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Comparative Study Over Securing Split Thickness Skin Grafts for Post-Traumatic Wounds Using Negative Pressure Wound Therapy versus the Conventional Tie Over Technique

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Abstract

Background: Split-thickness skin grafts (STSG) are crucial for managing soft tissue defects, requiring close contact between the graft and the recipient wound bed for success. Negative pressure therapy has been used to promote wound healing and secure skin grafts by ensuring tight adhesion.

Objective: Comparing Securing STSGs for post-traumatic wounds using NPWT to the conventional tie-over technique

Patients and Methods: A prospective, randomized, blinded clinical trial was conducted on 30 post-traumatic wound cases eligible for STSGs. Patients were divided into two groups: Group A received negative pressure wound therapy (NPWT) for securing STSGs, while Group B underwent the tie-over technique. Outcomes were evaluated based on time to 90% graft take, graft failure, contraction, complications, and patient satisfaction with aesthetic appearance.

Results: The mean time for 90% graft take was 6.7±2.8 days in Group A and 9.3±3.7 days in Group B. Patient satisfaction regarding aesthetic appearance scored 7.5±1.1 in Group A and 5.9±1.7 in Group B. No statistical difference was observed in operative time or postoperative hospital stay between the two groups.

Conclusions: Securing STSGs for post-traumatic wounds using NPWT is advantageous compared to the conventional tie-over technique, resulting in shorter time to 90% graft take, lower infection rates, reduced graft failure, and better cosmetic outcomes.

Key Words: *Skin Grafts – Traumatic – Negative Pressure Wound Therapy – Tie Over.*

Ethical Committee: This study was approved form Ethical Committee Faculty of Medicine, Cairo University (MS-394-2021).

Disclosure: No disclosure.

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Introduction

Achieving successful coverage of soft tissue defects, whether post-traumatic or post-burn, is a primary goal in daily reconstructive surgical practice **[1]**. Complications following surgery can extend a patient's hospital stay, diminish their quality of life, and increase healthcare expenses **[2]**. Consequently, the approach to wound covering has grown significantly **[3]**.

Split-thickness skin grafting (STSG) is a routinely employed technique for reconstructing extensive skin defects. For the grafted skin to be successful, it must undergo three critical phases: Serum imbibition, revascularization, and maturation **[4]**.

Revascularization, highly susceptible to external influences, is the most vital stage. The success of a skin graft depends on factors such as the thickness of the graft, the underlying soft tissue bed, and the type of dressing applied. Therefore, it is essential to identify the optimal method for covering grafted skin to enhance graft survival. Common causes of graft failure include infection, hematoma formation beneath the graft, and shear forces. If a significant portion of the grafted skin is lost, a secondary procedure may be necessary to address the wound bed **[5]**.

A tight contact between the graft and recipient wound bed, along with a well-granulated wound bed, is required for effective STSG **[6]**.

Traditional postoperative care for the recipient site typically involves applying petroleum gauze and cotton gauze with a tie-over dressing method. However, this conventional approach has drawbacks, such as shearing at the interface and uneven pressure distribution, which can contribute to

hematoma formation beneath the grafted skin, ultimately leading to poor graft adherence **[8,9]**.

Negative pressure wound therapy (NPWT) has been employed to prepare wound beds for both flap closure and grafting **[10]**. It has also been utilized to stabilize skin grafts by enhancing microcirculation and ensuring close adhesion between the graft and the recipient bed. Previous studies have documented the application of NPWT on grafted skin, with several investigations reporting encouraging results **[11-13]**.

Therefore, this study aims to evaluate the efficacy of NPWT in securing STSG and to compare the outcomes of NPWT versus the conventional tie-over dressing increasing take of the graft, minimize complications and improving the aesthetic outcome of the resultant scar.

Patients and Methods

Study design:

This prospective randomized blinded clinical trial was conducted from August 2021 to February 2022. We included 30 patients with acute post-traumatic wounds who were candidates for STSGs.

Informed written consent was obtained and this study was approved form our institution's Ethical Committee (MS-394-2021).

