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IDEAS AND INNOVATIONS

Burns

Customized Negative Pressure Wound Therapy: Innovative Design in Polyurethane Foam for Complex Burn Reconstruction

Juan Sebastián Amaris-Acuña, MD*
Bibiana Mendoza-Toro, MD†
David Camacho-Obando, MD†
Viviana Gómez-Ortega, MD†

Summary: The use of negative pressure wound therapy (NPWT) throughout the entire treatment of a burn patient boosts wound healing and recovery. Hand burns require specialized management that enhances wound healing and facilitates early physical rehabilitation. Thus, this article showcases a novel idea of NPWT foam customization that boosts recovery and rehabilitation in patients with hand burns. We present two patients with hand burns treated with NPWT using a customized foam design that allowed for early rehabilitation while providing and optimized recovery. In the two cases presented, the patients required two surgical stages; in the first surgery, debridement of the burns was performed and customized NPWT with instillation was applied, and in the second surgical stage, the bed was reconstructed with partial-thickness skin grafts, which were bolstered with customized conventional NPWT. The management, reconstruction, and rehabilitation were accomplished in under 2 weeks, achieving a remarkable 100% success rate in graft integration during the acute phase on the first attempt. This highlights the effectiveness of incorporating NPWT across all burn treatment phases, expediting recovery and ensuring optimal functional outcomes for patients. Surgeons can customize different NPWT foam shapes that facilitate its use on difficult-to-treat areas, allowing for a faster recovery and better rehabilitation outcomes. *(Plast Reconstr Surg Glob Open 2024; 12:e6028; doi: 10.1097/GOX.0000000000006028; Published online 6 August 2024.)*

INTRODUCTION

Burn injuries remain a significant challenge for healthcare systems due to their high morbidity and mortality rates, particularly in developing countries and resource-limited communities.[1] This issue highlights the urgent need for accessible and effective burn treatment strategies suited to low-resource settings.

Effective management of hand burns involves dressings that not only aid in treatment but also act as splints to prepare the area for early physical rehabilitation. In developing countries like Colombia, advancements in healthcare technology play a crucial role in enhancing medical services. The leading authors, who are deeply experienced in treating burn patients during both acute and reconstructive phases using negative pressure wound therapy (NPWT), highlight the challenges posed by the varied and unpredictable nature of burns. Consequently, prioritizing strategies for the widespread implementation of this therapy is essential.[2–6]

In this context, we introduce an innovative methodology for applying NPWT to challenging areas, designed to optimize effectiveness and coverage. This technique also incorporates splinting the areas in functional positions to facilitate recovery. This approach enhances outcomes in burn care and contributes to wound treatment innovation, addressing the need for practical healthcare solutions in under-resourced environments.

PATIENTS AND METHODS

The two patients presented required two surgical stages, during which the following procedures were performed:

*From *Universidad de Los Andes, Bogotá, Colombia; and †Burn Unit and Plastic and Reconstructive Surgery Department, Fundación Santa Fé de Bogotá, Bogotá, Colombia.*

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First Surgical Stage (Acute Phase)

1. Escharectomy
2. Application of NPWT with saline solution installation in a functional position of the hand.
3. The applied therapy consisted of 15 minutes of dwell time and 2.5 hours of suction at a continuous pressure of −125 mm Hg.
4. The NPWT with instillation was applied for 6 days.
5. The volume was calculated by the Smart-Instill software of the device.

Second Surgical Stage (Reconstructive Phase)

1. Removal of NPWT with instillation.
2. Evidence of a bed suitable for reconstruction.
3. Harvesting of partial-thickness skin grafts using an electric dermatome from the inner thigh.
4. Reconstruction of the defect with partial-thickness skin grafts, which are fixed with continuous Monocryl sutures.
5. Application of a gauze-type dressing with 3% bismuth tribromophenate (Xeroform).
6. Application of conventional NPWT using granufoam at a continuous pressure of −100 mm Hg, with the hand in a functional position for a period of 4 days.

Case 1

Patient 1 experienced flame burn injuries on the left hand and forearm with deep second-degree and third-degree burns (Fig. 1).

Case 2

Patient 2 had second and third-degree burns on his right hand and forearm due to an electrical flash burn (Fig. 2).

RESULTS

We present the treatment of two patients undergoing comprehensive NPWT throughout all care stages, including acute and reconstructive phases. NPWT was strategically applied during the acute phase to prepare the wound bed for future reconstruction and halt burn progression. During reconstruction, NPWT significantly improved skin graft integration rates, enabling immediate initiation of physical rehabilitation and leading to superior physical recovery by treatment completion.

Takeaways

Question: How to address the challenges burn patients face in wound healing and skin graft acceptance, impacting recovery.

Findings: Using customized negative pressure wound therapy foam shapes significantly improves wound healing and graft integration, especially in challenging areas such as hands.

Meaning: The article emphasizes that using negative pressure wound therapy throughout the entire treatment process is crucial for enhancing burn patient outcomes, promoting faster recovery, and improving graft integration success rates.

Fig. 1. Initial burn of case 1. The supplementary video outlines the case from start to finish, showcasing the custom foam design for NPWT with instillation and its customization in the reconstructive phase postgrafting. It also shows the grafts after 4 days and the hand's functionality during the first postreconstruction dressing change.

Fig. 2. Image showing the burned hand of case 2. A, Initial burn. B, Bed suitable for grafting after NPWT with installation. C, Photograph displaying the reconstructive phase with grafts fixed with Monocryl. The supplementary video presents the second case in the reconstructive phase, featuring the custom design of the foam for bolstering the grafts, followed by a demonstration of hand functionality and finger movement.

