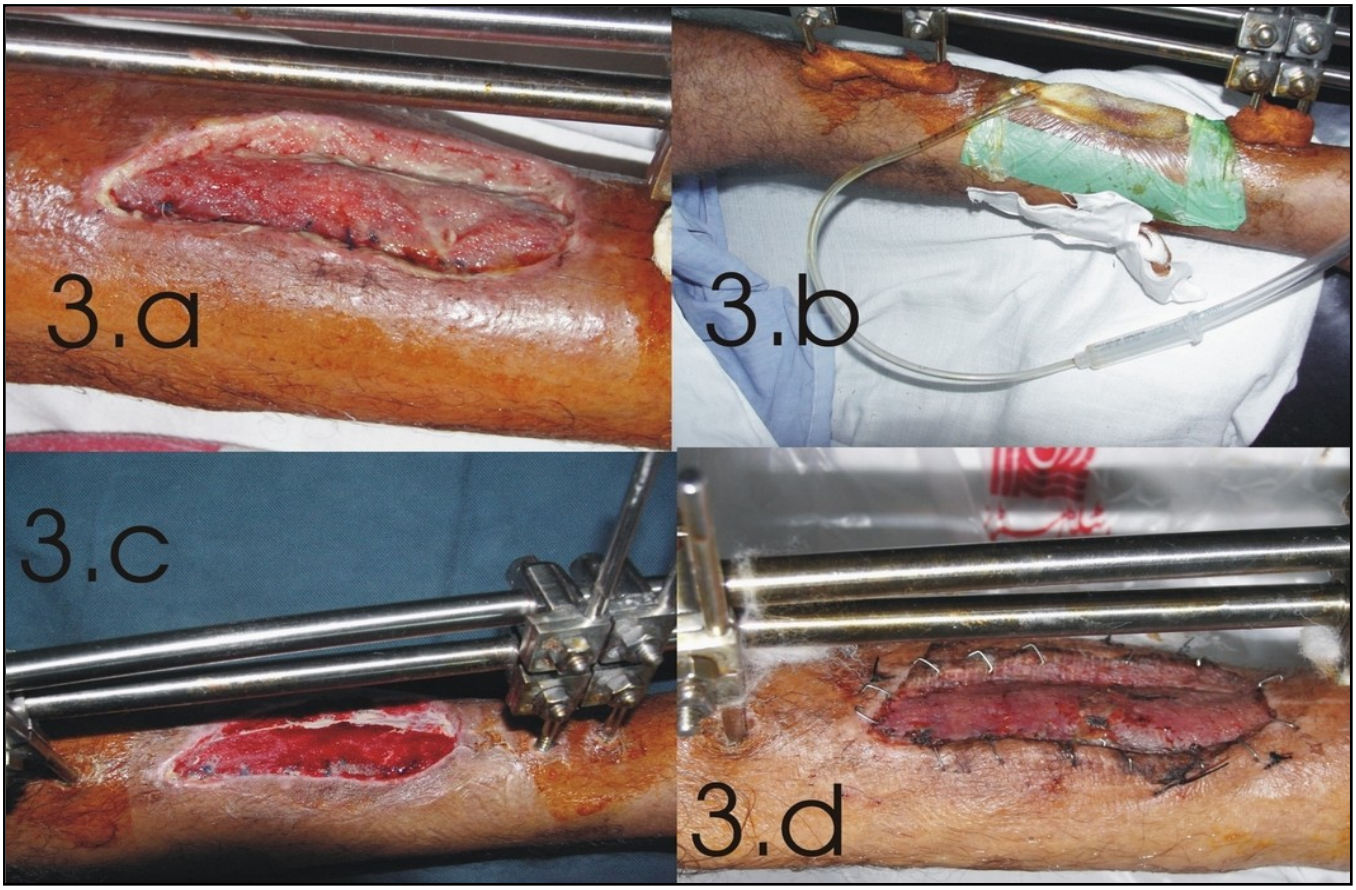


FIGURE III: EXTERNAL FIXATOR



DISCUSSION

Argenta et al[1] reported the use of VAC technique in 300 patients with non-healing ulcers, 99% of which healed. They concluded that the VAC negative pressure technique significantly increases the rate of granulation tissue formation and local blood supply, and therefore a useful adjunct to wound care. Our results are comparable to those of Clare et al[13] and confirm the effectiveness of this technique for the treatment of chronic non-healing wounds or ulcers. Clare et al reported severe PVD (Peripheral Vascular Disease) as the most common reason for failure of VAC, and suggest that patients with severe PVD should be treated by other modalities. In our study, we get Doppler done in all our cases and did not encounter any case of PVD and therefore failure of VAC. Ford et al[14] reported improved results in patients with chronic

