



***Optimizing Adherence  
of Skin Grafts, Living  
Skin Equivalents, and  
Collagen Bioscaffolds  
with Smart Dressings***

***“Smart” dressings  
can reduce wound  
healing time.***

**Adam Landsman, DPM, PhD**  
Assistant Professor of Surgery

HARVARD UNIVERSITY SCHOOL OF MEDICINE  
DIVISION OF PODIATRIC SURGERY  
BETH ISRAEL DEACONESS MEDICAL CENTER,  
BOSTON, MA

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## Callouts:

The optimal wound covering can be left in place for up to a week without drying or macerating the wound.

The theory behind smart dressing usage with a graft, collagen, or an LSE is that the conditions for attachment of the graft to the wound bed will occur more rapidly and predictably, so that fewer grafts will be needed, and the wound will heal at a faster rate.

Application of TheraSkin is similar to the application of any split-thickness skin graft.

Regardless of the graft material used (allograft or laboratory grown), TheraGauze moisture regulation enhances incorporation of the graft and reduces the time to healing.

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## Introduction

As the treatment of complex wounds evolves, the use of advanced modalities such as living skin equivalents (LSE's) and collagen bioscaffolds has exploded. These modalities, along with cadaveric and fresh split thickness skin grafts, have been proven to greatly enhance the wound closure process. (1-4) By providing essential building blocks — growth factors and collagen — these products serve to stimulate the healing process. (2,3,4) In order to enhance their actions, these products must be applied to the wound properly, in an environment that will optimize the delivery of the desired factors.

Once the decision to utilize an advanced treatment regimen is made, the next factor to consider is how the wound will be dressed. Generally, this is a point that most clinicians do not dwell upon. The fundamental needs are that the material be non-adherent, and that it remains moist while the graft or other advanced modality mates to the wound surface. The optimal wound covering can be left in place for up to a week without drying or macerating the wound.

The problem takes on an added dimension when the bed of the wound is not uniformly moist. Wounds with exposed tendons for example, tend to be excessively moist where the tendon is, and dry in the surrounding areas. Similarly, highly exudative wounds tend to macerate around the edges, while the central regions can remain quite dry. Tunneling wounds, exposed bone, and necrotic areas add additional complexity to the wound environment.

In the last few years, the availability of “smart” dressings has helped to make environmental moisture control less of a chore. Smart dressings can “sense” the conditions of the wound and adjust them accordingly. The best smart dressings can actually moisten one portion of the wound while drying an adjacent area. TheraGauze (Soluble Systems, Newport News, VA) is one of the newest smart dressings to become available. It was used to determine if the addition of a smart dressing may actually help to reduce the number of grafts required to get a wound closed and/or improve the time to wound closure.

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## Smart Dressings

Among the new smart dressings, TheraGauze has become one of the most widely recognized. It has a unique polymer structure which enables it to either absorb or release moisture (Figure 1). This is a dramatic departure from hydrogels which absorb but do not release moisture, film dressings which only prevent moisture loss, and gauze which absorbs until saturated, then macerates. Moisture regulation with TheraGauze has been clinically proven to close wounds more rapidly and more often when compared to these other options (5).

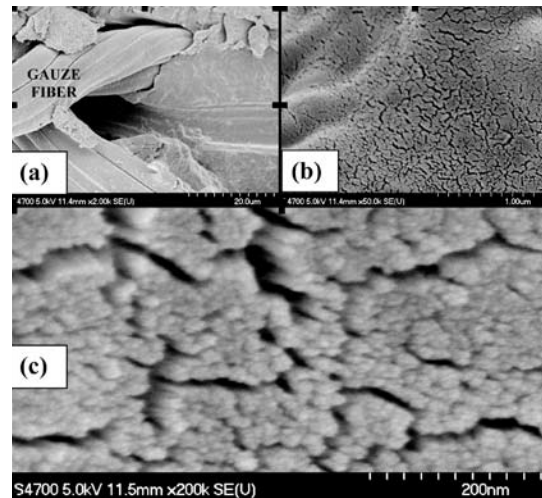


FIG. 1: Scanning electron micrographs of TheraGauze demonstrate (a) Polymer is held in place by gauze mesh. Even at 2,000X, it is clear that the polymer does not adhere to the gauze. (b) Increased magnification (50,000X) clearly shows the microscopic series of canals which run through the surface of the polymer, helping it to shift fluid towards or away from a specific area. (c) At 200,000X, the tubules can be clearly observed. These either draw up or release fluid to the graft surface, based on the local needs and capillary action. This unique structure allows the regulation of fluid to be coordinated vertically, rather than horizontally, so that one area can be hydrated immediately adjacent to an area that requires drying.

