CONTINUOUS TISSUE EXPANSION

An effective method for enhanced lower extremity wound healing

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Tissue expansion is an important technique for reconstruction of soft tissue defects. It is commonly used in the care of burns, breast reconstruction and pediatric plastic surgery. The phenomenon of tissue expansion is well known and observed in pregnancy. Skin expands in response to tension generated by the increased abdominal volume during pregnancy. This response has been found to be a metabolically active process resulting in increased mitotic activity and vascularity of the expanded skin.[1]

Tissue expansion for medical purposes was first reported in 1905 by Codvilla who attempted to lengthen tissue in the hip area.[2] Neuman, in 1957, used controlled tissue expansion with a rubber balloon to aid in reconstruction of an ear defect.[3] Interest in tissue expansion then waned until the late 1970's. Techniques were developed for breast reconstruction over the course of the next decade. Pioneering this technique was Radovan in 1982.[4] Since that time, tissue expansion has become an accepted standard technique in providing soft tissue coverage of increasingly complex wounds.

Tissue expansion in the field of lower extremity wound care has also undergone an evolution over the past several decades. Mechanical skin stretching was attempted with devices such as the Sure Closure Skin Stretching System.[5] However, the rigors of adjusting the device proved to be an obstacle to its continued use. Recently a device has been developed that provides continuous tissue expansion for enhancing lower extremity wound healing. The inconvenience of adjusting the device has been eliminated and the preliminary results are encouraging. The device is marketed under the trade name DermaClose® RC. (Wound Care Technologies – Chanhassen MN)

Physiology:

Skin has three important physical properties that make tissue expansion possible. Skin tension is a function of the elastic fiber network. This is the phenomenon surgeons see when making a skin incision and seeing the contraction of the wound edges away from the incsion. Skin extensibility is the response of skin to mechanical forces. An example of this is the stretching of skin over the elbow as the arm flexedand extended. The final property is viscoelasticity. This is creep and stress relaxation. As tissue is stretched, less force is required to maintain that stretch over time.

Traditional tissue expansion happens in one of two ways. Prolonged tissue expansion (PTE) occurs over 1-6 weeks. Rapid intraoperative

Figure 1: Excisional debridement of the wound with undermining of the wound margins

Figure 2: Application of skin anchors

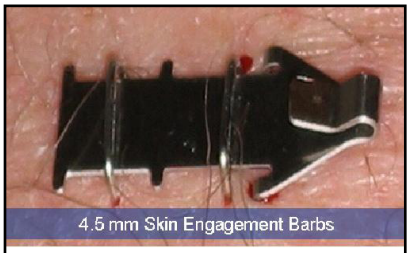


Figure 3: 4.5mm barbs of the skin anchor engage the subcutaneous tissue

Figure 4: Tightening of tensioning device with nylon line engaging the skin anchors

tissue expansion (RITE) occurs entirely in the operating room setting. RITE depends entirely on the viscoelastic properties of the skin in response to load cycling.[6] PTE induces changes in vascularity and cellular activity of the expanded skin. The epidermis initially thickens slightly as the dermis and adipose tissue thins.[7] The expanded skin then becomes hyperemic resulting in a hardier flap than one produced from nonexpanded skin.[1] It has also been found that the expanded skin flap is more resistant to bacterial invasion than random cutaneous flaps.[8]

Technique:

The DermaClose® RC kit contains a tension controller containing a 52cm loop of nylon line, 10 skin anchors, a skin stapler and a staple remover pack. Wounds suitable for application of this technique include non-infected foot ulcers, surgical wounds and traumatic wounds.

Anesthesia is administered and the area is prepped in the usual sterile manner. When used on a chronic wound, fibrotic margins of the wound are excised and wound margins are undermined 0.5-1.0 cm. This releases the margin of the skin to begin creep. (Figure 1) After obtaining hemostasis, the skin anchors are applied by pressing them into the skin. (Figure 2) The skin anchors have a pair of flat angulated barbs 4.5mm in length. The barbs are inserted 1-1.5 cm from the margin of the wound and 2-3 cm from each other. Because of the length of the barbs, the subcutaneous tissue is engaged for eventual migration. The anchors are secured with two skin staples. (Figure 3)

The tension controller has a rotary knob with a clutch and an adapted line chute that fits over the hooked end of one of the skin anchors. The enclosed line is placed over the hooked edge of the anchors and the knob is tightened. (Figure 4,5) The tension controller cannot be over tightened because of a clutch mechanism. The knob will "slip" on the clutch when a force of 1.2 kg is obtained. The device is then locked. 1.2 kg of force will be maintained on the line until the device is removed or all of the line is retracted back into the tension controller. This eliminates any need for retightening the device and provides for continuous dynamic tension on the wound margins resulting in expansion of the surrounding tissue. This expanded tissue migrates to the wound providing coverage. (Figure 6) No dead space is produced since the subcutaneous tissue is mobilized with the skin margins.

