

Received: 2026.05.05
Accepted: 2026.08.12
Available online: 2026.09.30
Published: 2026.XX.XX

Negative Pressure Wound Therapy After Extensive Debridement of a Pediatric Plantar Puncture-Wound Infection: A Case Report

Authors' Contribution:

Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

ABCDEF 1 **Sosanna Ierodiasconou** 
ABCDG 1 **Ioannis Fragkakis**
ACD 1 **Pantelis Ch. Tsoumpas** 
ACD 1 **Dimitris Tatarakis** 
ACD 1 **Anna Konstantopoulou** 
CD 2 **Thomaella Tsouvaltziou**
CD 3 **Alexander Seuser**
ACDG 1 **Georgios Tagaris**

1 Department of Orthopaedics, 'Karamandaneio' Children's Hospital of Patras, Patras, Greece
2 General Practitioner, Healthcare Center of Akratas, Akrata, Greece
3 Department of Orthopaedics and Trauma Surgery, University Hospital of Bonn, Bonn, Germany

Corresponding Author: Sosanna Ierodiasconou, 40 Erithrou Stavrou Str. 26331, Patras, Greece
Phone: 0030 261 063 5100, e-mail: sosanna76@hotmail.com

Financial support: The VAC device and dressings required for dressing changes were provided by Health Technologies (www.health-technologies.gr)
Conflict of interest: None declared

Patient: Female, 5-year-old
Final Diagnosis: Deep soft tissue infection
Symptoms: Fever • infection • redness • swollen foot
Clinical Procedure: —
Specialty: Orthopedics and Traumatology

Objective: Unusual or unexpected effect of treatment

Background: Puncture injuries of the pediatric foot can lead to deep soft-tissue infections with substantial morbidity, often requiring complex surgical management or reconstructive procedures. Although negative pressure wound therapy (NPWT) is widely used in adults, its use in children remains limited, and reports of its use as definitive treatment for pediatric foot infections are rare.

Case Report: We report the case of a 5-year-old girl who developed a severe plantar soft-tissue infection after stepping on a rusted nail. Radiographic evaluation excluded retained foreign material, whereas magnetic resonance imaging findings were suspicious for possible early osteomyelitis of the calcaneus. She was treated with intravenous antibiotics for a total of 6 weeks, along with tetanus immunoglobulin. Wound cultures grew methicillin-sensitive *Staphylococcus aureus*. Surgical debridement was performed down to the tarsal bones, with removal of extensive necrotic tissue, including the fibularis brevis tendon. Postoperatively, NPWT was applied, with dressing changes twice weekly for 1 month. The wound demonstrated progressive granulation tissue formation and gradual reduction in size, ultimately achieving complete closure within approximately 2 months without the need for skin grafting or reconstructive surgery. At follow-up, the patient was pain-free, fully weight-bearing, and had full passive range of motion in the foot and ankle. Although active eversion was lost due to tendon sacrifice, no functional limitation or gait disturbance was observed.

Conclusions: This case suggests that NPWT, combined with timely and adequate debridement, may serve as component of definitive treatment for deep pediatric foot infections, potentially avoiding reconstructive procedures in select patients.

Keywords: Debridement • Foot • Negative-Pressure Wound Therapy • Pediatrics • Soft Tissue Infections • Wound Healing

Full-text PDF: <https://www.amjcaserep.com/abstract/index/idArt/954016>

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Introduction

Puncture injuries of the pediatric foot can progress to deep soft-tissue infections and are associated with substantial morbidity. Management of these infections is often challenging and may require complex surgical intervention or reconstructive procedures. Negative pressure wound therapy (NPWT) is an advanced wound management technique that applies controlled subatmospheric pressure to promote wound healing. It has become an established adjunct in the management of complex wounds by reducing local edema, improving vascular and lymphatic circulation, decreasing bacterial burden, and promoting angiogenesis and cellular proliferation. Although NPWT is widely used in adults, reports of its use as definitive treatment for pediatric foot infections are rare [1,2]. This case report illustrates the feasibility of using NPWT after adequate surgical debridement in a selected case of pediatric foot infection, which resulted in successful wound healing without requiring reconstructive surgery.