Patients and materials:

Thirty patients aged between 12-50 years old with post-traumatic wounds, and post-burn wounds who required STSGs in either extremities or trunk were included. Any patient with complex soft tissue defects that need flap coverage, post-surgical defects, children under 12 years, and defects in the head and neck region were excluded. Preoperative evaluation of patients includes; thorough history taking regarding age, sex, mode of trauma, and any concomitant medical illness. Then preoperative wound evaluation and debridement under general anaesthesia in two to three sessions.

Randomization:

The patients were randomly assigned according to sealed envelopes with random–number generator method to two equal groups. Group (A) included 15 patients; underwent NPWT to secure STSGs. Group (B) included 15 patients; underwent conventional tie over technique to secure STSGs.

Operative procedure:

Using the electrical dermatome (Zimmer Biomet® Electric Dermatome) STSGs were harvested from the thigh with a thickness ranging from 0.2 mm to 0.3mm. The grafts were applied to a clean well-vascularized bed. Then they were covered and fixed with either a NPWT or conventional tie over dressing. And eventually the operative duration was recorded in all patients.

- *Group A: Negative pressure wound therapy (NPWT):*

The graft was applied and not fixed, then the sponge was cut to a suitable shape in order to cover the grafted region. The adhesive laminate was placed over the sponge and surrounding undamaged skin. After securing the seal covering, the sponge was then attached to the portable unit. The vacuum mode was set at continuous -75mm Hg. Additional adhesive dressings were used to control any leakage.

- *Group B: Conventional tie over technique:*

The graft was applied and fixed using interrupted absorbable sutures, then it was covered with non-adhesive petroleum gauze and dry tie over.

Follow-up and outcome analysis:

First graft check was done in the 5th post operative day. Then every three days till complete re-epithelialization of the raw area. The percentage of graft take was assessed at every visit. And time needed for 90% of graft take was recorded and compared in both groups. Patients' satisfaction with the appearance of the graft was assessed at the end of six months post operative. The patient will give score from 1-10, as 1: Indicates the least patient satisfaction and 10: Indicates the highest patient satisfaction.

All cases completed face-to-face follow-ups to conduct skin or scar reviews, graft contraction in the two groups was documented, the percentage of graft loss in both groups was calculated, and complications such as infection or hematoma were documented.

Statistical analysis:

SPSS v28 was used for performing the statistical analysis (IBM Inc., Armonk, NY, USA). Qualitative variables were expressed as frequency and percentage (%) and were analysed utilizing the Chi-square test or Fisher's exact test when appropriate. Quantitative variables were expressed as mean and standard deviation (SD) and compared between the two groups utilizing unpaired Student's *t*-test. A two tailed *p*-value <0.05 was deemed statistically significant.

Results

We assessed 67 cases for eligibility in this study, 12 patients refused to participate and 25 cases did not meet the criteria of the study. The remaining 30 cases were randomly allocated into two groups (15 cases in each). All included cases were followed up and analysed statistically as shown in Fig. (1).

