

Comprehensive Management of Delayed Pediatric Nail Puncture Injury Complicated by Severe Soft-Tissue Infection: The Adjunctive Role of Negative Pressure Wound Therapy

Viktor Marku¹, Chrysa Andrikopoulou², Ioannis Fragkakis³, Vasileios Leivaditis⁴, Theodora Skoura⁵, Panagiotis Antzoulas⁶, Konstantinos Tasios⁷, Elias Liolis⁸, Andreas Antzoulas⁹, Dimitrios Litsas¹⁰, Panagiotis Dimitrios Papadopoulos¹¹, Thomaella Tsouvaltzi¹², Sosanna Ierodiaconou³, Konstantinos Nikolakopoulos¹³, Spyros Papadoulas¹³, Agron Dogjani¹, Francesk Mulita^{2,9*}

¹Department of Orthopedics and Trauma Surgery, University Hospital of Trauma, Tirana, Albania

²Department of General Surgery, General Hospital of Aigio, Achaia, Greece

³Department of Orthopedics and Trauma Surgery, Karamandaneio Children's Hospital of Patras, Patras, Greece

⁴Department of Cardiothoracic and Vascular Surgery, Westpfalz Klinikum, Kaiserslautern, Germany

⁵Medical School Researcher, National and Kapodistrian University of Athens (NKUA), Aretaeion Hospital, Athens, Greece

⁶Department of Orthopedics, General University Hospital of Patras, Patras, Greece

⁷John Radcliffe Hospital Emergency Department, University Hospitals NHS Foundation Trust, Headley Way, Headington, Oxford UK

⁸Department of Oncology, General University Hospital of Patras, Patras, Greece

⁹Department of Surgery, General University Hospital of Patras, Patras, Greece

¹⁰Department of Surgery, General Hospital of Lamia, Lamia, Greece

¹¹Department of Surgery, Spital Herisau, Appenzell Ausserrhoden, Switzerland

¹²Healthcare Center of Akrotas, Achaia, Greece

¹³Department of Vascular Surgery, General University Hospital of Patras, Patras, Greece

*Corresponding author:

Francesk Mulita, MD
Department of Surgery
General University Hospital of Patras Rio,
265 04 Patras, Greece
Phone: +302613603300
E-mail: oknarfmulita@hotmail.com
ORCID Id: <https://orcid.org/0000-0001-7198-2628>

Rezumat

Context: Plăgile prin înțepare la copii sunt frecvent subestimate, în special atunci când prezentarea este întârziată sau leziunea inițială trece neobservată. Corpii străini reținuți cresc substanțial riscul de infecție profundă a țesuturilor moi, formarea de abcese, artrită septică și osteomielită. Diagnosticul prompt și tratamentul chirurgical adecvat sunt esențiale pentru a preveni complicațiile grave.

Prezentarea cazului: Un copil în vârstă de 4 ani s-a prezentat cu un istoric de 10 zile de durere progresivă, umflare, eritem și secreție purulentă a piciorului drept în urma unei leziuni prin înțepare a unghiei. Evaluarea clinică și radiologică a relevat o infecție extinsă a țesuturilor moi asociată cu material străin reținut. În urma debridării chirurgicale agresive, îndepărtării corpului străin și irigației, a fost inițiată terapia antimicrobiană intravenoasă empirică, ulterior ghidată de rezultatele culturii microbiologice. Terapia plăgilor cu presiune negativă (NPWT) utilizând un sistem de închidere asistată de vid (VAC) a fost aplicată timp de trei săptămâni. La o lună de urmărire după finalizarea terapiei cu presiune negativă (NPWT), rana a demonstrat o acoperire completă cu țesut de granulație sănătos, o reducere semnificativă a dimensiunii și adâncimii plăgii, rezolvarea infecției și o recuperare funcțională satisfăcătoare fără a fi nevoie de intervenții chirurgicale suplimentare.