Case Report

A 5-year-old girl presented to the emergency department of our hospital after she had stepped on a rusted nail while

wearing a shoe 1 week prior. On physical examination, the affected right foot was extensively swollen, with clear clinical signs of infection. Peripheral pulses were palpable, and adequate blood supply was confirmed by Doppler ultrasonography. Radiographic evaluation revealed no retained foreign body at the entry site (**Figure 1**). The injured limb was immobilized with a splint. Because of pronounced swelling, fever, signs of infection, abnormal laboratory findings, and concern for possible compartment syndrome, the patient was admitted to the hospital. She began receiving intravenous broad-spectrum antibiotics for a deep tissue infection, as well as tetanus immunoglobulin. She received intravenous vancomycin and ceftriaxone for 2 weeks, intravenous piperacillin/tazobactam and clindamycin for the subsequent 2 weeks, and oral amoxicillin/clavulanate for the final 2 weeks. Antibiotic treatment continued for a total of 6 weeks.

Ultrasonography revealed a plantar collection at the nail entry site (**Figure 2**). Therefore, magnetic resonance imaging was performed before and after contrast administration, revealing extensive cellulitis. The plantar fascia had a wavy appearance, with focal disruption of fiber continuity and fluid along its course. A high-protein fluid collection was identified beneath the plantar fascia, extending posteriorly around the



Figure 1. Radiographic evaluation revealed no retained foreign body at the entry site.

