CASE STUDY

Persistent edema leading to subcutaneous scarring in healed diabetic foot ulcer: a case study of ultrasonographic findings

Adam Astrada
Assistant Professor, School of Nursing, Faculty of Health Sciences, Esa Unggul University, Jakarta, Indonesia
*Corresponding author email adam.astrada@esaunggul.ac.id

Abstract

Background Subcutaneous fibrosis is a recognised complication following wound healing, mainly caused by persistent edema. It causes irreversible changes to the anatomical structure of the foot risking recurrent foot ulceration and lowering the quality of life. However, its identification may be challenging due to it having similar features to edema. This case report highlights the ultrasonographic characteristics of phlebolymphedema-related subcutaneous fibrosis following the healing of an infected diabetic foot ulcer.

Case Presentation A 50-year-old male patient with diabetes presented with persistent swelling on the dorsal aspect of his right foot after healing of an infected ulcer, complicated by non-compliance with edema management. Ultrasonography revealed extended adipose globules with low echogenicity in the interstitial spaces and foci of pooled fluid, suggesting subcutaneous fibrosis. In contrast, a comparative case of edema without fibrosis showed diffusely distributed anechoic interstitial fluid.

Conclusion This case underscores the utility of ultrasonography in detecting subcutaneous fibrosis, a potential long-term consequence of persistent edema during wound healing. Early recognition through imaging can guide timely intervention and appropriate management strategies to mitigate functional impairments associated with this complication.

Keywords ultrasonography, edema management, scar, fibrosis, diabetic foot ulcer

For referencing Astrada A. Persistent edema leading to subcutaneous scarring in healed diabetic foot ulcer: a case study of ultrasonographic findings. Wound Practice and Research. 2025;33(1):39-42.

DOI https://doi.org/10.33235/wpr.33.1.39-42

Submitted 16 July 2024, Accepted 5 August 2024

Introduction

Subcutaneous fibrosis, or scarring, is a common complication following wound healing, particularly in cases of wounds associated with lymphedema. Lower limb edema is a common characteristics in in diabetic foot ulcers (DFUs) and has been identified to be a significant factor leading to amputation, while its incidence is yet to be well documented.[1,2] Persistent edema, or swelling, can exacerbate the development of subcutaneous fibrosis by increasing the inflammatory response and altering the wound healing cascade.[3] While edema is preventable and relatively easier to manage, fibrosis on lower extremity causes irreversible changes to the anatomical structure of the foot, leading to gait changes, worse plantar pressure distribution, risking recurrent foot ulceration, and lowering the quality of life. Subcutaneous edema and fibrosis might exhibit similar clinical manifestations, yet the management is more challenging in fibrosis. Simple physical examination might overlook the difference, hindering the appropriate course of treatment. Therefore, further diagnostic modalities such as imaging are needed.

The use of ultrasonography in the assessment and monitoring of wound healing has gained increased attention in recent years. Ultrasonography offers a non-invasive, real-time imaging modality that can provide valuable information about the wound bed, surrounding tissues, and potential complications. Several studies have explored the utility of ultrasonography in evaluating wound characteristics, such as tissue perfusion, edema, and the presence of foreign bodies or abscesses.[4–8] While the ultrasound appearance of subcutaneous fibrosis has been described in various contexts, including post-surgical scarring[9] and radiation fibrosis,[10,11] its specific visualisation in the context of lower

extremity wounds has not been documented in the literature. Therefore, the objective of this case report is to highlight the ultrasonographic characteristics of phlebolymphedema-related subcutaneous fibrosis following the healing of an infected DFU.

Case Presentation

This case study was conducted in a home setting. Two cases are presented to contrast the ultrasonographic characteristics of subcutaneous fibrosis and edema.

Case 1

A 50-year-old male patient with type 2 diabetes and obesity presented with unresolved swelling on his right foot (Figure 1) since having an infected diabetic foot ulcer that had healed approximately 3–4 weeks prior. The patient had peripheral neuropathy, but no meaningful bony deformities or osteomyelitis were observed. The surrounding skin appeared xerotic, and the dorsal aspect of the right foot exhibited induration, evenly solid without a clear border, and no pitting was observed. The Ankle Brachial Index (ABI) was not assessed.

Further anamnesis revealed that during the wound healing period, the patient did not comply with the recommended foot elevation or compression recommended by the wound care practitioner. His daily activity mostly involved sitting on a chair. The patient expressed no particular discomfort or complaints aside from concern regarding the swelling, which hindered him from wearing appropriate footwear.