A primary dressing is applied that will manage wound exudate.The wound under tension from the DermaClose® RC device tends to have increased exudates initially and extra absorbant dressings are suggested. Secondary dressings are chosen based on the anatomy of the area. The tissue expander stays in place for 1-7 days depending on the size of the wound and the elasticity of the tissue being mobilized.

When the device is removed several retension sutures are applied to maintain the tissue expansion over the next couple of weeks. (Figure 7) This effectively results in the physiologic changes expected with PTE. Primary wound healing has not been our

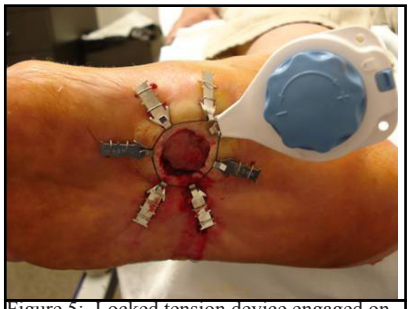


Figure 5: Locked tension device engaged on skin anchor

Figure 6: 48 hours of continuous dynamic tension resulting in expanded skin and smaller wound size

Figure 7: Retention sutures applied after tissue is fully expanded to cover the original wound.

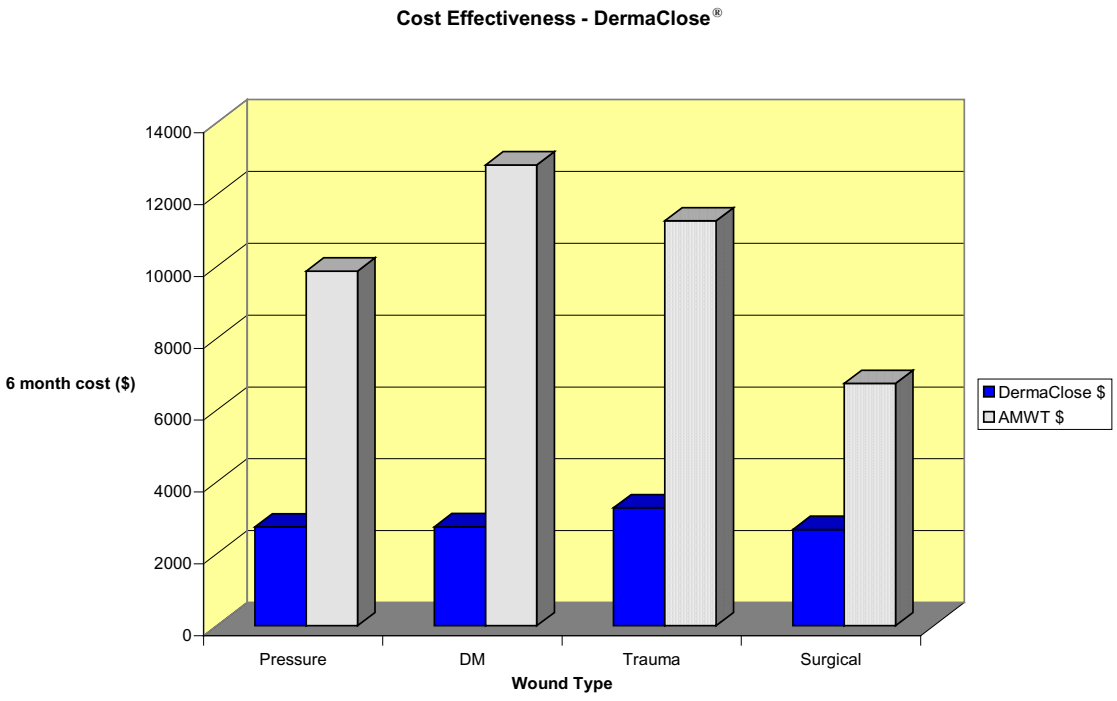
Figure 8: Two weeks after presentation with partial thickness wound remaining

typical treatment goal, however the rate to complete epitheliatization has been rapid utilizing this wound reduction technique. (Figure 8,9)

Cost Effectiveness:

The rate of wound healing and time to epithelialization with continuous tissue expansion in our wound care clinic lead us to perform a relative cost analysis of this device versus standard wound care. Reimbursement information was obtained from the hospital managing our wound care center. A six month cost evaluation was made of the first diabetic foot ulcers, pressure ulcers and surgical wounds we used the DermaClose® device on. The billing records were reviewed and those costs were compared to the cost associated with similar ulcers (size, depth, vascular status, location) during the 6 months prior to our use of this device. Our standard wound care algorithm was followed to help with this analysis. (Diagram 1) The results are found in diagram. [2] The use of the DermaClose® RC device resulted in a 72% overall dollar savings compared to advanced moist wound technology (AMWT). The savings by wound type were as follows: 72% (Pressure ulcer stage 3 and 4), 78% (Diabetic foot ulcers), 71% (Trauma) and 60% (Surgical Wounds). The sample only included our first 12 applications of DermaClose® RC, but the initial results are encouraging.

