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Pressure distribution under Wound VAC® therapy vs tie-over bolster dressing

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Split thickness skin grafts (STSG) are a widely accepted technique for wounds, however the incorporation of the graft to the wound can be easily affected by multiple factors such as the patient's comorbidities but also the dressing type and its pressure distribution. Securing a newly applied skin graft effectively can often be a difficult task however, a tie-over bolster dressings and the use of negative pressure wound therapy using reticulated open-cell foam (NPWT/ROCF) as delivered by V.A.C.® Therapy (KCI Licensing, Inc., San Antonio, TX) are widely accepted dressings for securing grafts. The purpose of this study was to compare sub-graft pressure distribution between NPWT/ROCF and tie-over bolster dressing where an experimental graft model was created to compare sub-graft pressure underneath the two dressings. It was found that peak pressure under the NPWT/ROCF graft was 14 pounds per square inch (psi) with a uniform, circular imprint. Peak pressure under the tie-over bolster dressing was 27 psi with three distinct bands of pressure and very low to no pressure distribution between the higher bands of pressure. In this study, NPWT/ROCF appears to have a better uniform pressure distribution compared to the tie-over dressing, which may be related to improved STSG incorporation into the wound.

Keywords: negative pressure wound therapy, pressure distribution, split–thickness skin graft, STSG, tie-over bolster dressing, VAC® therapy

Securing newly applied skin grafts to wounds of the lower extremity continues to be a challenge. In order for a split thickness skin graft (STSG) to achieve optimal healing, it requires immobilization of the graft to prevent infection, hematoma, and desiccation. Achieving all three components for successful split-thickness skin graft take has been difficult due to possible complexity in the contour of the soft tissue, and uneven pressure distribution [1].

Traditionally, tie over bolster dressings were applied over STSG to achieve immobilization on the wound in order to achieve optimal healing. However, negative pressure wound therapy using reticulated open-cell foam (NPWT/ROCF) as delivered by V.A.C.® is becoming a more common choice in wounds that have irregularity in the contour of the soft tissue. NPWT/ROCF allows a more uniform pressure distribution on the STSG that are implemented on soft tissue irregularities. This study shows different pressure distributions between tie over bolster dressings, and NPWT/ROCF and to observe the correlation between graft take, and pressure distribution [1].

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Methods

Comparative Evaluation of Pressure Distribution under NPWT/ROCF vs. Tie-over Dressings

An experimental graft model was created to compare the sub–graft pressure distribution under a compressed NPWT/ROCF dressing and a tie–over bolster dressing. A circular, full-thickness wound was made in a porcine extremity (Figure 1A). A tactile sensing system sensor (Tekscan Pressure Measurement System 4.11F, Tekscan, Inc, South Boston, MA) was trimmed to the wound shape and placed in the base of the wound (Figures 1A-C) to measures static pressure distribution. The pressure sensing system uses specialized software and thin, flexible sensors that accommodate most contours and provide accurate local pressure readings.

A human cadaveric mesh STSG was trimmed to the wound size and placed over the sensor (Figure 1D). Figures 2A and 2B show examples of the NPWT/ROCF and tie-over dressings, respectively. The graft/surface interface pressures were measured 1) without a dressing, 2) with a tie-over dressing utilizing 3-0 monofilament nylon suture over a moist cotton ball bolster, and 3) under the NPWT/ROCF dressing at a continuous pressure of -125 mmHg. A non-adherent interface dressing was placed directly over the STSG on all models.

Results

Analysis of Pressure Distribution beneath NPWT/ROCF vs. Tie-Over Dressing Techniques in Porcine Wound Model

The peak pressure under the STSG without a dressing was 6 psi with a uniform, circular implant (Figure 3C). The peak pressure measured under the graft with a tie–over dressing was 27 psi with three distinct bands of pressure and zero to very low pressure distributions between the higher bands of pressure (Figure 3B). The white area indicated no pressure reading. The peak pressure measured underneath the graft with NPWT/ROCF was 14 psi with a uniform circular imprint (Figure 3A).

