Clinics in Surgery

Research Article
Published: 25 Apr, 2017

Direct Inflicting Causes of Diabetic Foot Ulcer & the Initial Action of Patient & Health Provider

*Siddig Ad-DawAlshareef[1] and Mohamed Elmakki Ahmed[1,2]**

[1]Department of Surgery, Jabir Abu Eliz Diabetic Centre, Khartoum, Sudan

[2]Department of Surgery, University of Khartoum, Sudan

Abstract

Background: The role of neuropathy and angiopathy in the causation of the diabetic foot are well established. The purpose of this study is to investigate the effects of direct precipitating causes of diabetic foot ulcer and the initial action of patient and primary health provider on outcome of DFU.

Patients and Method: This prospective study was conducted in Jabir Abu Eliz Diabetic Centre (JADC), Khartoum, Sudan. Recorded data included patient's demographics, DFU direct inflicting cause, initial behaviour of the patient, information related to the 1st health provider, and outcomes.

Results: A total of 134 patients who had diabetic foot ulcer (DFU) were included. The mean age of the studied patients was 56.78 ± SD 10.2 years with a male to female ratio (4.6: 1). The mean duration of DFU was 36 ± SD 97 days. Neuropathy and angiopathy were reported in 76.9% and 25.3% of patients respectively. Grade of infection was significantly associated with foot self-examination (p=0.006), and duration of DFU (p=0.032). The common direct causes of foot ulcer were blister (28.4%), penetrating injuries / sharp injuries (23.1%), and unidentified causes (22.4%). Outcome of ulcer was significantly associated with direct precipitating causes of DFU (p=0.033), level of 1st health provider (p=0.000), and the action of 1st health provider (p=0.007). Major lower limb amputation and chronic ulcers were encountered in ulcers precipitated with ill-fitting shoes/socks or penetrating / sharp injuries, seen by physicians, and treated with antibiotics after sever sepsis.

Conclusion: The most direct precipitating causes of DFU are avoidable. Presentation of DFU is affected with patient behaviour and delay in presentation to JADC. We recommend developing a community intervention programme to increase the awareness among diabetic patients and encourage earlier multidisciplinary team assessment to reduce disparities and improve foot outcomes in patients with diabetes.

Keywords: Diabetic foot ulcer; Inflicting causes; Major lower limb amputation

OPEN ACCESS

Correspondence:
Mohamed El Makki Ahmed, Department of Surgery, Jabir Abu Eliz Diabetic Centre, Khartoum, Sudan, E-mail: rasheid@usa.net

Received Date: *25 Jan 2017*
Accepted Date: *18 Apr 2017*
Published Date: *25 Apr 2017*

Citation:
Ad-DawAlshareef S, Ahmed ME. Direct Inflicting Causes of Diabetic Foot Ulcer & the Initial Action of Patient & Health Provider. Clin Surg. 2017; 2: 1432.

Introduction

Foot ulcers rarely result from a single pathology; instead many overlapping factors lead to foot ulceration. They put the foot at risk, precipitate a break in the skin, or impair healing [1-4]. Those factors that put the foot at risk like peripheral neuropathy, peripheral vascular disease, limited joint mobility, and deformity are well-studied [1,3,5-8]. On the other hand little is known about the exact precipitating factors and their impact on the presentation and outcome of the DFU.

There have been few studies of psychosocial factors in the pathway to ulcers and the impact of the patient behaviour on the presentation and outcome of the DFU Vileikyte [9]. Few studies were done to evaluate if the level of, and the initial management modality undertaken by the first health-care professional will affect the presentation and outcome of the DFU.

The vast majority of diabetic foot ulcers were attributed to inadequate footwear in the western communities [10-12]. In Africa the nature of the precipitating causes of the DFU were undefined most of times [11,13]. Widatallaand his colleagues in 2009 reported no inflicting cause were identified in the majority of the patients in Sudan [14]. Studies from USA and UK indicate that 39–76 percent of amputations were similarly initiated by ill-fitting footwear [15,16]. The relation between the precipitating factors of the diabetic foot ulcer and outcome needs to be clarified in the developing countries.

The aim of this study was to see the effects of direct inflicting causes of the diabetic foot and the initial action of the patient and primary health provider on outcome of DFU.

Table 1: Grading of infection at presentation in study group (n=134).

Grades	Wagner classification	SSS classification
Grade 1	16 (11.9 %)	18 (13.4%)
Grade 2	49 (36.6 %)	56 (41.8%)
Grade 3	46 (34.3%)	55 (41%)
Grade 4	21 (15.7%)	5 (3.7%)
Grade 5	2 (1.5%)	—
Total	134	134

Table 2: Precipitating causes of diabetic foot ulcer in study group (n=134).