Figure 9: Fully epithelialized wound at four weeks after presentation

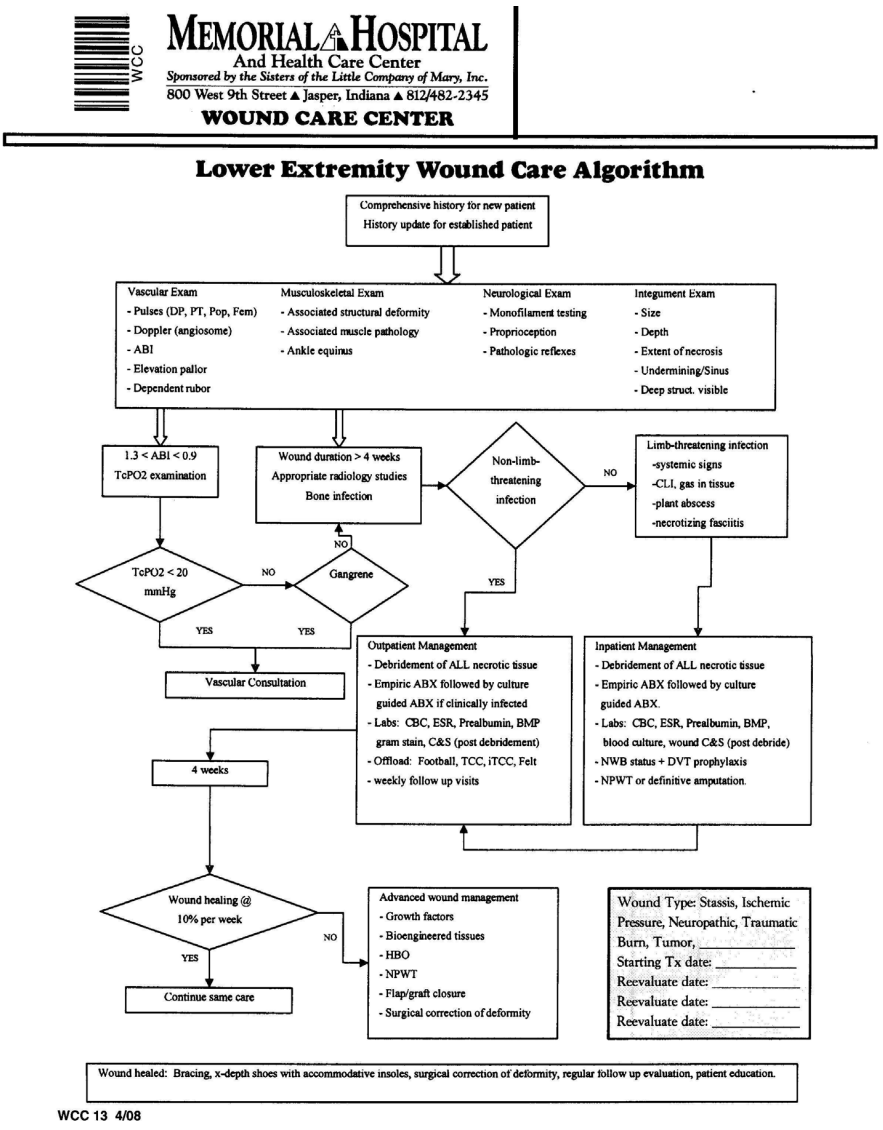


Cost effectiveness comparison between DermaClose® and Advanced Moist Wound Therapy.

Summary:

Continuous tissue expansion offers the wound care physician a reproducible and reliable method of obtaining local donor tissue for rapid and durable epithelialization of lower extremity wounds. The technique described takes advantage of the physicologic properties of skin placed under prolonged tissue expansion producing increased epidermal mitosis and enhanced microcirculation. In this author's opinion, these effects synergistically result in enhanced rapid healing of chronic wounds.

The DermaClose® RC device is easily applied in an outpatient setting. As an external device, the complications expected would be relatively low. Our early analysis of cost savings when utilizing this device is encouraging. In addition to cost effectiveness, the rapid wound healing time and durability should result in lower morbidity. Scientific studies will be needed to confirm these early observations, but this device would appear to be one of the few true innovations in lower extremity wound care.



Wound Care Center algorithm utilized. DermaClose therapy was compared to Advanced Moist Wound Therapy utilizing this algorithm.

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