The theory behind smart dressing usage with a graft, collagen, or an LSE is that the conditions for attachment of the graft to the wound bed will occur more rapidly and predictably, so that fewer grafts will be needed, and the wound will heal at a faster rate. Through moisture regulation, the graft is less likely to dry out prematurely, or to float off the wound surface due to excessive moisture, leading to maceration. Whether collagen or a cellular product releasing growth factors is used, intimate contact and integration into the wound bed is essential for successful wound closure.

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## Study Methods

In a retrospective assessment of 11 patients with wounds treated with Apligraf, 1 treated with Derma-Graft, and 5 treated with TheraSkin human skin allograft (SWAI, Soluble Systems, Inc., Newport News, VA), we examined the rate of wound closure as well as the number of grafts needed to achieve closure. We identified qualified patients according to the following criteria:

**TABLE 1: Inclusion and Exclusion Criteria**

INCLUSION CRITERIA	EXCLUSION CRITERIA
• Plantar ulcer	• Active Infection
• Wagner Grade 1 or 2	• Exposed Bone
• Off-loading w/ healing shoe, fixed ankle walker, or NWB	• Osteomyelitis assoc. w/ ulcer
• Age 18—70	• Purulent discharge
• IDDM or NIDDM	• Cellulitis
• HgA1C < 10.0	• Dorsal ulcers
• Palpable DP and/or PT pulses	• Ischemic ulcers
• 1—8cm <sup>2</sup>	• Evidence of gangrene

Typically, our patients with ulcers were evaluated on a weekly basis. We followed them for up to 12 weeks, and then re-assessed data from weeks 16 and 20. Patients included in this study had wound tracings and photographs available from these visits. The number of grafts needed, time to closure, and percentage of wounds closed were recorded. Comparisons were made to results from the literature wherever possible. In between office visits, TheraGauze was used as the cover dressing regardless of whether or not Apligraf, TheraSkin, or DermaGraft was applied.

Our outcomes with Apligraf were compared to data from Veves, et al. (3) and Edmonds, et al., (4) which demonstrated 56% and 51.5% closure at 12 weeks, with an average of 3.9 grafts (Veves, et al.). In the Veves, et al. study, the cover dressing was Tegapore (non-adherent nylon mesh), backed by dry gauze, backed by petroleum dressing, and wrapped with a roll of gauze.

Therefore, our closure rate was comparable, but the number of weeks required to achieve closure, and the number of Apligraf grafts required to achieve closure were much smaller when Apligraf was used in conjunction with TheraGauze.

Of the 5 cases treated with TheraSkin human skin allograft, 3 wounds closed within 6 weeks and the remaining 2 wounds were still open after 12 weeks, representing a 60% closure rate. On average, 2.3 grafts were required to achieve closure, even though the average wound (5.8cm<sup>2</sup>) was much larger than the wounds in the Apligraf group. Average time to closure was 6.5 weeks. We were unable to locate comparable data to determine if this number of grafts was comparable to other investigators' experiences. A reference which describes the use of human skin allografts is included here for completeness (1).

Application of TheraSkin is similar to the application of any split-thickness skin graft. In our case, we held it in place using a baseball stitch around the perimeter. The material was then covered directly with TheraGauze. We consistently observed integration of the graft in the wound bed during the first week. If not closed, we re-applied every 2 to 3 weeks, with up to 5 applications during the 12 week period. In cases where the wounds were more heavily exudative, we sometimes fenestrated TheraGauze and backed it with an absorbent gauze pad to catch overflow drainage. On one patient, we also used a negative pressure wound vacuum between applications. The TheraSkin was applied to the wound bed, covered with fenestrated TheraGauze, and then covered with sponge under vacuum. (Figure 3 back page)

The single case treated with DermaGraft required 4 grafts to achieve closure over a 6 week period. Although this appears to be an improvement over the literature, no conclusions can be drawn from a single isolated case like this.

## Results

The majority of our patients reviewed were treated with Apligraf. In each case, the cover dressing was TheraGauze. We found that wound closure was achieved in 54% of the cases during the first 12 weeks when a non-adherent moisture-regulating dressing (TheraGauze) was used as the cover dressing. Among the 54% of wounds that closed, the average time to closure was 3.5 weeks, and the average number of grafts required was 1.3 grafts. The average wound measured 1.8cm<sup>2</sup>. Figure 2 shows some sample wounds.