Cause	Frequency	Percent
Undefined cause	30	22.4
Blister	38	28.4
Penetrating injuries/Sharp injuries	31	23.1
Ill-fitting shoes/socks	22	16.4
Thermal injury	4	3.1
Paronychia	1	0.7
acute mechanical trauma	5	3.7
Others	3	2.2
Total	134	100.0

Patients and Methods

This was a prospective study done among patients with DF attending Jabir Abu Eliz Diabetic Centre (JADC) Khartoum, between April 2013 and April 2014. JADC is a multidisciplinary polyclinic established in1998. The center offers outpatient medical, surgical, ophthalmic, dermatological and dental care with supportive services in prophylactic foot screening, offloading and shoe-making factory. The centre receives 300- 350 patients with diabetes daily, of whom about 150 patients with diabetic foot with an average of 10 -20 new cases with diabetic foot seen daily.

143 patients with DF attending JADC were studied. Treatment included surgical, debridement and removal of callus and necrotic tissue, antibiotics given empirically and later on culture and sensitivity and off-loading as required. Patients with clinical evidence of ischemia were seen by the vascular surgeon.

The degree of infection was assessed using the Wagner classification and System Staging System classification [17,18]. Somatic sensory neuropathy was assessed by the 10g (Semmes–Weinstein) monofilament and a 128 Hz tune fork insensitivity at hallux [19,20]. Ankle-brachial index (ABI) was used to assess the peripheral arterial disease (PAD) and was considered compatible with ischemia when lower than 0.9 [21].

All patients were followed as required up to 6 months. Patient's attitude towards his foot was assessed by reporting if the discovery of DFU was by the patient himself or by other person. The immediate reaction of the patient toward his/her DFU after discovery and duration from the time of injury to the presentation at JADC in Khartoum.

Statistical analysis

We used the statistical package for social sciences (IBM SPSS) for Windows version 22.0 statistical software (SPSS Inc., Chicago, IL, USA).

Chi-square tests were used to assess the association between the precipitating causes of DFU, patient behaviour, and first health-care professional variables and the presentation and outcome of the DFU. Another multinomial regression analysis was performed to assess which variables were independently associated with the presentation and outcome of the DFU. The statistical significance was defined as a P value < 0.05.

Results

One hundred thirty four patients with diabetic foot ulcer were included. The mean age was 56.78 ± 10.2 years. Male to female ratio was 4.6: 1.0. The majority of patients were resident in Khartoum state (61.2%) and the rest were coming from different regions. Almost half of the sample were hard labour (52.2%) and of low socio economic status (59%). More than half of patients were wearing regular footwear (n=89, 66.4%), thirty seven patients (27.6%) used special diabetic footwear, and eight patients (6%) were bear feet during the injury.

The mean duration of diabetes was 13 ± 8 years. Majority of patients (n=118, 88.1%) were Type 2 DM. 58.2% are on insulin, 39.6% on oral hypoglycaemic drugs, and 2.2% on diet. Forty eight patients had previous DFU. Twenty nine patients (60.4%) healed without amputation Thirteen patients (27.1%) healed with minor amputation, and 6 (12.5%) ended with major lower limb amputation.

According to the Wagner classification 16 patients were grade1 (11.9%), 49 patients were grade 2 (36.6 %), and 46 patients were grade 3 (34.3%).According to the simple staging system classification 18 patients were grade 1(13.4%), and 56 patients were grade 2 (41.8%) (Table 1).

One hundred and three patients (76.9%) had neuropathy as tested by 10 gram monofilament test. ABI were more than 1.3 in 16 patients (11.9%), normal 1.3–0.9 in 84 patients (62.8%), mild ischemia 0.8 in 33 patients (24.6%) and sever ischemia in one patient (0.7%).

The most common direct causes of foot ulcer were blister (28.4%), followed by penetrating injuries/sharp injuries (23.1%) (Table 2).

Wagner classification grades 1 and 2 collectively were 61.29% in ulcers precipitated with penetrating/sharp injuries, 50% in ill-fitting shoes/socks, 43.4% in undefined cause, and 42.1% in blister. There were no significance association between the grade of infection and precipitating cause of DFU (p-value = 0.860).

Healing was achieved in 92.1% of ulcers precipitated with blister and 83.8% of penetrating/sharp injuries. Chronic ulcers were mainly precipitated with penetrating/sharp injuries (12.9%) and blister (7.89%). Major lower limb amputation were mostly encountered in ulcers precipitated with ill-fitting shoes/socks (36.36%) and undefined cause (33.33%) (p=0.033) (Table 3). The majority of patients discovered their foot lesion by themselves (n= 120, 89.6%) and the rest by another member (n=14, 10.4%). Wagner classification grades 3, 4 and 5 collectively were 46.67% in patients discovered their foot lesion by themselves, and 92.9% in those discovered by other person (p-value =0.005).Major lower limb amputation was 14.17% in patients discovered their foot lesion by themselves, and 21.43% in those discovered by other person (p-value = 0.674).