The management, reconstruction, and rehabilitation were accomplished in under 2 weeks, achieving a remarkable 100% success rate in graft integration during the acute phase on the first attempt. This highlights the effectiveness of incorporating NPWT across all burn treatment phases, expediting recovery and ensuring optimal functional outcomes for patients. [**See Video (online),** which displays the evolution of burn care in two cases through NPWT, highlighting tailored foam applications during the acute phase (NPWT with instillation) and the reconstructive phase (NPWT to bolster skin grafts), with a focus on restoring hand functionality postreconstruction.] Pain is well managed by the patients and is not increased by the application NPWT. Additionally, another benefit is that the patients do not report bad smells or saturation of dressings, which does occur when dressings other than NPWT are used.

The supplementary video demonstrates the precise process of customization of foam for instillation therapy and NPWT, allowing tailored treatment for each finger and enabling early physical rehabilitation alongside advanced wound therapy, highlighting our commitment to personalized care and optimized recovery.

DISCUSSION

Burn injuries contribute significantly to disabilities, morbidities, and mortality rates in developing countries. Regardless of their classification or location, the primary goal of treatment is quick and effective healing to minimize lasting effects, especially in cases of partial or full-thickness burns, which typically take over 3 weeks to heal optimally. These injuries are often complex wounds prone to scarring and contractures, emphasizing the importance of proper treatment from the outset to prevent such issues.[3]

Early and appropriate positioning is crucial, as it not only assists in early rehabilitation but also promotes functional splinting positions. Such positioning simultaneously acts on the wounds, promoting their healing without the risk of retraction. This proactive approach prevents long-term mobility issues and ensures that the healing process is oriented towards restoring function, thereby significantly improving patient outcomes.[7]

Negative pressure devices represent a revolutionary technology, offering a swift and effective solution for complex wound cases. This therapy is not only notable for its ability to reduce infections, enhance local blood flow, and stimulate cell growth, but it has also proven crucial in achieving better clinical outcomes for patients. In burn patients, the use of NPWT has been shown to promote the growth of granulation tissue, increasing skin graft integration success rates and wound resolution in these patients with shorter in-hospital stays. Additionally, as demonstrated in these cases, it allows for early appropriate functional positioning, which supports and shortens functional rehabilitation.[2,3,5]

Expanding upon the groundwork laid by Yoshida et al on glove-shaped foam for the fixation of skin grafts on hands, our study introduces notable refinements.[8]

We have successfully implemented this technique in several patients with burns during the acute phase. First, using NPWT with instillation the wound bed was properly prepared. After, skin grafting was performed. Postgrafting, we used NPWT at −100 mm Hg for 4 days. This regimen achieved 100% graft adherence, facilitated early rehabilitation, and reduced the risk of adverse sequelae.

In essence, our study has refined the original concept through:

1. The application of this therapeutic approach to acute burn cases.
2. The early use of instillation therapy to condition the injured site for reconstruction.
3. The strategic application of NPWT during the reconstruction phase, which is pivotal in maintaining a functional position for expedited rehabilitation.

These advancements not only streamline healing but also enhance patient recovery, ensuring a swift return to daily activities.

This article and related studies[9,10] explore the innovative use of NPWT across various phases of burn treatment, with specific emphasis on hand burns. While conventional NPWT has been traditionally used postdebridement after a few days, our article introduces a novel approach using NPWT with instillation from the initial treatment phase, followed by conventional NPWT during reconstruction. This method not only prepares the wound bed effectively but also supports early rehabilitation by using custom-designed foam that encapsulates the hand, enhancing functional recovery.

Comparatively, the first study reviewed uses traditional NPWT without instillation and begins the therapy several days postinjury, focusing on long-term outcomes without the initial acute phase instillation. In contrast, our approach initiates NPWT immediately and incorporates instillation, which is shown to expedite the healing process and improve graft integration, as evidenced by our clinical outcomes. Both studies underscore the versatility and effectiveness of NPWT in managing complex burn injuries, though our article pushes the boundary by integrating immediate instillation and showcasing through videos the detailed process of foam customization and the resultant functional mobility. This direct comparison highlights our contribution to advancing NPWT application in burn care, particularly in enhancing early functional recovery and optimizing therapy customization.

CONCLUSIONS

The management of burn injuries in developing nations requires innovative approaches to improve patient care outcomes. NPWT is vital in this context due to its efficiency and effectiveness.

This article demonstrates the effectiveness of customized NPWT for managing hand burns, enhancing recovery, and rehabilitation. The treatment began with NPWT instillation and debridement, followed by skin graft reconstruction supported by conventional NPWT. This approach not only accelerated recovery but also optimized functional outcomes, showcasing the benefits

of immediate instillation and tailored foam designs for improving early rehabilitation and burn care.

Viviana Gómez-Ortega, MD
Burn Unit and Plastic and Reconstructive Surgery Department
Fundación Santa Fé de Bogotá
Bogotá, Colombia
E-mail: viviana.gomez@fsfb.org.co

David Camacho-Obando, MD
Burn Unit and Plastic and Reconstructive Surgery Department
Fundación Santa Fé de Bogotá
Bogotá, Colombia
E-mail: davidcamacho2431@gmail.com

DISCLOSURES

Dr. Viviana Gómez-Ortega is a Clinical Consultant for Solventum. All the other authors have no financial interest to declare in relation to the content of this article.

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