**Hypothesis:** Use of the vacuum assisted closure device (VAC) for securing split-thickness skin grafts (STSGs) is associated with improved wound outcomes compared with bolster dressings.

**Design:** Consecutive case series.

**Patients and Setting:** Consecutive patients at a level I trauma center requiring STSG due to traumatic or thermal tissue loss during an 18-month period.

**Main Outcome Measure:** Repeated skin grafting due to failure of the initial graft. Secondary outcome measures included dressing-associated complications, percentage of graft take, and length of hospital stay.

**Results:** Sixty-one patients underwent STSG placement. Indications for STSG were burn injury (n=32), soft tissue loss (n=27), and fasciotomy-site coverage (n=2). Patients were treated with the VAC (n=34) or the bolster dressing (n=27). The VAC group required significantly fewer repeated STSGs (1 [3%] vs 5 [19%]; P=.04). Two additional graft failures occurred in the no-VAC group, but repeated STSGs were refused by these patients. No difference was seen between the groups in age, percentage of graft take, or hospital length of stay. The no-VAC group had significantly larger grafts (mean±SD, 984±996 vs 386±573 cm²; P=.006). The patients requiring repeated STSGs (n=6) did not have significantly larger grafts than those not requiring repeated STSGs (mean±SD, 617±717 vs 658±857 cm²; P=.62). No dressing-associated complications occurred in the VAC group.

**Conclusions:** The VAC provides a safe and effective method for securing STSGs and is associated with improved graft survival as measured by a reduction in number of repeated STSGs.

Arch Surg. 2002;137:930-934

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SOF TISSUE coverage for complicated wounds remains a difficult management problem for patients sustaining traumatic injuries and burns. Several methods achieve wound coverage, and placement of split-thickness skin grafts (STSGs) is often required. The literature is replete with recommendations for securing STSGs to wounds, but little is known about the use of the vacuum assisted closure device (VAC; Kinetic Concepts, Inc, San Antonio, Tex) and its impact on graft outcome.

The VAC is a modified dressing consisting of a sponge and suction tubing that is secured to the wound with an occlusive dressing. Use of the suction tubing creates a continuous negative-pressure dressing. This device has been associated with accelerated development of granulation tissue, earlier reepithelialization of wounds, and faster healing of burn wounds and has been used to manage very complex wounds successfully. The VAC has been used in a variety of clinical situations, including securing STSGs to the cranium, where it has met with success in this notoriously difficult region. We evaluated the safety and efficacy of the VAC at securing skin grafts in patients who had sustained traumatic or thermal tissue loss.

**RESULTS**

Sixty-one patients underwent STSG placement; grafts were managed with bolster dressings in 27 and with the VAC in 34 (56% VAC use rate). The STSGs were placed for the following indications: burn (n=32 [52%]), soft tissue loss (n=27 [44%]), and fasciotomy-site coverage (n=2 [3%]).

We saw no significant difference in age, total hospital length of stay, post-STSG length of stay, or day of postoperative wound evaluation between the groups. There were significantly fewer repeated STSGs required in the VAC group (3% vs 19%). The mean graft size was larger in the no-VAC group (Table 1).

When comparing patients who required repeated skin grafts with those who did not, we found no significant difference in age, graft size, or day of postoperative wound evaluation. The patients un-
PATIENTS AND METHODS

We reviewed consecutive STSG placements at a level I trauma center during an 18-month period. We identified all patients on the trauma surgery service who required STSGs during the study period by using registry data, and we reviewed their medical charts. The STSGs were all harvested using a Zimmer dermatome (Zimmer, Inc, Warsaw, Ind) to obtain a 0.03-cm (0.012-in) STSG that was meshed.

In the no-VAC group, the STSG was secured to the recipient site using circumferential staples followed by a fine mesh gauze covering that was stapled circumferentially to the site. The entire site was bolstered with bulky cotton gauze dressing, wrapped with a cotton gauze bandage, and kept moist with 5% mafenide (Sulfamylon) solution. Based on the location of the injury, bed rest, a sling, or a splint was used to keep the area immobilized.