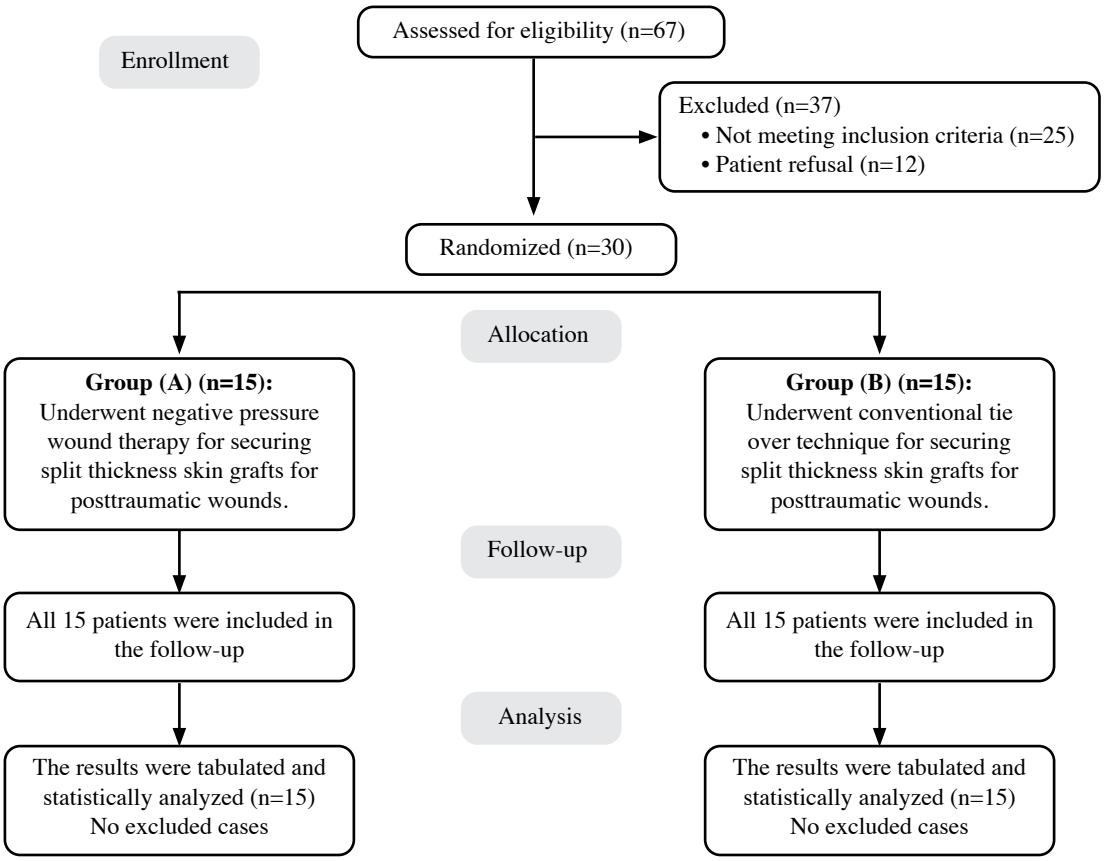


Fig. (1): CONSORT flowchart of the enrolled patients.

The participants were classified randomly into two groups: 50% treated by the NPWT and 50% by conventional dressings. Regarding gender, side and site of the raw area, medical co-morbidities i.e. (diabetes, hypertension), and mode of injury, no significant variation was reported between the two studied groups as summarized in Table (1).

No significant difference were observed between the two groups under study regarding the time between admission and operation. The time till 90% graft take among VAC group was significantly lower than Group Tie over as demonstrated in Table (2).

Regarding the complications, 13.3% of the patients in the NPWT group had wound infections, while 33.3% of the patients in the conventional dressings group had wound infections. A significant variation was found between both groups regarding wound infection in favor of the NPWT group. Graft failure occurred in 6.7% and 33.3% of both groups respectively. A significant variation was found between both groups regarding graft failure in favor of NPWT Group. Regarding graft contraction, no significant variation was reported between both groups. Table (3).

Table (1): Basic characteristics of the two studied groups.

Variable	NPWT group (n=15)	Conventional group (n=15)	*p*-value
Age (years):			
Mean ± SD	27.5±12.8	29.3±1.3	0.744
Gender:			
Male	11 (73.3%)	10 (66.7%)	>0.999
Female	4 (26.7%)	5 (33.3%)	
Side:			
Right	7 (46.7%)	6 (40%)	>0.999
Left	8 (53.3%)	9 (60%)	
Site:			
Foot	4 (26.7%)	4 (26.7%)	0.711
Ankle	4 (26.7%)	3 (20%)	
Leg	2 (13.3%)	1 (6.6 %)	
Forearm	3 (20%)	3 (20%)	
Hand	2 (13.3%)	4 (26.7%)	
Medical comorbidities:			
No	10 (66.7%)	11 (73.3%)	>0.999
Yes	5 (33.3%)	4 (26.7%)	
Mode of injury:			
Road traffic accident	7 (46.7%)	5 (33.3%)	0.102
MBA	5 (33.3%)	7 (46.7%)	
Others	3 (20%)	3 (20 %)	

Data were expressed as mean ± SD or frequency (%).

Table (2): Operative data among the two studied groups.

