Use of a Novel Epidermal Harvesting System in Resource-Poor Countries

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ABSTRACT

The 2010 earthquake in Port-au-Prince, Haiti, highlighted the need for wound care in resource-poor countries. Subsequently, the University of Miami in Florida established one of the first interprofessional wound care centers located at Bernard Mevs Hospital in the central portion of Port-au-Prince, caring for patients with acute and chronic wounds. In 2012, the authors used a novel epidermal harvesting system (CelluTome Epidermal Harvesting System; Kinetic Concepts Inc, San Antonio, Texas) to harvest epithelium to be grafted on 7 patients at the Mevs Hospital with longstanding wounds. Epidermal microblisters were obtained from each patient's thigh using the CelluTome Epidermal Harvesting System. After 35 minutes, microblisters were raised using the device harvester, and an adhesive dressing was inserted into the harvester for transfer to the wound site. In patients with lower-extremity wounds, a 2-layer compression dressing was placed over epidermal grafts. Six of the 7 wounds improved or achieved complete closure in 4 weeks. One of the patients with a 2-year-old thigh wound failed to demonstrate improvement; this may have been secondary to an inability to adequately secure the graft. All donor sites healed without any visible scarring. The authors were able to conclude that epidermal grafting may represent a viable reconstructive option for patients in resource-poor countries.

KEYWORDS: epidermal graft, wound healing, donor site

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INTRODUCTION

Surgeons have long used the reconstructive ladder, which describes a series of procedures arranged in ascending order from simple to complex,[1] in choosing procedures to close acute wounds. The advent of newer technologies, as described in this study, may allow expansion of the ladder to include chronic wounds.

Autologous skin grafting (full- and split-thickness) occupies the lower rungs of the ladder; as such, these procedures are utilized frequently in acute wounds. However, these procedures have several disadvantages that have limited their use in chronic wounds: (1) oftentimes, patients must be taken to the operating room setting under anesthesia by a surgically trained physician, and (2) the donor sites are painful and, on occasion, difficult to heal.[2]

Epidermal grafting has several advantages over traditional skin grafting. First, epidermal harvesting removes only the epidermis, leaving the dermis intact. Pain fibers in the dermis, therefore, are not affected by the procedure. As a result, the procedure causes little or no discomfort to the patient, and the procedure can be readily performed in the outpatient setting without anesthesia.[2,3] In the past, epidermal micrografts were created using a freehand blade or syringes that applied negative pressure to produce an epidermal blister.[4–6] However, these procedures require more skill; can remove the dermis, resulting in patient discomfort; and can be time consuming. The CelluTome Epidermal Harvesting System (Kinetic Concepts Inc, San Antonio, Texas) harvests up to 128 epidermal blister grafts from a donor site (usually on the inner thigh) typically within 30 to 45 minutes. The grafts are collected on a dressing and can easily be transferred to another area of the body. Finally, physicians do not need to be surgically trained to use this system. To date, epidermal grafting has been used primarily for pigmentation disorders, such as vitiligo.[3–4,7–9]

After the 2010 earthquake in Port-au-Prince, Haiti, the University of Miami in Florida established a wound clinic at the Bernard Mevs Hospital. The busy clinic provides superb wound care; however, cost constraints limit the use of advanced wound care products. Noninvasive, low-cost procedures that can achieve closure of difficult-to-heal wounds are ideally suited to resource-poor locations. In this study, the authors report their initial clinical experience using the CelluTome Epidermal Harvesting System for harvesting epidermal grafts in Haiti for use in patients with lower-extremity chronic wounds. These are some of the first cases that utilize this device for harvesting epidermal grafts.