In the VAC group, the STSG was secured to the recipient site using circumferential staples, followed by placement of a nonadherent dressing (Adaptic; Johnson & Johnson Medical, Inc, Arlington, Tex). The VAC sponge was cut to match the contour of the wound and was secured to the surrounding skin using benzoin spray and an adherent, occlusive dressing (Ioban; 3M, St Paul, Minn) (Figures 1, 2, and 3). The VAC was placed to continuous −125-mm Hg suction. Continuous negative pressure was ensured by clamping the VAC tubing and assessing for an air leak within the dressing. If an air leak was present, the leaking site was identified and repaired with a strip of the adherent dressing. The VAC dressing was left decompressed and clamped while the patient was transported to the recovery room and back to the hospital room. Once in the hospital room, the wound VAC was returned to suction until the dressing was removed. During the postoperative period, attempts were made to keep the affected area immobilized.

The dressings in both groups were left in place until the fourth postoperative day unless signs suggestive of wound infection developed, at which point the dressing was removed and the wound was evaluated.

We reviewed medical charts for demographic data, the indication for skin graft, the size of the skin graft (obtained from the dictated operative report), an estimate of graft take based on physician progress notes, the need for repeated skin grafting to the same site, the size and location of the repeated graft, hospital length of stay, and the post-STSG hospital length of stay. We compared the group of patients treated with the VAC to the group treated without the VAC using a 1-way analysis of variance for continuous data and the Fisher exact test for dichotomous data. Significance was accepted at P<.05.

Figure 1. Application of a nonadherent dressing (Adaptic; Johnson & Johnson Medical, Inc, Arlington, Tex) over the split-thickness skin graft.

Figure 2. Application of an adherent, occlusive dressing (Ioban; 3M, St Paul, Minn) over the sponge of the vacuum assisted closure device (VAC; Kinetic Concepts, Inc, San Antonio, Tex), a nonadherent dressing (Adaptic; Johnson & Johnson Medical, Inc, Arlington, Tex), and the split-thickness skin graft.

In addition to the 6 patients undergoing repeated STSG placement, 2 additional patients in the no-VAC group had graft failure, but both refused repeated skin grafts. These 2 patients were excluded from the analysis of the repeated STSG group. No dressing-related complications were identified in the VAC group. The distribution of graft failure, based on indication for graft placement and dressing type, is shown in Table 4.

Our data suggest that a negative-pressure dressing over an STSG site may improve overall graft survival, as measured by fewer episodes of repeated grafting. Several pos-
Figure 3. Completed occlusive dressing, decompressed and placed to continuous −125-mm Hg suction via the vacuum assisted closure device (VAC; Kinetic Concepts, Inc, San Antonio, Tex).

Table 1. Comparison of STSG Using the VAC or Bolster Dressing*

<table>
<thead>
<tr>
<th>Patient Group</th>
<th>Data From Patients in Study (N = 61)</th>
<th>VAC (n = 34)</th>
<th>No-VAC (n = 27)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>33 ± 23</td>
<td>41 ± 20</td>
<td>.14†</td>
<td></td>
</tr>
<tr>
<td>Graft size, cm²</td>
<td>387 ± 573</td>
<td>984 ± 996</td>
<td>.006†</td>
<td></td>
</tr>
<tr>
<td>Graft take, %</td>
<td>96 ± 6</td>
<td>89 ± 20</td>
<td>.06†</td>
<td></td>
</tr>
<tr>
<td>Total LOS, d</td>
<td>27 ± 16</td>
<td>32 ± 25</td>
<td>.37†</td>
<td></td>
</tr>
<tr>
<td>Post-STSG LOS, d</td>
<td>14 ± 10</td>
<td>19 ± 15</td>
<td>.10†</td>
<td></td>
</tr>
<tr>
<td>Wound evaluation day, No. of postoperative days</td>
<td>4 ± 1</td>
<td>4 ± 1</td>
<td>.77†</td>
<td></td>
</tr>
<tr>
<td>Repeated STSG to same site, No. (% of patients)</td>
<td>1 (3)</td>
<td>5 (19)</td>
<td>.04‡</td>
<td></td>
</tr>
</tbody>
</table>

*Unless otherwise indicated, data are given as mean ± SD. STSG indicates split-thickness skin graft; VAC, vacuum assisted closure device (Kinetic Concepts, Inc, San Antonio, Tex); and LOS, length of stay.
†Determined by 1-way analysis of variance.
‡Determined by Fisher exact test.

