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ORIGINAL RESEARCH

Diabetic Foot Ulcers: Surgical Characteristics, Treatment Modalities and Short-Term Treatment Outcomes at a Tertiary Hospital in South-Western Uganda

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Background: Diabetic foot ulcers (DFUs) are a prevalent and serious consequence of poorly controlled diabetes. Hospitalizations are frequent among DFU patients, and these patients are at risk of lower extremity amputations (LEA). Uganda has few studies detailing DFUs and their management. We described the surgical characteristics, treatment modalities and short-term treatment outcomes of DFUs at Mbarara Regional Referral Hospital, in southwestern Uganda.

Methods: A prospective cohort study involving 62 patients with DFUs was conducted from February 2021 to September 2021. We captured socio-demographic data, surgical characteristics, treatment and treatment outcomes of DFUs over a 5-week follow-up period, through an interviewer-administered structured questionnaire. Descriptive statistics were used at analysis.

Results: The mean age of participants was 57.0 ± 12.27 years, comprising 35 (56.5%) females. Majority had diabetes mellitus (DM) for more than 10 years, predominantly type 2 (93.5%), and 33.9% with very poor glycaemic control (HBA1c>9.5%). Most ulcers involved the toes (27.4%), with 80.7% being large (>3 cm^2). Severe DFUs (Wagner grade 3–5) were seen in 66.2% of patients. Clinically infected ulcers mainly had *Pseudomonas spp* cultured. Arterial occlusion was detected in 35.5% through lower extremity Doppler ultrasonography. Initial surgical interventions were surgical debridement and LEA performed in 50.0% and 46.8%, respectively. Eight (42.1%) patients suffered surgical site infection, while 26.3% had persistent gangrene after initial surgery. Revision surgery was performed in 25.8% of the participants. Mortality rate was 1.6%, and mean length of hospital stay was 17.0 ± 11.1 days.

Conclusion: More than half of the patients had advanced DFUs (Wagner grades 3–5). Poor glycemic control and late presentation were common. Lower extremity amputation was a common initial treatment modality for DFUs. Routine lower extremity Doppler ultrasonography is recommended to assess peripheral arterial disease for DFU patients. Wound swabbing for culture and sensitivity testing is encouraged for appropriate antibiotic coverage.

Keywords: diabetic foot ulcer, Wagner classification, Uganda

Introduction

Diabetic foot ulcer is defined by the International Consensus on the Diabetic Foot (IDF) as a full thickness break in the skin occurring on or below the ankle of either foot, directly resulting from diabetes or a complication of the disease.[1] They result from peripheral neuropathy, vascular compromise and poorly controlled diabetes mellitus.[2] A lifetime risk, as high as 25%, exists for the emergence of a foot ulcer among diabetic patients.[3]

The global prevalence of DFUs is estimated to be 6.3%.[4] A systemic review and meta-analysis conducted from 19 African nations revealed an average prevalence of 13% of DFU.[5] In low and middle-income nations, the high prevalence

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of DFU is attributed to socio-cultural factors and deficiency of knowledge on diabetic foot and related complications.[6] In Nigeria the diabetic foot prevalence is 17.8%, in Ethiopia 14.8%, and in Kenya 4.6%.[7–9] In Uganda, the prevalence of DFU is unknown, but a study about diabetic patients and their quality of life conducted at Mulago Hospital, Uganda's national referral hospital, revealed that 53.9% of the 219 diabetic participants reported having suffered from DFUs at a given point in time.[10]

In many African nations, DFUs are usually advanced at the time of presentation due to patient delays in soliciting medical care or late patient referrals influenced by socio-cultural factors, availability of medicines and barriers to opportune diagnosis, in addition to the limited use of multidisciplinary team approach in the care of these patients.[11] This has resulted in major amputations being done in approximately 15% reported cases in Africa.[5]

Characteristics of a diabetic foot ulcer such as the anatomic location, wound depth, infection and ischemia of the foot lesion upon presentation, as well as glycaemic management, all have an impact on the outcome.[12,13] The grading of ulcer severity is critical in the care of DFU patients, and it has been reported to have a higher impact on the final treatment success than the ulcer site.[14]

When DFUs are treated by a multidisciplinary team specializing in foot care, the prognosis is better, and amputation rates are lower.[38] Both medical and surgical interventions are used in the management of DFUs. The former mainly entails control of blood sugar levels and antimicrobial therapy, while the latter involves wound debridement, revascularization, and lower extremity amputations (LEA), among others.[15] Lower extremity amputations (LEA) are the most feared of diabetes complications, and constitute about 40–60% of non-traumatic LEA globally.[16] Length of hospital stay (LoHS) is disproportionately higher in patients with DFU. This is linked to the chronic nature of these wounds and increased frequency of surgical procedures that the patients undergo.[17] There are high mortality rates (14.2%) that have been documented for in-hospital DFU patients.[5] Diabetic foot disease is reported to have 5-year mortality rates that are comparable or exceed those of some common types of cancers such as prostate cancer, breast cancer and colon cancer.[3]

The surgical characteristics of diabatic foot disorders vary in the confines of and among geographical regions. This is predominantly due to distinctness in socioeconomic status, prevalence of varied co-morbidities, nature of footwear worn, and foot care standards.[38] Therefore, the present study sought out to identify the surgical characteristics, treatment modalities and short-term outcomes of treatment of patients with DFUs, and also aims to breach the information scarcity that exists about DFUs within the region.