Received: 14.04.2026
Accepted: 17.06.2026

Concluzie: Acest caz evidențiază importanța recunoașterii precoce și a managementului complet al plăgilor pediatrice prin înțepare tardive. Debridarea chirurgicală combinată cu terapia antimicrobiană adecvată și NPWT adjuvantă pot controla eficient infecția, pot promova vindecarea rănilor și pot facilita conservarea cu succes a membrilor în leziunile complexe ale țesuturilor moi pediatrice.

Cuvinte cheie: rană înțepătoare, corp străin reținut, infecție a țesuturilor moi, terapie a plăgilor cu presiune negativă, rană pediatrică, prezentare tardivă

Abstract

Background: Puncture wounds in children are frequently underestimated, particularly when presentation is delayed or the initial injury goes unnoticed. Retained foreign bodies substantially increase the risk of deep soft-tissue infection, abscess formation, septic arthritis, and osteomyelitis. Prompt diagnosis and appropriate surgical management are essential to prevent serious complications.

Case Presentation: A 4-year-old child presented with a 10-day history of progressive pain, swelling, erythema, and purulent discharge of the right foot following a nail puncture injury. Clinical and radiological evaluation revealed extensive soft-tissue infection associated with retained foreign material. Following aggressive surgical debridement, foreign-body removal, and irrigation, empirical intravenous antimicrobial therapy was initiated and subsequently guided by microbiological culture results. Negative pressure wound therapy (NPWT) using a vacuum-assisted closure (VAC) system was applied for three weeks. At one-month follow-up after completion of NPWT, the wound demonstrated complete coverage with healthy granulation tissue, marked reduction in wound size and depth, resolution of infection, and satisfactory functional recovery without the need for further surgical intervention.

Conclusion: This case highlights the importance of early recognition and comprehensive management of delayed pediatric puncture wounds. Combined surgical debridement, appropriate antimicrobial therapy, and adjunctive NPWT can effectively control infection, promote wound healing, and facilitate successful limb preservation in complex pediatric soft-tissue injuries.

Keywords: puncture wound, retained foreign body, soft-tissue infection, negative pressure wound therapy, pediatric wound, delayed presentation

Introduction

Puncture wounds of the foot are common injuries in children but are often underestimated, particularly when the initial trauma is considered trivial, presentation is delayed, or the injury goes unrecognized by caregivers. Although many cases follow an uncomplicated course, retained foreign bodies, especially nails or wooden fragments, substantially increase the risk of deep soft-tissue infection, abscess formation, septic arthritis, and osteomyelitis if not identified and removed promptly (1-3).

The diagnosis of retained foreign material may be challenging because the external wound is often small and the clinical findings may initially appear disproportionate to the extent of the underlying tissue injury. Delayed presentation beyond 48 hours has consistently been associated with higher rates of infectious complications, more extensive tissue destruction, and an increased likelihood of surgical intervention (2-4). Early clinical assessment, appropriate imaging,

and timely surgical management are therefore essential to prevent progression to severe infection and preserve limb function.

Negative pressure wound therapy (NPWT) has become an established adjunct in the management of complex soft-tissue wounds by promoting granulation tissue formation, reducing edema, improving local perfusion, and facilitating wound-bed preparation following adequate debridement (5-7). However, reports describing its application in delayed pediatric puncture wounds remain limited. We present the case of a four-year-old child with a delayed presentation after a nail puncture injury complicated by extensive soft-tissue infection, who was successfully treated with aggressive surgical debridement, culture-guided antimicrobial therapy, and adjunctive NPWT.

Case Report

A 4-year-old child of Roma origin presented to the emergency department with a 10-day history of

progressively worsening pain, swelling, erythema, and purulent discharge from the right foot following a puncture injury. According to the caregiver, the child had accidentally stepped on a nail, which remained embedded in the plantar aspect of the foot for several days before spontaneously dislodging. No medical attention had been sought during this period.

