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Surgical Management of Patients with Diabetic Foot Ulcers at MOI Teaching and Referral Hospital, Eldoret, Kenya

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Abstract: Background: The Diabetic Foot Ulcer (DFU) is a break in epidermis below ankle in person with Diabetes Mellitus (DM). The prevalence of this disorder is increasing and there is a 15% chance in lifetime of a diabetes mellitus patient developing it. The worldwide prevalence of DFUs has been estimated to be between 4% - 17%. In Kenya, diabetes has a prevalence of 3.3 % - 10%. It is a public health problem particularly in developing countries. DFU is due to neuropathy and poor blood circulation, which can progress to complications such as gangrene and infection, which are attributed to late presentation, poor awareness both among healthcare workers and patients, as well as late referral once they occur. The management of patients faces many challenges though the combination of nonoperative and operative strategies are in use. There is paucity of publication locally, hence the need for this study. Objective: To evaluate the surgical management of patients with diabetic foot ulcers at Moi Teaching and Referral Hospital (MTRH), Eldoret, Kenya. Methods: A cross sectional study done in the surgical wards and the diabetic clinic of MTRH between 1st May 2017 and 31st April 2019, involving census of 89 adult patients with diabetic foot ulcers who met the inclusion criteria. Characterization of these patients had been previously done by same team of authors. Relevant data regarding the management with particular interest in treatment modality, and association between some risk factors (peripheral neuropathy, body mass index and glycated haemoglobin) and treatment modality was collected using interviewer administered questionnaires. Data was then cleaned, coded and analyzed using statistical package (SPSS version 19). Presentation was in diagrammatically and in prose formats. Results: The 89 patients were graded using Wagner's classification: grade 1- 4 were 19, 30, 28 and 12 respectively. Debridements were done to 78 (87.6%) while amputation to 11 (12.4%). Of factors associated with surgical management (debridement and amputation), statistically significant findings ($p<0.05$) were for peripheral neuropathy (pricking and weakness). However, there was no statistically significant association between body mass index and surgical treatment as well as glycated haemoglobin and surgical treatment. Conclusion: Grade 2 DFUs was the commonest. Debridements were done in most patients, while eleven patients with grade 4 were done amputations. Association between surgical management and peripheral neuropathy was statistically significant. Recommendations: Creating public awareness, early identification of DFUs in patients and appropriate management to salvage the foot are necessary to prevent progression into stage requiring amputation. Multidisciplinary team approach should be adopted.

Keywords: Amputation, Body mass index, Debridement, Diabetic foot Ulcer, Glycated haemoglobin, Neuropathy, Surgical management.

INTRODUCTION

The foot problems related to diabetes mellitus were first discovered in the 19th century but there was no progress in the management even into the first half of the 20th century (Connor, 2008). Most of these patients presented late and amputation was the common mode of management (Boulton, 2004; Connor, 2008). Despite the time that has passed since then, some countries still apply this management for most of their patients. In a study conducted in Barbados in 2001, 75% of bed occupancy of the surgical ward was of patients with diabetic foot ulcers while a third of them ended up with major amputation (Boulton, 2008; Walrond, 2001).

In Nottingham-England, Pryce - a surgeon – recognized over 100 years ago the connection between diabetes and foot ulceration; reporting that diabetes played an active part in causation of perforating ulcers and that the actual cause of this was peripheral nerve degeneration. The sensory loss associated with foot problems in diabetes was understood from work done in leprosy. Despite the fact that the cause of sensory loss in the two is different, work in leprosy helped in the understanding of foot problems associated with diabetes. In India, the work by Doctor Paul Brand -a surgeon- pioneered research on the causation of foot problems in leprosy (Bergtholdt & Brand, 1976). He further added science to the art of foot care by recommending that, to reduce amputation in diabetes, the physicians should remove patients' shoes and socks and to examine the feet (Boulton, 2004). Brand also pioneered research on abnormal foot pressures during walking and described use of thermography to assess areas at risk of breaking down. He taught principles of management of feet that were insensate, emphasizing on the need to offload plantar neuropathic ulcers (Bauman & Brand, 1963; Bergtholdt & Brand, 1976; Boulton, 2004). One remark he made was that any patient with a plantar ulcer walking into the clinic without a limp, has neuropathy (Bauman & Brand, 1963; Boulton, 2004).

