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Diabetic Foot Ulcer Etiopathogenesis And Various Treatment Modalities A Prospective Study

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ABSTRACT

Background: Diabetic foot is a serious complication of diabetes which aggravates the patient's condition and also having significant socioeconomic impact.
Aim: The aim of this study is to summarize the causes and pathogenetic mechanisms leading to diabetic foot, and to focus on the management of this important health issue. Increasing physicians' awareness and hence their ability to identify the ''foot at risk,'' along with proper foot care, may prevent diabetic foot ulceration and thus reduce the risk of amputation.
Method: A total of 63 diabetic patients with foot ulcers were included in this prospective observational study conducted at Government Medical college Jammu over a period of 12 months. Diabetic patients with new foot ulcers presenting during a 12-month period had demographics and ulcer characteristics recorded at presentation. Ulcers were followed-up until an outcome was noted.
Results: The majority of ulcers were neuropathic (66.0%) and present on the forefoot (77.8%) with a median (interquartile range) area of 1.5 (0.6±4.0) cm2. Amputations were performed for 7% of ulcers; 65% healed; 16% remained unhealed and 2% of patients died. The median (95% confidence interval) time to healing was 10 (8.8±11.6) weeks. Ulcer area at presentation was greater in the amputation group compared to healed ulcers (3.9 vs. 1.2 cm^2 , $P < 0.0001$). Ulcer area correlated with healing time ($rs = 0.27$, $P < 0.0001$) and predicted healing ($P = 0.04$).
Conclusions: Ulcer area, a measure of ulcer size, predicts the outcome of foot ulcers. Its inclusion into a diabetic wound classification system will make that system a better predictor of outcome.

Keywords: Diabetes Mellitus, Diabetic Foot Ulcers, Wound Healing, Management

Introduction:

Diabetic foot is one of the most significant and devastating complications of diabetes, and is defined as a foot affected by ulceration that is associated with neuropathy and/or peripheral arterial disease of the lower limb in a patient with diabetes. The prevalence of diabetic foot ulceration in the diabetic population is 4–10%; the condition is more frequent in older patients. It is estimated that about 6% of all patients with diabetes present with a history of foot ulceration, while the lifetime risk of diabetic patients developing this complication is 15%. The majority (70–80%) of foot ulcers will heal, while 10–15% of them will remain active, and 5–24% of them will finally lead to limb amputation within a period of 6–18months after the first evaluation. Neuropathic wounds are more likely to heal over a period of 30 weeks, while neuroischemic ulcers take longer and more often lead to limb amputation. It has been found that 40–70% of all non traumatic amputations of the lower limbs occur in patients with diabetes. Furthermore, many studies have reported that foot ulcers precede approximately 85% of all amputations performed in diabetic patients [1].
The most significant risk factors for foot ulceration are diabetic neuropathy, peripheral arterial disease, and consequent traumas of the foot. Diabetic neuropathy is the common factor in almost 86% of diabetic foot ulcers [2,3].
Some studies have shown that foot ulceration is more common in men with diabetes than in women [4,5]. The risk of foot ulceration and limb amputation increases with age and the duration of diabetes [6,7]. The prevention of diabetic foot is crucial, considering the negative impact on a patient's quality of life and the associated economic burden on the healthcare system [8].
The gold standard for diabetic foot ulcer treatment includes debridement of the wound, management of any infection, revascularization procedures when indicated, and off-loading of the ulcer. Other methods have also been suggested to be beneficial as add-on therapies, such as hyperbaric oxygen therapy, use of advanced wound care products, and negative pressure wound therapy (NPWT). However, data so far have not provided adequate evidence of the efficacy and cost-effectiveness of these add-on treatment methods. Debridement should be carried out in all chronic wounds to remove

surface debris and necrotic tissues. It improves healing by promoting the production of granulation tissue and can be achieved surgically, enzymatically, biologically, and through autolysis.
Negative-pressure wound therapy (NPWT) has emerged as a new treatment for diabetic foot ulcers. It involves the use of intermittent or continuous sub atmospheric pressure through a special pump (vacuum-assisted closure) connected to a resilient open-celled foam surface dressing covered with an adhesive drape to maintain a closed environment. The pump is connected to a canister to collect wound discharge and exudates. Experimental data suggest that NPWT optimizes blood flow, decreases tissue edema, and removes exudates, pro inflammatory cytokines, and bacteria from the wound area [9]. It should be performed after debridement and continued until the formation of healthy granulation tissue at the surface of the ulcer.

