Closure of Difficult Wounds by External Tissue Expansion

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Abstract: The open nonhealing wound is a persistent challenge to physicians. Infections, foreign bodies, osteomyelitis, and skin coverage of repaired structures remain problems. As the body ages, the elderly are prone to the development of pressure sores and foot ulcers, particularly patients with diabetes. Many elderly patients will have comorbid conditions making closure of these wounds difficult. The authors have more than 100 combined years of experience treating wounds. Throughout their long careers the authors have treated numerous wounds with various types of methods. Antibiotics were introduced during World War II; specially developed colloidal dressings, growth factors, and negative pressure wound therapy were introduced to expedite epithelial coverage of wounds. The plastic surgery field was developed through the introduction of flaps to close wounds. In the last 12 years, we have closed most wounds with an external tissue expansion device usually in 1 to 2 weeks. A quickly closed wound improves the quality of life for the patient and reduces the cost to the healthcare system.

The open nonhealing wound continues to challenge the physician. Infections, full-thickness skin coverage, involvement of bone, the presence of foreign bodies, and ischemia are common underlying factors. Elderly patients often have comorbid conditions that facilitate pressure, leg, and foot ulcer development, creating wounds that are difficult to close. The literature abounds with methods for closure of nonhealing wounds that continue to challenge the physician.

In general, morbidity has increased. The main culprit is the alarming escalation of patients with diabetes mellitus where an incidence of 85% of amputations is due to infected foot ulcers. Likewise, an increasing incidence of pressure sores is presently associated with more than 60,000 annual deaths, not to mention the care and expense connected with the management of these patients.

An open nonhealing wound presents the physician with a basic decision: wound management or wound closure. Traditionally, the wound has been managed to promote epithelialization by creating a moist wound environment. More recently, negative pressure wound therapy has been used to
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wound. In these instances the edges of the wound are
adheres to underlying structures in an effort to close the
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over most of the body. Two main devices were available,
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tinue activities after a short while, but the Proxiderm
is presently available. Both authors during the past 12
years have closed more than 650 chronic or dehisced
wounds following a simple philosophy: control infec-
tion and close the wound. Unfortunately, these methods
require a lot of time, cover the wound with scar tissue,
and the results remain to be improved. It is worth exam-
ining the current situation more critically to ascertain
which method or combination of methods can or cannot
improve treatment results.

In the 1990s, skin expansion was achieved using
external skin expanders. This technique has been shown
to be simple to use and to successfully close wounds
over most of the body. Two main devices were available,
the Sure-closure and the Proxiderm. The former discon-
tinued activities after a short while, but the Proxiderm
(Progressive Surgical Products, Westbury, NY; [Figure 1])
is presently available. Both authors during the past 12
years have closed more than 650 chronic or dehisced
wounds following a simple philosophy: control infec-
tion, and close the wound with a minimally invasive sur-
gical technique that includes the use of an external tissue
expansion wound closure device. This approach has pro-
duced the best results and will serve as the basis of this
overview.

At the outset, it should be noted that patients with vas-
cular issues are not included in this overview. These cases
require referral to a vascular service for evaluation and
treatment.

Methods

Four case reports are used to illustrate the wound clo-
sure technique. The wounds were rendered as clean as
possible, and inflammation and infection were con-
trolled. In many chronic wounds the skin inverts and is
adheres to underlying structures in an effort to close the
wound. In these instances the edges of the wound are
either sharply or gently undermined, the latter usually by