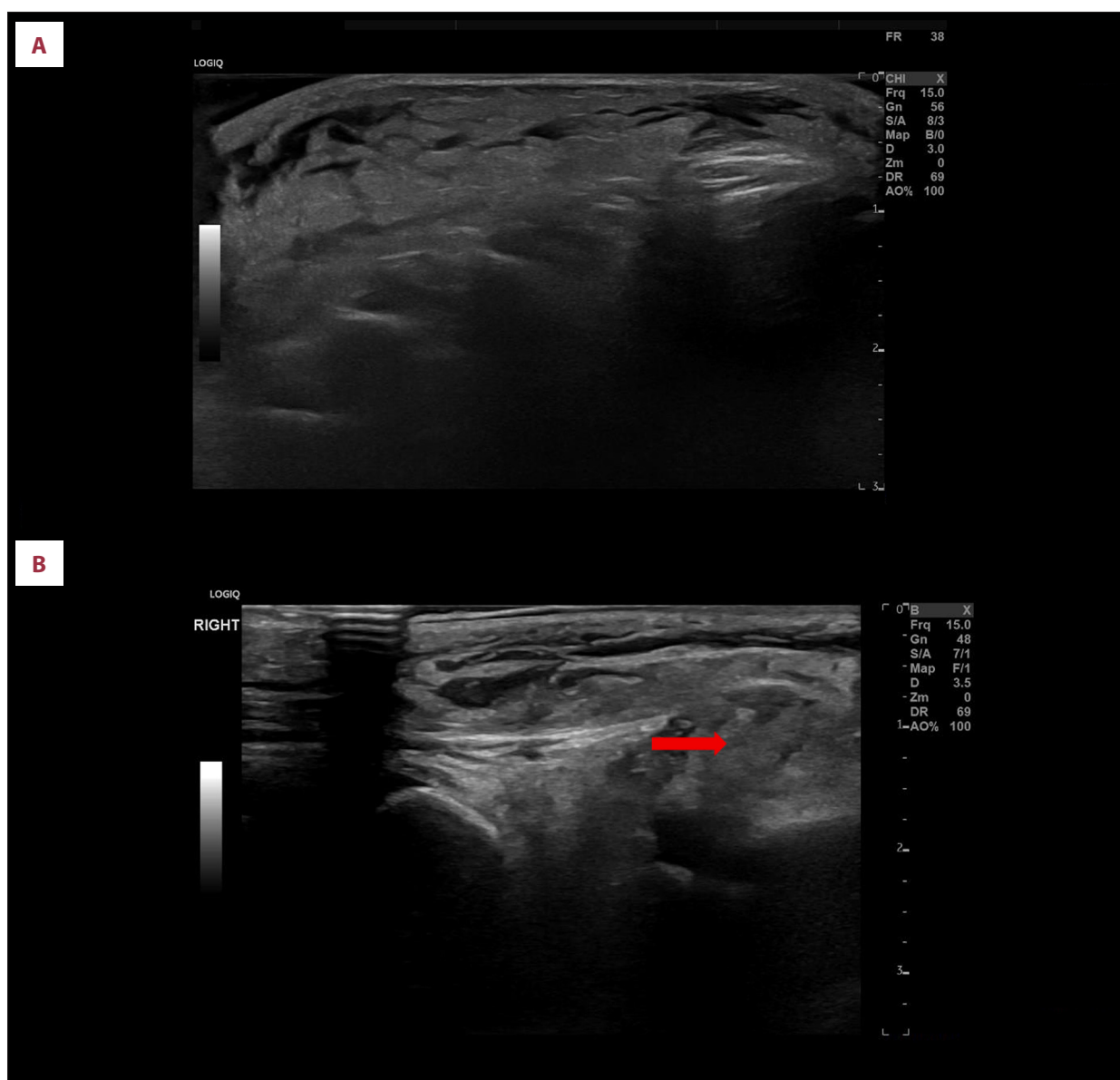


Figure 2. Ultrasonographic evaluation revealed diffuse cellulitis around the entry site of the rusted nail (A) and a plantar high-protein fluid collection containing pus (red arrow) (B).

calcaneus and anteriorly to the tarsal bones, metatarsals, and dorsal aspect of the foot. A similar fluid collection was noted within the soft tissues between the tibia and fibula. Bone marrow edema of the calcaneus was also present, with focal subperiosteal sites of fluid collection; these findings did not confirm or rule out osteomyelitis (Figure 3A-3D).

The inflammatory collection was drained, and tissue and blood samples were obtained for culture. Microbiological analysis identified methicillin-sensitive *Staphylococcus aureus* as the causative organism. Because the inflammatory collection was increasing in the region anterior to the tarsal bones, metatarsals, and dorsal foot, surgical debridement was performed. An

approximately 2-cm-wide excision was carried down to the tarsal bones to remove infected and necrotic tissue, including the fibularis brevis tendon and articular capsule (Figure 4A, 4B).

A second surgical debridement was performed immediately before placement of a vacuum-assisted closure (VAC) device (Figure 5).

A white polyvinyl alcohol foam sponge with a pore size of 200 μm was initially applied directly over the exposed bones, blood vessels, and tendons to provide a protective interface. Subsequently, a spiral polyurethane foam dressing with a pore size of 400 to 600 μm was placed over the polyvinyl alcohol

