

PREVENTION AND MANAGEMENT OF DIABETIC FOOT ULCERS

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ABSTRACT

Background:

Diabetic foot ulcer (DFU) is one of the most serious complications of diabetes mellitus, affecting about 15–20% of diabetic individuals during their lifetime. It causes severe physical, psychological, and socioeconomic burdens and is a leading cause of lower limb amputation. In India, DFUs are aggravated by low health literacy, barefoot walking, and lack of proper patient education and trained health professionals. Improving awareness and preventive foot care practices is crucial to reduce the risk and recurrence of DFUs.

Methods:

This observational study was conducted in the Department of General Surgery, Mahatma Gandhi Medical College and Research Institute, Puducherry, over six months (January–June 2024). Fifty diabetic patients with foot ulcers attending the outpatient department were enrolled. Data were collected using a structured questionnaire to assess demographic details, ulcer characteristics, and knowledge and practices regarding foot care. Clinical evaluation included Wagner's grading, vascular assessment (ABI), and infection status. Preventive education and structured foot care counselling were provided, and their impact was evaluated using follow-up visits.

Results:

Most participants were older adults with long-standing type 2 diabetes. Neuropathy, peripheral arterial disease, and poor foot hygiene were the major risk factors identified. About 27.2% of patients showed complete ulcer healing, 63.3% had partial healing but discontinued treatment, and 9.1% required amputation. The majority lacked basic knowledge of daily foot care. After receiving structured patient education, a noticeable improvement in self-care practices and ulcer healing rates was observed.

Conclusion:

Diabetic foot ulcers are preventable and manageable with early detection, multidisciplinary care, and strong patient education. Structured preventive education significantly improved foot care practices and treatment compliance, which can reduce recurrence, amputation risk, and associated healthcare costs. Empowering healthcare workers to deliver routine foot care education is vital to improve patient outcomes.

Keywords:

Diabetic foot ulcer, diabetes mellitus, prevention, patient education, foot care, wound management

INTRODUCTION

Diabetic foot ulcer (DFU) is one of the most serious complications of diabetes, affecting around 15% of patients during their lifetime. It arises from a combination of neuropathy, vascular disease, and biomechanical factors, leading to loss of protective sensation and unnoticed trauma. DFUs carry significant health and socioeconomic consequences, including pain, disability, hospitalization, loss of productivity, and high treatment costs (1). Even in developed countries, the prevalence of DFU is about 8%, with one in six diabetics developing an ulcer. In India, the problem is worsened by illiteracy, low socioeconomic status, walking barefoot,

improper footwear, lack of awareness, limited patient counseling, and shortage of trained healthcare professionals (2).

Health professionals play a key role in educating patients on foot hygiene, nail care, and proper footwear, as daily self-care practices are vital to reduce ulcer risk. Patient education (PE) has been shown to improve compliance and outcomes in DFU management. Lin et al. (2004), in a study involving 4,463 patients, highlighted the importance of PE in increasing knowledge and satisfaction among high-risk DFU patients. However, there is insufficient evidence that PE alone can significantly improve health-related quality of life (HRQoL) or reduce the incidence of ulcers and amputations (3,4).

In India, few studies have assessed the HRQoL of patients with DFU, and healthcare is predominantly physician-driven, with limited support from non-physician health workers. Considering this gap, we undertook the present study at a tertiary care teaching hospital in South India to evaluate the impact of patient education on HRQoL in DFU patients. The growing burden of type 2 diabetes mellitus—driven by aging populations, obesity, sedentary lifestyles, and earlier onset of the disease—further emphasizes the need to address duration-dependent complications such as DFU through effective education and preventive strategies (5,6).



Figure 1: Stages of Diabetic foot ulcer

Diabetic foot disease encompasses neuropathy, PAD, infection, ulceration, and related complications, with foot ulcers being the most severe. Ulceration arises mainly from neuropathy, foot deformities, and abnormal pressure, often worsened by minor trauma or ill-fitting footwear. Callus formation and continued ambulation on an insensitive foot further delay healing, making DFUs a major cause of morbidity, reduced quality of life, and economic burden (7).