Table 2. Comparison of Data of Patients Requiring Repeated STSGs With Patients Who Did Not*

<table>
<thead>
<tr>
<th>Patients in Study (N = 61)</th>
<th>Repeated STSG (n = 6)</th>
<th>No Repeated STSG (n = 55)</th>
<th>P Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>32 ± 9</td>
<td>37 ± 23</td>
<td>.62</td>
</tr>
<tr>
<td>Graft size, cm²</td>
<td>617 ± 717</td>
<td>658 ± 857</td>
<td>.91</td>
</tr>
<tr>
<td>Wound evaluation day, No. of postoperative days</td>
<td>4 ± 1</td>
<td>4 ± 1</td>
<td>.44</td>
</tr>
<tr>
<td>Total LOS, d</td>
<td>58 ± 37</td>
<td>26 ± 15</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Post-STSG LOS, d</td>
<td>35 ± 14</td>
<td>14 ± 11</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

*Data are given as mean ± SD. Abbreviations are explained in the first footnote to Table 1.
†Determined by 1-way analysis of variance.

Notes:
1. Continuous −125-mm Hg suction via the VAC dressing.
2. The negative-pressure dressing provides continuous removal of wound fluid, which prevents the accumulation of hematoma or seroma while maintaining graft-to-wound apposition.
3. Desiccation is detrimental to wound healing and is reduced with the occlusive nature of the VAC dressing, in which a moist environment is maintained. Last, infection contributes to graft loss. The VAC has been associated with lower bacterial counts at wound sites, and this reduction in the local bacterial flora may enhance graft survival.

Shear stress to the grafted site after STSG placement is a risk regardless of the method used to secure the graft. We kept the VAC decompressed and clamped from the operating room until the patient reached the hospital room, and we tried to minimize episodes of suction release. This effort was intended to reduce shear injury potentially associated with loss of suction to the VAC and, in this study, graft loss due to suction loss never occurred. Another important aspect to reducing shear injury is limiting the mobility of the graft on the wound bed. The VAC device provides graft stabilization and may reduce the chance for shear injury to the graft from movement.

The grafts were significantly larger in the no-VAC group, and this may lead to the conclusion that the larger wounds contributed to the poorer graft survival in the no-VAC group. However, this contention has not been supported by the literature. Also, despite the discrepancy in graft size between the groups, comparison between the subset of patients who had graft failure culminating in repeated grafting and those who did not showed no significant difference in age, graft size, or day to postoperative evaluation. In fact, when the 6 repeated grafts were evaluated, the repeated grafts were of small to moderate size in highly contoured or poorly vascularized regions.

This study has the weakness of being a retrospective review, and retrospective evaluation of the percentage of graft take is difficult to determine, as it is an estimation that is wrought with observer bias at best. Therefore, we chose to emphasize what we consider to be clinically more important, ie, that the patients who were treated with the VAC required fewer return trips to the operating room for a second graft to the same site (3% vs 19%). We deemed the need for repeated grafting to be an easily identifiable event that would suggest the graft loss incurred by the patient was clinically important.

Not surprisingly, patients who required repeated grafting had longer post-STSG and overall hospital lengths of stay, due in part to the time required for repeated skin grafting. At most institutions, the VAC is likely to be more costly than bolster-type dressings. However, reducing the
need for repeated grafting should eliminate repeated surgical expenses, reduce the extra hospital days incurred by graft loss, and potentially offset the cost of the VAC.

**CONCLUSIONS**

We reviewed a larger number of patients than have been previously described, and our results continue to suggest that the VAC is an excellent alternative for securing skin grafts to the wound bed and achieving better graft outcome. From our observations, we support using negative-pressure dressings over skin graft sites and believe that, to better quantify outcome measures, further study of this device in a prospective, randomized fashion is warranted.

This paper was presented at the 73rd Annual Meeting of the Pacific Coast Surgical Association, Las Vegas, Nev, February 17, 2002, and is published after peer review and revision. The discussion is based on the originally submitted manuscript and not the revised manuscript.