Methods

This prospective observational study was conducted at Government Medical College Jammu on diabetic patients with new foot ulcers presenting during a 12-month period. This study was done from from first November 2021 to 31 October 2023.
At presentation, each patient's age, sex and type and duration of diabetes, as well as ulcer site, were recorded. After wound debridement, the area of each ulcer was measured using a wound-mapping chart (3M Health Care Ltd, Loughborough, UK). A diagnosis of wound infection was made if there was purulent discharge and/or two local signs (warmth, erythema, lymphangitis, lymphadenopathy, oedema and pain). Depth was assessed semi quantitatively using the University of Texas wound classification system. The ability to probe to bone, with the presence of local or systemic infection and suggestive radiological features were used to make a diagnosis of osteomyelitis. The diagnosis of lower extremity vascular insufficiency was made if both pedal pulses of the involved foot were absent and/or the ankle–brachial pressure index was less than 0.9. The presence of sensory neuropathy was assessed to measure vibration perception threshold (VPT) at the tip of the great toe and the simplified Neuropathy Disability Score. The diagnosis of clinically significant neuropathy was made if the VPT was more than 25 V and/or the Neuropathy Disability Score was more than 6/10. Ulcers were termed 'neuropathic' if there was evidence of significant neuropathy and no vascular insufficiency, and termed 'neuroischemic' if there was simultaneous evidence of neuropathy and vascular insufficiency.
As part of our normal practice, patients were initially seen on a weekly basis for regular ulcer care: wound debridement, dressing and pressure relief. Clinically infected ulcers were treated with appropriate antibiotics. Osteomyelitis was also treated with oral antibiotics for a minimum of 8 weeks. Patients with clinical evidence of lower extremity ischemia had noninvasive vascular studies and were seen by the vascular surgeons if there was evidence of critical ischemia or gangrene. Amputations were performed for nonhealing, gangrenous ulcers, to a level of adequate blood supply. Ulcers were followed-up at 1- month. 3-month ,6 -months or until the end of the study period (12 months). Once an ulcer had healed or a lower limb amputation was performed the outcome was noted and the patient was deemed to have completed the study.

Data analysis and Statistical methods:
All information from study proforma entered in Microsoft excel sheet to prepare master chart and subjected to statistical analysis. Linear variables described as mean and standard deviation and analyzed by using unpaired „t" test and one-way Anova test. Nominal / categorical variables expressed as proportions (%) and analyzed by using Chi-square test / Fisher exact test. Ordinal variables summarized as frequency and percentage. P value < 0.05 taken as significant.Medcalc 16.4 version software used for all statistical calculations.

Results:

A total of 63 patients with new foot ulcers presented over a 12 month period at our institute. The group comprised 39 males and 24 females, and 51 patients had Type 2 diabetes. The mean (± SD) age and duration of diabetes was 55.76± 11.7. Of the 63 ulcers, 71.51% were neuropathic, 22.67% neuroischemic, 2.2% ischemic and 6.12% had no identified underlying factors [Table 1].

Table 1: Patient demographics and ulcer characteristics

Variables	**% (Mean±SD)**
Age	**59.9±14.8**
Male/female	**39/24**
Type 2 diabetes (%)	**82.6**
Neuropathic ulcers	**71.51**
Neuroischemic	**22.67**
Ischemic	**2.2**
No identified underlying factors	**6.12**

Most ulcers (74%) were superficial, while 16% penetrated to tendon and 16% penetrated to bone. Additionally, 38% of all ulcers showed clinical evidence of infection at presentation [Table 2].