On examination, a deep ulcerative plantar wound with exposed soft tissues, extensive necrotic material, fibrinous deposits, and purulent exudate was identified, consistent with advanced local infection (*Fig. 1*). The surrounding tissues were markedly edematous and discolored. Laboratory investigations demonstrated a systemic inflammatory response, with elevated C-reactive protein levels and leukocytosis.

Plain radiography and ultrasonography confirmed retained foreign-body fragments and extensive soft-tissue involvement, without radiological evidence of osteomyelitis at presentation. Empirical intravenous antimicrobial therapy with meropenem and vancomycin was initiated using body weight-adjusted pediatric doses to provide broad-spectrum coverage pending microbiological results.

Given the delayed presentation, retained foreign material, extensive tissue necrosis, and established infection, urgent surgical intervention was undertaken. Thorough debridement of all devitalized tissue, meticulous irrigation, and complete removal of the retained foreign-body fragments were performed. Intraoperative cultures isolated *Staphylococcus aureus* and *Enterobacter cloacae*, confirming a polymicrobial wound infection.

To optimize wound healing following debridement, negative pressure wound therapy (NPWT) was initiated using a polyurethane VAC foam dressing connected to a vacuum-assisted closure system. Continuous negative pressure of -100 mmHg was applied in accordance with standard pediatric practice. Dressings were changed twice weekly, and NPWT was maintained for a total of three weeks. Throughout treatment, serial wound assessments demonstrated progressive development of healthy granulation tissue, reduction of fibrinous slough, improved tissue perfusion, and gradual contraction of the wound defect (*Fig. 2*).

The patient subsequently received culture-guided intravenous antimicrobial therapy using body weight-adjusted pediatric doses for a total treatment duration of three weeks. Clinical and laboratory parameters progressively normalized throughout hospitalization. After completion of antimicrobial therapy, local wound care alone was continued. Repeat wound cultures were negative, and no further antibiotic treatment was considered necessary.

One month after discontinuation of NPWT, the



Figure 1. Initial appearance of the wound at presentation to the emergency department

wound demonstrated marked clinical improvement (*Fig. 3*). The defect was completely covered by healthy, mature granulation tissue, with a substantial reduction in both wound depth and overall dimensions. There were no signs of persistent or recurrent infection, including erythema, purulent discharge, malodor, or surrounding cellulitis. Satisfactory epithelialization had developed at the wound margins, while the overall appearance of the wound indicated stable progression toward complete healing without the need for additional surgical intervention.

The child gradually regained full weight-bearing ability without pain or functional limitation. The patient's parents expressed high satisfaction with the treatment outcome, particularly the successful preservation of the affected limb, the avoidance of further



Figure 2. Appearance of the wound after 15 days of NPWT.



Figure 3. Appearance of the wound one month after the final dressing change and cessation of NPWT

surgical procedures, and the restoration of normal ambulation. A chronological overview of the patient's presentation, treatment, and follow-up is provided in *Table 1*.

Discussion

Delayed presentation remains one of the most important determinants of adverse outcomes following pediatric puncture wounds. Although these injuries are often initially perceived as minor, retained foreign bodies may serve as a persistent nidus for bacterial contamination, allowing progressive extension of infection into deeper soft tissues and substantially increasing the risk of abscess formation, septic arthritis, and osteomyelitis (1-4,8-10). In the present case, the prolonged retention of the nail resulted in extensive tissue necrosis and polymicrobial infection with *Staphylococcus aureus* and *Enterobacter cloacae*, ultimately necessitating aggressive surgical interven-

tion. This clinical course highlights the importance of maintaining a high index of suspicion for retained foreign material in children presenting with delayed symptoms after puncture injuries.

Successful management depended primarily on timely surgical source control. Thorough debridement of all devitalized tissue and complete removal of the retained foreign material were essential prerequisites for infection control and wound healing. Although antimicrobial therapy plays a crucial role in the treatment of established soft-tissue infection, antibiotics alone cannot adequately penetrate necrotic tissue or eliminate persistent foreign bodies. Consequently, early surgical exploration should be strongly considered whenever delayed presentation, retained foreign material, or extensive tissue destruction is suspected (2-4,9,10).