The Proper surgical management of patients with Diabetic Foot Ulcers (DFUs) includes taking a good history, doing a comprehensive physical examination and having a treatment plan, as documented in a previous study about the characterization of patients with diabetic foot ulcers managed at Moi Teaching and Referral Hospital, Eldoret, Kenya (Obare, Ayumba & Ongaro, 2026) which can be useful guide. The primary goal is wound closure as soon as possible. Diabetes mellitus is a multi-organ system disease and therefore a patient with a foot ulcer due to this disorder requires a multidisciplinary approach for a good outcome.

A multidisciplinary team consists of a general practitioner, a nurse, an educator, an orthotic specialist, a podiatrist and consultations with specialists such as vascular surgeons, dermatologists, endocrinologists, dieticians and Orthopaedic Specialists.

Surgical intervention is opted for when the DFUs. These could include debridement or amputation.

Debridement is more commonly the first line in case of surgical management, where all the non-viable tissue is removed. This is accompanied by supportive care including antibiotic cover and/or offloading whenever necessary. The other mode of surgical management is by amputation, this would increase morbidity and mortality of the patient but in cases where it is necessary, for example, gangrene, avoiding it may increase risk of mortality up to 54% in 2 years (Brem, Sheehan & Boulton, 2004).

Debridement could be either an emergency or an elective surgery and is useful in arresting or limiting acute infection. Emergency debridement may be incision and drainage in case of accumulation of a purulent exudate in the plantar spaces, while elective surgical debridement involves removing necrotic or other devitalized tissue.

Necrotic, devitalized tissue and foreign material are a focus for infection. The aim of debridement therefore is to remove these tissues, as well as devitalized wound bed and keratinized tissue at the edge of the wound, all of which hinder healing (Cardinal, *et al.,* 2009; Katherine, Elizabeth, Marjana & Robert, 2012). Following debridement, there is a decrease in the bacterial count, stimulation of production of local growth factors and proper wound drainage (Yazdanpanah, Nasiri & Adarvishi, 2015). The chronic ulcer is converted into an acute ulcer, thus stimulating a host immune response to prevent infection (Cardinal, *et al.,* 2009).

Elective surgeries may also be aimed at relieving pain that may come about due to deformities such as hammer toes, bunions, and bone spurs but with no peripheral sensory neuropathy and with a low risk of developing an ulcer. Prophylactic surgeries are done to prevent occurrence or recurrence of an ulcer in patients with neuropathy. This can include lengthening of the Achilles tendon to relieve pressures on the metatarsal heads and promote ulcer healing, but this can alter the gait and increase the risk of getting heel ulcers, therefore should be avoided in patients with sensory loss of the heel. Curative surgeries are performed in the case of a non-healing ulcer where noninvasive methods have failed. This may be multiple surgical procedures done to reduced peak pressures or done to resect infected bone or joints (Yazdanpanah, Nasiri & Adarvishi, 2015).

Various debridement techniques are available, and they can be classified as either surgical, mechanical, autolytic, biological and enzymatic debridement (Armstrong & Lipsky, 2004; Cardinal, *et al.,* 2009). Surgical (sharp) debridement is considered the most effective method as it involves rapid cleaning of the ulcer by cutting away dead and infected tissues to convert the wound into an acute ulcer (Katherine, *et al.,* 2012). Sterile scissors or a scalpel are the only requirement, it is therefore quite cost effective. However proper training is needed so as not to be overenthusiastic in removal of tissues, widening the wound excessively and thus hindering healing further.

Mechanical debridement involves use of high-pressure water jet dissection, pulsed lavage, wet dressings and hydrotherapy (Armstrong & Lipsky, 2004; Cardinal, *et al.,* 2009). It is mostly used before surgical debridement and is most beneficial in case of hardened necrotic tissue (Armstrong, *et al.,* 2001). It can however be painful for patients as it does not discriminate necrotic tissue from granulation tissue.

Autolytic debridement involves creating a healthy, moist environment where the process of debridement will occur naturally (Sherman, 2003). Dressings like hydrated polymer dressing (also known as hydrogel) are used. They facilitate granulation, epithelialization and autolytic debridement (Morgan, 2013). It is not advised to use such dressing in wounds that have a heavy exudate and it is time consuming.

