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Negative Pressure Wound Therapy (NPWT) in Head and Face Trauma, Can it Change the Reconstruction Ladder?

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ABSTRACT

Introduction: Trauma to the head and neck region especially the face is becoming more and more common due to the speed of our life style. Exposed bone in this region presents a daily challenge to the reconstruction surgeon as each of the options available for reconstruction (grafts, flaps, free flaps over even secondary intentions) comes at a price. Negative Pressure Wound therapy evolved over the last few decades offering a way to cover almost all kinds of raw areas. The effectiveness of NPWT over exposed bones have been studied and proven. The use of NPWT in the head and neck trauma setting is still understudied today due to the specific topographic nature of the head and neck making its fixation challenging.

Patients and Methods: This randomized prospective control study was conducted on the first 40 patients presenting to the author in the period from April 2017 to April 2021. Patients were randomized into 2 groups. Group A patients treated with NPWT and Group B patients treated with conventional dressing. NPWT was applied on a continuous mode between 100-125mm Hg. The size of the defect as well as the time needed for healing were one of the main parameters recorded.

Results: Out of the 40 patients recruited for this study only 35 patients (18 in group A & 17 in group B) fulfilled the inclusion and exclusion criteria The time needed for the raw area to be ready for definitive management was statistically significant with a *p*-value of <0.001 in favor of the NPWT group. This shows a superiority of the NPWT in reducing the time for healing as well as decreasing the frequency of dressing thus decreasing the psychological burden on the patient.

Conclusion: Negative Pressure Wound Therapy is a useful tool in covering head and faces exposed bones with shorter recovery time and more ease and comfort for the patient. This study suggests it as modality for treatment in certain conditions as an alternative and not as replacement for other well established techniques such as local and free flaps.

Key Words: *VAC – NPWT – Exposed – Bone.*

Conflict of Interest: None

Ethical Committee Approval: Approved.

INTRODUCTION

With the increased urban development, motor vehicle accidents (MVA) are becoming more and more common. The head, particularly the face, is more prone to injury in this setting leaving the reconstructive surgeon with tough decisions to make **[1]**.

Reconstruction of the complex deficiency ,while maintaining form and function, in the head region can be achieved by using local or distant tissues. Flaps carry the risk of transferring tissues with different color match & different distribution of hair follicles. In addition, the risks of flap failures or the risk of the flap appearing too bulky over shadows the decision. A free flap might be the best option but needs a special training and special settings which represent a technical challenge in some cases.

Negative pressure wound therapy (NPWT) emerged in the last 3 decades as a useful weapon in the management of wounds regardless of their etiology. NPWT involves the placement of a microporous foam sponge into the depth of a wound, sealing the wound with an occlusive plastic drape, and applying a suction tubing device to deliver controlled negative pressure to the wound bed **[2]**.

In 1997, Argenta et al., suggested a new system (NPWT) for treating all kind of wounds (chronic, subacute & acute) wounds. NPWT proved to be a success in treating wounds all over (chest, abdomen, perineum, and extremities). Its success encouraged its application in both acute and chronic wounds, fistulae, and surgical dehiscence in the head and neck **[3]**. Though NPWT is becoming the GO TO technique in a lot of areas, yet its use in the head trauma setting remains scarce **[2]**.

Head trauma is usually associated with exposed bone making it difficult to manage owing to the poor vascularity of the exposed bone. This gives rise to an important question of “can we use NPWT on an exposed bone without periosteum?”. A lot of speculations and questions rose yet it has been proven that NPWT can be applied safely over virtually any tissue type, as well as to non-native

surgical implants, including dermis, fat, fascia, tendon, muscle, blood vessels, bone, Gortex graft, synthetic mesh, and hardware, so long as the wound is well vascularized and has been debrided of nonviable tissue **[4,5]**.

Dressings in the head and neck present a challenge. They are difficult to keep in place; fluid discharge is always a nuisance, in addition to the pain of frequent dressing change. NPWT has always been compared in literature to conventional dressing. It showed less frequent changes of dressing, shorter hospital & wound care time. Even when all costs are factored in, NPWT shows a lesser overall cost **[6]**.