Methods

Study Setting, Study Design and Study Population

This was a prospective cohort hospital-based descriptive study conducted in the surgical and medical wards of Mbarara Regional Referral Hospital (MRRH) from February 2021 to September 2021. The hospital also serves as a teaching hospital for Mbarara University Science and Technology (MUST), and has a total bed capacity of 350. Our study population were patients with diabetic foot ulcers admitted at MRRH, which were all included, with the exception of participants that opted out of the study during the study period.

Sample Size and Sampling

The sample size has been generated using the OpenEpi ®, Version 3, open- source calculator [Accessed 10 October 2020]. This is based on a study done in Pakistan, where 36.4% of the patients with Wagner grade 3 diabetic foot ulcers underwent major lower extremity amputation. This gave us a sample size of 62 participants who were enrolled based on the inclusion criteria, through consecutive sampling. Written informed consent was obtained from each study participant before recruitment and participation in the study.

Data Collection and Study Definitions

Data were collected using interviewer-administered structured questionnaire. The questionnaire was first prepared in English and then translated to the local language (Runyankole). It was then translated back to English to ensure its

consistency. The research assistants were registered nurses, who were trained about the data collection tool and study procedures.

The questionnaire captured sociodemographic information including patient age, sex, level of education and occupation. Medical factors such as body mass index, pre-existing medical conditions, the length of time with diabetes mellitus and adherence to treatment were also captured. Ulcer characteristics such as duration of the ulcer and local foot examination findings were recorded. Information from investigations including complete blood cell count (CBC), glycosylated haemoglobin (HbA1c), presence of occlusive arterial disease as per Doppler ultrasonography (dUSG), and wound swab test findings were recorded. The treatment modalities of the specific diabetic foot ulcer and short-term treatment outcomes were also captured in the tool.

Data Management and Analysis

Data were entered into Redcap and exported to STATA version 15 (*StataCorp*, College Station, Texas, USA) for analysis. Patient's characteristics were described using summary statistics and presented in the form of means, median, and standard deviation for continuous variables. For categorical variables, percentages and frequencies were generated. The distribution of diabetic foot ulcer grades with regard to treatment modalities was expressed as proportions and presented in tables and bar charts.

Results

Five hundred and twenty- nine diabetic patients were screened during the study period. Sixty-three individuals satisfied the inclusion criteria, and they were sensitized about the study. A total of 62 diabetic foot ulcer patients were enrolled in the study, with one patient declining to participate (Figure 1).

Socio-Demographic Characteristics of Study Participants

Of the 62 participants enrolled into this study, the mean age was 57.0±12.3 years. Majority were female 35 (56.5%). Most had attained primary education 23 (37.1%). Most participants had no history of smoking nor alcohol consumption (Table 1).

The majority were referred-in from other centres 40 (64.5%). At the time of admission at MRRH, most of the patients (74.2%) had visited a health facility, at least on three occasions for the diabetic foot ulcer. The majority had type 2 diabetes mellitus 58 (93.5%), while only 4 (6.5%) had type 1 diabetes. Seven (11.2%) were newly diagnosed with diabetics. The duration of diabetes was more than 10 years for most patients. Most of the participants (56.5%) had no associated chronic illness, while 25 (40.3%) had hypertension (Table 2).

Most of the participants (33.9%) had very poor glycemic control, as reflected by elevated glycosylated haemoglobin (HBA1c) levels of more than 9.5%. We found that 46.8% of the patients were of normal weight (body mass index between 18.5 and 24.9) (Table 3).

The most common anatomic site for DFUs were the toes 17 (27.4%), with 15 (23.2%) participants having involvement of the whole foot, the dorsum and plantar area were affected in 12 (19.4%) of the patients, respectively. Four (6.5%)

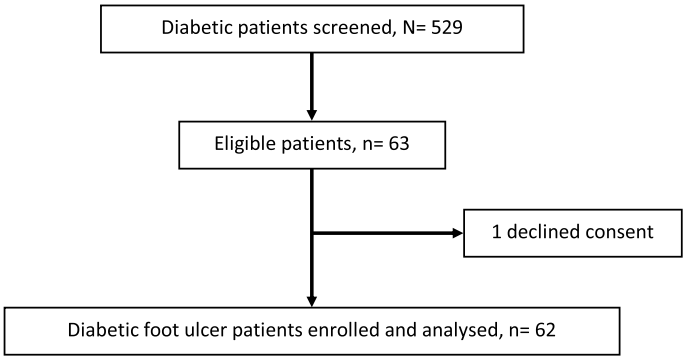

Figure 1 Participant flow chart.