METHODS

The procedures were conducted at the Bernard Mevs hospital wound care center in Port-au-Prince, Haiti, under the direction

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of A.F. and J.M. A.F. preselected patients with wounds with a clean granulating base appropriate for grafting. The procedure for using the CelluTome Epidermal Harvesting System was explained to the patient, and consent was given for the procedure. The donor site (inner thigh) was prepared by shaving the hair and preparing the skin with alcohol. The harvester plate was then affixed to the patient's inner thigh and held in place using a Velcro strap (Figure 1A). The harvester head was then affixed to the plate (Figure 1B). The control unit created and regulated the vacuum at -400 to -500 mm Hg and warmed the skin to 40° C, which was delivered to the harvester via the vacuum head and tubing. The development of epidermal blisters was observed through the window in the harvester head (Figure 1C). Epidermal blisters developed within 30 to 45 minutes and were raised using the device harvester. An adhesive dressing was inserted into the harvester, which served to secure the microblisters and permit transfer to the wound site. By actuating the harvester handle, the microblisters were cut from the thigh and captured onto the dressing. The dressing was then transferred to the patient's wound. In patients with lower-extremity wounds, a 2-layer compression dressing (Coban-2; 3M Company, Minneapolis, Minnesota) was placed over the epidermal graft. The patients returned to the clinic weekly for dressing changes. The adhesive dressing was removed at 1 week, which is typically when clinicians would expect to see graft adherence, if visible.

RESULTS

A total of 7 patients with lower-extremity wounds were treated with epidermal grafts (Table). The Table also lists wound dimensions during initial presentation to physician and after epidermal grafting. The average blister formation time was 32.8 minutes (range, 25–35 minutes). Six of the 7 patients had a positive result with decreasing wound size at 4 weeks. Two phenomena were observed during the healing process: (1) graft take was observed in 3 of the patients, and (2) the remaining 3 patients had marked improvement in their wounds, but complete graft take was not observed. However, with this method of skin grafting, the harvested grafts may be too small for graft take to be visualized. One of the patients with a 2-year-old thigh wound failed to demonstrate improvement, which may have been secondary to an inability to adequately secure the graft. The following cases are representative of a complete graft take (case study 1), moderate graft take (case study 2), and poor graft take with improved wound healing (case study 3).

Case Study 1

The patient in this case was a 20-year-old woman (patient 2 in the Table) with lymphatic filariasis involving the right leg. She had developed a wound on the dorsum of her right foot. The initial wound was 8.5 × 4.5 × <0.5 cm (Figure 2A). Compression wrapping controlled her lymphedema, but despite the fact that the wound was clean and granulating, it was not progressing toward closure. In this type of population, past experience shows that wounds associated with this disease can take months to years to heal. Epidermal grafts were transferred to the wound site (Figure 2B). The dressing was held in place using a 2-layer compression wrap (Coban-2). At 1 week, the authors observed nearly 100% take of the micrografts (Figure 2C). The grafts continued to expand covering the wound area, as demonstrated in Figures 2D and 2E. In addition, the patient demonstrated repigmentation of the skin at follow-up on day 30. Immediately after leaving the clinic at her 1-month follow-up visit, her right foot was run over by a motorbike. In the congested streets of Port-au-Prince, this is not an uncommon occurrence. She returned to the clinic, and removal of the compression wrap revealed an intact graft (Figure 2F). Figure 2G shows the donor site (ie, thigh area) 30 days after harvesting with no visible signs of scarring.

Figure 1A–C.

A. HARVESTER PLATE AFFIXED TO THE PATIENT'S INNER THIGH. B. HARVESTER HEAD AFFIXED TO THE PLATE. C. DEVELOPMENT OF EPIDERMAL BLISTERS OBSERVED THROUGH THE WINDOW IN THE HARVESTER HEAD