PATIENTS AND METHODS

This randomized prospective control study was conducted on the first 40 patients presenting to the author in the period from April 2017 to April 2021. Patients were included in the study if they fulfilled the following criteria:

Inclusion criteria:

- Post Traumatic Cases.
- Exposed facial bones (Maxilla, Zygoma, Frontal bone, Calvarium bones).
- Bone is denuded of periosteum.
- Previously failed reconstruction either by pedicle or free flap.
- Previously failed reconstruction with a skin graft leaving an exposed bone.
- Age between 18 years old and 60 years.
- Patients willing to participate in the study.

Exclusion criteria:

- Previously Irradiated sites.
- Presence of a fistula.
- Presence of an underlying Neurosurgical emergency.
- Osteomyelitis.
- Malignancy.
- Non Consenting patients.
- Patients not adhering to study protocol and fall out patients.

Patients included in the study were randomly allocated into 2 equal groups using the website Research Randomizer (https://www.randomizer.org).

Group A included patients who underwent NPWT while group B included patients on conventional dressing as a control group.

In both groups, patients presenting at the time of the initial trauma followed the classical trauma survey. While in patients presenting following a previous trial of a reconstruction, confirmation was obtained that the attempt didn't yield its desired goal.

All patients underwent an initial session of debridement under general anesthesia to remove all debris and dead tissues as well as copious lavage. VersaJet Hydrosurgery system® (Smith & Nephew, Memphis, TN, USA) was used in areas where tissue preservation was crucial (e.g. over nerves course) but was not routinely used in all cases.

A conventional wet dressing was applied on the wound and patients were scheduled for a second look after 48 hours from initial management. Facial and scalp hair were clipped in both groups to prevent any cross contamination as well as providing a better method of fixation of the dressing. Obtaining consent for clipping was challenging especially in female patients.

On the second look surgery, further debridement and lavage of the wound was done with documentation of the size & dimensions of the wound and photography.

In group A, NPWT was applied using the Renasys ®(Smith & Nephew, Memphis, TN, USA) due to its availability with no conflict of interest. The foam was trimmed to be smaller than the edges of the wound to allow for the macrodeformation mechanism of the NPWT. An occlusive seal provided in the same wound care set was applied on top of the foam then attached to the suction port. It was preferred to use white gauze during the first dressing to decrease the maceration of the skin. Pressure was applied between 100 to 125mmHg in a continuous mode. NPWT dressing was changed 3 times a week. The machine comes with an air leak alarm that was monitored.

To minimize the cost of NPWT in patients presenting with 2 or more raw areas with exposed bone, a bridge was made connecting both wounds to a single suction port. A layer of occlusive seal was put on the healthy skin to avoid maceration of the skin by the foam. On top of the occlusive seal a layer of foam was added connecting both raw areas through a bridge of foam or gauze. Once the suction is applied to one raw area, the suction power is transmitted to the other raw area through the handmade bridge. The following dressings were either made bed side or even at home. Fig. (1).

Fig. (1): Patient presenting with 2 raw areas with exposed bones in both of them treated with a single NPWT. Notice the handmade bridge connecting both raw areas by a single soft port. Suction is transmitted from the soft port on the zygoma through the bridge to the forehead defect. This can illustrated with application of the NPWT as the gauze starts to collapse in the forehead raw area.

In group B, a conventional wet dressing was applied on the wound trying to maintain stability of the dressing even in geographically challenging areas. Dressing change was done on daily basis either bed side or at home.

Patients in both groups were followed-up with recording of the time needed for complete coverage of the exposed bone and the bed being ready for grafting. In the forehead region, the desired effect was complete healing by secondary intentions without the need for a skin graft as the literature states that it provides a better long term aesthetic result.

RESULTS

Out of the 40 patients recruited for this study only 35 patients (18 in group A & 17 in group B) fulfilled the inclusion and exclusion criteria. In group A, 10 patients (55.6%) were males while 8 (44%) were females. In group B, 12 patients (70.6%) were males while 5 patients were females (29.4%). The mean age in group A was 30.67 (±10.94) with a minimum of 18 years and a maximum of 58 years. The reciprocal data in group B were 31.6 (±11.42) with a minimum of 16 years and a maximum of 58 years. The main 2 etiologies for defects were road traffic accidents (14 patients Group A, 13 patients in group B) or failed previous attempt of reconstruction (e.g. failed previous flap or skin graft) (4 patients in each group).