Table 1 Sociodemographic Characteristics

Characteristics	Frequency (%)
Age (mean ± SD) years	57.0 ± 12.3
Sex	
Male	27 (43.5)
Female	35 (56.5)
Level of education	
No formal education	12 (19.4)
Primary	23 (37.1)
Secondary	17 (27.4)
Tertiary	10 (16.1)
Marital status	
Single	4 (6.5)
Married	42 (67.7)
Divorced	4 (6.5)
Widow/widower	12 (19.3)
History of smoking	
Yes	14 (22.6)
No	48 (77.4)
History of alcohol consumption	
Yes	19 (30.6)
No	43 (69.4)

Abbreviation: SD, Standard deviation.

had involvement of the heel and 2 (3.2%) of DFUs were located on the ankle alone. Fifty of the patients (80.7%) had ulcers that were more than 3 cm2 in size. Most of the patients (82.3%) had newly occurring foot ulcers. At the time of admission to MRRH, 61.3% of the patients had had the ulcer for at least two weeks. Based on the Wagner classification, 25.8% of the patients presented with deep foot ulcers with tendon or joint foot involvement (grade 2). We noted that 66.2% had Wagner grades ≥3. Of these, 15 (24.2%) of the patients had localized gangrene (grade 4), while grades 3 and 5 were seen 13 (21.0%) patients, respectively (Table 4).

There were 29 (46.8%) participants with clinically infected foot ulcers from whom wound swabs specimens were taken for culture analysis. *Pseudomonas spp* was the most isolated microorganism, affecting 12 (41.4%) of the participants, followed by *Staphylococcus aureus*, other *Staphylococcus spp, Klebsiella spp*, and *Proteus spp* being isolated in 8 (27.6%), 5 (17.2%), 3 (10.3%) and 1 (3.5%) of the patients, respectively (Figure 2). The antibiotic susceptibility tests showed that the isolated organisms were more sensitive to Imipenem, effective in 17 (58.6%) patients and most resistant to Ciprofloxacin 14 (48.3%) patients. Pseudomonas was more susceptible to Imipenem and Amikacin at 66.7% and 58.3%, respectively. Staphylococcus aureus showed the greatest susceptibility to Ciprofloxacin (5, 62.5% patients).

Doppler ultrasonography (dUSG) findings of our participants revealed that the majority 40 (64.5%) had no occlusion of the major lower extremity arteries. There were 22 (35.5%) participants whose dUSG detected arterial lumen occlusion. Of these, 10 (16.1%) had involvement of the tibial artery, 5 (8.2) popliteal artery, 3 (4.8%) deep peroneal artery and 2 (3.2%) having involvement of the deep femoral and dorsalis pedis arteries, respectively (Figure 3).

In our study, all the patients with DFUs received antidiabetic medications and empirical antibiotic coverage. Thirty-one cases (50.0%) underwent surgical debridement of the ulcers, while 29 (46.8%) had lower extremity amputations (LEA) performed as the initial surgical intervention after admission. Minor LEA were performed in 15 (24.2%), while 14 (22.6%) participants underwent major amputations. No revascularization surgeries were done during the study period (Table 5).

The majority of minor LEA were toe disarticulations which were performed in 37% of the patients, while transmetatarsal and metatarso-phalangeal amputations constituted 10% and 3% of the minor LEAs, respectively. Below-knee

Table 2 Medical Characteristics

Characteristics	Frequency (%)
Referral status	
Not referred	22 (35.5)
Referred	40 (64.5)
Number of visits to clinic/health facility or Hospital	
None	6 (9.7)
1–3 visits	46 (74.2)
4–9 visits	10 (16.1)
Pre-existing Comorbidities	
None	35 (56.5)
Hypertension	25 (40.3)
Cardiac disease	2 (3.2)
Renal disease	2 (3.2)
Eye disease	4 (6.5)
HIV status	
Negative	40 (64.5)
Positive	11 (17.7)
Unknown	11 (17.7)
Diabetes mellitus (DM)	
Type 1 DM	4 (6.5)
Type 2 DM	58 (93.5)
Known history	51 (82.3)
Newly diagnosed	7 (11.2)
Duration of diabetes (years)	
≤ 1	11 (17.7)
1–10	24 (40)
> 10	27 (45)