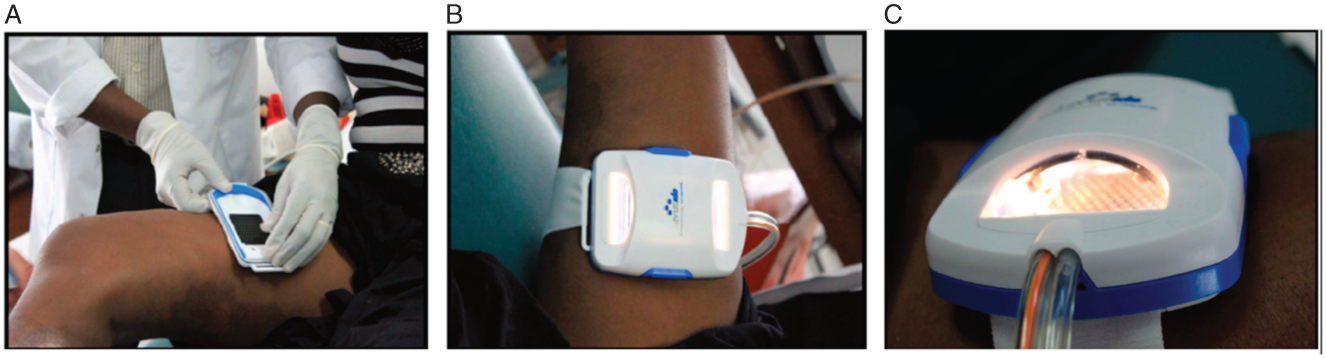


Table.

PATIENT DEMOGRAPHICS

Patient	Age, y	Sex	Wound Type and Location	Comorbidities	Wound Duration, mo	Initial Wound Size, cm	Wound Size After Graft Placement, cm
1	35	Female	Venous ulcer on right anterior mid tibia	None	3	9 × 2.5 × 0	7 × 3 × 0
2[a]	20	Female	Lymphatic filariasis on dorsum right foot	None	0.7	8.5 × 4.5 × <0.5	9 × 7 × 0
3[b]	76	Female	Venous ulcer on left distal medial tibia	Rheumatoid arthritis	96	8.5 × 5 × 0	5 × 2.5 × 0
4	65	Female	Venous ulcer on left distal anterior tibia	None	36	3.5 × 2.5 × 0	5.0 × 3.5 × 0
5[c]	60	Male	Venous ulcer on left Achilles tendon	Diabetes mellitus, repeat graft, sickle cell anemia	18	5 × 2.5 × 0	4 × 1.5 × 0
6	44	Female	Venous ulcer on left distal anterior and lateral lower leg	None	19	8.5 × 3.5 × 0	6 × 3.5 × 0
7	19	Male	Postinfectious wound on left anterior proximal thigh	None	12	16.5 × 3.5 × 0	16 × 3 × 0

[a]Case study 1.
[b]Case study 2.
[c]Case study 3.

Case Study 2

A 76-year-old woman (patient 3 in the Table) with an 8-year-old left lower-extremity medial gaiter venous leg ulcer presented to the wound clinic with an initial wound of 8.5 × 5 cm (Figure 3A). Previous treatment consisted of moist wound dressings (Hydrofera Blue; Hydrofera, LLC, Willimantic, Connecticut) and gauze bandage rolls (Kerlix Gauze Bandage Rolls; Covidien, Mansfield, Massachusetts). Patient comorbidities included rheumatoid arthritis. Epidermal grafts were transferred to the wound site (Figure 3B). The dressing was held in place using a 2-layer compression wrap (Coban-2). Moderate take of the micrografts was noted at 1 week (Figure 3C). The grafts continued to expand covering the wound area, as demonstrated in Figure 3D. At the 4-week follow-up (Figure 3E), the wound size had decreased to 5.0 × 2.5 cm. There was evidence of graft take covering 85% of the grafted area.

Case Study 3

A 60-year-old diabetic man (patient 5 in the Table) with sickle cell anemia had a nonhealing, complex mixed ulcer (diabetic, venous, and arterial) of 18 months' duration over the left Achilles tendon. The wound measured 5 × 2.5 cm before grafting. Up to this point, the wound had been treated with a topical silver gel (Silvasorb Gel; Medline Industries, Mundelein, Illinois) and Unna boot compression. Epidermal grafts were transferred to the wound site (Figure 4A). The dressing was held in place using a 2-layer compression wrap (Coban-2). At the first follow-up visit 1 week after grafting, the wound was smaller, and the granulation tissue appeared healthier. Micrograft take was not seen to the same extent as in the previous 2 cases (Figure 4B). The wound continued to show improvement over the next month, as demonstrated in Figures 4C and 4D. At the 1-month follow-up visit (Figure 4E), the wound size had decreased to 4.0 × 1.5 cm. Although micrograft take was not observed as in the previous 2 cases, the epidermal grafts promoted closure of this long-stalled nonhealing wound.