Evaluation of pedal circulation is a crucial step in the assessment of patients at risk of peripheral arterial disease (PAD). The initial clinical approach involves determining whether at least one palpable pedal pulse is present or if there is evidence of diminished circulation. To supplement the physical examination, arterial pedal waveforms can be assessed using a handheld Doppler device, alongside measurements of ankle and toe pressures. These values are then used to calculate the ankle-brachial index (ABI) and the toe-brachial index (TBI), as detailed in Appendix B (8,9).

A lower probability of PAD is suggested when pedal Doppler waveforms are triphasic or biphasic, the ABI falls between 0.9 and 1.3, and the TBI is ≥ 0.70 . In selected clinical scenarios, transcutaneous oxygen pressure (TcPO₂) measurements may provide additional insight into tissue perfusion (10).

The degree of perfusion deficit is a key factor in estimating the likelihood of wound healing versus the risk of amputation. However, more accurate prognostic information is obtained when perfusion data are combined with wound depth and the severity of foot infection, as incorporated into the WIfI (Wound, Ischemia, and foot Infection) classification system (11).

Aggregation-Induced Synthesis (AIS) represents an emerging strategy in asymmetric synthesis that leverages the unique properties of chiral aggregates to achieve stereoselective transformations. Recent studies demonstrate that controlling aggregation conditions—such as solvent composition, concentration, and temperature—can directly influence the stereochemical outcome, providing a versatile tool for chemists in both academic and industrial settings (12).

Decision-making regarding the stand-down of Medical Emergency Teams (METs) is critical to ensure efficient resource utilization and patient safety in acute care settings. Despite the importance of timely MET stand-downs, there is limited guidance on standardized criteria, leading to variability in clinical practice. This study employed a Delphi methodology to gather expert consensus on the factors and processes guiding MET stand-down decisions(13,14).

METHODS AND METHODOLOGY

This observational study was conducted in the Department of General Surgery at Mahatma Gandhi Medical College and Research Institute (MGMCRI), Puducherry, India, over a six-month period from January 2024 to June 2024. The study population comprised 50 patients with diabetes mellitus who presented with foot ulcers and were aged 20 years or older. Patients attending the General Surgery outpatient department during the study period were screened for eligibility. Those who met the inclusion criteria and provided written informed consent were enrolled in the study. Individuals with non-diabetic foot ulcers or those unwilling to participate were excluded.

Data were collected using a structured proforma that captured detailed demographic and clinical information. Demographic variables included age, sex, duration of diabetes, and presence of comorbidities. Clinical characteristics of the ulcers, such as anatomical site, size, depth, duration, and infection status, were meticulously documented. Ulcer severity was graded according to Wagner's classification system.

Peripheral arterial disease (PAD) was assessed through clinical examination of pedal pulses and measurement of the ankle-brachial index (ABI), while peripheral neuropathy was evaluated using a 10 g Semmes-Weinstein monofilament test in combination with a 128 Hz tuning fork. Evidence of infection was determined based on clinical signs, and wound culture reports were obtained when necessary to confirm microbial involvement.

All participants received structured education on diabetic foot care. This included guidance on daily self-inspection of the feet, maintenance of proper hygiene, selection of appropriate footwear, and early recognition of warning signs that may indicate worsening of the ulcer. Patient adherence to foot care practices and follow-up visits was systematically recorded throughout the study period.

The primary outcomes assessed were the proportion of patients achieving complete healing, partial healing, or requiring amputation. Secondary outcomes included identification of risk factors influencing ulcer healing and evaluation of changes in patient knowledge and foot care practices following the educational intervention.

STATISTICAL ANALYSIS

All collected data were entered into Microsoft Excel and analysed using descriptive statistical methods. Each participant's demographic and clinical details were coded and compiled for analysis. Categorical variables such as sex, comorbidities, Wagner's grade, infection status, vascular and neuropathy findings, and healing outcomes were expressed as frequencies and percentages to describe their distribution. Continuous variables such as age, duration of diabetes, ulcer size, and ankle-brachial index (ABI) values were calculated as mean $\pm$ standard deviation (SD) to summarize central tendency and variation. Data were displayed in the form of tables, bar charts, and pie diagrams for clear visual presentation and easy interpretation.