Table 3 Medical Characteristics and Investigations

Characteristics	Frequency (%)
Random blood glucose (mean±SD)†	16.9 ± 7.95 mmol/L
Glycosylated Haemoglobin (HBA1c)	
6.5–7.5% (good control)	12 (19.4)
7.6–8.5% (fair control)	13 (20.9)
8.6–9.5% (poor control)	16 (25.8)
> 9.5% (very poor control)	21 (33.9)
WBC (median ±SD)†	13.8 ± 7.63 $\times 10^9$/L
Hemoglobin (g/dL)†	
Normal (≥12)	17 (27.4)
Mild Anemia (11–11.9)	17 (27.4)
Moderate anemia (8–10.9)	24 (38.7)
Severe anemia (<8)	4 (6.5)
Body mass index (kg/m^2)	
Underweight (<18.5)	8 (12.9)
Normal (18.5–24.9)	29 (46.8)
Overweight (25.0–29.9)	19 (30.7)
Obese (≥ 30)	6 (9.7)

Note: †Data collected on day 0.
Abbreviations: SD, Standard deviation; WBC, white blood cell count; g, gram; Kg, kilogram; dL, decilitre; m, metres.

Table 4 Surgical Characteristics of DFUs at MRRH

Surgical Characteristics	Frequency (%)
Duration of ulcer	
< 2 weeks	24 (38.7)
≥2 weeks	38 (61.3)
Anatomic location	
Toes	17 (27.4)
Dorsum	12 (19.4)
Plantar	12 (19.4)
Heel	4 (6.5)
Ankle	2 (3.2)
Whole foot	15 (23.2)
Recurring ulcer	
Yes	11 (17.7)
No	51 (82.3)
Size of ulcer	
Medium (1–3 cm^2)	12 (19.4)
Large (>3 cm^2)	50 (80.7)
Ulcer severity (Wagner grading system)	
Grade 1: Superficial ulceration	5 (8.1)
Grade 2: Deep ulcer involving tendons or joints	16 (25.8)
Grade 3: deep ulcer with abscess, or osteomyelitis	13 (21.0)
Grade 4: Localized gangrene	15 (24.2)
Grade 5: Entire foot with gangrene	13 (21.0)

Abbreviation: cm, centimetre.

amputations constituted the most common type of major LEA among the participants, followed by above-knee amputations and knee disarticulations, being performed in 37%, 10% and 3%, respectively (Figure 4).

Of the 40 patients who had no arterial occlusion on Doppler ultrasonography, 12 underwent LEA as an initial surgical intervention (Table 6).

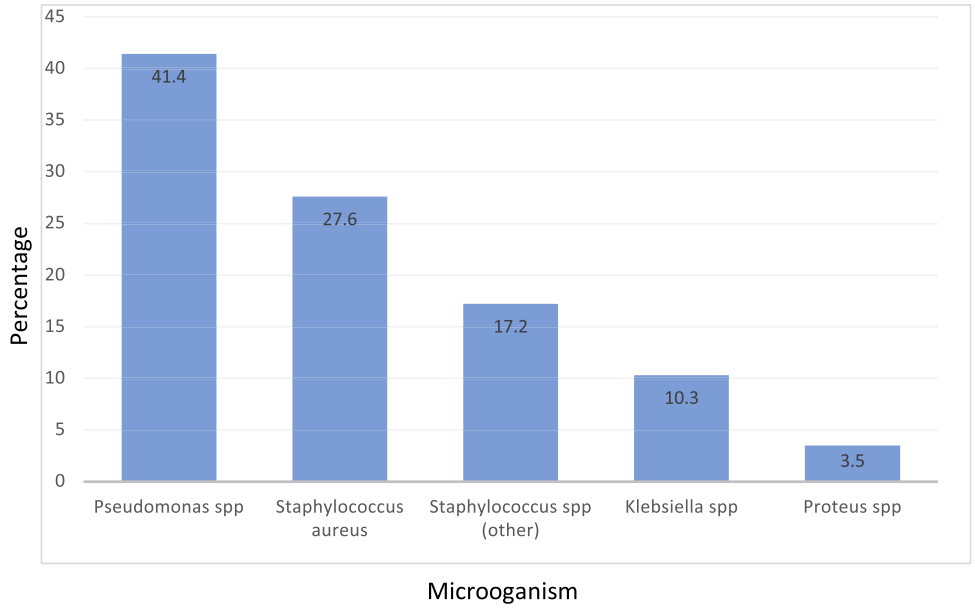

Figure 2 Bacteriological patterns of isolated microorganism of DFUs at MRRH.