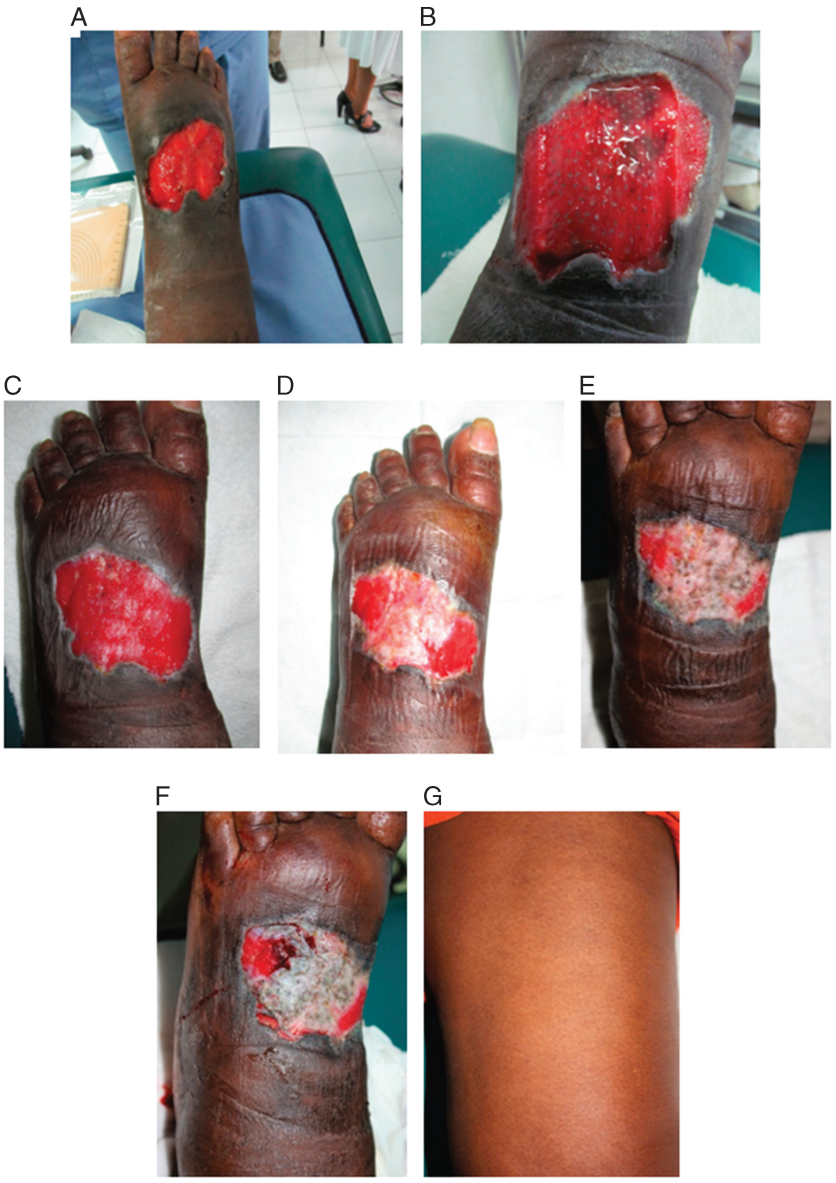
DISCUSSION

Recently, the World Health Organization identified acute and chronic wounds as a significant health problem, suggesting training of care providers and increased resources was necessary.[10] The treatment of chronic wounds in Haiti underscores the challenges faced in providing care in a developing country. Through the efforts of US physicians, Haitian physicians and nurses have received basic training and education in wound care. However, like so many resource-poor countries, they do not have access to advanced wound care modalities. For example, although cost-effective in the United States and European Union, V.A.C. Therapy (Kinetic Concepts Inc), a mainstay in the treatment of complex wounds at the Project Medishare tent hospital established at the Port-au-Prince airport after the 2010 earthquake, is sometimes too costly for hospitals in less developed countries.[11] The use of the CelluTome Epidermal Harvesting System for harvesting epidermal grafts may provide a more economical and effective alternative to other commercial wound healing products.