Biological debridement, also called maggot debridement therapy has been used (Sherman, 2003). Sterile larvae of the blowfly (*Lucilia sericata*) are used as they affect only necrotic tissue and actively void newly formed healthy tissue (Yazdanpanah, Nasiri & Adarvishi, 2015). Different types of larva from flies have been isolated from infected wounds, most commonly larva of the housefly (*Musca domestica*). They cannot be used in

maggot debridement therapy as they aggressively invade healthy tissue causing myiasis (Wolff & Hansson, 2003). The study by Wolff and Hansson also showed that larval debridement was effective in 86% of the ulcers, requiring only one application on two thirds of the patients. It also reduced wound odour (Wolff & Hansson, 2003). However, this method may not be agreeable to all patients.

Enzymatic debridement involves use of manufactured proteolytic enzymes to degrade necrotic tissue. They digest the proteins fibrin, elastin and collagen, commonly found in the necrotic exudate of a wound. However, it is expensive therefore not available to all patients (Yazdanpanah, Nasiri & Adarvishi, 2015).

Vascular surgery is considered in cases where standard management has been employed as discussed above, but with no improvement; in a patient who shows has lower limb ischaemia with symptoms, for example, no palpable foot pulses, poor capillary refill, claudication, hair loss and skin atrophy. Therefore, any patient who does not recover despite adequate treatment requires referral to a vascular surgeon to know whether revascularization is an option for them. Vascular surgery improves arterial perfusion, which in turn helps in healing and antibiotic administration (Armstrong & Lipsky, 2004). Revascularization may be endovascular which is less invasive or bypass grafting open) surgery which is invasive. Endovascular surgery is preferred for chronic neuroischaemic ulcers with borderline toe pressures and short lesions, while bypass grafting is used for long lesions. In the case of a large ulcer defect, to improve the perfusion following revascularization, a micro vascular free flap transfer should be done (Lepantalo, *et al.*, 2011).

Amputation is another mode of surgical intervention. It should be noted that the aim of management of diabetic foot ulcers is limb salvage, but this should be in accord with what would give the best functional outcome and save the rest of the patients' limb and life. Extensive gangrene, extensive osteomyelitis, severe and chronic soft tissue infection and peripheral arterial occlusion are some of the indications for amputation. Coming to the decision to amputate is difficult but necessary in cases where treatment has not been successful. Therefore, the patient needs to be given time to accept it and go through counseling, that is unless it is an emergency. Amputation should be done at the most distal level compatible with healing. It has been observed that major amputations are associated with a higher mortality (Armstrong & Lipsky, 2004). A study showed that patients with new onset diabetic foot ulcers were at a higher risk of death following amputation (Moulik, Mtonga & Gill, 2002). Davis, *et al.*, (2006) on the other hand documented on the predictors, consequences and costs of diabetes mellitus related lower extremity amputations. They documented that lower extremity amputation is associated with peripheral neuropathy, and that high BMI is associated with increased incidences of DFUs which are predictors of high incidences and risks for lower extremity amputations.

Other diabetic foot ulcer interventions including the general measures still need taking a good history and asking for features associated with the main etiological factors, that is, peripheral neuropathy and peripheral arterial disease; doing a thorough physical examination by assessing the skin, vascular, neurological and musculoskeletal systems.

Patient Education is a step that is necessary, including brief education, to demonstrations, hands on teaching and even telephone reminders (Yazdanpanah, Nasiri & Adarvishi, 2015). Some reviews state that patient education only improves short term

knowledge and modestly reduces risk of foot ulceration and eventual amputation (Singh, Armstrong & Lipsky, 2005). Bloomgarden *et al.* found no greater improvement in HbA_1C, fasting blood glucose and lipids in the educated as compared to the controls (Bloomgarden, *et al.,* 1987).

While Barth *et al.* came to the conclusion that improvement in terms of foot care and overall foot complications occurred when intensive foot care education was done including, extended time span, greater patient contact time, patient foot care training sessions and use of cognitive motivational techniques, as compared to the conventional brief foot care education (Barth, Campbell, Allen, Jupp & Chisholm, 1991).