RESULT

The distribution of diabetic foot ulcers among the study participants, as illustrated in Figure 1, reveals that the majority of cases were classified as Wagner grade II (37%), followed by grade III (27%), grade IV (24%), grade I (11%), and grade V (1%). This suggests that most patients presented with advanced stages of ulceration, emphasizing the need for early detection and intervention to prevent progression and related complications.

DISTRIBUTION OF DIABETIC FOOT ULCER

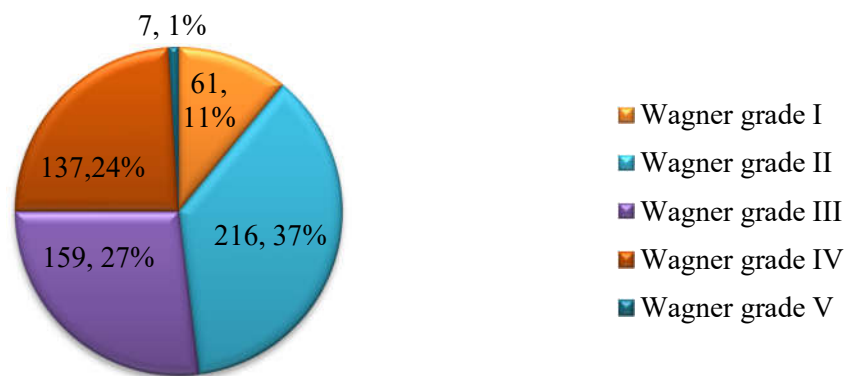


Figure 2: Distribution of Diabetic foot ulcer

The age-wise distribution of patients with diabetic foot ulcer showed that the maximum incidence occurred in the age group of 46–55 years (36%), followed by 56–70 years (28%) and 36–45 years (24%). A relatively lower incidence was noted in the age groups 71–80 years (20%) and 26–35 years (12%). Thus, middle-aged adults, particularly those between 46–55 years, were found to be at the highest risk of developing diabetic foot ulcers.

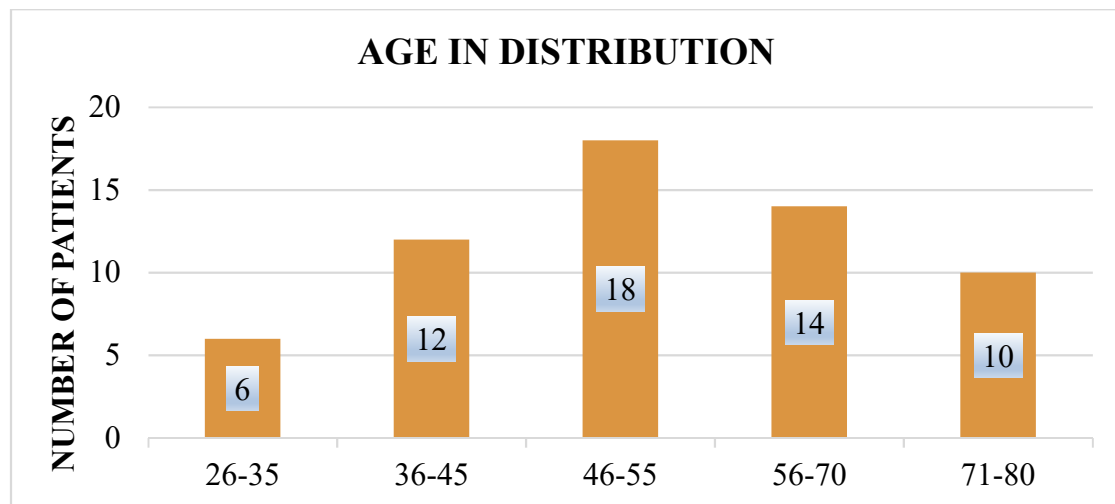


Figure 3: Distribution of Diabetic foot ulcer patients according to age incidence

The gender-wise distribution of patients revealed that the incidence of diabetic foot ulcers was markedly higher among males (66.7%) compared to females (33.3%). Out of the total sample, 40 were male and 20 were female. This indicates that male patients are more predisposed to diabetic foot complications, possibly due to higher prevalence of risk factors such as prolonged outdoor activity, barefoot walking, and occupational exposure.