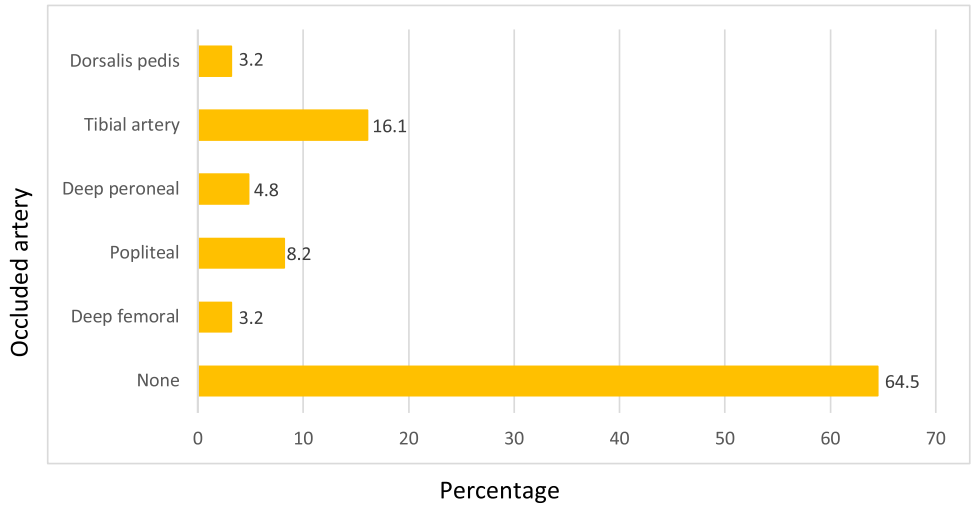

Figure 3 Doppler ultrasonography: peripheral arterial occlusion.

Following the initial surgery, 19 (30.6%) of the patients developed complications. Eight (42.1%) of these patients experienced surgical site infection. Recurrent gangrene occurred in 5 (26.3%) of participants, while wound dehiscence and stump bone protrusion were seen in 2 (10.5%), respectively. Sixteen (25.8%) of the participants underwent revision surgery during the study period. These included 6 (37.5%) who underwent revision LEA, 7 (43.8%) debridement, and 2 (12.5%) having stump refashioning. The mean length of hospital stay was 17.0 ± 11.1 days. There were 12 patients that were still under admission on the last day of follow-up. One study participant died (Table 7).

Discussion

Our study was an observational study involving 62 participants and documented the surgical characteristics, treatment modalities and short-term treatment outcomes of sixty-two consecutively enrolled diabetic patients with diabetic foot ulcers admitted at Mbarara Regional Referral Hospital, south-western Uganda, over an 8- month period from February, ending September 2021, when the last patient follow-up was done.

Surgical Characteristics of Diabetic Foot Ulcers

The toes were the most common location of DFUs among our participants (27.4%). This is in line with data from other research, which show that the forefoot is the most common site of foot ulcers in diabetic patients.[18] However, Ellis and allies found that 59% of their patients had DFUs involving the forefoot.[19] A possible explanation could be the presence

Table 5 Treatment Modalities According to Wagner Classification

Type of Intervention, n= 62	Wagner Grading, n (%)					Total
	1	2	3	4	5	
Antidiabetic drugs	5	16	13	15	13	62 (100.0)
Insulin	3	14	13	15	13	58 (93.5)
Oral	2	2	0	0	0	4 (6.5)
Antibiotics	5	16	13	15	13	62 (100.0)
Blood Transfusion	1	2	5	1	5	14 (22.6)
Surgical Debridement	4	15	12	0	0	31 (50.0)
Dressing only/daily wound care	1	0	0	0	0	1 (1.6)
Lower extremity amputation (LEA)	0	1	3	15	12	29 (46.8)
Minor LEA	0	1	0	14	0	15 (24.2)
Major LEA	0	0	1	1	12	14 (22.6)

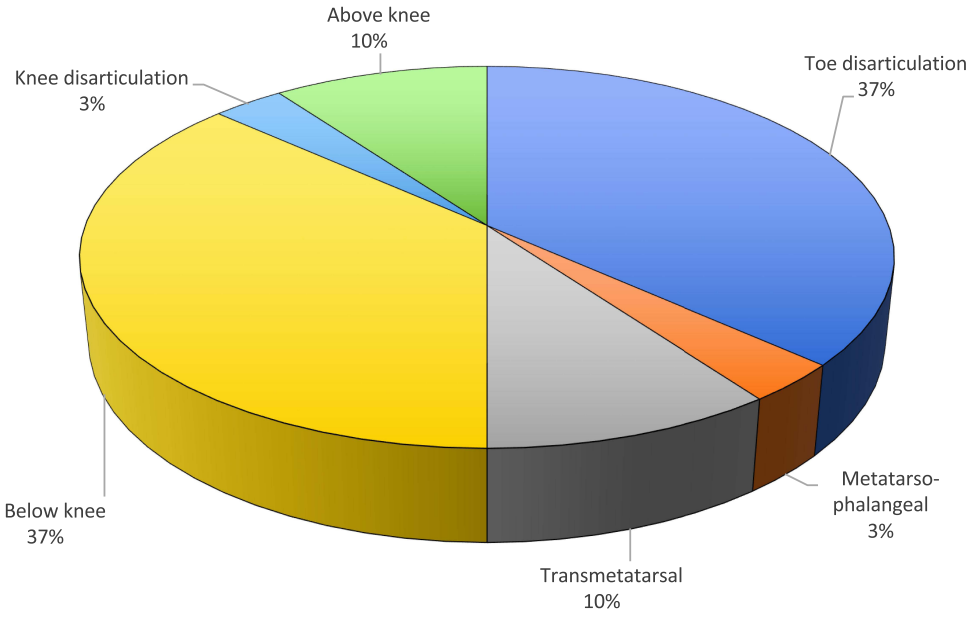

Figure 4 Types of lower extremity amputations.