Blood Sugar is an important metabolic factor in the pathophysiology of diabetic foot ulcers. Elevated blood glucose >11.1mmol/l has been associated with decreased neutrophil function, suppressed inflammatory response and decreased host response to infection (Yazdanpanah, Nasiri & Adarvishi, 2015). Glycated haemoglobin (HbA_1C) is used to measure the average blood glucose concentration over a 90-day span.

With good blood glucose control, each percentage point reduction in HbA_1C is associated with a 35% reduction in microvascular complications and there is a continuous relationship between glycemic control and development of complications (Harrison, *et al.,* 2015).

In a Kenyan study (Nyamu, *et al.,* 2003), an association between poor knowledge of foot care and HbA_1C. Where 18.3% of those patients had an HbA_1C of 7% or less, and also noted that females were the predominant in this group. They attributed this to the underprivileged of women in the community, where the woman has to depend on the husband for maintenance. This eventually translates to the having a longer mean duration of ulcers compared to males (Nyamu, *et al.,* 2003).

Poor glycemic control leads to increase in HbA_1C level, predisposing to development of DFUs and subsequently lower extremity amputation (Adler *et al.,* 2010). These authors documented that for every increase of 1% in HbA_1C level, there is a 26%- 36% risk increase for lower extremity amputation. Sadriwala, Gedan and Akhtar, (2018) documented that higher HbA_1C levels and higher grade of wound (Wagner classification) are indicators of poor glycemic control. Other authors (Sadriwala, Gedan & Akhtar, 2018; Saleem et al., 2017) however found no statistically significant association between HbA_1C levels and lower extremity amputations. Saleem et al., (2017) documented further that 58% of diabetes mellitus patients with DFUs had higher level of HbA_1C, and therefore more likely to be candidates for lower extremity amputations.

Pischerer et al., (2012) on the other hand documented that cumulated incidences of diabetes mellitus patients as associated with increased HbA_1C levels, with 18.2% having lower extremity amputation. Males are seemingly more affected than females and more likely to be amputated; females are less likely to be amputated since they demand better care. The incidence being higher in patients who are over 70 years old, but lower when less than 50 years old. When the level of HbA_1C is more than 7.5%, the incidence of DFUs rises and so is the higher likelihood of lower extremity amputation.

Lower extremity amputations have also been linked to and associated with peripheral neuropathy which is a known risk factor for DFUs as documented by some authors (Burns & Jan, 2012; Sadriwala, Gedan & Akhtar, 2017). Peripheral neuropathy is a risk factor

for DFUs- which are predictors of higher incidence of cases and biggest risk factor of non-traumatic lower extremity amputations (Burns & Jan, 2012).

Infection Control could adopt the use of antibiotics but should always go alongside surgical interventions (Boulton, *et al.,* 2004). A microbiology culture sample should be collected from the deepest part of the wound (Armstrong & Lipsky, 2004). Of note is that infections in these patients are polymicrobial with both aerobes and anaerobes, therefore antibiotic therapy should target these organisms. Antibiotics used can be topical (mostly for superficial infections), or parenteral for severe infections. Brem, Sheehan and Boulton, (2004) added their voice by introducing a protocol for treatment of diabetic foot ulcers.

Offloading is a mode of management that aims to remove pressure from the ulcer and is mostly used in treatment of neuropathic ulcers. It is contraindicated in ischemic and acutely infected ulcers. There are many modalities of offloading, including use of casts or boots, half shoes, sandals and felted foam dressings (Boulton, Kirsner & Vileikyte, 2004). Casts include total contact casts, removable cast walkers and instant total contact casts. The total contact cast is considered the gold standard in offloading (Boulton, 2004). It relieves pressure and distributes pressure over the entire surface of the foot; therefore, the site of the wound is protected.

Histological evidence from ulcers managed with total contact casts before debridement showed better healing as shown by angiogenesis with the formation of granulation tissue (Sherman, 2003). This positive result is attributed to increased adherence because the patient is unable to remove it, so there is forced compliance and reduced activity. Various disadvantages limit its use, for example, it requires expertise in application, otherwise it causes complications such as irritation and even frank ulceration; it is expensive in terms of time and money as it requires weekly replacement; it also does not allow daily assessment of the foot by the patient; also considering the restriction on daily activity, it is not preferred by many patients.