**REFERENCES**


**DISCUSSION**

Gail T. Tominaga, MD, Honolulu, Hawaii: Bolster dressings are a classic method of graft fixation that has been successful in the majority of patients. However, inadequate graft bed, hematoma, fluid collection, movement, infection, and technical error can contribute to graft loss. Attempts at grafting on mobile surfaces or complex contoured surfaces are more problematic. The authors describe a technique that immobilizes the graft, eliminates fluid collections, and decreases wound bacterial counts, resulting in enhanced healing. The authors retrospectively reviewed 61 patients undergoing STSG due to traumatic or thermal tissue loss. Thirty-four patients were managed with the vacuum assisted closure device (VAC) and 27 patients with bolster dressings. There was no significant difference in age, total hospital length of stay, post-STSG length of stay, or day of postoperative wound evaluation between the 2 groups. The 2 groups did differ on 2 parameters: (1) graft size (the no-VAC group had a larger mean graft size) and (2) need for repeat skin grafting (the no-VAC group had 5 out of 27 patients regrafted). The VAC group had 1 out of 34 patients regrafted. Four of the 6 patients with graft failures had sustained burns, and all were in heavily contaminated or heavily contoured or poorly vascularized surfaces.

**Table 3. Characteristics of the 8 Patients Whose STSGs Failed**

<table>
<thead>
<tr>
<th>Patient Group</th>
<th>VAC (n = 34)</th>
<th>No-VAC (n = 27)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burns</td>
<td>0/11</td>
<td>4/21</td>
<td>NS</td>
</tr>
<tr>
<td>Fasciotomy site</td>
<td>0/2</td>
<td>0/0</td>
<td>NS</td>
</tr>
<tr>
<td>Soft tissue loss</td>
<td>1/21</td>
<td>1/6</td>
<td>NS</td>
</tr>
<tr>
<td>Total Group</td>
<td>1/34</td>
<td>5/27</td>
<td>0.04†</td>
</tr>
</tbody>
</table>

*Abbreviations are explained in the first footnote to Table 1.*

**Table 4. Distribution of Graft Failures Based on Indication for STSG and Dressing Type**

<table>
<thead>
<tr>
<th>Age, y</th>
<th>Use of Wound VAC</th>
<th>Original Graft Size, cm²</th>
<th>Original Indication for STSG</th>
<th>Size of Regrafted STSG, cm²</th>
<th>Location of Graft Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>No</td>
<td>300</td>
<td>Burn</td>
<td>300</td>
<td>Scapula, axilla</td>
</tr>
<tr>
<td>33</td>
<td>No</td>
<td>800</td>
<td>Burn</td>
<td>800</td>
<td>Posterior thighs, popliteal fossae</td>
</tr>
<tr>
<td>33</td>
<td>No</td>
<td>2000</td>
<td>Burn</td>
<td>400</td>
<td>Bilateral hands, wrists</td>
</tr>
<tr>
<td>47</td>
<td>No</td>
<td>200</td>
<td>Burn</td>
<td>200</td>
<td>Posterior thigh, buttock</td>
</tr>
<tr>
<td>33</td>
<td>No</td>
<td>200</td>
<td>Soft tissue loss</td>
<td>50</td>
<td>Dorsum of foot</td>
</tr>
<tr>
<td>22</td>
<td>Yes</td>
<td>200</td>
<td>Soft tissue loss</td>
<td>20</td>
<td>Exposed Achilles tendon</td>
</tr>
<tr>
<td>48</td>
<td>No</td>
<td>1500</td>
<td>Burn</td>
<td>Refused by patient</td>
<td>Bilateral ankles, dorsum of feet</td>
</tr>
<tr>
<td>36</td>
<td>No</td>
<td>2100</td>
<td>Burn</td>
<td>Refused by patient</td>
<td>Bilateral lower legs, ankles, feet</td>
</tr>
</tbody>
</table>

*Data are given as the number of graft failures divided by the total number of patients per group. NS indicates not significant. Other abbreviations are explained in the first footnote to Table 1.*

†Determined by Fisher exact test.
The authors conclude that the use of the VAC resulted in less graft failures as measured by the need for regrafting. Could the need for regrafting be due to the type and location of the wound and not the use of the wound VAC? The VAC group had 11 burns and the non-VAC group had 21 burn wounds. The distribution of complex contoured wounds in each group was not elucidated in the paper. Additionally, the title states that there is improved graft survival with the VAC system; however, their data demonstrated no difference in graft survival: 90% graft taken in the VAC group and 89% in the no-VAC group. Additionally, the authors stated that the cost of the VAC would be offset by the cost of repeat surgical expenses and extra hospital days. However, their data demonstrated that the overall length of stay was not statistically different between the 2 groups.