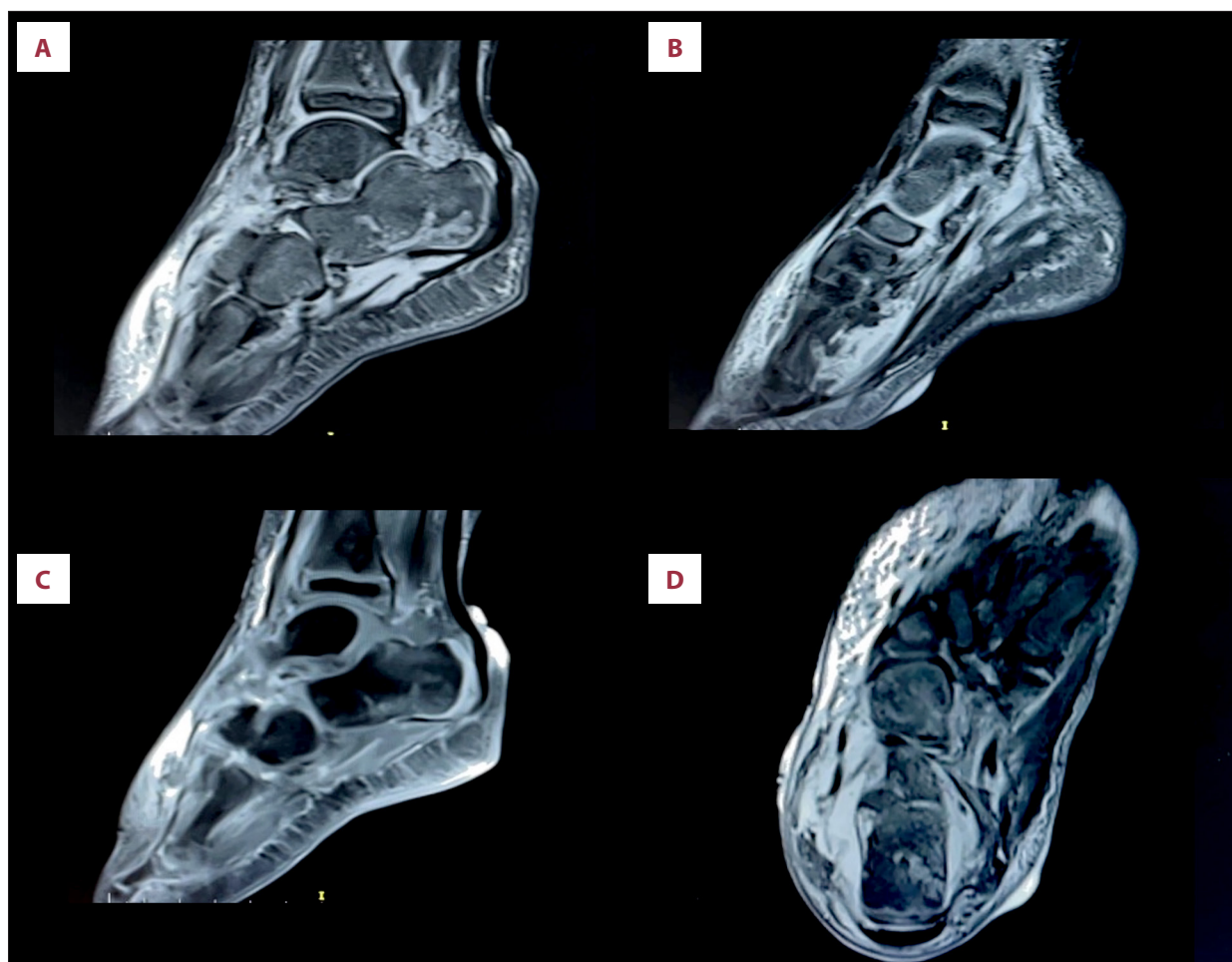


Figure 3. Magnetic resonance imaging scans of the patient's foot. T2-weighted short tau inversion recovery (STIR) sagittal sequences demonstrating disruption of the plantar fascia, fluid collection beneath the calcaneus, calcaneal edema, and additional sites of fluid collection beneath the metatarsals (**A**, **B**). T1-weighted sagittal sequence showing plantar sites of fluid collection (**C**). T2-weighted STIR axial sequence demonstrating sites of fluid collection surrounding the calcaneus, including a calcaneal subperiosteal collection site (**D**).