The exposed bone without periosteum was; zygoma [5 patients (27.8%) in group A, 3 patients (17.6%) in group B], frontal bone [6 patients (33.3%) in group A, 3 patients (17.6%) in group B], calvarium [6 patients (33.3%) in group A,9 patients (52.9%) in group B]. Lastly the exposed maxilla was treated only in 1 case in group A and no patients in group B. The longest diameters of the raw areas were measured after the second look debridement to be sure that it is the final size of the defect. In group A, the longest diameter was 14cm (mean 6.22±3.78) with the largest raw area being 11x5 (55cm^2). While In group B, the longest diameter was 13cm (mean 7.35±3.06) with the largest raw area being 12x7 (84cm^2). This was statistically insignificant with a *p*-value of 0.232.

Only 2 patients in group A did not tolerate the NPWT during the first 48 hours of treatment. This was either due to pain or due intolerance to the noise the machine produces. The treatment was stopped for a while then resumed again. Both patients tolerated NPWT after a few cycles of on and off.

The head represents a challenge for fixation of any dressing due to its unique geographical nature. In NPWT group, the air seal (to maintain negative pressure) was initially hard to achieve needing the use of a lot of fixation. The machine used in this study gives an alarm whenever there was an air leak. The maximum number of air leaks in one patient during the whole treatment was 5 times (mean 1.44±1.46). During the conventional dressing group, a bulky dressing was needed that sometimes covered the whole head and neck to keep the dressing in place. The number of dressings change due to disturbance by dressing fall was measured. The maximum number of dressing fall during the whole course of treatment was 8 times (mean 2.88±2.6).

The time needed for the raw area to be ready for definitive management was a crucial phase of this study and was measured in days. The end point was either being ready for skin graft or healing completely by secondary intention. Secondary intention was intended in small raw areas and in the forehead over the frontal bone where it is believed to yield better cosmetic results. The time from the start of treatment till the end point was as follows: NPWT group mean was 27 days (±4.83 days) with a minimum of 18 days and a maximum of 36 days. Those were in contrast with the results from the conventional dressings group were mean was 34.76 days (±6.16 days) with a minimum of 22 days and a maximum of 47 days. Though the numbers don't show a significant numerical difference, statistical assessment showed a *p*-value of <0.001 which is highly significant. This falls in favor of NPWT showing a shorter recovery period.

Fig. (2): Patient presenting with raw area at the forehead following RTA (A) At time of presentation (B) 48 hours at the second look procedure (C) After 3 dressings with NPWT (D) After 4 weeks of dressing (E) The end point here was total closure without skin grafting notice the raw area contracting (F) 2 months post-operative (G) 6 months post-operative.

Fig. (3): Patient presenting with raw area over the Zygoma Post RTA (A) At time of presentation debridement was done using Versajet for tissue preservation (B) 48 hours at the second look procedure (C) After 3 dressings with NPWT (D) After 4 weeks of dressing (E) The end point here was having enough granulation to cover the exposed bone in preparation for skin graft (F) 2 months postoperative (G) 6 months post-operative.

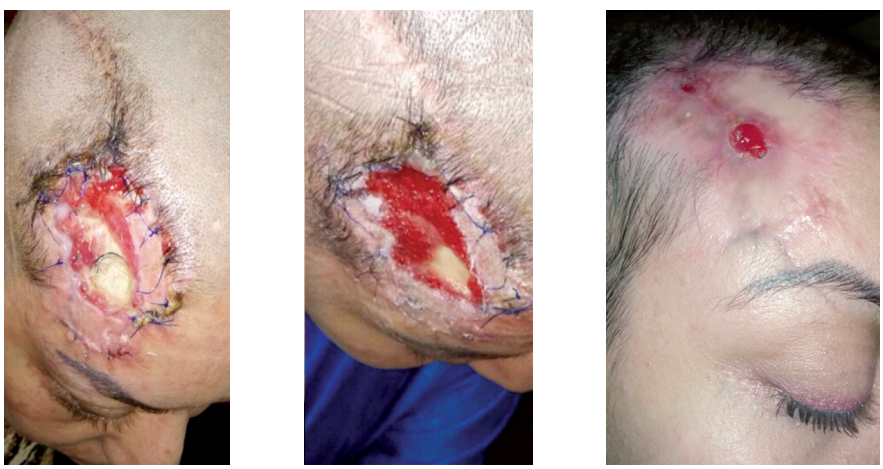

Fig. (4): Patient presenting after a failed flap for coverage of the exposed bone. Notice the change in the size of the defect over a period of 3 weeks. The last picture is before the final closure of the defect without the need for a skin graft.