The removable cast walker on the other hand can be easily be removed; therefore, the patient can inspect their foot, bathe and sleep comfortably (Boulton, *et al.,* 2004). However, it is associated with non-compliance and thus, longer wound healing period. The instant total contact cast is a modification of the above discussed modalities. A removable cast walker is wrapped with a single layer of cohesive bandage, elastoplast or casting tape. This forces the patient to adhere to the cast but also allows easier application and removal whenever necessary, like during an examination.

It has been noted that in patients treated with the above, healing of superficial noninfected, non-ischaemic diabetic plantar foot ulcers was as follows 89.5% for total contact casts, 65% for removable cast walkers and 58.3% for half shoes, over a 12 week period (Armstrong, *et al.,* 2001).

Healing sandals, half shoes and wedged shoes are also available for removal of pressure on the forefoot. Patients reject these because they are difficult to walk in. When compared to casts, they have the slowest rate of healing of ulcers (Robins, 2008).

Felted foam dressing is mostly used for plantar ulcers. A multi-layered felted foam dressing is applied to the foot, the area where the ulcer is cut out. The dressing is then fixed to the foot with adhesive and secondary dressing (Giacalone, 2006), which may be healing sandals or removable cast walkers. The disadvantage is that the cut edge may cause

impediment to normal healing of the edges of the wound by causing vertical and shear forces, therefore cannot be used in patients with friable skin or allergy to adhesive (Giacalone, 2006). A rule of thumb is emerging that once a diabetic foot ulcer is being managed, it should reduce by 50% in four weeks if not then consider adjuvant therapy or re-evaluate the vascular status of the patient or your treatment plan (Boulton, *et al.,* 2004; Giacalone, 2006).

Diabetic foot ulcer is a chronic complication of diabetes mellitus among patients living in both developed and developing economies. Because of this, it is a major concern to both Physicians and Orthopedic Surgeons. In Kenya, it is a major cause of hospitalization and accounts for about 60% of non-traumatic amputations. Among those who get hospitalized, they often present with other complications such as severe sepsis and or gangrene. This is despite the fact that it is a preventable condition whose risk factors could best be identified and managed prior to onset of the ulcer. Diabetes mellitus is indeed increasing the burden of disease in Kenya (Jones, 2013). Information concerning surgical management modalities is limited in published studies conducted in Western Kenya, especially at the Moi Teaching and Referral Hospital (MTRH) which is also a nationwide referral facility is unknown. Recent publication by Obare, Ayumba and Ongaro, (2026) is probably the first of its kind in this locality, and has added the well-deserved knowledge to the practitioners managing diabetes mellitus patients.

Inadequate management of the diabetic foot ulcers will not only interfere with the patients' quality of life but their overall well-being, reduced economic productivity and diversion of family income to preventable conditions. There is need to pay more attention towards comprehensive preventive and management measures both in the community and healthcare settings.

Conducting this study is justified in that there is need to validate the findings of previous published studies elsewhere and get updated information on the management of patients with DFUs, which involves medical, surgical care, and complex preventive interventions. There is need to determine the surgical management options currently adopted at a national teaching and referral hospital to influence management guidelines and improve patient outcomes.

Therefore, the findings of this study will fill the existing knowledge and practice gaps on management of patients with DFUs and will inform both hospital management and policy makers on probable intervention options in order to better the care of affected patients.

METHODOLOGY

Study Location: The study was carried out in the diabetic clinics at Chandaria, medical and surgical wards at Moi Teaching and Referral Hospital (MTRH), Eldoret City, Kenya. The hospital is situated along Nandi Road in Uasin Gishu County, approximately 350 kilometers North-west of Nairobi the capital city of Kenya. It serves Uasin Gishu County, a predominantly agricultural region, Western Kenya, Eastern Uganda and parts of Southern Sudan, a catchment area of 20 million people. It is a training center for Moi University College of Health Sciences, Kenya Medical Training College and many other institutions. The Academic Model Providing Access To Healthcare collaborates with MTRH in research activities as well as taking care of patients (MTRH website, 2021).

Study Design: This was a cross-sectional study design. Patients with diabetic foot ulcers, who met inclusion criteria, were recruited until the desired sample size was reached. Patients were interviewed using a standard questionnaire, done by trained Research Assistants supervised by the Principal Investigator. There were two Research Assistants. They were trained on grading of DFUs and were well oriented concerning the questionnaire.