Table 2: Ulcer characteristics among the study population

Ulcer characteristics	%
Superficial	74
penetrated to tendon	16
penetrated to bone	16
Infection at presentation	38

With regard to management, 31 (49.20%) patients managed with conservative management by wound debridement, 12 (19.04%) patients with skin grafting and 16 (9.52%) patients had amputation and remaining 5 (7.93) patients managed with Negative-pressure wound therapy [Fig 1].

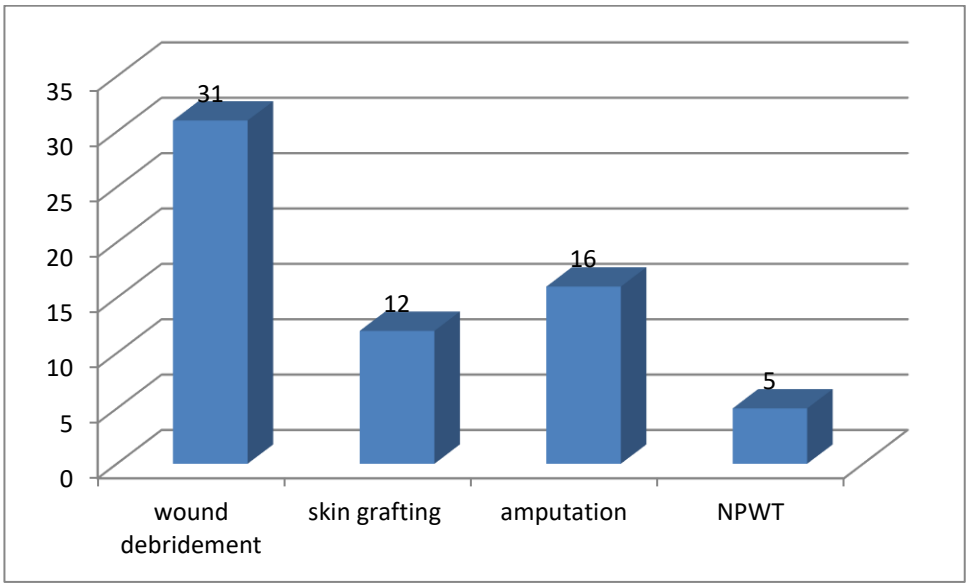

Fig 1

The outcome of each of the 63 ulcers was noted after a minimum follow-up period of 6 months. At study termination, 65% of ulcers had healed completely, 16% remained unhealed, 3.5% of ulcers were lost through patient death. More than 70% of amputations were minor (distal to the mid-foot). The median (95% confidence interval (CI)) time taken for ulcers to heal was 10 (8.4–11.6) weeks [Fig 2].

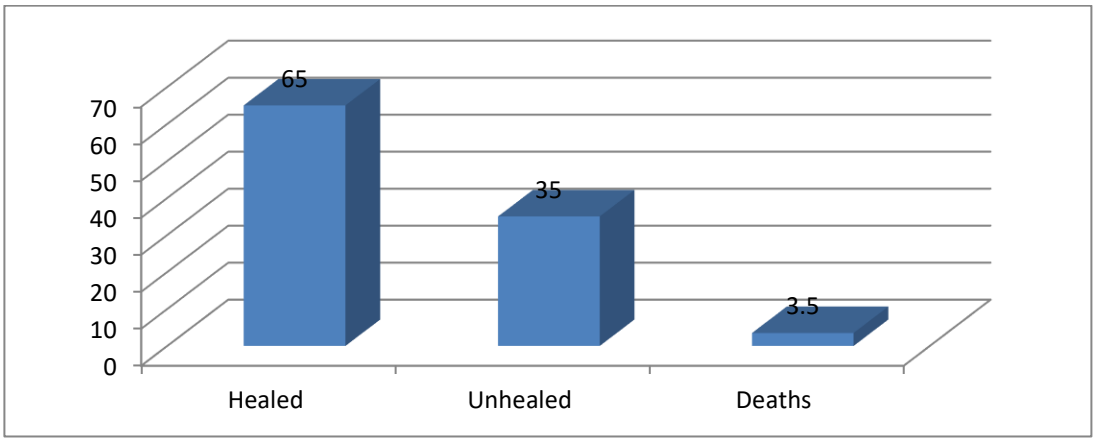

Fig 2

Fig 1a. Dressing after amputation

Fig 2b.