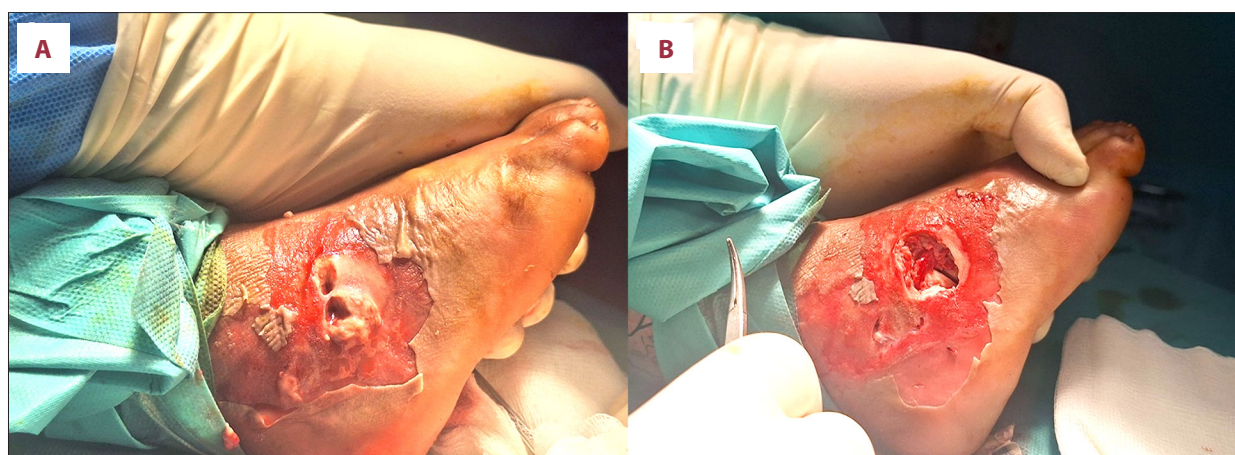


Figure 4. Before the first surgical debridement, the affected area was carefully assessed (**A**). The procedure involved an approximately 2-cm-wide excision extending down to the tarsal bones to remove infected and necrotic tissue, which included the fibularis brevis tendon and portions of the articular capsule (**B**).



Figure 5. An extensive second surgical debridement of the affected foot was performed to remove infected and necrotic tissue; this was followed by placement of a vacuum-assisted closure device. The yellow arrow indicates the calcaneus, blue arrow indicates the cuboid, and white arrow indicates the lateral cuneiform bone.



Figure 7. Five weeks after removal of the negative pressure wound therapy device, the patient presented for follow-up with a completely healed wound despite not having undergone the recommended plastic surgical intervention.