Following adequate debridement, NPWT provided an effective adjunctive treatment. Previous pediatric studies have demonstrated that NPWT is safe and facilitates the management of complex traumatic, contaminated, and infected wounds by reducing edema, improving local perfusion, promoting angiogenesis, and stimulating the formation of healthy granulation tissue (5-8,11-13). Experimental and clinical evidence further suggests that negative pressure optimizes the wound microenvironment by removing excess exudate, decreasing bacterial burden, and promoting mechanical microdeformation, thereby accelerating tissue repair (7,8,14-16). In the present patient, these effects were reflected by progressive improvement of the wound bed during treatment, allowing successful healing without the need for reconstructive procedures.

An additional strength of this case is the favorable outcome despite the prolonged delay before presentation. At one-month follow-up after completion of NPWT, the wound remained free of recurrent infection, demonstrated mature granulation tissue and satisfactory epithelialization, and was associated with complete restoration of painless weight bearing. The sustained clinical improvement observed after

Table 1. Chronological overview of the patient's clinical course, including presentation, treatment, and follow-up.

Time	Clinical event
Day 0	Nail puncture injury to the right foot.
Days 1–9	Progressive pain, swelling, erythema, and purulent discharge without medical evaluation.
Day 10	Presentation to the emergency department. Clinical and radiological assessment. Intravenous antibiotics initiated.
Day 10	Surgical debridement, foreign-body removal, irrigation, and initiation of NPWT.
Weeks 1–3	NPWT with twice-weekly dressing changes and culture-guided antimicrobial therapy.
Week 3	NPWT discontinued following satisfactory wound bed formation and infection control.
One month after NPWT	Complete granulation tissue coverage, negative cultures, satisfactory wound healing, and functional recovery.

discontinuation of NPWT further suggests successful stabilization of the wound environment and progression from the inflammatory and proliferative phases toward physiological tissue remodeling (16-18).

Beyond the individual case, this report also underscores the importance of early recognition of puncture wounds in children, particularly in socially vulnerable populations where delayed presentation may occur more frequently. Caregiver education regarding the need for prompt medical assessment after penetrating foot injuries, especially when foreign-body retention is suspected, may help reduce preventable infectious complications. Careful clinical examination, appropriate imaging, timely surgical debridement, culture-guided antimicrobial therapy, and selective use of NPWT represent complementary components of successful management in complex pediatric puncture wounds.

Conclusion

Delayed presentation of pediatric puncture wounds may result in severe soft-tissue infection requiring extensive surgical management. This case demonstrates that prompt surgical debridement, culture-guided antimicrobial therapy, and adjunctive negative pressure wound therapy can achieve excellent infection control and durable wound healing, even in advanced cases. Early recognition, appropriate imaging, and comprehensive multidisciplinary management remain the cornerstones of successful treatment and may help prevent limb-threatening complications.

Author's Contributions

Conceptualization, V.M., V.L. and C.A.; methodology, I.F., T.S., K.T., F.M. and P.A.; validation, E.L.; formal analysis, A.A., D.L. and F.M.; investigation, P.D.P., T.T., and S.I.; resources, K.N., and S.P.; data curation, S.P. and A.D.; writing—original draft preparation, F.M., S.P., V.M., E.L., V.L. and C.A.; writing—review and editing, P.A., K.N., K.T., I.F., A.A. and A.D.; visualization, F.M. and V.L.; supervision, F.M. and C.A. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest: None.

Financial Support and Sponsorship

The study was funded by HEALTH TECHNOLOGIES (KAS. PAPADAKI & CO O.E.) company. There was no conflict of interest.

Ethical Statement

This case report has been prepared in accordance with the SCARE 2020 guidelines. The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of the University of Patras (protocol code 31092/23.01.2026).