The authors, who are familiar with wound care in Port-au-Prince, immediately recognized the potential for epidermal grafting in this setting. A.F. identified patients with granulating wounds appropriate for grafting; these wounds varied in chronicity from several weeks to several years. Despite multiple comorbidities (rheumatoid arthritis, diabetes mellitus, and sickle cell anemia), epidermal grafts harvested using the CelluTome Epidermal Harvesting System resulted in a decrease in wound size in 6 of the 7 patients at 4 weeks. This is in agreement with Sheehan et al,[12] who showed that a change in wound size (>53% reduction) of diabetic foot ulcers at 4 weeks was a strong predictor of complete healing. One patient (patient 2 in the Table) with a traumatic wound complicated

Figure 2A–G.

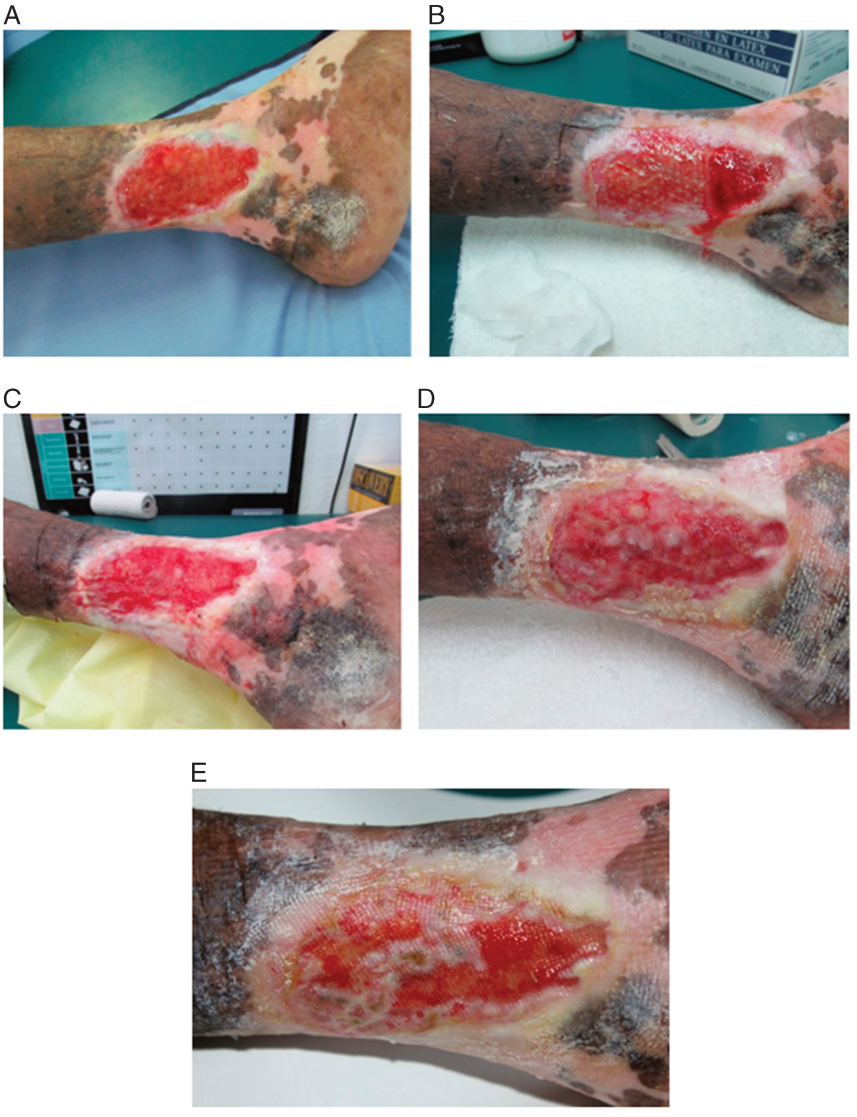
A. INITIAL PRESENTATION OF WOUND. B. PLACEMENT OF MICROGRAFT. C. 1 WEEK POSTMICROGRAFT. D. 14 DAYS POSTMICROGRAFT. E. 21 DAYS POSTMICROGRAFT. F. INTACT MICROGRAFT AFTER ACCIDENT. G. DONOR SITE 30 DAYS POSTMICROGRAFT



by lymphatic filariasis achieved complete closure in only 4 weeks. However, a motorbike ran over the grafted site only minutes after she left the clinic. The trauma disrupted less than 5% of the graft. This single case suggests that epidermal grafting may provide a durable closure. Although graft take was observed in 3 cases, the other cases still showed improved healing and decreases in wound size using epidermal grafts, which may have been helped by the use of good wound care and proper compression.