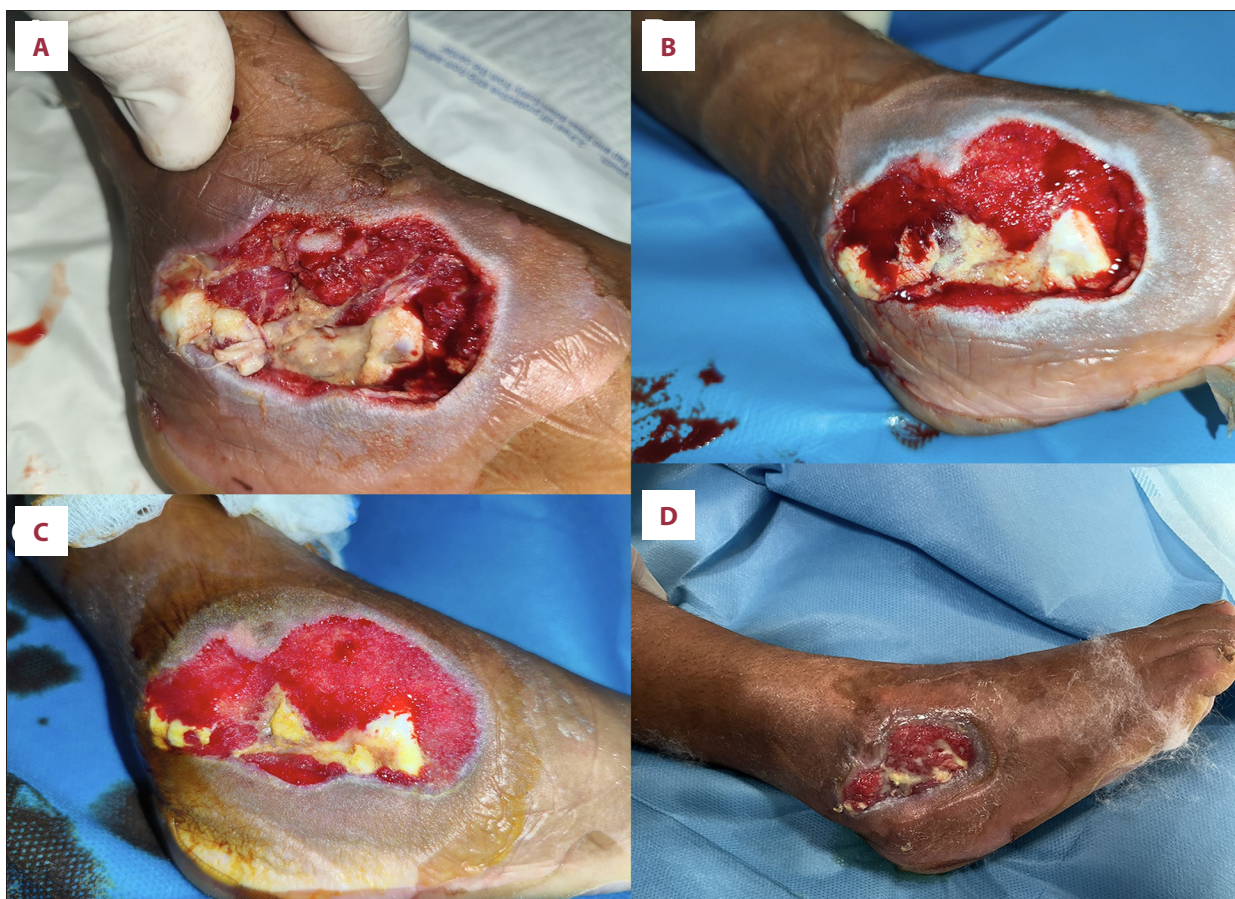


Figure 6. The patient's foot displayed progressive improvement, with healthy granulation tissue forming throughout the treatment period. Panels **A-C** show the foot 3 days, 1 week, and 20 days after placement of the vacuum-assisted closure device, respectively. Panel **D** shows the first outpatient follow-up visit 1 week after device removal, when the wound was covered with a clay-impregnated dressing and immobilized with a splint.

layer. The entire dressing assembly was sealed with adhesive drapes; a vacuum pad connected to the NPWT unit through a silicone tube was utilized to establish a negative pressure of 90 mm Hg.

The NPWT dressings were changed twice weekly under sedation in the operating room for 1 month. The foot was also immobilized with a splint. At close follow-up, the wound showed progressive improvement, with healthy granulation tissue forming throughout the treatment period (**Figure 6A-6D**).

Although consultation with plastic surgeons for wound reconstruction was recommended, the patient's family did not follow this recommendation. The patient presented to the outpatient department for follow-up at 1 week and then 5 weeks after removal of the VAC device, with a completely healed wound and without having undergone plastic surgical intervention (**Figure 7**). Splint immobilization was discontinued; the patient was advised to begin weight-bearing and gradual return to normal activities.

At the latest follow-up, the patient was pain-free, demonstrated full range of motion in the ankle and foot, and had resumed full weight-bearing. Loss of active foot eversion was noted due to involvement of the fibularis brevis muscle, without clinically significant functional impairment. Progressive granulation tissue formation and wound contraction ultimately allowed wound closure without flap reconstruction while preserving acceptable short-term foot function.

Discussion

Plantar nail puncture wounds are common injuries and may lead to severe complications, including cellulitis, necrotizing fasciitis, deep tissue abscess, osteomyelitis, and pyarthrosis [3,4]. Necrotizing fasciitis is a severe, rapidly progressive infection of the fascia that causes extensive tissue necrosis and systemic toxicity. It typically begins in the superficial fascial layers and can rapidly spread to deeper tissues, posing a life-threatening risk if not treated promptly. Although the limbs are most commonly affected, the infection can also involve the head, neck, trunk, and perineal regions [5].