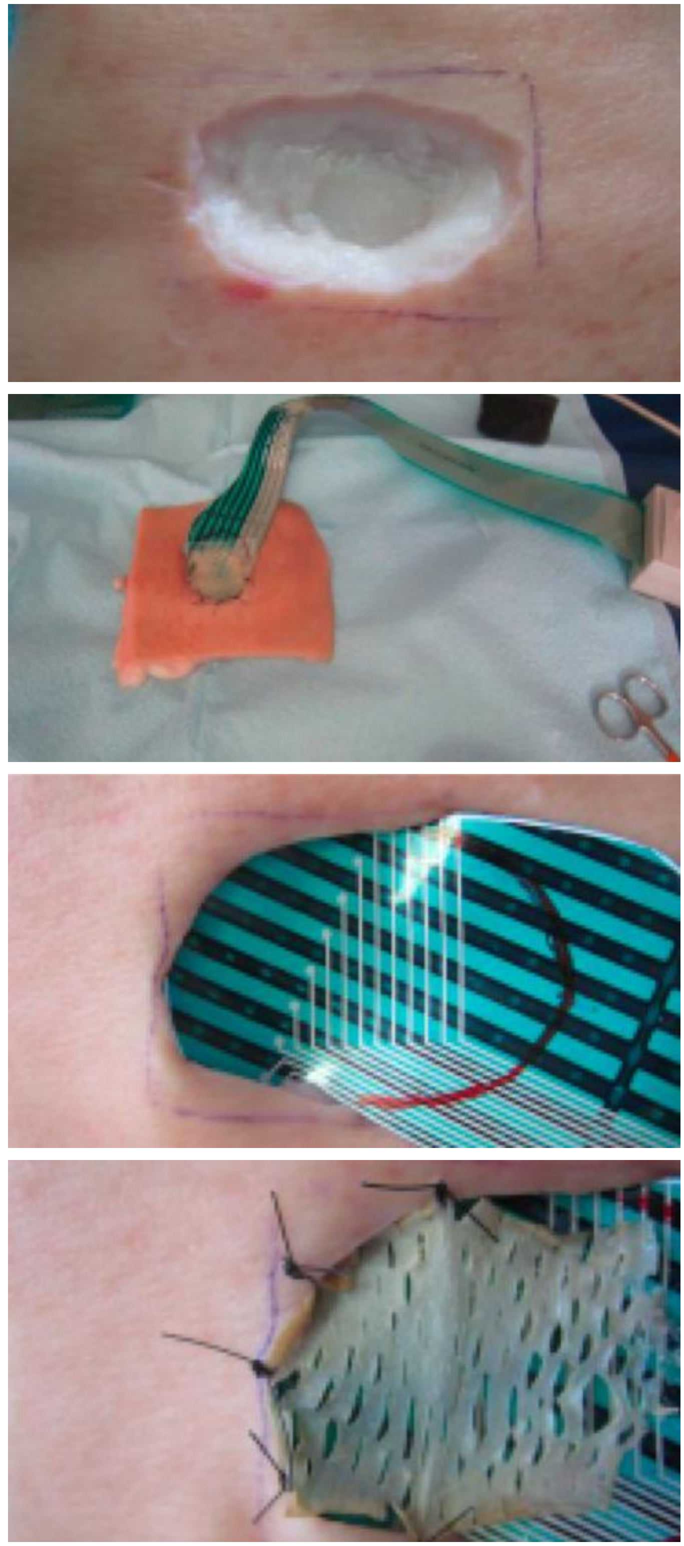

Figure 1 (A) Circular, full-thickness wound created in a porcine extremity. (B) Tactile sensing system sensor used to measure subgraft pressure. (C) Tactile sensing system sensor trimmed to wound shape and placed in the base of the wound. (D) Human cadaveric meshed STSG trimmed to the wound size and placed over the sensor.

Figure 2 (A) Tie-over bolster dressing applied over the STSG and pressure sensor. (B) NPWT/ROCF dressing applied over the STSG and pressure sensor.

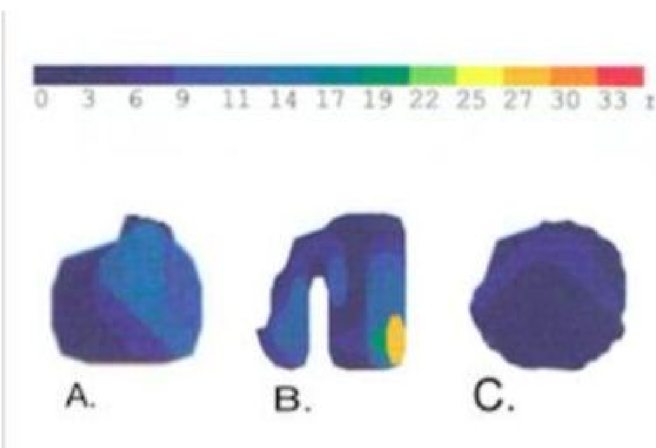

Figure 3 (A) Pressure under STSG with NPWT/ROCF dressing (14 psi with a uniform circular imprint). (B) Pressure under STSG with tie-over dressing (27 psi with three distinct bands of pressure and no to very low pressure distributions between the higher bands of pressure). (C) Pressure under STSG with no dressing (6 psi with uniform, circular imprint).

Discussion

In many practices, NPWT/ROCF after adequate debridement has become a powerful workhorse in STSG management, particularly in cases of patients with comorbidities or wounds in difficult anatomic locations. The even distribution of pressure aids in immobilization, restriction of shearing to the graft, and prevention of seroma or hematoma formation. Distinct bands of low to no pressure displayed beneath the tie-over dressing in the porcine model indicate a lack of continuous contact between the dressing and graft, thus depriving areas of the graft from the beneficial effects of the dressing.

Our scientific findings dovetail similarly with the histological findings observed in a scientific study by Simman et al. [2]. In a comparative porcine model, NPWT/ROCF showed decreased wound edema, faster narrowing of the separation plane between the graft and recipient wound bed, and earlier termination of the acute inflammatory reaction as compared to a bolster dressing on postoperative days 3, 5, 7, 9, and 11. Authors proposed that a decrease in edema and plane of separation could increase oxygen and nutrient delivery to tissue, leading to accelerated healing [2]. The higher peak pressure observed with the tie-over dressing (27 psi) versus NPWT/ROCF (14 psi) in our study is notable. Further scientific studies would be appropriate to determine optimum pressure at the interface of the wound graft in various patients and wound types.

The current authors postulate that mechanical factors played a critical role in outcome. The micromechanical force exerted by the negative pressure and compressed open-cell foam has been shown to cause individual cell deformation and increased proliferation and granulation tissue formation [3]. Following NPWT/ROCF application to cells in an *in vitro* model, Wilkes et al., [4] reported a change in cell morphology, with cells appearing thicker and with an organized actin cytoskeleton.

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