Variable	NPWT group (n=15)	Conventional group (n=15)	*p*-value
Duration (hours)	1.2±0.3	1.2±0.3	0.749
Time between admission and operation (days)	7.8±3.1	9.4±4.5	0.366
Time till 90% graft take	6.7±2.8	9.3±3.7	0.022*

Data presented as mean ± SD.
*: Significant as *p*-value <0.05.

Table (3): Post operative infection among the two studied groups.

Variable	VAC group (n=15)	Tie over group (n=15)	*p*-value
Infection:			
No	13 (86.7%)	10 (66.7%)	0.041*
Yes	2 (13.3%)	5 (33.3%)	
Graft failure:			
No	14 (93.3%)	10 (66.7%)	<0.001*
Yes	1 (6.7%)	5 (33.3%)	
Graft contraction:			
No	11 (73.3%)	10 (67.7%)	>0.999
Yes	4 (26.7%)	5 (33.3%)	

Data presented as frequency (%).
*: Significant as *p*-value <0.05.

Table (4): Cosmetic appearance among the two studied groups.

Variable	NPWT group (n=15)	Conventional dressing group (n=15)	*p*-value
Cosmetic appearance	7.5±1.1	5.9±1.7	0.020*

Data presented as mean ± SD.
*: Statistically significant as *p*-value <0.05.

Table (5): Length of post operative hospital stay for the groups studied.

Variable	VAC group (n=15)	Tie over group (n=15)	*p*-value
Length of post-operative hospital stay	7.4±2.1	7.6±1.2	0.718

Data presented as mean ± SD.
*: Statistically significant as *p*-value <0.05.

Cosmetic appearance is according to patient satisfaction scale from 1 to 10 (1 is the least satisfaction and 10 is the highest satisfaction). The mean patient satisfaction regarding cosmetic appearance was 7.5±1.1 and 5.9±1.7 among both groups respectively. Regarding cosmetic appearance, a significant variation was found between both groups in favor of the NPWT group.

Regarding length of hospital stay, no significant variation was reported between both groups. Length stay in the hospital post-operative is the same in both groups as the patients were discharged to follow-up in the outpatient clinic after 2nd graft check.

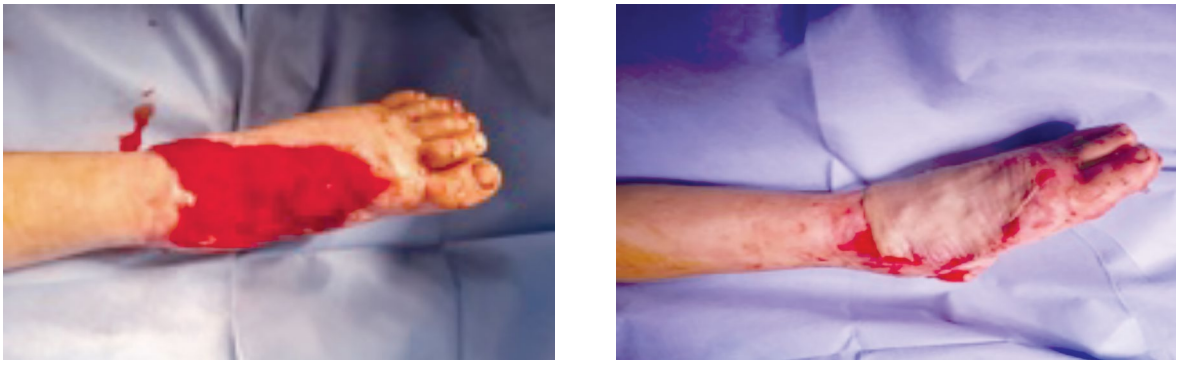
Figs. (2-5) illustrates results of two patients who were included in our study.

(A) (B)

Fig. (2): Post traumatic raw area on the medial aspect of the dorsum of the foot: (A) After preparation of bed of the wound by repeated debridement. (B) Intra operative after application of the graft, before VAC application.