Further examination using B-mode ultrasound (M-Turbo, SonoSite, Fujifilm, Japan). A linear probe 15–6MHz) revealed extended adipose globules and low-echogenicity in the interstitial space between the adipose tissue of the dorsal right foot (Figure 2A and 2B). A maneuver involving gentle pushing of the soft tissue showed no “squish sign,”[6] indicating the absence of free fluid within the interstitial space. Additionally, an anechoic region, suggestive of fluid accumulation, was observed (Figure 2A), but it was limited to a pooled focus.

Case 2

This case serves to contrast the ultrasonographic characteristics of subcutaneous edema with the fibrosis observed in Case 1. A 50-year-old obese male patient presented with a diabetic foot ulcer complicated by osteomyelitis, evidenced by exposure of the distal head of the second metatarsal bone. The patient exhibited peripheral neuropathy, xerosis, and induration of the peri-wound skin. Although the ABI was not assessed, ultrasound examination of the dorsal foot area revealed diffuse anechoic regions within the interstitial space of the soft tissue, indicative of edema or fluid accumulation (Figures 2C and 2D).

Discussion

This case report is the first to document and highlight the ultrasonographic visualisation of subcutaneous fibrosis specifically on the dorsal of the foot, following the healing of an infected wound complicated by persistent edema. The ultrasound characteristics of subcutaneous fibrosis

Figure 1. Clinical presentation of Case 1, a foot with subcutaneous fibrosis exhibits a swollen appearance on the dorsal area. A) A white arrow points to the healed drainage incision site. B) The contralateral unaffected foot. C) Both feet.

could be recognised by identifying low echogenicity in the interstitial spaces, instead of hypo- or anechoic, between expanded adipose globules and foci of pooled fluid. This detailed imaging allows healthcare providers to differentiate subcutaneous fibrosis from other soft tissue abnormalities, such as edema or infection, which may present with similar clinical signs.

The presence of persistent edema, as observed in Case 1, may have further exacerbated the inflammatory response and stimulated excessive collagen deposition within the interstitial spaces of the soft tissue, contributing to the development of subcutaneous fibrosis that is observed as low-echogenic region within the extended adipose globules. On the other hand, in an early phase of edema, as seen in Case 2, extended adipose globules were also observed but the fluid accumulation was diffusely distributed in the interstitial space, shown as anechoic spaces. Based on this observation, presence of low-echogenicity within the interstitial space of the extended adipose globules that may and may not be accompanied with pooled fluid foci, should alert practitioners to the formation of fibrosis in the affected body location.

The pathophysiology of subcutaneous fibrosis due to secondary lymphedema, also known as phlebolymphedema-related fibrosis, involves a complex interplay of cellular and molecular processes.[12,13] Venous insufficiency which is common in patients with obesity combined with impaired lymphatic drainage leads to accumulation of fluid, proteins, and cellular debris in the interstitial space in the lower extremity, creating a pro-inflammatory environment.[1] Concurrently, lymphatic dysfunction impairs the local immune response, further perpetuating bacterial and fungal invasion, exacerbating the existing lymphedema and contributing to a chronic, self-perpetuating cycle of inflammation and fibrosis.[1] This involves immune cell recruitment, including macrophages, fibroblasts, CD4+ T cells, and Th2 cells, that facilitate adipose expansion and fibrosis in lymphedema.[3] Prolonged edema and inflammation leads to Th2 cell response, promoting fibroblasts and macrophages migration to the expanded interstitial space, which leads to increased collagen, cytokine, and matrix metalloproteinase (MMP) production.[3] The elevated levels of IL-6, MMP-9, and TNF-α, potent pro-inflammatory cytokines, in lymphedema in cancer patients were also known to be associated with fibrosis formation.[14] This sustained inflammatory response leads to tissue remodeling towards fibrosis, characterised by an increase in deposition of excessive collagen and glycosaminoglycans within the skin and subcutaneous tissue, accompanied by adipose expansion and connective tissue overgrowth.[1,3]

The clinical implications of subcutaneous fibrosis are multifaceted. The formation of scar tissue is to date irreversible