Figure 3A–E.

A. INITIAL PRESENTATION OF WOUND. B. PLACEMENT OF MICROGRAFT. C. 1 WEEK POSTMICROGRAFT. D. 2 WEEKS' POSTMICROGRAFT. E. 4-WEEK FOLLOW-UP

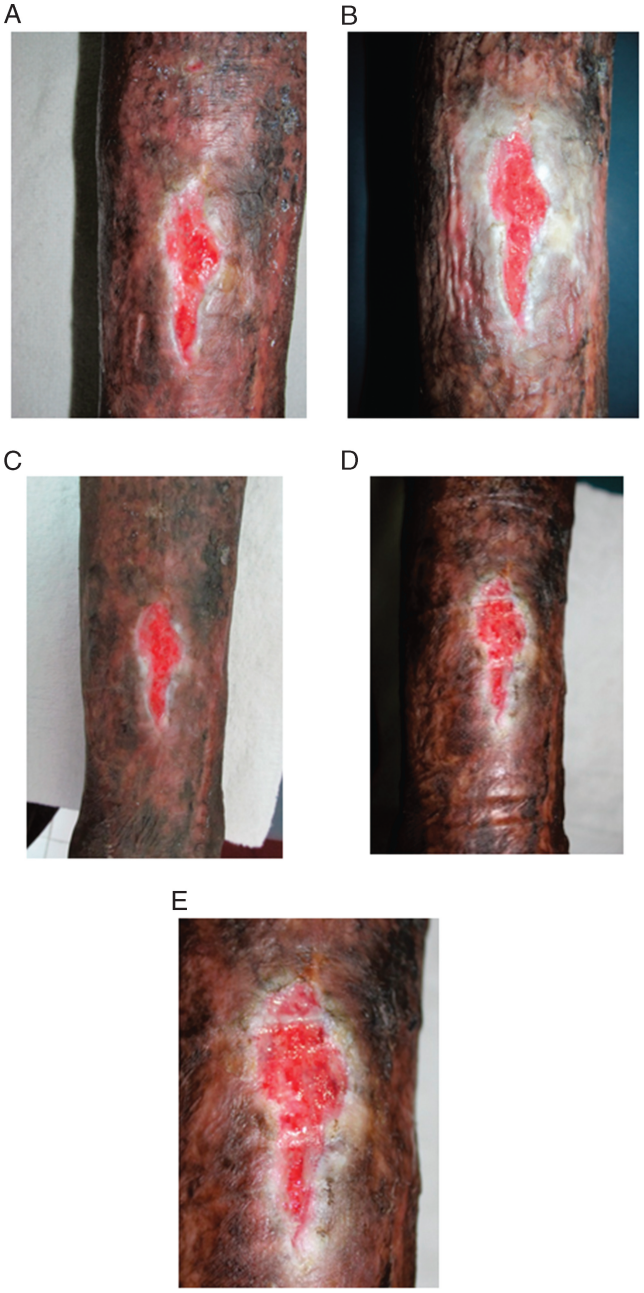


Chronic wounds treated with advanced modalities typically epithelialize from the margins. This was observed with epidermal grafting in this case series. However, when the epidermal micrografts exhibited graft take, the wound also healed from within the wound bed, resulting in a more rapid closure. This observation warrants further study, and laboratory studies are currently underway.

The CelluTome Epidermal Harvesting System proved to be a safe, easy, and effective method for epidermal grafting in this case series and offers an alternative to full- and split-thickness skin grafting.[13] This epidermal harvesting system also has several advantages over traditional split-thickness skin harvesting, which makes it ideal for this setting: Epidermal harvesting does not require specialized surgical training, it can be performed at bedside without anesthesia, and donor sites heal in 3 to 4 days. It also has advantages over previous techniques for creating epidermal micrografts (eg, freehand blade or syringe), which can be cumbersome and

Figure 4A–E.