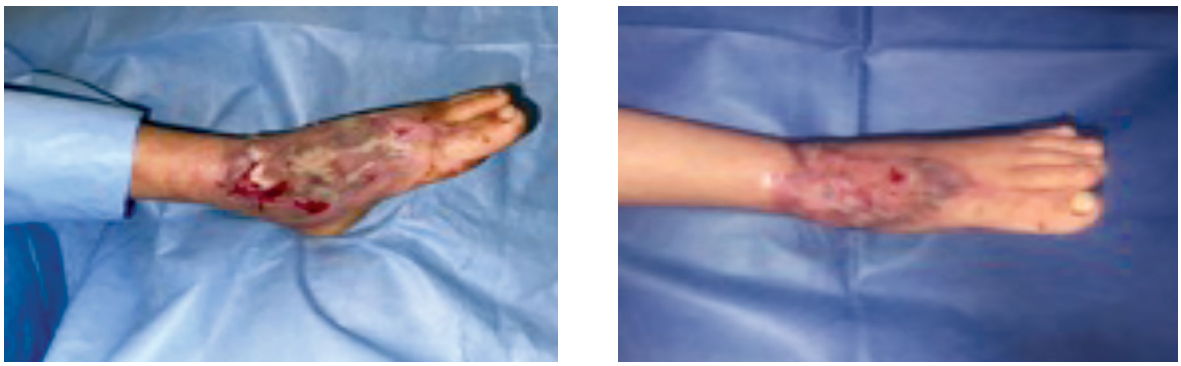
(A) (B)

Fig. (3): Post operative photos of the same patient. (A) Two weeks post-operative. (B) Three months postoperative.



(A) (B)

Fig. (4): Post traumatic raw area on the medial aspect of the dorsum of the foot: (A) After preparation of bed of the wound by repeated debridement. (B) Intra operative after application of the graft, before traditional tie over dressing application.



(A) (B)

Fig. (5): Post operative photos of the same patient. (A) Two weeks post operative. (B) Three months postoperative.

Discussion

As a result of using NPWT as a bolster during surgery with autograft on cases with wounds, the pain score, duration of wound healing, and workload of caregivers and nursing staff are reduced. Early wound healing lessens the chances of contracture development and leads to early rehabilitation **[14]**. Securing free skin grafts is usually performed using tie-over dressing; however, it can cause some adverse events such as the formation of seroma or hematoma due to the uneven application of pressure **[15]**.

This comparative interventional research was performed on 30 cases that needed STSGs for post-traumatic wounds, their mean age of this study was 27.6±10.8 years, 70% of them were males. 43.3% of this study participants had right side affection and 56.7% had Left side affection. There were 26.7% who had wound in foot, 23.3% in ankle, 10% in leg, 20% in forearm, and 20% in hand. The wound size among the patients were categorized into 13.3% small (size from 1 to 5cm^2), 66.7% medium (size 6 to 10cm^2), and 20% large (size more than 10cm^2).

In our study, the participants were randomized into group (A) (included 15 patients; underwent negative pressure for securing STSGs) and group (B) (included 15 patients; underwent conventional tie-over technique for securing STSGs), aiming to find out differences between both modalities and study their impact on graft take and patient wound healing. The two groups were matched as regards age, sex, side of wound, wound site and wound size. Regarding comorbidities, 66.7% and 73.3% of groups A and B had no medical comorbidities. So, no significant variation regarding medical comorbidities was reported between the two studied groups. Among the current study participants, the most common modes of injury were road traffic accidents and motor bicycle accidents.

The mean time between admission and operation of group VAC was 7.8±3.1 days and group tie over was 9.4±4.5 days. Time between admission and operation was insignificantly different between the two studied groups. The mean operative duration of VAC group was 1.2±0.3 hours and tie over group was 1.2±0.3 hours. Operative duration showed no difference between the two studied groups.

Nakamura et al. **[16]** reported that the average operative time from skin graft harvesting to graft stabilization was 73.5 minutes (range, 32–156) for the tie-over group and 40.3 minutes (range, 23–70) for the negative pressure closure (NPC) group. Although the NPC group had a shorter operative time compared to the tie-over method, the difference was not statistically significant (p=0.0931).

Inatomi et al. **[17]** conducted a study on STSGs cases who were classified into two groups: A control group using conventional fixings, and a 'no suture' group using only NPWT, they reported that mean surgical time tended to be shorter in the no suture group (31.5 minutes) compared to in the control group (55.7 minutes), with insignificant difference.