One hundred and three patients (76.9%) reported to health facilities, 24 patients (17.9%) had traditional treatment, and 7 patients (5.2%) did not seeking treatment. There are no difference between

Table 3: Relationship between precipitating cause of DFU and outcome, neuropathy and ischemia.

Precipitating cause of DFU	Outcome												Total
	Healed			Major lower limb amputation			Chronic ulcer			Death			
	Frequency	N	A	Frequency	N	A	Frequency	N	A	Frequency	N	A	
Undefined cause	18(60%)	12	7	10(33.33%)	8	3	1(3.33%)	1	1	1(3.33%)	1	-	30
Blister	35(92.1%)	32	7	-	-	-	3(7.89%)	3	2	-	-	-	38
Penetrating injuries / Sharp injuries	26(83.87%)	18	4	1(3.23%)	1	-	4(12.9%)	4	-	-	-	-	31
Ill-fitting shoes/socks	12(54.55%)	9	3	8(36.36%)	4	4	1(4.54%)	1	-	1(4.54%)	-	-	22
Thermal injury	3(75%)	3	2	-	-	-	1(25%)	-	-	-	-	-	4
Paronychia	1(100%)	1	-	-	-	-	-	-	-	-	-	-	1
acute mechanical trauma	5(100%)	3	-	-	-	-	-	-	-	-	-	-	5
Others	2(66.67%)	1	1	1(33.33%)	1	-	-	-	-	-	-	-	3

N: number of patients with neuropathy in the selected group of outcome.
A: number of patients with angiopathy in the selected group of outcome.

the three groups regarding the grades of Wagner classification and outcome of DFU in the study group (p-value = 0.811). The mean duration from time of injury to presentation to JADC was 36 ± 97 days. The chances for presenting with advanced grade of infection by SSS classification were increased by 1 for every single day delay in presentation to JADC (p-value =0.022). There was statistically significant relationship between this duration and the grade of infection by Wagner classification (p-value =0.032), and SSS classification (p-value =0.003).

The level of 1st health provider was a junior doctor in 40 patients (29.9%), medical assistant/nurse in 36 patients (26.9%), surgeon specialist in 35 patients (26%), and non- surgeon specialist in 23 patients (17.2%). There are no difference between the four categories regarding the grades of Wagner classification of DFU in the study group (p-value = 0.905). Healing were achieved in 91.43% of ulcers firstly seen by surgeon specialists, 75% in junior doctors, 69.44% in medical assistants0/nurses and 65.22% in non- surgeon specialists. Major lower limb amputation were mostly encountered in patients firstly seen by junior doctors (20%), followed by non- surgeon specialists (17.39%), medical assistants/nurses (16.67%) and at last surgeon specialists (5.71%). Chronic ulcers were mainly seen by non-surgeon specialists (13.04%) and medical assistants/nurses (11.11%). The level of the 1st health provider have statistically significant relationship with the outcome and strong impact on it (p-value =0.000).

The action taken by the 1st health provider toward the DFU was surgical treatment in 87 patients (64.9%), antibiotic and supportive management in 35 patients 26.1%, and referral to a surgical specialist in 12 patients (9%). Grades 3, 4 and 5 by Wagner classification were collectively 52.87% in patients treated firstly by surgical treatment, 51.43% in antibiotic and supportive management group and 41.67% in those referred to a surgical specialist (p-value = 0.903). Healing was achieved in 82.78% of patients firstly treated by surgical treatment, 66.67% in patients referred to a surgical specialist and 62.85% in antibiotic and supportive management group. Major lower limb amputations were mostly encountered in patients treated with antibiotic and supportive management (28.57%). The effect of behaviour of health-care professional have statistically significant relationship with the outcome (p-value=0.007).

The mean duration of healing of DFU in the study group was 132 ± 115 days. Sixty four patients (47.8%) healed without amputation. Thirty eight patients (28.4%) healed with minor amputation. Twenty patients (14.8%) ended with major lower limb amputation, 10 patients (7.5 %) developed chronic ulcer, and 2 patients died (1.5 %). Both deaths were male (48 & 52 years old), Type 2 diabetes mellitus with no comorbidity. Their injury were precipitated with ill-fitting shoes/socks and undefined cause. Both had exposure to private diabetic centre and presented to JADC after more than 2 weeks from the initial injury. They died from sever sepsis.