Case Reports

Case 1. A 64-year-old hospitalized patient developed a
sacral pressure ulcer measuring 8.6 cm x 9.6 cm, which
was treated conservatively for 3 months (Figures 2A–H).
The patient was transferred to a nursing home and treat-
ed for 3 months without any improvement. After debride-
ment of the necrotic tissue and wound cleansing, a series
of paired 2-0 nylon sutures are placed 2 cm–3 cm from
the wound margins and 2 cm apart, the ends are left 7 cm
long. One suture of each pair is tied and passed through
rubber booties; the adjacent suture is left untied secured
by Steristrips and tied at the first dressing change. The
tied sutures decrease the size of the wound and assist in
obliteration of dead space. Proxiderms are applied
approximately 2 cm–3 cm apart and the long ends of the
previously tied sutures are looped around the expanders
and tied to secure the expanders to the patent. Combin-
es are placed under the ends, between, on the side, and over
the expanders. Elastoplast and/or adhesive tape is placed
over the combines and secured to the patient about 5 cm
from the wound margins. The patient was placed on an
air flotation bed. Sacral pressure ulcers necessitate daily
evaluation to prevent fecal soiling of the wound and any
pressure necrosis of skin by the wound care devices. On
postoperative day 1, the wound was cleansed, untied
sutures were tied, and the wound was irrigated. An addi-
tional application of expanders was indicated. This
process of suture and expander application should be
repeated until there is an abundant amount of tension-
free tissue to allow for primary closure by suture. After 6
daily applications of expanders followed by 2 days of

Figure 1. Proxiderm wound closure device.
intensive local wound care therapy and irrigation, the skin edges are freshened, and the wound was well vascularised and tension-free. Sutures were used for final closure. A catheter is placed subcutaneously and the wound is irrigated. An additional 1-day application of expanders allows the wound to heal in a tension-free environment.

**Case 2.** A 21-year-old man sustained a gunshot wound to the left groin, which severed the femoral artery (Figures 3A–C). After the femoral artery was repaired, a diagnosis of compartment syndrome was made and a fasciotomy was performed to decompress the anterior compartment. Three days later the necrotic and devascularized muscles of the anterior compartment were excised. Appearance post fasciotomy revealed exposed tendon with significant tissue and muscle loss. Initially, the physician used Proxiderm (model PS 460), which were spaced
2 cm apart. As the wound became smaller, Proxiderm (model D 460) were utilized. Combines were placed beneath the ends, between, and over the expanders to assist in stabilization and to minimize external pressure. The expanders and padding were wrapped with dry gauze and/or Unna boot or Elastoplast and secured to the patient using adhesive tape. The wound was evaluated every 2 to 3 days. Expanders were replaced as required. Tissue expansion lasted 15 days. The wound went on to heal satisfactorily. The stretch marks disappeared in about 3 months.

Case 3. A 51-year-old patient with diabetes presented with a plantar ulcer of 2 years’ duration (Figures 4A–E). After debridement, the wound measured 4.4 cm x 5.6 cm. Proxiderm expanders (models D460 and PS460) were applied. Non-weight bearing with the expanders in place is essential—this is best achieved through complete bed rest, and less optimally, crutches or wheelchair. After 5 days of expansion followed by 2 days of irrigation and 1-day of expansion, the exposed bone was resected and the wound closed by suture. One-week post closure a 2-mm dehiscence was closed by suture. A closed plantar wound will take approximately 2–4 weeks to bear the ambulating weight of a 180 lb–200 lb patient. During this time the patient should offload with crutches or wheelchair.

Case 4. A 51-year-old insulin dependent patient was admitted with toe necrosis (Figures 5A–F). Guillotine trans-metatarsal procedure resulted in a defect measuring 9.6 cm x 5.6 cm with exposed bone. Below the knee amputation was recommended. The wound was undermined deeply 1 cm–2 cm above the exposed bone, and a deep subcutaneous thick flap was created before the expanders were applied. A line of sutures were placed and expanders were applied. The wound was closed with sutures after 5 days of expansion and 3 days of irrigation. A full-thickness skin graft was placed on a non-weight bearing area measuring 1.5 cm x 5.2 cm.