Discussion:

Diabetic foot ulcer is very common complication in diabetic patients and important cause of morbidity to patient. Beckert et al in a prospective study of 1000 patients with diabetic foot ulcers, proposed a clinical severity scoring system, diabetic ulcer severity score (DUSS). [10] In our study of 63 patients with diabetic foot ulcer, 39 (61.90%) were male while 24 (38.09%) were female i.e., the majority of patients were male.

Beckert et al studied 1000 patients and found that 675 (67.5%) were male and 325 (32.5%) were female. [10] There were 81% male and 19% female in a study conducted by Kumar et al, 68% male and 32% female in Sharma et al and Shashikala et al. [11-13] In this study, majority of patients with duration of diabetes mellitus less than 10 years were in score 0, 1 and 2, same was found in a study conducted by Kummankandah., et al. [14]

Wound depth and the presence of infection and neuroischemia also affected outcome. However, only ulcer area and ischemia at presentation predicted healing within the study period. The largest ulcers were the deepest and most infected at presentation. Ulcers passed through different stages of deterioration and improvement in terms of depth and the presence of infection before finally reaching an endpoint. These important confounding factors may have altered or underestimated the predictive power of area at presentation on outcome.

Age had no effect on healing time or the number of amputations, but patients who died during this study were significantly older compared to those that survived. These patients died of co-existing disease, e.g. ischaemic heart disease, chronic obstructive airway disease and strokes, but one elderly patient did die from severe septicemia related to her infected foot ulcer. The deleterious effects of foot ulcers, wound infection and osteomyelitis on morbidity and mortality in diabetic patients have previously been published [15,16-18]. The excess mortality seen in the older age group may be a result of the presence of co-existing diseases and not the patient's age. This interesting finding requires further investigation.

The duration of diabetes prior to presentation had no effect on the outcome of diabetic foot ulcers. Previous studies have demonstrated the inhibitory effects of diabetes on wound healing [19-23] but the duration of diabetes independently may not be as important as overall blood glucose control (which was not looked at in this study). As expected there were fewer Type 1 diabetic patients in this study, but the type of diabetes had no effect on number of amputations or ulcer healing time.

Ulcer site (forefoot, mid-foot or hind-foot) had no effect on ulcer healing time or the likelihood of an ulcer leading to an amputation. A previous study has shown that ulcer depth is more important than ulcer site [24] in an ulcer classification system. Negative-pressure wound therapy (NPWT) has emerged as a new treatment for diabetic foot ulcers. In our study 5 (7.93) patients were managed with Negative-pressure wound therapy. It involves the use of intermittent or continuous sub atmospheric pressure through a special pump (vacuum-assisted closure) connected to a resilient open-celled foam surface dressing covered with an adhesive drape to maintain a closed environment. The pump is connected to a canister to collect wound discharge and exudate. Experimental data suggest that NPWT optimizes blood flow, decreases tissue edema, and removes exudate, proinflammatory cytokines, and bacteria from the wound area [25]. It should be performed after debridement and continued until the formation of healthy granulation tissue at the surface of the ulcer. Currently, NPWT is indicated for complex diabetic foot wounds [25]; however, it is contraindicated for patients with an active bleeding ulcer. Two small studies [26,27] and one larger study [28] provide some encouraging data concerning the possible benefit of NPWT in the healing rate and time of diabetic foot ulcers. However, more randomized trials are needed in order to confirm these results.

Conflict of interest: Nil

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