From the above analysis of precipitating cause of DFU, behaviour of patient toward his/her DFU, level of first health-care professional, and behaviour of health-care professional we found the following:

If the DFU was precipitated by blister, discovered by the patient, the duration from time of injury to presentation to JADC < 2 weeks, the first health-care professional is surgical specialist and he treated the ulcer with surgical management this will result in healing.

If the DFU was precipitated by ill-fitting shoes/socks, discovered by other person, the duration from time of injury to presentation to JADC >2 weeks, the first health-care professional is non-surgeon specialist and he treated the ulcer with antibiotic and supportive management this will result in major lower limb amputation.

If the DFU was precipitated by penetrating/sharp injuries, the first health-care professional is non-surgeon specialist and he treated the ulcer with antibiotic and supportive management this will result in chronic ulcer regardless the duration from time of injury to presentation to JADC.

Discussion

In this prospective observational study of one hundred thirty four patients with diabetic foot ulcer were included. Patients were predominately male and had Type 2 diabetes. Male to female ratio was [4.6: 1] which is similar to other study [11,22,23]. This is because males are more prone to trauma and have less foot care.

The mean age in our study (56.7±SD10 years) is in accordance to Widatalla "et al." [24] (56.7 ± SD11 years), and to what was reported by Doumi in Western Sudan (56.8 ± SD12 years) [25]. But it is occurred in older age in UK (66.1 ± 15.1) [23].

The mean duration of diabetes was 13 ± 8 years. Morbach "et al." (11) Found a significantly long mean duration of diabetes among German (14.0 ± 10.8 years) and Indian (11.7 ± 7.1 years) patients than among Tanzanian patients (5.1 ± 4.8 years) [26]. This finding may imply the differences in the quality of diabetes care where German and Indian patients, on average have longer duration of diabetes exposure before they develop foot ulcers. This similarity to our finding may be explained by that 35.8% of patients had past history of DFU. And they presented with shorter duration of diabetes at their first DFU.

This study showed higher prevalence of neuropathy (76.9%) when compared to angiopathy (25.3%). This is similar to the reports from developing countries where ischemic disease accounts for only 20–30 % of cases [11,27-30]. In contrast, Western Europe and the USA, although reporting high prevalence of neuropathy, but show prevalence of ischemic disease usually between 40 and 50 % or more [23,31-33]. The high prevalence of obesity and consequently atherosclerotic disease as well as older mean age and possibly higher rates of smoking in the population from developed countries place diabetic individuals at higher risk for ischemic disease.

The vast majority of diabetic foot lesions (DFL) were attributed to inadequate footwear in the western communities [10-12]. In our study blisters (28.4%), penetrating injuries/sharp injuries (23.1%), unidentified causes (22.4%), and ill-fitting shoes/socks (16.4%) represent the most common direct cause of foot ulcer in this study.

In their study in, Ogbera et al from Nigeria reported similar figures where spontaneous blisters (26.5%) and unidentified causes (21.2%) were the most common precipitating factors for DFL [13]. Similarly, unidentified causes were found to represent 22% of the causes of DFL in Tanzania [11]. In a study done at JADC, Widatalla et al found no inflicting cause were identified in the majority of the patients (40.4%). Sharp injuries were reported in 17.8 % [14]. This reduction in the unidentified group may be explained by the growing prevalence of diabetes mellitus and DFU.

Our study reveals statistically significant relationship between the precipitating cause of DFU and outcome. The most favourable outcome seen in ulcers precipitated with blister (healing achieved in 92.1%) which is the first common direct cause of DFU. Blisters represent fluid filled cavities that develop usually at the sites of increased pressure and represent a closed ulcer. The high incidence of blisters in the studied population might be due to the high incidence of neural impairment, foot deformity leading to dry skin, fissuring and callosities. These blisters also may be the predisposing factors in the "unidentified group" as they represent ports of entry for bacteria leading to infection without obvious preceding agent.

Major lower limb amputation was mostly encountered in ulcers precipitated with ill-fitting shoes/socks (36.36%). This finding is in accordance to other studies that indicate that 39–76 percent of amputations were similarly initiated by ill-fitting footwear [15,16]. Chronic ulcers were mainly precipitated with penetrating/sharp injuries (12.9%). Penetrating injuries were the second most common precipitating factors. The impaired visual acuity of the diabetic population, the absence of night illumination in most of the country, the dry hot weather, and the agricultural nature of the Sudan which make open light shoes a convenient accommodation may be the main factors in its causation.