Study Population: Patients with diabetic foot ulcers managed at MTRH. Among these patients, only those who meet the eligibility criteria were included in the study.

Eligibility Criteria: Included were patients with diabetic foot ulcers in the diabetic clinic at Chandaria, medical and surgical wards at MTRH, willing to participate in the study. Excluded were patients who did not consent, and patients below 18 years of age.

Sample Size: The Principal Investigator did a census of the patients with DFUs seen at MTRH in order to get the patients who formed the study population. From the hospital records, approximately 120 patients with diabetic foot ulcers were seen annually between 2014 and 2015. A total of 89 patients were recruited for this study. The study period was between 1st May 2017 and 31st April 2019.

Data Collection: Patients were enrolled into the study once they were admitted in medical and surgical wards of MTRH as well as those being followed up at the diabetic clinic, and had consented to participate. Data was collected following history taking and a physical examination and was also via interviewer administered questionnaire. The variables studied included: Demographics: age, sex, residence; Duration of living with diabetes-according to the Wagner classification; comorbidities- Retinopathy, nephropathy, hypertension and stages of DFUs as highlighted in the previous study (Obare, Ayumba & Ongaro, 2026) conducted at MTRH. The details regarding the treatment modality- medical and surgical and the outcomes were well documented. Variables were coded and assigned numerical values for quantitative analysis.

Data Management: There was double data entry into SPSS version 19. Data was checked for consistency, completeness and accuracy; analysis done as per the study objective requirement. Data presentation was done diagrammatically and in prose format forms.

Ethical Considerations: Permission to carry out the study was sought from IREC (Reference: IREC/2016/131; FAN IREC 1737, Dated 23/09/2016) before the study was carried out. Consent was sought from the patients and confidentiality was maintained. Patients were informed of the purpose of the study and its benefit to them.

No patient was coerced into becoming a participant. Withdrawal from the study was voluntary at any point of the study.

Dissemination of the Research Findings: through oral presentation (thesis defense), bound book and publication hopefully in peer reviewed journal.

Study Limitations: Noncompliance of the patient to treatment might have led to inaccurate collection of data. To mitigate, the Principal Investigator and the Research Assistants counseled patients on the importance of good glycemic control and compliance with the medical instructions following surgical management.

Some of the patients might have withheld sensitive information on risk factors, for example, smoking and alcohol intake history. This was mitigated by building of good rapport

with the patients and the assurance that there would be absolute confidentiality with the information gathered.

RESULTS

Surgical Management of Patients Presenting with Diabetic Foot Ulcers

Among all the patients presenting with diabetic foot ulcers, more than four-fifths (87.6%; n=78) had debridement as a surgical intervention offered while the rest got amputation. When classified as per the Wagner Classification, those with Grade 1, 2 and 3 all got debridement for their diabetic foot ulcers. However, nearly all (91.7%; n=11) those with Grade 4 diabetic foot ulcers had amputation, with only one having undergone a debridement procedure. The study further reported a statistically significant association (***p***-value<0.001) between Wagner Classification grading and the surgical intervention offered as shown in Figure 1. No mortality was recorded.