A. PLACEMENT OF MIGROGRAFT. B. 1 WEEK POSTMICROGRAFT. C. 11 DAYS POSTMICROGRAFT. D. 1 MONTH POSTMICROGRAFT. E. 1-MONTH FOLLOW-UP VISIT



difficult to perform, may remove dermis resulting in patient discomfort, and are time consuming. This novel system simplifies the process, allowing for uniform blister formation and distribution with up to 128 epidermal blisters from a single donor site on the inner thigh. It creates blisters in a more timely manner (35–45 minutes) compared with the 1- to 4-hour blister development time using other techniques.[4–6] In addition, grafts are collected on a dressing that can easily be transferred to the recipient site. There is also minimal patient discomfort. The authors did not observe scarring at the donor site in a dark-skinned population prone to hypertrophic scarring and keloid formation. This is another advantage in resource-poor countries, where the creation of a second wound donor site could lead to infection and increased morbidity.

The epidermal graft process can be performed in an office setting as an outpatient procedure, which is beneficial for countries that have limited access to hospital resources. Many countries do not have surgeons or physicians skilled in skin grafting. This simple harvesting system permits nonsurgically trained clinicians to perform epidermal harvesting and grafting in a simple reproducible fashion. Thus, epidermal grafting may represent a viable reconstructive option for patients in resource-poor countries. The authors' initial clinical findings warrant additional studies with larger patient populations to confirm the effectiveness of epidermal grafting as well as comparative studies to determine cost-effectiveness. ●

REFERENCES

1. Janis JE, Kwon RK, Attinger CE. The new reconstructive ladder: modifications to the traditional model. Plast Reconstr Surg 2011;127:205S-12S.
2. Rusfianti M, Wirohadidjodjo YW. Dermatosurgical techniques for repigmentation of vitiligo. Int J Dermatol 2006;45:411-17.
3. Njoo MD, Westerhof W, Bos JD, et al. A systematic review of autologous transplantation methods in vitiligo. Arch Dermatol 1998;134:1543-9.
4. Budania A, Parsad D, Kanwar AJ, et al. Comparison between autologous noncultured epidermal cell suspension and suction blister epidermal grafting in stable vitiligo: a randomized study. Br J Dermatol 2012;167:1295-301.
5. Burm JS, Rhee SC, Kim YW. Superficial dermabrasion and suction blister epidermal grafting for postburn dyspigmentation in Asian skin. Dermatol Surg 2007;33:326-32.
6. Yamaguchi Y, Yoshida S, Sumikawa Y, et al. Rapid healing of intractable diabetic foot ulcers with exposed bones following a novel therapy of exposing bone marrow cells and then grafting epidermal sheets. Br J Dermatol 2004;151:1019-28.
7. Tang WY, Chan LY, Lo KK. Treatment of vitiligo with autologous epidermal transplantation using the roofs of suction blisters. Hong Kong Med J 1998;4:219-24.
8. Koga M. Epidermal grafting using the tops of suction blisters in the treatment of vitiligo. Arch Dermatol 1988;124:1656-8.
9. Gupta S, Jain VK, Saraswat PK, et al. Suction blister epidermal grafting versus punch skin grafting in recalcitrant and stable vitiligo. Dermatol Surg 1999;25:955-8.
10. World Health Organization. Noncommunicable Diseases Country Profiles 2014. Geneva, Switzerland: World Health Organization; 2014.
11. Perez D, Bramkamp M, Exe C, et al. Modern wound care for the poor: a randomized clinical trial comparing the vacuum system with conventional saline-soaked gauze dressings. Am J Surg 2010;199:14-20.
12. Sheehan P, Jones P, Caselli A, et al. Percent change in wound area of diabetic foot ulcers over a 4-week period is a robust predictor of complete healing in a 12-week prospective trial. Diabetes Care 2003;26:1879-82.
13. Biswas A, Bharara M, Hurst C, et al. The micrograft concept for wound healing: strategies and applications. J Diabetes Sci Technol 2010;4:808-19.