FIGURE IV: FOURNIER'S GANGRENE

osteomyelitis after VAC treatment. They postulated that the negative pressure created by the VAC device facilitates antibiotic penetration from surrounding capillaries into the bone, thus controlling infection.

The precise mechanism by which VAC negative pressure technique effects wound closure is unknown. Morykwas et al[9] showed in a pig model that peak blood flow levels were 4 times higher than baseline values with continuous pressure of 125-mmHg. They also found a significantly higher rate of granulation tissue formation and a significant decrease in bacterial flora after 4 to 5 days of treatment. Clinical and experimental studies have shown that removal of third-space fluid results in a decrease in tissue turgor and a decrease in capillary after-load, which promoted capillary circulation and inflow. In addition, the removal of excess exudates from the wound is believed to remove inhibitory factors, which inhibit vascularity. These fluids contain high levels of matrix metelloproteinases and their degradation products, which have been shown to suppress the proliferation of keratinocytes, fibroblasts and vascular endothelial cells in

FIGURE V: LEG WOUND

vitro[15].

Bacterial counts in human wound tissues treated with VAC have demonstrated significant decrease after 3 to 4 days, paralleling the results of animal studies[9]. Because the negative pressure applies controlled tension to every point on the inner surface of the wound, the sum of the applied forces becomes large and tends to draw the edges of the wound inward. Prospective, randomized trials have showed a decrease in the ulcer volume and in the mean number of polymorphous neutrophils and lymphocytes in wound treated with VAC [3].

Mullner et al conducted a prospective clinical trial from 1994 to 1996 in 45 patients and evaluated the efficacy of a vacuum sealing technique in dealing with sacral pressure ulcers, acute traumatic soft tissue defects and infected soft tissue defects following rigid stabilization of lower extremity fractures [16]. They described decrease in the dimension of initial wounds after VAC therapy in 84% of the patients, thus facilitating healing time and eradication of any pre-existing infection. In another study De Franzo et al used VAC therapy on 75 patients with open wounds of lower extremity but without osteomyelitis [3]. They reported a rapid granulation tissue formation, reduction in bacterial count and successful wound closure in 95% of cases.

The results of present study were compared with that of Ghani et al[17], in which trauma was the commonest cause (68%) comparable to this series (60%). In contrast to current series they excluded wounds with concomitant osteomyelitis, gross infection, and wounds having slough and devitalized tissues. We include all such cases and performed surgical debridement prior to application of VAC. The culture and sensitivity report in our series was positive in 60% of cases and yet we proceed with VAC. Probably the inclusion of such cases explain greater mean VAC application in our series when compared to Ghani et al (mean 5.3 in study by Ghani et al vs 11.6 in diabetics and 6.9 in non-diabetics in this study).

In one patient, we used VAC after skin grafting in order to decrease the exudate from the recipient area in the early period of VAC application. The same technique was also used by Senchenkov et al[18]. Application of VAC is very versatile and can be used on various anatomical sites with good results. It has also been used after resection of musculoskeletal tumors and for closure of partial foot amputations [19, 20]. In one case of our series, we used VAC on the post-debridement wound after Fournier's gangrene involving scrotum, penile shaft and lower abdomen. The wound responded well and the remaining defect was closed by a split-thickness skin graft (Fig. 4). We used sub-atmospheric pressure of 125±5-mmHg, which is similar to the pressure used in most of the other studies [1, 20, 21]. In another study by Timmers, the continuous negative pressure was used in the range of 25-300 mmHg and using two types of foams, i.e. black polyurethane foam (PU) and white polyvinyl alcohol (PVA) foam [22]. Significant cutaneous blood flow was found in both types of foams upto pressure of 300-mmHg. They proposed that type of foams may affect the end result, whereas we used locally available foam commonly used for filling of cushions etc. and achieved comparable results.