Table (1): Demographics of both groups.

	Group A VAC		Group B conventional		*p*-value
	Count	%	Count	%	
Mode of injury:					
RTA	14	77.8	13	76.5	1
Failed Flap	4	22.2	4	23.5	
Sex:					
M	10	55.6	12	70.6	0.358
F	8	44.4	5	29.4	
Exposed bone:					
Zygoma	5	27.8	3	17.6	0.647
Frontal bone	6	33.3	5	29.4	
Maxilla	1	5.6	0	0.0	
Calvarium	6	33.3	9	52.9	

Table (2): Comparison between Group A & B as regards to: Age, Time to be ready for definitive management, Largest Diameter of the raw area.

	Group A VAC					Group B conventional					*p*-value
	Mean	SD	Median	Minimum	Maximum	Mean	SD	Median	Minimum	Maximum	
Age	30.67	10.94	27.50	18.00	58.00	31.06	11.42	28.00	16.00	58.00	0.858
Time to be ready in days	27.00	4.83	27.00	18.00	36.00	34.76	6.16	36.00	22.00	47.00	<0.001
Largest diameter	6.22	3.78	5.00	2.00	14.00	7.35	3.06	7.00	3.00	13.00	0.232

DISCUSSION

Despite facial and head trauma being very common and Negative Pressure Wound therapy (NPWT) being a bench mark and standard of care in plastic surgery, till now, there is a lack of publications in literature combining both variables.

Of all the areas the plastic surgeon confronts in his practice the head and face represent a new challenge every time due to multiple factors. The face and head are areas with a special topography making their reconstruction a tedious job. In other areas of the body regaining full function only might be an achievement while in the face acceptable cosmetic results are as important as the functional outcome.

It is difficult to manage wounds containing exposed bone due poor vascularity of the exposed tissue. The main etiologies of those wounds are resection of malignant tumors, failed reconstruction procedures and trauma. The armamentarium for this area included primary closure, healing by secondary intentions, local and distant tissue transfer, grafts and flaps either free or pedicled. The reconstructive elevator is used in a lot of cases **[7]**.

Since its introduction a few decades ago, NPWT has gained popularity proving its benefit in a new area every day. NPWT accelerate wound healing via multiple mechanisms, including and not limited to: Removal of wound exudates, reduction in tissue swelling & bacterial burden, increasing vascularity & granulation formation stimulation of fibroblasts and endothelial cell proliferation, and mechanical contracture of the wound bed **[8]**.

Despite NPWT being an established technique with over 1500 publications, its uses in head and neck has been sparse. Most of those publications recommend the face, head & neck as areas that could benefit from further research **[9]**.

The debate of the safety of application of NPWT over various tissues has been solved. NPWT can be applied over virtually any tissue as long as the wound has been properly cleaned with no non viable tissues. It can be applied over dermis, blood vessels, bone and even hardware. In 2017 Chen et al., compared NPWT and conventional therapy effect on exposed cranial bones in a rabbit model. NPWT showed superiority in decreasing the healing time by 5 days. The paper concluded that NPWT doesn't only decrease the healing time but it also increased wound collagen content and vessel density **[10]**.

In the era of evidence based medicine, Mir et al., **[11]** yielded in a review 522 cases of NPWT use in head and neck in 57 studies. The total number of trauma cases in all studies (13) was astonishingly only 50 cases in all studies. None of those studies compared the use of NPWT against any other kind of treatment modalities. The largest of these studies was done by Asher et al., **[2]** their study included only 12 trauma cases out of 108 cases of other uses of NPWT in head & neck. The second largest trauma study was done by Geiger et al., **[12]** and it included 11 war wounds. This study included 18 patients with NPWT used in a trauma setting in the head and face region being the largest study to date.