Informed Consent Statement

Informed consent was obtained from the parents of the patient.

References

1. Steele MT, Tran LV, Watson WA, Muellemann RL. Retained glass foreign bodies in wounds: predictive value of wound characteristics, patient perception, and wound exploration. *Am J Emerg Med.* 1998;16(7):627-30.
2. Levine MR, Gorman SM, Young CF, Courtney DM. Clinical characteristics and management of wound foreign bodies in the ED. *Am J Emerg Med.* 2008;26(8):918-22.
3. Fitzgerald RH Jr, Cowan JD. Puncture wounds of the foot. *Orthop Clin North Am.* 1975;6(4):965-72. PMID: 241038.
4. Weber EJ. Plantar puncture wounds: a survey to determine the incidence of infection. *J Accid Emerg Med.* 1996;13(4):274-7.
5. Baharestani MM. Use of negative pressure wound therapy in the treatment of neonatal and pediatric wounds: a retrospective examination of clinical outcomes. *Ostomy Wound Manage.* 2007;53(6):75-85.
6. McCord SS, Naik-Mathuria BJ, Murphy KM, McLane KM, Gay AN, Bob Basu C, et al. Negative pressure therapy is effective to manage a variety of wounds in infants and children. *Wound Repair Regen.* 2007;15(3):296-301.
7. Argenta LC, Morykwas MJ. Vacuum-assisted closure: a new method for wound control and treatment: clinical experience. *Ann Plast Surg.* 1997;38(6):563-76; discussion 577.
8. Plikaitis CM, Molnar JA. Subatmospheric pressure wound therapy and the vacuum-assisted closure device: basic science and current clinical successes. *Expert Rev Med Devices.* 2006;3(2):175-84.
9. Edlich RF, Rodeheaver GT, Horowitz JH, Morgan RF. Emergency department management of puncture wounds and needlestick exposure. *Emerg Med Clin North Am.* 1986;4(3):581-93.
10. Dixon RS, Sydnor CH 4th. Puncture wound pseudomonas osteomyelitis of the foot. *J Foot Ankle Surg.* 1993;32(4):434-42.
11. Lavery LA, Armstrong DG, Wunderlich RP, Mohler MJ, Wendel CS, Lipsky BA. Risk factors for foot infections in individuals with diabetes. *Diabetes Care.* 2006;29(6):1288-93.
12. Pataky Z, Herrmann FR, Regat D, Vuagnat H. The at-risk foot concerns not only patients with diabetes mellitus. *Gerontology.* 2008;54(6):349-53.
13. Normandin S, Safran T, Winocour S, Chu CK, Vorstenbosch J, Murphy AM, et al. Negative Pressure Wound Therapy: Mechanism of Action and Clinical Applications. *Semin Plast Surg.* 2021;35(3):164-170.
14. Webster J, Scuffham P, Stankiewicz M, Chaboyer WP. Negative pressure wound therapy for skin grafts and surgical wounds healing by primary intention. *Cochrane Database Syst Rev.* 2014;(10):CD009261. Update in: *Cochrane Database Syst Rev.* 2019;3:CD009261.
15. Orgill DP, Bayer LR. Negative pressure wound therapy: past, present and future. *Int Wound J.* 2013;10 Suppl 1(Suppl 1):15-9.
16. Gabriel A, Rauen B. Simplified negative pressure wound therapy with instillation: advances and recommendations. *Plast Surg Nurs.* 2014;34(2):88-92.
17. Wallace HA, Basehore BM, Zito PM. Wound Healing Phases. 2023 Jun 12. In: StatPearls (Internet). Treasure Island (FL): StatPearls Publishing; 2026 Jan.
18. Baharestani M, Amjad I, Bookout K, Fleck T, Gabriel A, Kaufman D, et al. Therapy in the management of paediatric wounds: clinical review and experience. *Int Wound J.* 2009;6 Suppl 1(Suppl 1):1-26.