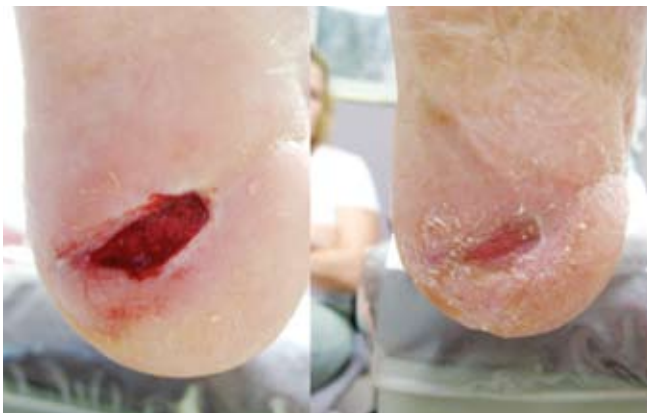


FIG. 2: Wounds treated with Apligraf and TheraGauze as the cover dressing showed rapid closure with fewer numbers of grafts needed. (a)The case shown here achieved closure after one week with only a single application of Apligraf and TheraGauze. (b) This case required 3 Apligraf grafts and TheraGauze to achieve closure.

When Apligraf and TheraGauze were used together, we consistently observed that the wound was not macerated. The edges of the wound remained flush, and the graft appeared to be rapidly incorporated. In some cases, the wound closed after a single application of the combination.



FIG. 3: (a) TheraSkin is applied to a very large wound. The wound is covered with TheraGauze and, in this particular case, negative pressure therapy was also used. After the first dressing change, the incorporation of TheraSkin is apparent. The wound goes on to close. (b) TheraSkin is stitched in place over a smaller ulcer and covered with TheraGauze. At the first dressing change, the absorption pattern is apparent in TheraGauze.

retains the complex assortment of growth factors and collagen found in natural skin grafts, but is more readily available and a single application costs less than half of Apligraf or DermaGraft. Based on our small sample, it appears to rapidly close even large wounds. In this study, the wounds treated with TheraSkin closed 60% of the time, with an average closure time of 6.5 weeks.

The purpose of this study was not to compare outcomes from Apligraf and TheraSkin, but rather to determine if the addition of TheraGauze and the regulation of moisture results in improved outcomes. Since our study is retrospective, we were not able to randomly direct wounds to one group or another. As a result, the wounds found in the TheraSkin group turned out to be much larger, measuring 5.8cm<sup>2</sup> on average, while the Apligraf wounds measured 1.8cm<sup>2</sup>, about a third of the size. Similarly, Apligraf-treated patients achieved closure in 3.5 weeks, on average, while TheraSkin-treated patients required 6.5 weeks, requiring 1.3 and 2.3 grafts, respectively. When normalizing the data, we find that wounds treated with TheraSkin closed at the rate of 0.89cm<sup>2</sup>/week, and wounds treated with Apligraf closed at a rate of 0.51cm<sup>2</sup>/week. Additionally, when you consider the number of grafts necessary to achieve closure, the wounds treated with Apligraf required application of 0.72 grafts/cm<sup>2</sup> of wound, while wounds treated with TheraSkin required only 0.40 grafts/cm<sup>2</sup> of wound, in order to achieve closure.

Clearly the sample size here, as well as the lack of subject and wound matching makes side-by-side comparisons difficult. However, what does clearly emerge is that, regardless of the graft material used (allograft or laboratory grown), TheraGauze moisture regulation enhances incorporation of the graft and reduces the time for healing.

## Conclusions

Although this study is significantly smaller than the studies by Veves and Edmonds, the preliminary data suggests that wounds treated with Apligraf and TheraGauze will close more quickly, and with fewer applications of Apligraf required, when compared to the same treatment backed with a non-adherent nylon mesh, gauze and petroleum dressings as described by Veves, et al. The authors feel that the improved take rate demonstrated (1.3 Apligraf vs. 3.9 Apligraf), and faster healing (3.5 weeks vs. 12 weeks) can be attributed to optimal moisture regulation achieved with TheraGauze.

TheraSkin human skin allografts represent the next frontier in wound care. This product is a cryopreserved, split-thickness human skin graft. It

## References

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