Clare et al, described some practical problems in the use of VAC for treatment of wounds located over a small area [13], but we did not encounter any such problem. The various complications of VAC technique

mentioned in the literature include localized infection, bleeding, increased pain, bad odour, toxic shock syndrome and anasarca [1, 3, 23, 24]. None of these complications occurred in our patients except bad odour at the time of change of dressings in a few cases. In some cases, there was mild oozing/bleeding from the hypervascular bed of wound. However, it was never threatening. To manage this oozing/bleeding we used place gauzes soaked with a diluted solution of adrenaline and packed for 2-3 minutes, which resulted in fairly bloodless field. In two cases we injected the diluted adrenaline solution through the VAC tube, waited for 15-20 minutes, and then changed the dressing._Similarly Price et al made a modification by injecting the 0.25% bupivacaine into the system 15-20 minutes before removing the dressing to avoid the pain during VAC changes [24]. It has also been postulated that tulle gauzes (e.g. Bactigras®, Sufratulle®) may be applied on the wound bed before application of VAC[25]. We used it in four cases, keeping the possibility in mind that the paraffin present in the tulle may block many of the holes of the drain tube.

It is difficult to seal the area with Opsite®, especially if there is marked exudate or if_perineum is involved. Because once there is fluid underneath the Opsite®, it will never be airtight again. We employed two ways to encounter this problem (i) by using the dry dressing gauzes around the margins and then sealed with Opsite®, (ii) by applying the hydrocolloid dressing (Duoderm®) and applied the Opsite® on top of it to obtain the air tight seal in two cases. Application of VAC becomes difficult in the presence of external fixators used in orthopaedic surgery. Sometime we included the whole fixators in the dressing using the sterile plastic bag.

Recently a randomized controlled trial comparing VAC with modern wound dressings for leg ulcer has been carried out by Vuesstaek et al[26]. The VAC proved superior with respect to the time to complete healing and wound-bed preparation time compared with conventional wound care.

CONCLUSION

VAC is relatively a new technique to our part of the world. It is very effective in promoting healing. It helps by reducing size of the wound and more importantly promoting granulation tissue formation. This technique is very simple to learn and practice.

REFERENCES

1. Argenta LC, Morykwas MJ. Vacuum-assisted closure: a new method for wound control and treatment: a clinical exposure. Ann Plast Surg. 1997;38(6):563-76; discussion 577.
2. Venturi ML, Attinger CE, Mesbahi AN, Hess CI, Gram KS. Mechanisms and clinical applications of vacuum-assisted closure (VAC) devices: a review. Am J Clin Dermatol. 2005;6(3):185-94.
3. DeFranzo AJ, Argenta LC, Marks MW, Molnar JA, David LR, Webb LX, et al. The use of vacuum assisted closure therapy for the treatment of lower extremity wounds with exposed bone. Plast Reconstr Surg. 2001;108(5):1184-91.
4. Schaffzin DM, Douglas JM, Stahl TJ, Smith LE. Vacuum assisted closure of complex preianal wounds. Dis Colon Rectum 2004;47(10)1745-8.
5. Wu SH, Zecha PJ, Feitz R, Hovius SER. Vacuum therapy as an intermediate phase in wound closure: a clinical experience. Eur J Plast Surg 2003;23(4):174-6.
6. Heller L, Levin SL, Butler CE. Management of abdominal wound dehiscence using vacuum assisted closure in patients with compromised healing. Am J Surg. 2006;191(2):165-72.
7. Van der Velde M, Hudson DA. VADER (vacuum-assisted dermal recruitment): a new method of wound closure. Ann Plast Surg 2005;55(6):660-4.
8. Mendonca DA, Cosker T, Makmana NK. Vacuum assisted closure to aid wound healing in foot and ankle surgery. Foot Ankle Int. 2005; 26(9):761-6.
9. 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. Ann Plast Surg.1997;38(6):553-62.
10. Chen SZ, Li XY, Xu LS. Effects of vacuum assisted closure on wound microcirculation: an experimental study. Asian J Surg 2005;28:211-6.
11. Morykwas MJ, Faler BJ, Pearce DJ, Argenta LC. Effects of varying levels of subatmospheric pressure on the rate of granulation tissue formation in experimental wounds in swine. Ann Plast Surg 2005;28(3):211-7.
12. Weed T, Ratliff C, Drake DB. Quantifying bacterial bioburden during negative pressure wound therapy: does the wound VAC enhance bacterial clearance? Ann Plast Surg. 2004;52(3):276-9.
13. Clare MP, Fitzgibbons TC, McMullen ST. Experience with the vacuum assisted closure negative pressure technique: the treatment of non-healing diabetic and dysvascular wounds. Foot Ankle Int. 2002;23(10):896-901
14. Ford CN, Reinhard ER, Yeh D. Interim analysis of a prospective randomized trial of vacuum assisted closure versus the health point system in the management of pressure ulcers. Ann Plast Surg. 2002;49(1):55-61.
15. Wysocki AB, Staiano-Colo L, Grinnell F. Wound fluid from chronic leg ulcers contains elevated levels of metelloproteinases MMP-2 and MMP-9. J