Results

Six hundred-fifty (650) dehisced, chronic, and traumatic wounds were closed using external tissue expansion (Table 1). In some lower extremity wounds, a combination of tissue expansion and skin grafts on non-weight bearing areas were used to close the wounds. The average wound closure time was 1–2 weeks. The principles of wound healing are still followed after wound closure to achieve a well-healed, stable wound. To the best of the authors’ knowledge there were 25 failures, the majority of which were lower limb failures due to lack of

Figure 3. A) A 21-year-old sustained a gunshot wound of the groin, which severed the femoral artery. After the femoral artery was repaired, a fasciotomy was performed. Three days later the necrotic and devascularized muscles of were excised. Appearance post fasciotomy reveals exposed tendon with significant tissue and muscle loss. B) Application of expanders. C) Appearance at 16 days.
Figure 4. A) A 51-year-old patient with diabetes and a plantar ulcer of 2 years’ duration. B) After debridement, the wound measured 5.6 cm x 4.4 cm. C) Application of expanders. D) Appearance 30 days post closure. E) Appearance at 5 months.

Figure 5. A) A 51-year-old insulin dependent patient required a guillotine trans-metatarsal procedure leaving a defect measuring 9.6 cm x 5.6 cm with exposed bone. B) A line of sutures is placed and expanders applied. Appearance at second postoperative day 2. C) Application of expanders. D) Wound was closed by suture. Skin graft was placed on a non-weight bearing area measuring 1.5 cm x 5.2 cm. E) Appearance at 5 weeks post closure. F) Patient weight bearing at 4 weeks.
In the 1990s, skin expansion was achieved through external skin expanders. This technique has been shown to be simple to use and successful for closing wounds over most of the body.

The application of the expanders and minimally invasive techniques allow for dedicated wound care as the wound closes, which stimulates angiogenesis and the production of growth factors (Table 2). The expansion of nearby skin creates additional soft tissue, which fills the wound cavity with subcutaneous padding. Most wounds can be closed via suture in 1 to 2 weeks by a method that is minimally invasive and which can often be carried out under local anesthesia and/or sedation, as required. External tissue expanders are cost effective and medically efficacious. Good wound care practices and a small, dedicated team are necessary ingredients to achieve optimal results.

### Table 1. Patient and wound characteristics.

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<th>No. cases</th>
<th>Average age (years)</th>
<th>Average wound closure (days)</th>
<th>Average size (cm)</th>
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<tr>
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<td>7.5 x 17.3</td>
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</tr>
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<td>5.4 x 8.1</td>
<td>Back</td>
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<td>7</td>
<td>6 x 11.7</td>
<td>Below the knee amputations</td>
</tr>
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<td>5.1 x 10.4</td>
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<td>1.6 x 2.2</td>
<td>Metatarsal</td>
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### Table 2. Advantages of tissue expansion.

- Minimally invasive technique
- Multi-stage closure of contaminated wounds
- Better quality skin (epidermis, dermis, and subcutaneous tissue)
- Close wound quickly (7–14 days)
- Stimulates angiogenesis and growth of additional soft tissue
- Stimulates production of growth factors
- Local anesthesia

Discussion

The authors look back at a more than 100 years of experience in the management of traumatic wounds, lesions of the lower extremities, and pressure ulcers, and are distressed to see the poor results that many patients can expect. As successful treatment modalities are available, the causes for these disappointing results require explanation.

Skin expansion techniques were introduced in the 1950s. An inflatable subcutaneous balloon was used to expand the overlying skin, after which the stretched skin was used to close the wound. However, this procedure was accompanied by such significant complications that it has virtually been abandoned for treatment of chronic wounds. In the 1990s, skin expansion was achieved through external skin expanders. This technique has been shown to be simple to use and successful for closing wounds over most of the body.

Patient compliance to non-weight bearing instruction. Failure of pressure ulcers were in patients on ventilators, tube feeding, dialysis, or who had an albumin level < 2.5.

### References

3. Manders EK, Oaks TE, Au VK, et al. Soft tissue expansion...