Previous studies have indicated that diabetic patients were up to 46 times more likely to have an amputation after a puncture injury compared with patients without diabetes [34-36]. Lavery et al reported that as many as 41% of puncture injuries in persons with diabetes occur while the patient is not wearing shoes [36]. This in contrast to our finding were 27 patients had penetrating/sharp injuries (83.7%) wearing regular footwear and 8 of them special diabetic footwear at the time of the injury. This finding may reflect that the special diabetic footwear available in the markets is not protective against the precipitating cause of DFU in the study group. Most of the special diabetic footwear available in the markets is designed for the western nations.

The evidence from this survey indicates that the majority of the patients discovered their foot lesion by themselves (89.6%) in spite of the high percentage of neuropathy (77.6). Both Wagner grade and major amputation were higher in those with sever neuropathy when the injury was discovered by a relative compared to those who felt the injury. This may be attributed that most of our patients are Muslims and they wash their feet as part of preparations for pray 5 times per day. Macfarlane "et al." [12], reported that about 50% of diabetic patients were unaware of their foot ulcers.

Our study revealed that the discovery of DFU by the patient is more protective against presentation with advanced grade of infection. Margolis "et al." [37] in study published in 2014 noted the minimal effect of patient foot self-examination on decreasing the rate of lower extremity amputations. A similar observation was made previously in a group of patients treated in the Veterans Administration system, USA [38,39].

This study also showed that the mean duration from time of injury to presentation to JADC was 36 ± 97 days. During this period most of patients received medical care by different health care personnel. This is in contrast to what have been reported from UK [12], where the average delay was only 4 days, and to what have been reported from Algeria [28], which was 31 days. Our study reveals significant relationship between this duration and the grades of infection. This delay may be due to lack of clear referral system in Sudan. Another reason is the majority of the sample was less educated about diabetes (regarding the importance of general foot care, the significance of diabetes and its complications), and from low socioeconomic level. Margolis "et al." [37] reported that areas with more diabetes based education reported lower rates of lower extremity amputations.

A qualitative study by Feinglass and his colleges in 2012 concluded that patients with low or marginal health literacy misunderstood the gravity of their medical history with respect to the onset of their lower extremity amputations [40].

Few studies tried to assess the behaviour of patients towards their foot lesions. This study showed that the general care of diabetic patients towards their DFL is sub-optimum. They either ignored their lesions completely or tried some local remedies mostly in the form of herbal medicines or honey. Even for those who sought medical advice for the control of their lesions, a considerable proportion went to junior doctors or medical assistants/nurses, who are generally not well-qualified in Sudan.

Different caregivers in this study provided different kinds of management to the DFU, with the surgeons being most likely on the right track. Junior doctors and medical assistants/nurses constituted 56.8% collectively of the1st health providers for the sample. This may be attributable to the lack of a national protocol to treat DFU. The most favourable outcome was achieved when patients initially seen by

surgeon specialists and referred to specialized diabetic centre.

The most unfavourable outcome percentage were seen in the category of non- surgeon specialists (34.78%) followed by medical assistants/nurses (30.56%), and junior doctors (25%). The effects of level of the 1st health provider have statistically significant relationship with the outcome and strong impact on it. These findings confirm what Ndip and his colleges in 2006 reported that physicians never examined the feet of 86% of diabetic patients [41]. However, it was Paul Brand (1914–2003) who added science to the art of foot care [42-44]. When he spoke at a US Department of Health conference and was asked to make a recommendation on reducing amputation in diabetes, most listeners expected an answer promoting vascular surgery or modern medications. They were surprised to hear that his key recommendation was a national campaign to encourage physicians to remove patients' shoes and socks and to examine the feet [42,45].

This study shows significant statistical relationship between the action taken by the 1st health provider toward the DFU and the outcome DFU. Among ulcers that healed without amputation; surgical treatment was the modality of treatment in 73.44% of all ulcers with same outcome. Also in ulcers that healed with major amputation antibiotic and supportive management was the modality of treatment in 50% of all major amputations. This finding is consistent with reports from other studies that surgical treatment is essential in healing a diabetic ulcer [46-50].

Piaggessi "et al." [51] reported that surgical treatment of neuropathic foot ulcers in diabetic patients proved to be an effective approach compared to conventional treatment in terms of healing time, complications, and relapses, and can be safely performed in an outpatient setting. Also Brem and his colleges [52] reported that antibiotics may be useful to treat superficial infections, but they are often not sufficient to heal chronic wounds and, specifically, uncomplicated diabetic neuropathic forefoot ulcers [46,53].