It may be that a larger study would show a statistically significant difference in both graft take and hospital length of stay. Earlier removal of the VAC from STSG has been reported by Argenta and Morykwas, previously, and this may result in decreased length of hospital stay.

My questions for the authors are: (1) Can you justify the extra cost of the VAC device when you demonstrated no statistical difference in your hospital length of stay and percent graft take? Did you do a cost analysis of the two groups? (2) Could the difference in regrafting be due to the location of the STSG? Does the non-VAC group have a larger number of complex or contoured wounds such as on the perineum? (3) Do you recommend the device for all patients undergoing STSG or a particular subset of patients such as the patients with complex contoured wounds?

I have a few technical questions: Do you staple the Adaptec in place over the graft to avoid shearing effects, and have you used the VAC device on the skin donor site as described by Gneccov [et al]? Anecdotally, we have used this device at our institution and have had positive results. I would like to congratulate the authors on their presentation today and encourage them to consider performing a prospective randomized trial using this device.

William P. Schecter, MD, San Francisco, Calif: The biggest factor determining the outcome of on-lay STSG is the condition of the wound bed. The type of tissue at the wound base, tendon, fascia, fat, or muscle will have some effect on the outcome. The bacterial count in the wound base will have a major effect on ultimate graft survival. In order for us to accept the results of this study, we would have to have a grading system for the wound base to ensure that the wounds in both groups were similar. I don’t think that we can absolutely certain that the wound bases in both groups are in fact equal.

Steven N. Parks, MD, Fresno, Calif: I have used the VAC dressing on a variety of wounds and am very impressed at how it seems to reduce infection, both by culture and by observation of the wounds. I have not used it on skin grafts. I have a technical question that I would like to ask. It looks like you placed the skin graft down and covered it and then placed your sponge over it. You held that down with an Ioban. Having it all held in position, it sounds like you then slit the Ioban, put the suction device in, and put another Ioban on. That’s a little different than the way you normally use the VAC dressing with its own thicker plastic covering. I was going to ask whether the Ioban was just holding the graft while you put the second one on.

James Peck, MD, Portland, Ore: How long was the VAC device used? The recommendation of the manufacturer is that it be changed every 48 hours. What was the reason there were bigger wounds in the bolster group? Were the size of the wounds too large for the open-cell foam? I am concerned that we may be comparing apples and oranges. There are more burns in the VAC group and more soft tissue injuries in the bolster group. Are there contraindications to the use of the VAC device in this setting? John Mayberry, MD, Portland: Yes, I enjoyed this too and I am glad that we are having a paper on the wound VAC, since I think a lot of us are using it. I am using it on trauma wounds, not for skin grafts. However, I have noticed one thing and that is that you really have to have continuous suction on it for several days, at least in the interval between the changes. So that is a significant reason in some cases not to use it. In other words, if the patient is on the wound VAC, it is my understanding that you really shouldn’t take them off suction and let them wander around the halls and ambulate like we would like to do in a lot of our patients.

Dr Owens: I will address each of your questions, hopefully, in the order that they were asked and concisely.

Dr Peck, the burns and the soft tissue loss. In fact, actually, they were equal in the 2 groups. That may have been misleading on the slide, but there was no statistical difference between the number of burn patients in the VAC group vs the number of burn patients in the bolster group.

Finally, Dr Mayberry, do you need to keep it to suction and is that going to prevent you from getting these patients mobilized? To sort of paraphrase and add to your question, the answer is no. As long as you have it at suction, you can clamp the tubing. If you don’t have an air leak, the suction will be maintained and the patient can be moved around and then placed back on suction once you’ve completed whatever movement the patient needs to be involved in. If it does not maintain the suction, then you really don’t have an adequate system seal and you need to patch the leak wherever it is.