of peripheral neuropathy, and the development of foot deformities such as Charcot's foot which results in bone and toe deformities. These may result in abnormal distribution of foot pressures, which are more exerted on the forefoot and toes while walking. Moreover, the use of inadequate footwear can result in blister formation in these areas, and advancement to more severe forms of DFUs is likely if prompt action is not taken to manage them.

Although our study found that most of the patients had newly occurring foot ulcers, almost one- fifth of the participants (17.7%) had recurring foot ulcerations that had previously healed. An Egyptian retrospective study found 61.3% recurrence rates of DFU, especially in the first year following resolution of initial ulceration,[20] which is much higher than our study findings. These recurrences are linked to diabetic peripheral neuropathy, which causes a loss of protective feeling in the foot and exposes the tissues to damage in an previously ulcerated foot.

Our study results indicated that 61.3% of the patients had the foot ulcer for at least two weeks, at the time of presentation. This finding is in line with what was reported in an Indonesian study on DFU clinical profiles and outcomes in which the majority of their patients presented with foot ulcers that had developed at least 4 weeks prior to presentation.[21] In the case of our study, the long ulcer duration by the time of admission could be due to delays in the referral of patients between facilities for further management based on our study also indicating that 64.5% of the study participants were referrals from other institutions. Diabetic patients frequently suffer from peripheral neuropathy which impairs sensation to the feet. Foot ulcers can therefore remain unidentified due to the painlessness of ulcers and only be

Table 6 Level of Occlusion on Doppler Ultrasonography (dUSG) and Level of Amputation

Level of Occlusion on dUSG, n=62	Amputation			
	No Amputation	Minor	Major	Total
None	28	9	3	40
Deep femoral	0	1	1	2
Popliteal	0	0	5	5
Deep peroneal	1	0	2	3
Tibial artery	3	4	3	10
Dorsalis pedis	1	1	0	2
Total	33	15	14	62

Table 7 Short- Term Outcomes of Treatment of Diabetic Foot Ulcers

Outcomes	Frequency (%)
Post-op complication n=19	
SSI	8 (42.1)
Dehiscence	2 (10.5)
Phantom limb	1 (5.3)
Stump bone protrusion	2 (10.5)
Recurrent gangrene	5 (26.3)
Seroma/hematoma	1 (5.3)
Type of revision surgery, n=16	
Debridement	7 (43.8)
Stump refashioning	2 (12.5)
Hematoma evacuation	1 (6.3)
Revision amputation	6 (37.5)
Toe disarticulation	1 (6.3)
Below knee	2 (12.5)
Above knee	3 (18.7)
Length of hospital stay (mean ± SD) in days	17.0±11.1
Patient outcome at 5 weeks	
Alive	61 (98.4)
Discharged	49 (79.0)
Still admitted	12 (19.4)
Lost to follow up	0
Dead	1 (1.6)

discovered when they are well established. Our study period also coincided with periods of national lockdown during which inter-district travels were restricted due to the Covid-19 pandemic, which could have contributed to these late presentations. These findings can be attributed to generally poor health-seeking behaviour in this geographical region, that are not confined to pandemic related restrictions.

The diabetic foot lesions of our participants were large ulcers measuring more than 3 cm^2 in size. This finding is in line with those of Pakistani study regarding baseline characteristics of infected DFUs, where 70.1% of the study participants were reported to have ulcer ≥3 cm^2.[22] An Indian study on diabetic foot ulcers reported that 64.9% of the patients had lesions ≥4cm^2.[23] Delays in seeking medical help, in combination to having ulcers for long periods of time may be a factor that promote continued ulcer growth and infection among our patients, leading to patients having large size ulcers at the time of presentation. In our study, we discovered that almost 10% of the patients had small, superficial (Wagner grade 1) DFUs, but were not aware of their presence until the initial foot examination was done by the researchers. This can be attributed to poor self-foot-care habits in this population, in addition to the painless nature of these ulcers as a result of the neuropathy these patients frequently have, making the patients unaware of any emerging foot ulcers.