Puncture wounds in pediatric patients may be complicated by soft-tissue defects, bone exposure, and infection, often requiring frequent dressing changes. Several treatment and wound coverage options are available, including NPWT, fasciocutaneous flaps, free flaps, and artificial dermal substitutes [6]. NPWT is widely used to manage complex wounds and has been shown to reduce local edema, improve vascular and lymphatic circulation, decrease bacterial load, and promote angiogenesis and cellular proliferation [7]. It is also used for post-traumatic

wounds, postoperative wounds such as those following spinal or cardiac surgery, abdominal wall conditions such as giant omphalocele, burns, and infection-related wounds [8-14]. The use of a VAC device represents an effective alternative to conventional wet-to-moist dressings because it provides an occlusive environment that promotes wound healing while minimizing the need for frequent, potentially distressing dressing changes in pediatric patients [1,13,15].

Supporting these findings, studies by Mayers et al and Halvorson et al demonstrated that VAC therapy reduces infection rates and minimizes the need for extensive soft-tissue reconstruction by accelerating wound healing [1,2]. Similarly, Mooney et al reported successful treatment of complex soft-tissue wounds in 27 pediatric patients using NPWT, with good tolerance and fewer dressing changes relative to conventional methods; complex microsurgical procedures were not required [16].

Furthermore, Slavkovic et al compared NPWT with wet-to-moist dressings in complicated pediatric extremity wounds and concluded that NPWT was more effective because it required fewer dressing changes, allowed simpler definitive wound closure, and resulted in improved scar outcomes; safety results were comparable. Their findings supported NPWT within 24 to 48 hours after surgical debridement, particularly in extensive or high-risk wounds [7].

Gabriel et al evaluated VAC therapy for various soft-tissue defects, including abdominal wounds, postoperative soft-tissue defects, traumatic wounds, stage III/IV pressure ulcers, and fasciotomy wounds. They reported that 54 of 58 wounds achieved complete closure [15]. These findings support the use of NPWT for extremity wounds, as well as wounds involving the trunk [13-15].

The role of NPWT in managing complex pediatric wounds is limited, as is evidence describing its use in extensive plantar puncture-wound infections with necrotizing soft-tissue involvement. The present case does not demonstrate a novel application of NPWT itself; rather, it illustrates successful use of NPWT as part of a reconstruction-sparing treatment strategy in a child with an extensive plantar infection requiring serial debridement and resulting in exposed deep structures.

The favorable outcome observed in our patient likely resulted from a combination of factors rather than NPWT alone, including early imaging, prompt and repeated surgical debridement, microbiological identification with targeted antibiotic therapy, preserved distal perfusion, and close multidisciplinary follow-up. Although resection of the fibularis brevis tendon resulted in some functional compromise, overall foot integrity and ambulatory function were preserved, allowing satisfactory functional recovery without flap reconstruction.

However, the generalizability of this approach remains uncertain in cases involving osteomyelitis, vascular compromise, delayed presentation, poor compliance, or more extensive structural and soft-tissue loss. Therefore, NPWT should be considered selectively in the context of careful multidisciplinary management. The present case expands the limited literature on reconstruction-sparing management of extensive pediatric plantar infections but should be considered hypothesis-generating, rather than evidence of superiority over alternative reconstructive approaches.

Conclusions

This case demonstrates the feasibility of NPWT as part of the definitive management of a deep pediatric foot infection after adequate debridement, which resulted in successful wound closure and an acceptable short-term functional outcome in a single child without requiring reconstructive surgery. In our patient, NPWT was well tolerated and facilitated postoperative wound management following serial debridement. Given the limited evidence in children, this report highlights the potential role of NPWT in selected pediatric orthopedic cases with extensive soft-tissue involvement and good patient compliance.

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Broader conclusions regarding avoidance of reconstruction, reduction of morbidity, improved comfort, and cost-effectiveness require validation in larger comparative studies.

Institution Where Work Was Done

‘Karamandaneio’ Children’s Hospital of Patras, Patras, Greece.

Informed Consent

Patient consent was obtained for publication.

Acknowledgments

The VAC device and dressings required for dressing changes were provided by Health Technologies (www.health-technologies.gr).

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