GENDER DISTRIBUTION

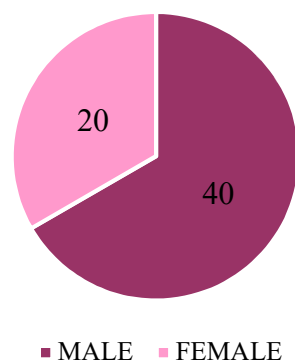


Figure 4: Distribution of Diabetic foot ulcer patients according to gender incidence

The barriers faced by patients in adopting preventive foot care practices were analyzed. The most frequently reported barrier was poor communication between patients and nurses (56.8%), followed by lack of knowledge regarding what to do (50.6%) and inconveniency for work (44.4%). Other significant barriers included lack of motivation/negligence (19.1%), perception that it was not important (19.7%), and barefoot walking as a common social practice (14.2%). Financial constraints such as the inability to afford shoes (9.2%), and physical limitations like not being able to see well (5.5%) or not being able to reach the foot (3.7%), were also noted. A smaller proportion cited lack of family support (6.8%) and other reasons (6.8%).

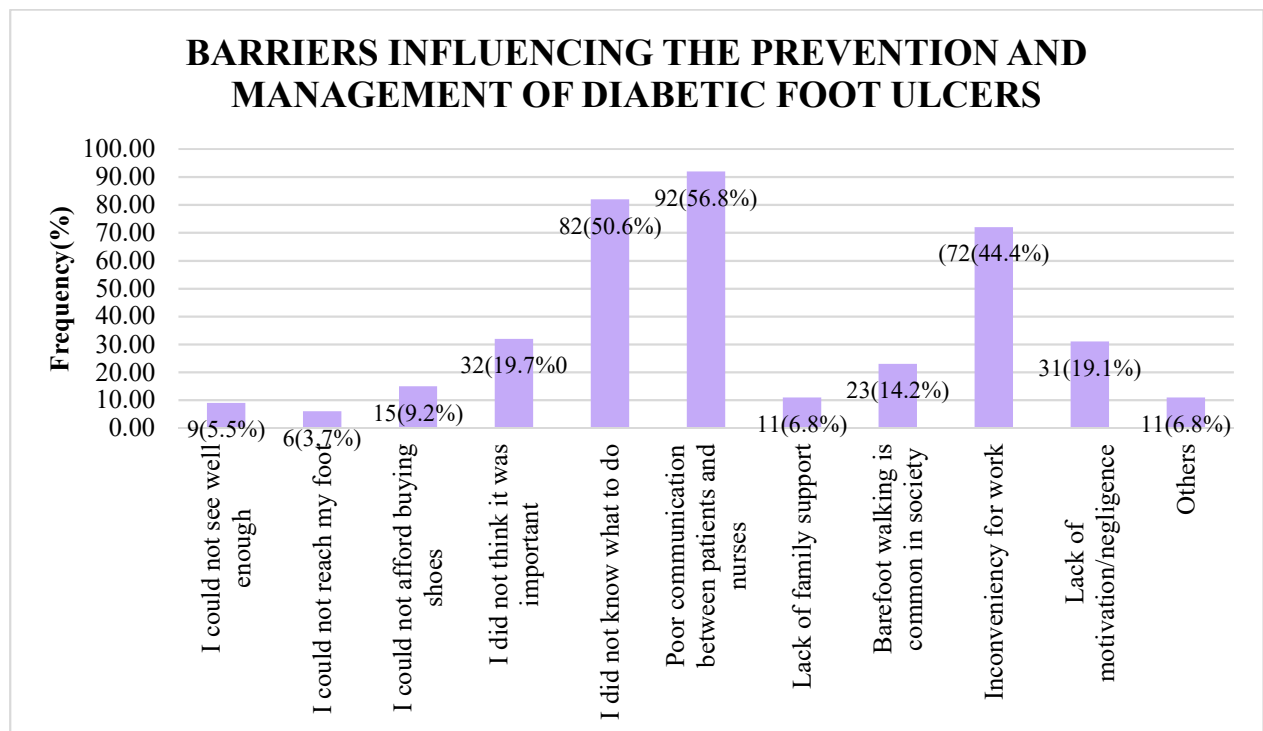


Figure: 5 – Barriers influencing the prevention and management of diabetic foot ulcers

With regard to treatment outcomes, it was observed that only 27.27% of patients achieved complete cure, while the majority (63.36%) showed partial healing but discontinued treatment before completion. A smaller proportion (9.09%) required toe amputation due to severe progression of the ulcer. This highlights that although partial improvement is possible with initial management, non-compliance and premature discontinuation of therapy contribute significantly to poor long-term outcomes.

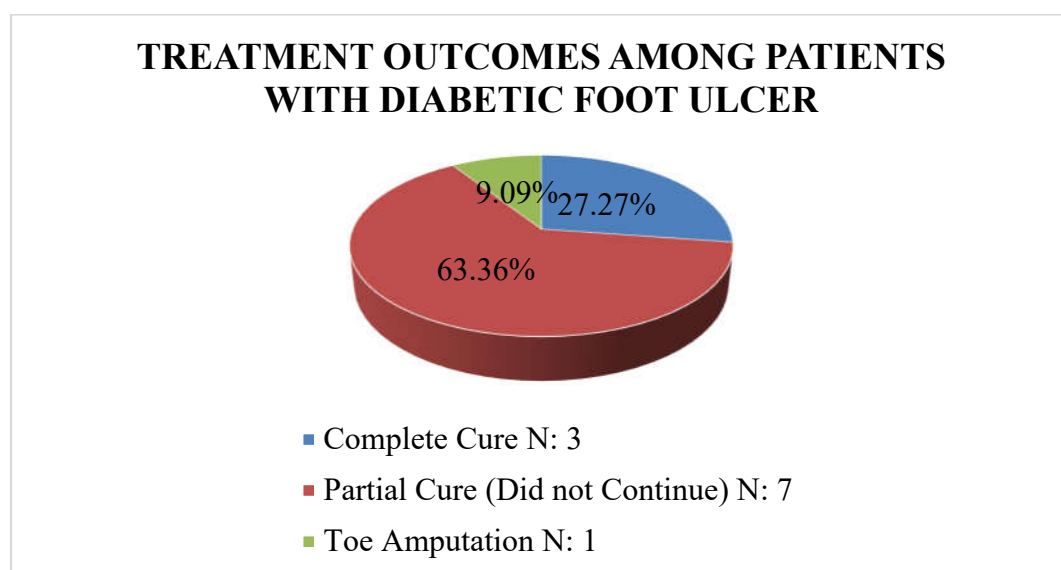


Figure: 6 – Treatment outcomes among patients with diabetic foot ulcer

DISCUSSION

In this study, the highest incidence of diabetic foot ulcers was observed in the 46–55 year age group, followed by 56–70 years. This suggests that middle-aged adults are more vulnerable due to the longer duration of diabetes and accumulation of vascular and neuropathic complications. Similar findings were reported by Armstrong et al., who noted that the risk of ulceration increases with age and disease duration. Interestingly, the incidence was lower in those aged 71–80 years, which may reflect reduced mobility or smaller representation of elderly patients in the study .

Gender distribution showed a male predominance, with two-thirds of cases occurring in men. Comparable results were observed in earlier studies, which attributed this pattern to occupational exposure, barefoot walking, and delayed health-seeking behavior among males. These findings reinforce the importance of gender-focused education and preventive strategies. The analysis of barriers to preventive foot care revealed that poor communication between patients and nurses (56.8%) and lack of knowledge (50.6%) were the most significant challenges. Work-related inconvenience (44.4%) and barefoot walking as a social norm (14.2%) were also important contributing factors. These observations align with Seid, who highlighted communication gaps and cultural practices as major obstacles to effective foot care. Interventions focusing on patient education, counseling, and community-based awareness could therefore significantly reduce the risk of complications (5).