The majority of the patients had advanced diabetic foot ulcers, with 67.8% of the lesions falling into the categories 3 to 5 of the Wagner classification. This is comparable to findings from Mexico, Pakistan and Indonesia, where it was found that the majority of foot lesions were more severe Wagner grades 3 and above in 93%, 78.2% and 70% of their participants, respectively.[18,21,24] However, it is important to note that these studies also reflected that most of their patients had Wagner grade 3 foot ulcers, contrary to participants in our study, in which most of our patients arrived with grade 2 ulcers (25.8%). This can be explained by the late presentation noted among patients with DFUs, possibly influenced by the painless nature of the lesions and patients erroneously thinking that the wound will be self-limiting.

There was a total of 29 patients with clinically infected ulcerations for which wound swabs were taken for culture and sensitivity testing. In this study, the bacterial profile of patients was obtained and showed predominance of

Pseudomonas spp (41.4%), followed by *Staphylococcus aureus* (27.6%), other *Staphylococcus spp* (17.2%), *Klebsiella spp* (10.3%) and *Proteus spp* (3.6%). Although the microbiology of diabetic foot infections is diverse, other studies have reported similar microbial isolations with the presence of *Staphylococcus aureus, Escherichia coli, Proteus mirabilis Pseudomonas spp*, and *Klebsiella pneumoniae* to be predominant in infected diabetic foot ulcers.[25–28] *Staphylococcus aureus* was the most frequently isolated bacteria in all the above studies. The observed differences in profiles of isolated bacteria from patients with DFUs seen in the present study, compared to other studies, could be due to the isolated bacteria being hospital acquired, possibly from the referring institutions, since our results reflect that the majority of the patients were referrals from other health centres. These differences could also be attributed to distinctions in sample collection methods, geographical regions, severity of infections and treatment therapies prior to presentation.[22]

It is important to note that 5 of the participants had diabetic foot ulcers that were found during examination, but were unaware of their presence. This can be due to poor self-foot-care habits and the painless nature of diabetic foot ulcers.

Our study identified 22 (35.5%) participants whose lower extremity Doppler ultrasonography detected arterial lumen occlusion. Peripheral arterial occlusive disease (PAOD) is up to 6 times more common in elderly diabetics than in non-diabetic elderly patients.[29] This is consistent with the age category of our study participants. DM is also linked to more severe PAD below the knee with involvement of the popliteal, anterior tibial, peroneal and posterior tibial arteries.[30] In our study, the tibial arteries were noted to be the most occluded arteries.

Treatment Modalities of Diabetic Foot Ulcers

Treatment that was offered included medical and surgical interventions. Medical interventions were antidiabetic medications, empiric antibiotic therapy and blood transfusion which were given to 100%, 100% and 22.6%, respectively. Initial surgical treatment included surgical debridement which was performed in 31 (50.0%). Twenty-nine (46.8%) of the participants required Lower extremity amputations (LEA) as the initial surgical intervention. The LEA were categorized as minor and major LEA, and these were performed in 15 (24.2%) and 14 (22.6) patients, respectively. In Indonesia, Pemayun et al also reported debridement as being the most performed surgical intervention for patients with DFUs, as it was done in 87.2% of the patients. They also reported that varying levels of LEA were performed in 36.3% of their study participants.[21]

Treatment of DFUs is mostly influenced by the size and the severity and extent of the wounds. The higher the severity, the more radical the procedure that may have to be performed. The majority of the patients had Wagner grade $\geq$ 3 DFUs, which more often than not require LEA. The level of LEA may also be influenced by the level of arterial occlusion based on imaging like Doppler ultrasonography and CT angiography. In the presence of arterial occlusion, revascularization offers a better chance of limb salvage. In our setting however, no revascularization procedures were performed. This is mainly due to the vascular surgery being underperformed due to scarcity of the equipment necessary to perform the procedures, regardless of expertise being available. Moreover, the costs are usually unattainable for patients and also. Most patients therefore end up undergoing LEA to prevent whole limb loss due to diabetic foot infections, when they would have benefited more from revascularization surgery.

Short- Term Outcomes of Treatment

In our study, short term treatment outcomes described the state of the patient up to 5 weeks of follow-up after hospital admission or at their deposition, within the same period. Patients that were still admitted at the time the follow-up period were those with complex ulcers or had developed morbidities.[31] These short-term treatment outcomes include the development of postoperative complications, the need for revision surgery and mortality.

Thirty-five percent of our study participants developed some form of complication after undergoing some form of surgical intervention. We witnessed that 42.1% of these patients developed varying degrees of surgical site infection (SSI). These figures reflect higher occurrence of local complications compared to findings of Wukich et al who found the rate of SSI among diabetic patients undergoing foot and ankle surgery be be 9.5%.[32] The difference in findings could be attributed to the fact that their study population included participants with or without diabetes and with distinct indications for foot surgery, while all our participants were diabetics with formed DFUs.

Our results reflect that 5 (26.3%) of participants that developed morbidities experienced persistence of gangrene after the initial surgical intervention (debridement/ LEA). A contribution to this could be the fact that some of these patients

are those who had arterial occlusion above the level of initial amputation, thus remaining with non-patent distal arterial segments which resulted in the persistent gangrene.