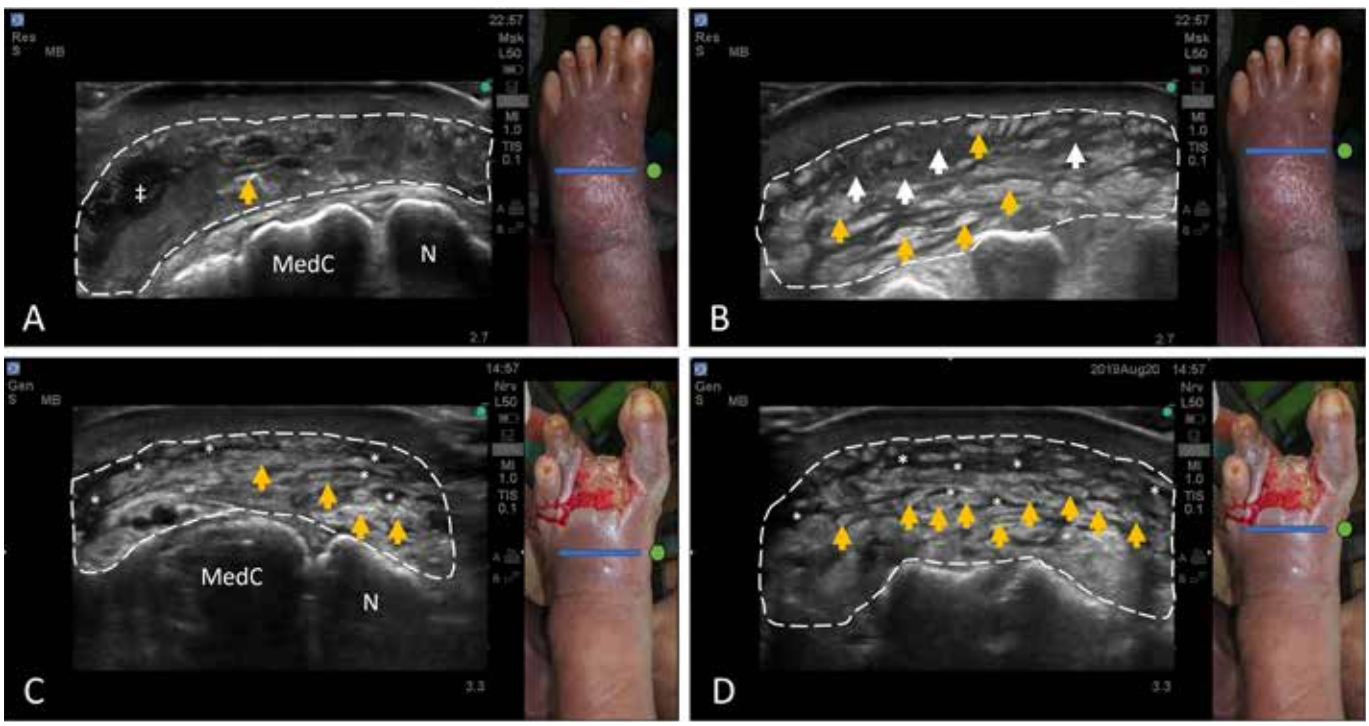

Figure 2. Soft tissue ultrasonography of the dorsal foot in Case 1 with subcutaneous fibrosis (A, B) and Case 2 with edema but without subcutaneous fibrosis (C, D). Blue bars indicate the probe position, and green dots indicate the probe orientation. (A, C) and (B, D) represent side-by-side comparisons of the same probe location in Cases 1 and 2, respectively. The subcutaneous tissue in both cases (white dashed lines) shows the Cobblestone sign, suggesting edema. However, in the foot without subcutaneous fibrosis (C, D), interstitial fluid accumulation appears as diffusely distributed anechoic areas (*) between the adipose globules (yellow arrowheads), in contrast to the foot with fibrosis, where fluid accumulation is pooled in larger foci (‡). The interstitial space in the foot with fibrosis is replaced by a denser extracellular matrix, exhibiting low echoic regions (white arrowheads). N = navicular bone; MedC = medial cuneiform bone.

and can result in anatomical and functional impairments, reduced mobility, and compromised quality of life for patients. In the context of the foot, subcutaneous fibrosis may lead to limitations in range of motion, gait abnormalities, and increased risk of secondary complications, such as foot deformities or pressure ulcers. Early recognition and appropriate management of subcutaneous fibrosis is crucial for the prevention of these problems. Ultrasonography has emerged as a valuable tool in the assessment and monitoring of wound healing and infection.[4] In this case, ultrasonography played a pivotal role in visualising the subcutaneous fibrosis and ruling out other potential complications, such as fluid collections or abscesses. Despite limitations in this home-based case study, including the inability to perform radiographs and measure ABI, the ultrasonographic findings provide important insights into differentiating between subcutaneous fibrosis and edema in diabetic foot complications. Integrating ultrasonography into routine wound care could enhance early detection and monitoring of subcutaneous fibrosis, facilitating timely intervention and appropriate management.

Conclusions

In conclusion, this case report underscores the importance of recognising subcutaneous fibrosis as a potential long-term consequence of persistent edema during wound healing process. Ultrasonography offers a valuable non-invasive technique for visualising and monitoring edema on the foot to identify subcutaneous fibrosis, enabling early intervention and appropriate management strategies. Further research and the development of standardised protocols can contribute to improving patient outcomes and advancing the field of wound care and orthopedic/podiatric management.