Healing without amputation was the most common outcome of DFL (47.8% of DFL). The percentages of patients who ended with minor amputation or major lower limb amputation were 28.4%, and 14.8% respectively. Our study reflect better outcome in comparison to what reported from Western Sudan. They reported 24.7% of patients ended with major lower limb amputation [25]. The mortality in this study was 1.5%, a much better figure than what was reported twenty eight years ago from Khartoum Teaching Hospital, where a mortality of 22.1% was reported [54]. These findings reflect the high quality of care which patients received with multidisciplinary polyclinic activities in JADC [55-60].

Chalya and his colleges in 2011 reported that a multidisciplinary team approach targeting at good glycaemic control, education on foot care and appropriate footwear, control of infection and early surgical intervention is required in order to reduce the morbidity and mortality associated with DFUs [50].

Finally in spite of the prevalence of neuropathy and angiopathy; this study showed that 77.6% of DFU were precipitated with identifiable and preventable causes. Pecoraro "et al." [5] reported that many amputations in diabetic patients were potentially preventable, and that minor trauma, neuropathy, ischemia, and infection were major contributory factors in the causal chain that ultimately resulted in amputation. Defining causal pathways that predispose to diabetic limb amputation suggests practical interventions that may be effective in preventing diabetic limb loss [61-65].

References

1. Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. Diabetes Care. 2004;27(5):1047-53.
2. Boulton AJ, Vileikyte L, Ragnarson-Tennvall G, Apelqvist J. The global burden of diabetic foot disease. Lancet. 2005;366(9498):1719-24.
3. Ahmed AM, Ahmed NH, Abdella ME. Pattern of hospital mortality among diabetic patients in Sudan. Practical Diabetes International. 2000;17(2):41–3.
4. Elbagir MN, Eltom MA, Elmahadi EM, Kadam IM, Berne C. A population-based study of the prevalence of diabetes and impaired glucose tolerance in adults in northern Sudan. Diabetes Care. 1996;19(10):1126-8.
5. Boulton AJ. Lawrence lecture. The diabetic foot: neuropathic in aetiology? Diabet Med. 1990;7(10):852-8.
6. Boulton AJ. The diabetic foot: from art to science. The 18th Camillo Golgi lecture. Diabetologia. 2004;47(8):1343-53.
7. Pryce TD. A case of perforating ulcers of both feet associated with diabetes and ataxic symptoms. Lancet. 1887;130:11–2.
8. Brem H, Sheehan P, Rosenberg HJ, Schneider JS, Boulton AJ. Evidence-based protocol for diabetic foot ulcers. Plast Reconstr Surg. 2006;117:193S-209S.
9. Singh N, Armstrong DG, Lipsky BA. Preventing foot ulcers in patients with diabetes. JAMA. 2005;293(2):217-28.
10. Mohamed IA, Ahmed AR, Ahmed ME. Amputation and prostheses in Khartoum. J R Coll Surg Edinb. 1997;42(4):248-51.
11. Oyibo SO, Abouaesha F, Connor H, Boulton AJ. The diabetic foot 2000. Diabet Med. 2000;17(12):875-6.
12. Bakker K, Gulam-Abbas Z, Ahmed ME, Foot IWGot D. Diabetes and foot care: time to act: IDF Communications; 2005.
13. Reiber GE, Vileikyte L, Boyko EJ, del Aguila M, Smith DG, Lavery LA, et al. Causal pathways for incident lower-extremity ulcers in patients with diabetes from two settings. Diabetes Care. 1999;22(1):157-62.
14. Adler AI, Boyko EJ, Ahroni JH, Smith DG. Lower-extremity amputation in diabetes. The independent effects of peripheral vascular disease, sensory neuropathy, and foot ulcers. Diabetes Care. 1999;22(7):1029-35.
15. Mueller MJ, Hastings M, Commean PK, Smith KE, Pilgram TK, Robertson D, et al. Forefoot structural predictors of plantar pressures during walking in people with diabetes and peripheral neuropathy. J Biomech. 2003;36(7):1009-17.
16. Jeffcoate WJ, Harding KG. Diabetic foot ulcers. Lancet. 2003;361(9368):1545-51.
17. Pecoraro RE, Reiber GE, Burgess EM. Pathways to diabetic limb amputation. Basis for prevention. Diabetes Care. 1990;13(5):513-21.
18. Sanders LJ. Diabetes mellitus. Prevention of amputation. J Am Podiatr Med Assoc. 1994;84(7):322-8.
19. Young MJ, Breddy JL, Veves A, Boulton AJ. The prediction of diabetic neuropathic foot ulceration using vibration perception thresholds. A prospective study. Diabetes Care. 1994;17(6):557-60.
20. Zimny S, Schatz H, Pfohl M. The role of limited joint mobility in diabetic patients with an at-risk foot. Diabetes Care. 2004;27(4):942-6.
21. Vileikyte L, Rubin RR, Leventhal H. Psychological aspects of diabetic neuropathic foot complications: an overview. Diabetes Metab Res Rev. 2004;20:S13-8.
22. Singh N, Armstrong DG, Lipsky BA. Preventing foot ulcers in patients with diabetes. JAMA. 2005;293(2):217-28.