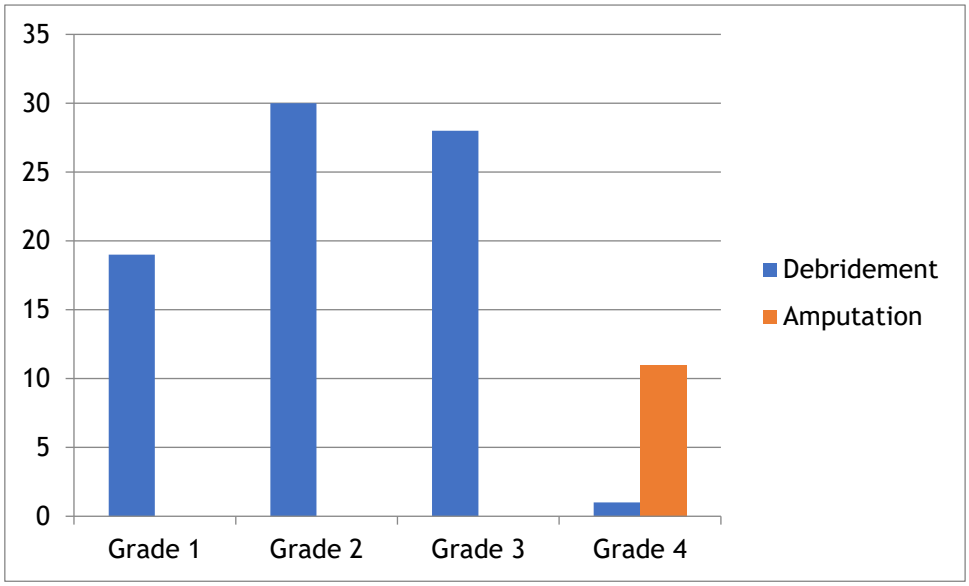

Figure 1: Surgical Management offered based on Diabetic Foot Ulcer Grades

Association between Peripheral Neuropathy Features and Surgical Management offered: This study assessed the association between peripheral neuropathy features (numbness, pricking sensation, burning sensation, weakness, dryness, fissures, deformities, *Tinia pedis* and edema) and the surgical management (debridement or amputation) offered. A statistically significant association was reported between pricking sensation (***p***-value = 0.018) and weakness (***p***=0.004).

Despite the fact that majority of the patients had debridement done, those presenting with pricking sensation (AOR=4.814, 95% CI: 1.102, 21.035) and weakness (AOR=6.324, 95% CI: 1.450, 27. 590) were five and six -times respectively, more likely to get amputation compared to patients with other features of peripheral neuropathy (Table 1).

Table 1: Association between Peripheral Neuropathy features and Surgical Management offered

Peripheral Neuropathy Features	Debridement	Amputation	Total	*p*-value
Numbness	39 (90.7%)	4 (9.3%)	43 (100%)	0.397
Pricking	34 (79.1%)	9 (20.9%)	43 (100%)	0.018
Burning	26 (78.8%)	7 (21.2%)	33 (100%)	0.051
Weakness	28 (75.7%)	9 (24.3%)	37 (100%)	0.004
Dryness	28 (80%)	7 (20%)	35 (100%)	0.078
Fissures	37 (88.1%)	5 (11.9%)	42 (100%)	0.902
Deformity	2 (100%)	-	2 (100%)	0.591
Tinea Pedis	5 (71.4%)	2 (28.6%)	7 (100%)	0.175
Edema	45 (88.2%)	6 (11.8%)	51 (100%)	0.843

Association between Body Mass Index and Surgical Management: There was no statistically significant association (***p***=0.144) found between the body mass index and the surgical management offered (Table 2).

Table 2: Association between Body Mass Index and Surgical Management

BMI status	Debridement	Amputation	*p*-value
Normal	46 (85.2%)	9 (14.8%)	0.144
Abnormal	32 (94.1%)	2 (5.9%)	

Association between Glycated Hemoglobin and Surgical Management: The study further reported that there was no statistically significant association (***p***=0.057) between HbA_1C and the surgical management offered (Table 3).

Table 3: Association between Glycated Hemoglobin and Surgical Management

HbA_1C	Debridement	Amputation	*p*-value
≤7	38 (95%)	2 (5%)	0.057
>7	40 (81.6%)	9 (18.4%)	

DISCUSSION

Surgical Management of Patients Presenting with Diabetic Foot Ulcers

The patients presenting with diabetic foot ulcers and required surgical management either had debridement as a surgical intervention or amputation.

Association between Peripheral Neuropathy Features and Surgical Management Offered: This study tested the association between peripheral neuropathy features (numbness, pricking sensation, burning sensation, weakness, dryness, fissures, deformities, *Tinea pedis* and edema) and the surgical management (debridement or amputation) offered.

From the findings, a statistically significant association was reported when pricking sensation (***p*= 0.018**) and weakness (***p*=0.004**) was compared to surgical management offered. Debridement and amputation were the only surgical interventions for patients with diabetic foot ulcers. However, majority of the patients had a debridement done. Patients presenting with a pricking sensation and weakness were five (AOR=4.814, 95% CI: 1.102, 21.035) and six (AOR=6.324, 95% CI: 1.450, 27. 590) times respectively, more likely to get an amputation compared to patients with other features of peripheral neuropathy.

