Ngr. J. Pharm. Sc. vol-1, issue-2 (Mar-2026) pp-60-63

ISSN: XXXX-XXXX (Online)

Nexus Global Research Journal of Pharmaceutical Sciences

Journal Homepage: https://nexusglobalresearch.com/journal/ngrjps/

Review Article

Advanced Management of Diabetic Foot Ulcers: Current Evidence, Emerging Therapies, and Future Perspectives

Mosrur Ahmed Laskar[1],

[1]*Individual researcher.*

ABSTRACT:

Diabetic foot ulcers (DFUs) remain one of the most complex and costly complications of diabetes mellitus, characterized by impaired wound healing, high infection rates, and significant risk of lower extremity amputation. Despite standard care protocols, clinical outcomes remain suboptimal, necessitating the integration of advanced therapeutic strategies. This review critically evaluates contemporary evidence on advanced DFU management, including biomaterial-based dressings, negative pressure wound therapy, revascularization strategies, antimicrobial innovations, and regenerative medicine approaches such as stem cell therapy and platelet-rich plasma. Additionally, emerging technologies including artificial intelligence and smart wound monitoring systems are discussed. The review emphasizes a precision medicine framework and multidisciplinary care model as essential for optimizing outcomes and reducing global disease burden.

Keywords: *Diabetic foot ulcer, advanced wound care, regenerative medicine, NPWT, angiogenesis, precision medicine*

1. INTRODUCTION

Diabetic foot ulcers (DFUs) represent a major clinical challenge due to their multifactorial etiology, chronicity, and high recurrence rates, making them a leading cause of non-traumatic lower limb amputations worldwide. Epidemiological data suggest that approximately 15–25% of individuals with diabetes develop DFUs during their lifetime, with mortality rates comparable to several malignancies [1,2]. The underlying pathophysiology involves a complex interaction between peripheral neuropathy, peripheral arterial disease (PAD), and infection, which together impair normal wound healing processes [3,4]. At the molecular level, persistent hyperglycemia induces oxidative stress, formation of advanced glycation end products (AGEs), and endothelial dysfunction, ultimately compromising angiogenesis and tissue repair [5]. These factors highlight the necessity for advanced, evidence-based management approaches beyond conventional wound care.

2. PATHOPHYSIOLOGY AND CLINICAL CHALLENGES

The development of DFUs is driven by a convergence of neuropathic, ischemic, and immunological abnormalities. Peripheral neuropathy results in loss of protective sensation, predisposing patients to unnoticed trauma, while motor neuropathy contributes to foot deformities and abnormal pressure distribution [6]. Concurrently, PAD reduces tissue perfusion, creating a hypoxic environment that delays wound healing and increases susceptibility to infection [7]. Chronic inflammation and impaired immune responses further exacerbate tissue damage, while biofilm-forming microorganisms complicate infection control [8]. These challenges necessitate a multimodal and targeted therapeutic approach.

3. ADVANCED WOUND CARE STRATEGIES

Advancements in wound care have led to the development of biomaterial-based dressings that actively modulate the wound microenvironment. Modern dressings such as hydrocolloids, alginates, and foam-based materials maintain moisture balance, facilitate autolytic debridement, and enhance extracellular matrix stability [9]. Additionally, antimicrobial dressings incorporating silver nanoparticles and iodine compounds have demonstrated effectiveness in reducing microbial load while minimizing cytotoxic effects [10]. Negative pressure wound therapy (NPWT) has further revolutionized DFU management by promoting angiogenesis, reducing edema, and stimulating granulation tissue formation through mechanical deformation and improved perfusion

Corresponding author: Mosrur Ahmed Laskar

Received: 08 Mar 2026; **Accepted:** 12 Mar 2026; **Published:** 14 Mar 2026

[11]. Clinical trials consistently report improved healing rates and reduced amputation risk with NPWT compared to conventional therapies [12].

4. INFECTION MANAGEMENT AND ANTIMICROBIAL INNOVATIONS

Infection remains a critical determinant of DFU progression and poor clinical outcomes. Diabetic foot infections are often polymicrobial and associated with biofilm formation, which confers resistance to conventional antibiotics [13]. While systemic antibiotic therapy remains essential, emerging approaches such as antimicrobial peptides, bacteriophage therapy, and photodynamic therapy have shown promising results in overcoming antimicrobial resistance [14]. These strategies not only target a broad spectrum of pathogens but also disrupt biofilm architecture, enhancing treatment efficacy.