23. Morbach S, Lutale JK, Viswanathan V, Möllenberg J, Ochs HR, Rajashekar S, et al. Regional differences in risk factors and clinical presentation of diabetic foot lesions. Diabet Med. 2004;21(1):91-5.

24. Macfarlane RM, Jeffcoate WJ. Factors contributing to the presentation of diabetic foot ulcers. Diabet Med. 1997;14(10):867-70.

25. Ogbera OA, Osa E, Edo A, Chukwum E. Common clinical features of diabetic foot ulcers: perspectives from a developing nation. Int J Low Extrem Wounds. 2008;7(2):93-8.

26. Widatalla AH, Mahadi SE, Shawer MA, Elsayem HA, Ahmed ME. Implementation of diabetic foot ulcer classification system for research purposes to predict lower extremity amputation. Int J Diabetes Dev Ctries. 2009;29(1):1-5.

27. Reiber GE. Who is at risk of limb loss and what to do about it? J Rehabil Res Dev. 1994;31(4):357-62.

28. Edmonds ME, Blundell MP, Morris ME, Thomas EM, Cotton LT, Watkins PJ. Improved survival of the diabetic foot: the role of a specialized foot clinic. Q J Med. 1986;60(232):763-71.

29. Schaper NC, Apelqvist J, Bakker K. The international consensus and practical guidelines on the management and prevention of the diabetic foot. Curr Diab Rep. 2003;3(6):475-9.

30. Wagner FW Jr. The dysvascular foot: a system for diagnosis and treatment. Foot Ankle. 1981;2(2):64-122.

31. Foster A, Edmonds M. Simple Staging System: a tool for diagnosis and management. The Diabetic Foot Journal. 2000;3(2):56-62.

32. Mueller MJ. Identifying patients with diabetes mellitus who are at risk for lower-extremity complications: use of Semmes-Weinstein monofilaments. Phys Ther. 1996;76(1):68-71.

33. Snyder RJ, Kirsner RS, Warriner RA, Lavery LA, Hanft JR, Sheehan P. Consensus recommendations on advancing the standard of care for treating neuropathic foot ulcers in patients with diabetes. Ostomy Wound Manage. 2010;56:S1-24.

34. Takolander R, Rauwerda JA. The use of non-invasive vascular assessment in diabetic patients with foot lesions. Diabet Med. 1996;13:S39-42.

35. Ince P, Game FL, Jeffcoate WJ. Rate of healing of neuropathic ulcers of the foot in diabetes and its relationship to ulcer duration and ulcer area. Diabetes Care. 2007;30(3):660-3.

36. Lauterbach S, Kostev K, Kohlmann T. Prevalence of diabetic foot syndrome and its risk factors in the UK. J Wound Care. 2010;19(8):333-7.

37. Widatalla AH, Mahadi SE, Shawer MA, Mahmoud SM, Abdelmageed AE, Ahmed ME. Diabetic foot infections with osteomyelitis: efficacy of combined surgical and medical treatment. Diabet Foot Ankle. 2012;3.

38. El Bushra A. Diabetic Septic Foot Lesions in El Obeid, western Sudan. Sudan J Med Sci. 2007;2(2):119-22.

39. Gulam-Abbas Z, Lutale JK, Morbach S, Archibald LK. Clinical outcome of diabetes patients hospitalized with foot ulcers, Dar es Salaam, Tanzania. Diabetic Medicine. 2002;19(7):575-9.

40. Mehmood K, Akhtar ST, Talib A, Talib A, Abbasi B, Siraj-ul-Salekeen, et al. Clinical profile and management outcome of diabetic foot ulcers in a tertiary care hospital. J Coll Physicians Surg Pak. 2008;18(7):408-12.

41. Benotmane A, Mohammedi F, Ayad F, Kadi K, Azzouz A. Diabetic foot lesions: etiologic and prognostic factors. Diabetes Metab. 2000;26(2):113-7.

42. Nather A, Bee CS, Huak CY, Chew JL, Lin CB, Neo S, et al. Epidemiology of diabetic foot problems and predictive factors for limb loss. J Diabetes Complications. 2008;22(2):77-82.

43. Abbott CA, Chaturvedi N, Malik RA, Salgami E, Yates AP, Pemberton PW, et al. Explanations for the lower rates of diabetic neuropathy in Indian Asians versus Europeans. Diabetes Care. 2010;33(6):1325-30.