Da Silva J et al., (2021) reported that diabetic foot ulcers (DFUs) are often complicated by drug-resistant infections and poor healing. Bioactive antimicrobial peptides (AMPs) show promise as alternatives to antibiotics due to their broad antimicrobial, anti-biofilm, and immunomodulatory actions. They also promote angiogenesis and tissue repair, aiding wound closure. While issues like stability, toxicity, and production cost remain, AMPs are emerging as potential therapeutic agents for infected DFUs (12).

Choosing the right wound dressing is essential for optimal healing, as different wounds require different approaches. Dressings are selected based on wound type, depth, exudate level, infection risk, and healing stage. For example, hydrocolloids and hydrogels are suited for dry wounds to maintain moisture, foam dressings manage moderate to heavy exudates, alginates are ideal for bleeding or highly exudative wounds, and antimicrobial dressings (silver, honey) help control infection by Shi C, Wang C et al., (2020) (7). Transparent films aid in superficial wounds, while composite dressings combine multiple functions. The goal is to create a moist, protected environment that promotes healing, prevents infection, and reduces patient discomfort. Herruzo R et al., (2023) found that the synergistic use of two hypochlorous acid formulations in 346 chronic ulcers enhanced antimicrobial action, disrupted biofilms, and significantly accelerated wound healing (2).

With respect to treatment outcomes, only 27.27% of patients achieved complete cure, while 63.36% discontinued after partial healing, and 9.09% required toe amputation. This reflects poor adherence to long-term therapy and is consistent with Kirwan J et al., (2023) who reported low quality of life and high discontinuation rates among DFU patients. The high rate of non-compliance in this study highlights the need for improved follow-up systems, psychosocial support, and affordable resources such as footwear and dressings to enhance adherence .

Systematic review demonstrated that the introduction of a multidisciplinary team care model led to a decrease in major amputations in 94% (31 out of 33) studies. There are numerous factors playing a role in the formation of diabetic foot ulcers. The two most significant risk

factors are peripheral neuropathy (sensory, motor and autonomic) and peripheral vascular disease (PVD). Trauma is also an important role in ulcer development; the most frequent cause in Western nations is poorly fitting shoes. Motor neuropathy causes structural modifications in the form of the foot and thus most normal shoes are inappropriate for diabetic patients. Sensory neuropathy diminishes the patient's sensory perception and therefore the patient does not even realize that the shoe is a poor fit and pressure injuries ensue (6).

Overall, these findings emphasize that prevention and management of diabetic foot ulcers must be multidisciplinary, involving early screening for neuropathy and peripheral artery disease, patient education on daily foot care, and interventions tailored to cultural practices. A multidisciplinary team approach, as recommended by Reardon, remains central to reducing recurrence, amputations, and improving quality of life. Future research should assess the long-term impact of structured education and counseling on adherence and recurrence rates in Indian patients.

CONCLUSION

This study highlights that diabetic foot ulcers are more prevalent in middle-aged adults, particularly those between 46–55 years, with males being disproportionately affected. Poor communication between patients and healthcare providers, lack of awareness, and work-related inconvenience were identified as the major barriers to preventive care. Treatment outcomes revealed a significant proportion of patients discontinuing therapy after partial healing, with a smaller group progressing to amputation, emphasizing the challenges of adherence.

The findings underscore the importance of a multidisciplinary approach that combines early detection, structured patient education, and culturally sensitive interventions to address modifiable risk factors. Ensuring affordable access to footwear, improving patient–provider communication, and strengthening follow-up services are essential to reduce recurrence and amputation rates. Future studies should evaluate the long-term effects of patient education and adherence strategies in Indian populations to further improve quality of life and clinical outcomes in patients with diabetic foot ulcers.

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