Invest Dermatol 1993;101(1):64-8.
16. Mu¨llner T, Mrkonjic L, Kwasny O, Ve´csei V. The use of negative pressure to promote the healing of tissue defects: a clinical trial using the vacuum sealing technique**.** Br J Plast Surg 1997;50(3):194 -9.
17. Ghani U, Malik M, Hussain Z, Javed-Ur-Rehman, Shukr I. Vacuum assisted closure (VAC) therapy for difficult wound management. PAFJ 2009;6(2):
18. Senchenkov A, Knoetgen J, Chrouser KL, Nehra A. Application of vacuum assisted closure dressing in penile skin graft reconstruction. Urology 2006;67(2):416-9.
19. Bickles J, Kollender Y, Witing JC, Cohen N, Maller I, Malawer MM. Vacuum-assisted closure after resection of musculoskeletal tumours. Clin Orthopaed Rel Res 2005;441:346-50.
20. Armstrong DG, Lavery LA, Boulton AJM. Negative pressure wound therapy via vacuum-assisted closure following partial foot amputation: what is the role of wound chronicity. Int Wound J 2007;4 (1):79-86.
21. Smith N. The benefits of VAC therapy in the management of pressure ulcers. Br J Nurs 2004;13 (22):1359-65.
22. Timmers MS, Le Cessie S, Banwell P, Jukema GN. The effects of varying degrees of pressure delivered by negative pressure wound therapy on skin perfusion. Ann Plast Surg 2005; 55(6):665-71.
23. Friedman T, Westreich M, Shalom A. Vacuum-assisted closure treatment complicated by anasarca. Ann Plast Surg 2005;55(4):420-1.
24. Price RD, Nagarajan M, Srinivasan JR. Local anaesthetic for change of vacuum assisted closure dressing. Plast Reconstr Surg 2006;117(7):2537-8.
25. Blackburn JH, Boemi L, Hall WW, Jeffords K, Hauck RM, Banducci DR, et al. Negative pressure dressings as a bolster for skin grafts. Ann Plast Surg 1998;40(5):453-7.
26. Vuerstaek JDD, Vainas T, Wuite J, Nelemns P, Neumann MHA, Veraat JCJM. State of the art treatment of chronic leg ulcers: a randomized controlled trial comparing vacuum-assisted closure (VAC) with modern wound dressings. J Vasc Surg. 2006;44(5):1029-37.

AUTHOR AFFILIATION:

Dr. Muhammad Ahmad *(Corresponding Author)*
Plastic, Reconstructive and Hand Surgeon
Aesthetic Plastic Surgery
Rawalpindi, Pakistan.
Email: plasticsurgeon999@yahoo.com

Prof. Saleem A Malik
Diplomat American Board of Plastic Surgery
Shifa International Hospital
Islamabad, Pakistan.