44. Lauterbach S, Kostev K, Becker R. Characteristics of diabetic patients visiting a podiatry practice in Germany. J Wound Care. 2010;19(4):140,142,144 passim.

45. Prompers L, Schaper N, Apelqvist J, Edmonds M, Jude E, Mauricio D, et al. Prediction of outcome in individuals with diabetic foot ulcers: focus on the differences between individuals with and without peripheral arterial disease. The EURODIALE Study. Diabetologia 2008;51(5):747-55.

46. de Sonnaville JJ, Colly LP, Wijkel D, Heine RJ. The prevalence and determinants of foot ulceration in type II diabetic patients in a primary health care setting. Diabetes Res Clin Pract. 1997;35(2-3):149-56.

47. Armstrong DG, Lavery LA, Quebedeaux TL, Walker SC. Surgical morbidity and the risk of amputation due to infected puncture wounds in diabetic versus nondiabetic adults. J Am Podiatr Med Assoc. 1997;87(7):321-6.

48. Lavery LA, Armstrong DG, Quebedeaux TL, Walker SC. Puncture wounds: normal laboratory values in the face of severe infection in diabetics and non-diabetics. Am J Med. 1996;101(5):521-5.

49. Lavery LA, Harkless LB, Ashry HR, Felder-Johnson K. Infected puncture wounds in adults with diabetes: risk factors for osteomyelitis. J Foot Ankle Surg. 1994;33(6):561-6.

50. Margolis DJ, Hoffstad O, Weibe DJ. Lower-extremity amputation risk is associated with variation in behavioral risk factor surveillance system responses. Diabetes Care. 2014;37(8):2296-301.

51. Johnston MV, Pogach L, Rajan M, Mitchinson A, Krein SL, Bonacker K, et al. Personal and treatment factors associated with foot self-care among veterans with diabetes. J Rehabil Res Dev. 2006;43(2):227-38.

52. Olson JM, Hogan MT, Pogach LM, Rajan M, Raugi GJ, Reiber GE. Foot care education and self management behaviors in diverse veterans with diabetes. Patient Prefer Adherence. 2009;3:45-50.

53. Feinglass J, Shively VP, Martin GJ, Huang ME, Soriano RH, Rodriguez HE, et al. How 'preventable' are lower extremity amputations? A qualitative study of patient perceptions of precipitating factors. Disabil Rehabil. 2012;34(25):2158-65.

54. Ndip EA, Tchakonte B, Mbanya JC. A study of the prevalence and risk factors of foot problems in a population of diabetic patients in cameroon. Int J Low Extrem Wounds. 2006;5(2):83-8.

55. Brand PW. Diabetic foot. In: Ellenberg M RH, editors. Diabetes mellitus: theory and practice. 3rd ed. New York: Medical Examination Publishing. 1983;829-49.

56. Bauman JH, Brand PW. Measurement of pressure between foot and shoe. Lancet. 1963;1(7282):629-32.

57. Bergtholdt HT, Brand PW. Temperature assessment and plantar inflammation. Lepr Rev. 1976;47(3):211-9.

58. Millington JT, Norris TW. Effective treatment strategies for diabetic foot wounds. J Fam Pract. 2000;49:S40-8.

59. Steed DL, Donohoe D, Webster MW, Lindsley L. Effect of extensive debridement and treatment on the healing of diabetic foot ulcers. Diabetic Ulcer Study Group. J Am Coll Surg. 1996;183(1):61-4.

60. Brem H, Sheehan P, Boulton AJ. Protocol for treatment of diabetic foot ulcers. Am J Surg. 2004;187(5A):1S-10S.

61. Sibbald RG, Williamson D, Orsted HL, Campbell K, Keast D, Krasner D, et al. Preparing the wound bed--debridement, bacterial balance, and moisture balance. Ostomy Wound Manage. 2000;46(11):14-22, 24-8, 30-5.

62. Chalya PL, Mabula JB, Dass RM, Kabangila R, Jaka H, McHembe MD, et al. Surgical management of Diabetic foot ulcers: A Tanzanian university teaching hospital experience. BMC Res Notes. 2011;4:365.

63. Piaggesi A, Schipani E, Campi F, Romanelli M, Baccetti F, Arvia C, et al. Conservative surgical approach versus non-surgical management for diabetic neuropathic foot ulcers: a randomized trial. Diabet Med. 1998;15(5):412-7.

64. Boulton AJ, Meneses P, Ennis WJ. Diabetic foot ulcers: A framework for prevention and care. Wound Repair Regen. 1999;7(1):7-16.

65. Ahmed ME. Diabetic septic foot lesions in Khartoum. East Afr Med J. 1986;63(3):187-90.