In this study, the time till 90% graft take among VAC group was significantly lower than Group Tie over.

Consistent with this observation, a systematic review and meta-analysis found that the rate of graft take for split-thickness skin was significantly higher in the NPWT group compared to the conventional therapy group. Specifically, the graft take rate improved by 7% with NPWT relative to conventional therapy **[11]**.

In the present study, there were 86.7% and 66.7% had no infection while 13.3% and 33.3% had wound infection among both groups respectively. A significant variation was reported between both groups regarding wound infection in favour of the VAC group.

Likewise, Blume et al. **[18]** observed fewer complications, including hematoma, seroma, and infection, in the NPWT group compared to the control group.

In a previously conducted study on 392 patients, 174 of the cases underwent conventional mechanical fixation and 218 underwent NPWT for skin grafting. The NPWT group had significantly lower rates of infection compared to the conventional mechanical fixation group (5.5% vs. 13.2% p=0.008) **[19]**.

In contrast, the pooled analysis in Yin et al. **[14]** found no significant difference in wound infection rates between the two groups (RR, 0.63; 95% CI, 0.31–1.27; p=0.20).

We observed that 93.3% and 66.7% had no graft failure while 6.7% and 33.3% had graft failure among both groups respectively. A significant variation was reported between both groups regarding graft failure in favour of VAC Group.

Yin et al. **[11]** study showed that the incidence of reoperation (after graft failure) was reduced significantly in NPWT compared to conventional therapy.

Also, Nakamura et al. **[16]** compared NPWT versus tie-over dressing to stabilize split-thickness skin grafts in large or muscle-exposing defects. They found that the tie-over had a mean proportion of the surviving skin grafts of 79.2% (range, 45.1–93.3%) and the NPC groups had an average proportion of surviving skin grafts of 97.9% (range, 96.1–99.1%).

Shen et al. **[20]** conducted a study on 186 cases; 114 received conventional mechanical dressing fixation and 72 received NPWT after skin grafting. They reported that for each anatomic site, the VAC group showed a greater survival rate compared to the dressing group.

We reported a significant difference in cosmetic appearance between both groups in favour of VAC Group.

A study was performed by Moisidis et al. **[22]** to evaluate whether topical NPWT improved split thickness skin graft take quantitatively or qualitatively compared to standard bolster dressings. Graft quality after topical NPWT was subjectively determined to be worse in three patients (15%), equivalent in seven patients (35%), and better in 10 patients (50%). Although the quantitative graft survival was not considerably improved by topical NPWT, the qualitative graft survival was significantly enhanced. (p<0.05). A significant improvement in qualitative appearance of split-thickness skin grafts was found in Topical NPWT compared to standard bolster dressings.

Seif et al., reported in their study that histopathological evaluation of the skin graft in both groups revealed more pronounced hyperkeratosis, pigmentation, neovascularization and collagen deposition in the Vac group **[23]**.

We found that the mean length of post-operative hospital stay in this study was 7.4±2.1 and 7.6±1.2 days among both groups respectively. The length of hospital stay was insignificantly different between both groups. Length of stay in the hospital is the same in both groups as the patients were discharged to follow-up in the outpatient clinic after 2nd graft check.

On comparing this study with other related studies, it is found that regarding the mean operative time (minutes), in this study & Inatomi et al. **[17]**, no significant variation was found, while in Nakamura et al. **[16]**, a significant variation was found between VAC group & conventional tie over group in favour of VAC group.

Regarding the cost-effectiveness of applying negative pressure wound therapy over split thickness skin grafts offers several advantages: Decreased operative time especially in medium sized and large defects, applying uniform pressure over the whole graft surface which is difficult to achieve with conventional tie over method. Consequently better graft take is achieved with decreased hospital stay, decreased cost of postoperative care and early return to work.

Limitations of the study: Our research had a relatively small sample size.

Conclusion:

We concluded that securing STSGs for posttraumatic wounds using NPWT is more advantageous than using the conventional tie-over technique as regards lesser time till 90% graft take, lower rate of infection, lower rate of graft failure, and better cosmetic appearance. Further larger multicentric randomized clinical trials might be needed to validate our findings.

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