In the Australian Fremantle Diabetes study, there was a statistically significant association (***p*=0.015**) between lower extremity amputation and peripheral neuropathy (Davis, *et al.*, 2006). The authors further argue that foot ulcerations are predictors of increased incidence and the biggest risk factor for nontraumatic lower extremity amputations (Burns & Jan, 2012; Davis, *et al.*, 2006). This is because more than three quarters of these amputations are preceded by active foot ulcers which are poorly healing (Boulton, 2008). However, the study by other authors(Davis, *et al.*, 2006) did not isolate the specific features of peripheral neuropathy.

This was also the case in an Indian study (Sadriwala, Gedan & Akhtar, 2018) where sensory motor neuropathy was statistically significantly associated (***p*=0.008**) with amputation among patients with diabetic foot ulcers.

The findings of this study contrasts with that conducted in Pakistan (Saleem, *et al.*, 2017) where no statistically significant association was observed between having presented with neuropathic diabetic foot ulcers and undergoing lower-extremity amputation. This contrast could be attributed to study design differences and duration of data collection. The current study adopted a cross-sectional study where data was only collected on contact while the Pakistani study (Saleem, *et al.*, 2017) followed the patients for more than one year. Longer duration of follow-up helps weed out other confounding factors that could affect the study findings.

Association between Body Mass Index and Surgical Management: This study did not find any statistically significant association between a patient's BMI and likelihood of having a debridement or amputation. Overall, majority of the patients had debridement done irrespective of their BMI status. Therefore, a patient's body mass index did not affect the surgical management offered to diabetic foot ulcer patients managed at MTRH.

This finding concurs with that in the Fremantle Diabetes Study in Australia where no statistically significant association was reported between BMI status and lower extremity amputations (Davis, *et al.*, 2006). The authors (Davis, *et al.*, 2006) excluded BMI status in their final analysis because it was not possible to measure it accurately in most of the baseline amputees.

Association between Glycated Hemoglobin and Surgical Management: When a cut-off of seven (7) was used to determine whether a patient with diabetic foot ulcer had hyperglycemia, there was no statistically significant association (***p*= 0.057**) between glycated hemoglobin levels and the type of surgical management offered. This is despite four-fifths (81.8%; n=9) were among those with HbA_1C values greater than 7.

In a systematic review and meta-analysis conducted on fourteen studies assessing the association between glycated hemoglobin levels and lower extremity amputations, it was determined that for every one percentage point (1%) increase in HbA_1C levels, there is an associated 26% to 36% increased risk of lower extremity amputation (Adler, *et al.*, 2010). This is even though diabetes increases the risk of lower extremity amputations. The studies reviewed had HbA_1C averages ranging between 7.1% and 13.5%, however, varying assay techniques were used and this could have interfered with standardization and test results (Adler, *et al.*,2010). Secondly the studies compared either or both Type 1 and Type 2 diabetes while this current study only focused on Type 2 Diabetes Mellitus.

This study had a cumulative incidence of diabetes-associated lower limb amputations of 12.4% (n=11) which was lower than the 18.2% cumulative amputation incidence reported in Austria (Pscherer, *et al.*, 2012). The Austrian study further reported that amputations are independently associated with higher HbA_1C levels, although the current study did not find any associations (Pscherer, *et al.*, 2012).

The current study concurs to an Indian study (Sadriwala, *et al.*, 2018) where no statistically significant association (***p*=0.132**) was determined between HbA_1C levels and amputations. It further concurs with a Pakistani study (Saleem,*et al.*, 2017) which did not find a statistically significant association (***p*=0.354**) between having elevated HbA_1C level and lower extremity amputation.

CONCLUSION

Grade 2 DFUs was the commonest. Debridements were done to most patients, while eleven out of twelve patients with grade 4 were done amputations. Association between surgical management (debridement and amputation) and peripheral neuropathy was statistically significant, with five and six-fold increased risk of having an amputation compared to patients with other features of peripheral neuropathy. Surgical management for DFUs was not affected by the BMI status and glycated hemoglobin levels of patients.

RECOMMENDATIONS

Creating public awareness (patient and professional health education) on the risk factors associated with development of DFUs, as well as the Wagner classification system of grading, is essential for early identification of DFUs in patients in order for appropriate management to be initiated to salvage the foot so as to prevent progression into stage requiring amputation. Overall the management of patients with DFUs should adopt a multidisciplinary approach to holistically address the problem and have good outcomes.

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