The mean age all 13 trauma studied were 33.3 years with a range from 5 to 96 years **[11]**. In the current study the mean age was 30.67 with a range from 18 to 58. Only 10 of the 13 studies reported gender data (17 patients overall) 16 of them were males **[11]**. While in this study out of 18 patients; 10 were males and 8 were females.

The etiology of the raw area was mainly RTA yet other causes were listed such as gunshots, shotguns, war wounds, dog bites or burns. The study at hand was limited to RTA and failed previous reconstruction. Most of those studies didn't specify the nature of the raw area and whether there was an exposed bone or not as their main concern was studying the effectiveness of NPWT in head and neck region **[11]**.

Application of NPWT in the face and head region is quite challenging. For NPWT to work properly it needs a proper sealing that necessitates clipping facial and head hair which was not always acceptable.

Asher et al., **[2]** study showed a raw area of a mean of 5.6±5.0cm in its longest diameter and application length of 3.7±1.4 days. Andrews et al., **[7]** did not report the longest diameter of any the defects while the duration of use of NPWT ranged from 5 days when used as a bolster over skin grafts to 6 weeks when applied over exposed bone. In the current study the longest diameter was 14cm with the largest raw area being 11x5 ($55cm^2$). The time needed to reach the desired effect in NPWT group mean was 27 days (±4.83 days) with a minimum of 18 days and a maximum of 36 days.

In the study at hand, longest diameter of the raw area after debridement in both groups was statistically insignificant with a *p*-value of 0.232. Thus making it wise to compare both groups while unifying the size of the defect as a variable.

Dressing change and time needed to heal are always on top of the patient and their families' worries. Each dressing represents to them a new traumatizing experience with new fears and new hopes. NPWT dressing is changed every 3 days while we had to change the dressing in the conventional dressing everyday to keep it moist to prevent desiccation of the underlying bone or infection that might hinder healing. This alone gives an edge for NPWT over conventional therapy when factoring the patients' emotional well being.

Despite less frequent dressing change, 2 patients couldn't tolerate the suction produced by the NPWT. They even claimed that it was more painful than the dressing process itself. This might be due to the continuous mode the NPWT was on or due the noise the machine produces. After proper counseling and explaining the pros and cons of this technology and giving periods of rests, both patients did tolerate the NPWT.

The other challenge the plastic surgeon faces in head and neck reconstruction is, how will I fix the dressing in place? A lot of methods have been recommended, from bulky occlusive dressings to tie overs to cast nets. In this study, the dressings in NPWT were easier to maintain in place with a good air seal. As we gained more experience, 2 or more raw areas were managed at the same time using a single soft port while maintaining perfect air seal. It is even recommended that NPWT should be use for simple grafts of the face & neck to increase graft take and maintain a stronger graft bed relationship.

Last but not least, the time needed for end of treatment was recorded. It was 27 days (±4.83 days) & 34.76 days (±6.16 days) in groups A & B respectively. The *p*-value was <0.001 which is highly significant. This showed that group A had a shorter time for the end treatment. Randomization of this study led that different raw areas of different locations and different sizes were compared. This wasn't the only limitation; the end goal of treatment was different. In certain areas the goal was just covering the exposed bone while in other areas like the forehead and over the frontal area the main aim was the complete healing of the raw area without the need for any further management.

Thus the current study tried to answer 2 main questions: Can NPWT therapy be used effectively in the head and face region? And is it superior to other modalities? Since there are a lot of variables, the current study emphasized on 2 points: Effectiveness in covering exposed bones and compared

it to the well established conventional dressings. It is believed that since it proved its effectiveness in this study it should be compared to other reconstruction modalities like local and regional flaps in relation to down time, aesthetic results, donor site morbidity and function.

Conclusion:

Negative Pressure Wound Therapy is a useful tool in covering head and faces exposed bones with shorter recovery time and more ease and comfort for the patient. This study suggests it as modality for treatment in certain conditions as an alternative and not as replacement for other well established techniques such as local and free flaps. Further study about the superiority of the aesthetic results of those techniques is highly recommended.

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