In the present study, 16 (25.8%) of the patients underwent revision surgery. Debridement was the most performed revision surgery (43.8%), mainly due to surgical site infection. Six of the 62 participants (9.7%) had lower extremity amputations done during the revision surgery. Comparable findings were documented from the Royal College of Surgeons of England, where 31% of patients with DFUs had to undergo revision surgery.[33] More recent studies have indicated higher frequency of revision surgery among DFU patients. It was found to be higher in a study on revision surgery for DFU patients, since 40% of the patients underwent revision surgery, also because they had persistent infection.[34] Similar findings were observed in a French study where their retrospective analysis of revision surgery among patients with diabetic foot ulcers revealed that 39% of participants having undergone revision surgery.[35] The high frequencies of revision surgeries in these patients can be attributed to the complex and challenging nature of diabetic foot ulcers, not to mention the complex anatomy of the foot. Based on the levels of arterial occlusions and types of initial LEA performed among our participants, it is highly possible that some of these amputations were below the level of vascular occlusion, thus leading to continuous vascular compromise of distal tissues, and thus possibly requiring revision amputation surgery.

One participant died during the study. Higher mortality rates among hospitalized DFU patients were reported to be 10.6% in a Thai study.[36] This study, however, was retrospective and done over a 3- year period, unlike our study which followed patients for only 5 weeks.

During the study period, we observed that the mean length of hospital stay for patients with DFUs was 17.0 ± 11.1 days. This is comparable with Pemayun et al's and Ozkara et al's findings reporting an average of 17.8 days and 17.2 days, respectively.[21,37] These can be explained by delayed wound healing that diabetic patients experience. Moreover, some of the patients underwent revision surgery, which can prolong their hospital stay. However, this duration differs from the average of 8 days of hospitalization of patients with DFUs found among patients in Bangkok.[36] The difference could be attributed to good health-seeking behaviour in the Bangkok population, therefore patients possibly presenting with less severe foot ulcers. Their setting was also a specialized diabetic foot centre with multidisciplinary care provision.

Conclusion

This study highlights that more than half of patients have advanced stages of DFUs (Wagner grades 3–5). This is influenced by poor control of diabetes, patient delay in seeking treatment, combined with low level of education among the patients. Lower extremity amputation is a common treatment modality of DFU among diabetics admitted to our hospital. Overall, 56.5% of the patients suffer varying levels of LEA, since 46.8% underwent LEA as an initial surgical intervention and others during revision surgery (9.7%). This adds to the significant socioeconomic, physiological, and psychological harm to patient well-being. The reason for this is that they will be unable to adequately execute their duties which usually involve physical activity, given the socio-economic level of this population.

Recommendations

We recommend early detection and management of diabetic foot ulcers in all hospital levels to prevent development of advanced DFUs.

We recommend routine lower extremity Doppler ultrasonography is recommended to assess peripheral arterial disease for DFU patients especially in resource-limited institutions where more advanced imaging modalities are not available.

We also recommend wound swabbing for culture and sensitivity testing is encouraged for appropriate antibiotic coverage.

Abbreviations

DFU, Diabetic Foot Ulcer; DM, Diabetes Mellitus; dUSG, Doppler Ultrasonography; HbA1c, Glycosylated Hemoglobin; IDF, International Diabetes Federation; LEA, Lower Extremity Amputation; LoHS, Length of Hospital Stay; WHO, World Health Organization.

Data Sharing Statement

The datasets generated and analysed for this study are available from the corresponding author, upon request.

Ethics Approval and Consent to Participate

Approval to conduct this study was obtained from the Mbarara University of Science and Technology Faculty Research Committee (MUST FRC), MUST Research Ethics Committee (REC No. 01/12-20) and Uganda National council of Science and Technology (UNCST Ref. No. HS1857ES), prior to commencing the study. Administrative clearance was obtained from the office of the Hospital Director- Mbarara Regional Referral Hospital. Each participant signed a written informed consent form to indicate their willingness to voluntarily participate in the study. Participants were free to withdraw from the study at any time during the study. Confidentiality and anonymity of the study participants was ensured by using unique study identification numbers. At the end of the interview, participants were given health education on diabetic foot ulcers and prevention of future occurrences. Participants received routine care as prescribed by the attending surgical and/or medical team. Precautionary measures to mitigate potential risk of exposure to COVID-19 were followed, in line the global recommendations by the World Health Organization (WHO), and the Ministry of Health (MoH) of Uganda. The study complies with the Declaration of Helsinki.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that they have no competing interests with regard to publication of this work. This research is an original study and the abstract thereof has been presented only as a poster presentation for Mbarara University of Science and Technology. This research and/or manuscript has otherwise not been published in any way.

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