5. VASCULAR INTERVENTIONS AND REVASCULARIZATION

Adequate tissue perfusion is a prerequisite for wound healing, particularly in ischemic DFUs. Advances in endovascular interventions, including angioplasty and stent placement, have significantly improved revascularization outcomes and limb salvage rates [15]. Surgical bypass remains an important option in selected cases with extensive vascular disease. Emerging therapies such as stem cell-mediated angiogenesis further enhance neovascularization and tissue perfusion, offering a novel approach to treating ischemic wounds [16].

6. REGENERATIVE AND BIOLOGICAL THERAPIES

Regenerative medicine has introduced innovative approaches aimed at restoring tissue integrity and function. Growth factor therapies, including platelet-derived growth factor (PDGF), stimulate cellular proliferation and angiogenesis, although their clinical utility is limited by cost and short biological half-life [17]. Platelet-rich plasma (PRP) has gained attention as an autologous and cost-effective alternative, delivering a concentrated source of growth factors that promote wound healing [18]. Stem cell therapies, particularly mesenchymal stem cells (MSCs), have demonstrated significant potential in enhancing vascularization, modulating inflammation, and promoting tissue regeneration [19]. Furthermore, bioengineered skin substitutes provide structural support and facilitate cellular migration, significantly improving healing outcomes in chronic DFUs [20].

7. OFFLOADING AND SURGICAL MANAGEMENT

Offloading is a cornerstone in DFU management, as mechanical stress significantly impedes wound healing. Total contact casting (TCC) is considered the gold standard for redistributing plantar pressure and ensuring patient compliance [21]. Alternative approaches, including removable cast walkers and customized orthotic devices, offer flexibility while maintaining effectiveness [22]. Surgical interventions are indicated in advanced cases involving deep infection, necrosis, or structural deformities. Procedures such as debridement, abscess drainage, and reconstructive surgery play a vital role in infection control and tissue preservation, while amputation remains a last resort [23,24].

8. MULTIDISCIPLINARY CARE AND INTEGRATED APPROACH

The complexity of DFU management necessitates a multidisciplinary approach involving endocrinologists, vascular surgeons, podiatrists, and wound care specialists. Evidence suggests that coordinated care significantly reduces amputation rates and improves healing outcomes [25]. Patient education, regular foot examination, and early intervention are essential components of preventive care.

9. EMERGING TECHNOLOGIES AND FUTURE DIRECTIONS

Recent technological advancements are reshaping DFU management. Artificial intelligence (AI)-based predictive models enable early diagnosis and risk stratification, while smart wound monitoring systems provide real-time assessment of wound parameters such as temperature, pH, and oxygen levels [26]. Additionally, 3D bioprinting offers the potential to create patient-specific skin constructs, representing a major advancement in regenerative medicine [27]. Despite these innovations, challenges such as high treatment costs and limited accessibility persist, highlighting the need for cost-effective and scalable solutions [28].

10. CONCLUSION

The advanced management of diabetic foot ulcers requires a comprehensive, multidisciplinary, and evidence-based approach that integrates modern wound care technologies, infection control

strategies, vascular interventions, and regenerative therapies. While significant progress has been made, ongoing research and innovation are essential to overcome existing challenges and improve clinical outcomes. The future of DFU management lies in precision medicine, where individualized treatment strategies guided by advanced diagnostics and emerging technologies can significantly reduce the global burden of this debilitating condition [29].

REFERENCE:

1. Armstrong DG, Boulton AJM, Bus SA. Diabetic foot ulcers and their recurrence. *N Engl J Med*. 2017;376(24):2367–75.
2. Singh N, Armstrong DG, Lipsky BA. Preventing foot ulcers in patients with diabetes. *JAMA*. 2005;293(2):217–28.
3. Jeffcoate WJ, Harding KG. Diabetic foot ulcers. *Lancet*. 2003;361(9368):1545–51.
4. Boulton AJM. The diabetic foot: from art to science. *Diabet Med*. 2004;21(1):1–3.
5. Brownlee M. The pathobiology of diabetic complications: a unifying mechanism. *Nature*. 2001;414(6865):813–20.
6. Vinik AI, Nevoret ML, Casellini C, Parson H. Diabetic neuropathy. *Diabetes Care*. 2013;36(9):2456–65.
7. Hinchliffe RJ, Brownrigg JRW, Apelqvist J, et al. IWGDF guidance on the diagnosis and management of peripheral artery disease in patients with foot ulcers in diabetes. *Diabetes Metab Res Rev*. 2016;32(S1):37–44.
8. Lipsky BA, Berendt AR, Cornia PB, et al. 2012 infectious diseases society of America clinical practice guideline for the diagnosis and treatment of diabetic foot infections. *Clin Infect Dis*. 2012;54(12):e132–73.
9. Frykberg RG, Banks J. Challenges in the treatment of chronic wounds. *Adv Wound Care*. 2015;4(9):560–82.
10. Percival SL, McCarty SM, Lipsky B. Biofilms and wounds: an overview of the evidence. *Int Wound J*. 2015;12(1):1–7.
11. Morykwas MJ, Argenta LC, Shelton-Brown EI, McGuirt W. Vacuum-assisted closure: a new method for wound control and treatment. *Ann Plast Surg*. 1997;38(6):553–62.
12. Blume PA, Walters J, Payne W, Ayala J, Lantis J. Comparison of negative pressure wound therapy using vacuum-assisted closure with advanced moist wound therapy in the treatment of diabetic foot ulcers. *Diabetes Care*. 2008;31(4):631–36.
13. Lipsky BA. Diabetic foot infections: current treatment and delaying the 'post-antibiotic era'. *Clin Infect Dis*. 2016;63(10):1327–32.
14. Willy C, Agarwal A, Andersen CA, et al. Antimicrobial treatment of diabetic foot infections. *Int J Antimicrob Agents*. 2017;49(2):151–61.
15. Norgren L, Hiatt WR, Dormandy JA, et al. Inter-society consensus for the management of peripheral arterial disease (TASC II). *J Vasc Surg*. 2007;45(Suppl S):S5–67.
16. Asahara T, Murohara T, Sullivan A, et al. Isolation of putative progenitor endothelial cells for angiogenesis. *Circulation*. 1997;95(5):964–67.
17. Steed DL. Clinical evaluation of recombinant human platelet-derived growth factor for the treatment of lower extremity ulcers. *Plast Reconstr Surg*. 2006;117(7 Suppl):143S–149S.
18. Driver VR, Fabbi M, Lavery LA, Gibbons G. The costs of diabetic foot: the economic case for the limb salvage team. *Ostomy Wound Manage*. 2010;56(4):24–30.
19. Dash NR, Dash SN, Routray P, Mohapatra S, Mohapatra PC. Targeting nonhealing ulcers of lower extremity in human through autologous bone marrow-derived mesenchymal stem cells. *Stem Cells Dev*. 2009;18(10):1411–18.
20. Veves A, Falanga V, Armstrong DG, Sabolinski ML. Graftskin, a human skin equivalent, is effective in the management of noninfected neuropathic diabetic foot ulcers. *Diabetes Care*. 2001;24(2):290–95.
21. Armstrong DG, Lavery LA, Harkless LB. Validation of a diabetic wound classification system. *J Am Podiatr Med Assoc*. 1998;88(9):440–48.

22. Bus SA, Armstrong DG, van Deursen RW, et al. IWGDF guidance on footwear and offloading interventions. *Diabetes Metab Res Rev*. 2016;32(S1):25–36.
23. Frykberg RG. Diabetic foot ulcers: pathogenesis and management. *Clin Podiatr Med Surg*. 2002;19(4):673–89.
24. Attinger CE, Evans KK, Bulan E, Blume P, Cooper P. Angiosomes of the foot and ankle. *Plast Reconstr Surg*. 2006;117(7 Suppl):261S–293S.
25. Krishnan S, Nash F, Baker N, Fowler D, Rayman G. Reduction in diabetic amputations over 11 years in a defined UK population. *Diabetes Care*. 2008;31(1):99–101.
26. Wang L, Pedrero M, Sakslund H, et al. Biosensors for wound monitoring. *Biosens Bioelectron*. 2019;126:193–204.
27. Murphy SV, Atala A. 3D bioprinting of tissues and organs. *Nat Biotechnol*. 2014;32(8):773–85.
28. Snyder RJ, Cardinal M, Dauphinée DM, Stavosky J. A post-hoc analysis of reduction in diabetic foot ulcer size. *Wound Repair Regen*. 2010;18(6):638–44.
29. Game FL. Management of the diabetic foot: new challenges. *Lancet Diabetes Endocrinol*. 2017;5(12):947–55.