Acknowledgements

The author expresses gratitude to Professor Hiromi Sanada (Ishikawa Prefectural Nursing University, Japan) and Professor Gojiro Nakagami (The University of Tokyo, Japan) for generously providing the ultrasonography device. Special appreciation is extended to Associate Professor Suriadi (Kitamura Clinic, Indonesia) for granting the author the privilege to conduct this study at his clinic.

Conflict of interest

No conflicts of interest to disclose.

Ethics statement

A written informed consent was obtained from the patients prior data collection. The study was approved by the Institutional Review Board at the Faculty of Medicine, Tanjungpura University, Indonesia (No. 3092/UN22.9/DL/2019).

Funding

There was no funding received for the study.

Author contribution

The author confirms sole responsibility for the whole study process including: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

References

1. Kanapathy M, Portou M, Tsui J, Toby Richards T. Diabetic foot ulcers in conjunction with lower limb lymphedema: pathophysiology and treatment procedures. Chronic Wound Care Manag Res. 2015;2:129–136. doi: https://doi.org/10.2147/CWCMR.S62919
2. Apelqvist J, Larsson J, Agardh CD. The importance of peripheral pulses, peripheral oedema and local pain for the outcome of diabetic foot ulcers. Diabet Med. 1990;7(7):590–594.
3. Duhon BH, Phan TT, Taylor SL, Crescenzi RL, Rutkowski JM. Current mechanistic understandings of lymphedema and lipedema: Tales of fluid, fat, and fibrosis. Int J Mol Sci. 2022;23(12):6621. doi: 10.3390/ijms23126621
4. Astrada A, Nakagami G, Fajrianita I, Matsumoto M, Kawamoto A, Jais S, et al. Ultrasonographic features of diabetic foot osteomyelitis: a case series. J Wound Care. 2022;31(9):748–754. doi: 10.12968/jowc.2022.31.9.748
5. Hayden GE, Upshaw JE, Bailey S, Park DB, Marin JR. Ultrasound-guided diagnosis of femoral osteomyelitis and abscess. Pediatr Emerg Care. 2015;31(9):670–673.
6. Frasure SE, Dearing E, Burke M, Portela M, Pourmand A. Application of point-of-care ultrasound for family medicine physicians for abdominopelvic and soft tissue assessment. cureus. 2020 Aug 13;12(8):e9723. doi: 10.7759/cureus.9723
7. Riebel TW, Nasir R, Nazarenko O. The value of sonography in the detection of osteomyelitis. Pediatr Radiol. 1996;26(4):291–297. doi: https://doi.org/10.1007/BF01372116
8. Squire BT, Fox JC, Anderson C. Abscess: Applied bedside sonography for convenient evaluation of superficial soft tissue infections. Acad Emerg Med. 2005;12(7):601–606.
9. Ud-Din S, Foden P, Stocking K, Mazhari M, Al-Habba S, Baguneid M, et al. Objective assessment of dermal fibrosis in cutaneous scarring, using optical coherence tomography, high-frequency ultrasound and immunohistomorphometry of human skin. Br J Dermatol. 2019;181(4):722–732. doi: https://doi.org/10.1111/bjd.17739
10. Gottlöber P, Kerscher MJ, Korting HC, Peter RU. Sonographic determination of cutaneous and subcutaneous fibrosis after accidental exposure to ionising radiation in the course of the Chernobyl nuclear power plant accident. Ultrasound Med Biol. 1997;23(1):9–13. doi: https://doi.org/10.1016/S0301-5629(96)00173-1
11. Cho YS, Park ES. Application of dual-frequency ultrasound to radiation-induced fibrosis in a breast cancer patient. Med lasers. 2017;6(2):86–89. doi: https://doi.org/10.25289/ML.2017.6.2.86
12. Lee B-B. Phlebolymphedema: Neglected outcome of combined venous and lymphatic insufficiency. Vasc Spec Int. 2020;36(1):1–3. doi: https://doi.org/10.5758/vsi.2020.36.1.1
13. Farrow W. Phlebolymphedema: A common underdiagnosed and undertreated problem in the wound care clinic. J Am Col Certif Wound Spec. 2010;2(1):14–23. doi: https://doi.org/10.1016/j.jcws.2010.04.004
14. Ridner SH, Dietrich MS, Sonis ST, Murphy B. Biomarkers associated with lymphedema and fibrosis in patients with cancer of the head and neck. Lymphat Res Biol. 2018;16(6):516–424. doi: 10.1089/lrb.2017.0074