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Original Research Paper

FACTORS ASSOCIATED WITH AMPUTATION IN DIABETIC FOOT ULCERS IN TERTIARY CARE CENTRE

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ABSTRACT:

Background and Objectives: Diabetic foot ulcers, often leading to lower limb amputations, represent a frequent, complex, and debilitating complication of diabetes. Recognizing the critical necessity to pinpoint the variables that govern the usage of hospital facilities, this study seeks to facilitate preventive care monitoring and curtail the potentially preventable fatalities associated with this level of care. **Method**: We conducted a forward-looking observational study involving a cohort of 140 patients at the M.S. Ramaiah Medical College Hospital and Memorial Hospital from November 2020 to June 2022. **Results**: The present study encompassed 140 individuals predominantly between the ages of 50 and 60 with a noticeable male preponderance (7:1). A significant portion hailed from lower socioeconomic backgrounds and exhibited a PEDIS score gravitating towards grade 3. Additionally, a majority had a history of diabetes mellitus exceeding a decade. Patients presenting with wounds persisting for over a month were more likely to necessitate advanced levels of amputation. Remarkably, those who initially sought Ayurvedic treatments or home remedies for their diabetic foot ulcers faced a higher likelihood of undergoing extensive debridement or escalated levels of amputation once admitted to the hospital. **Conclusion**: This study elucidates that a multitude of factors including age, gender, socioeconomic standing, the longevity of diabetes mellitus, wound duration, smoking habits, and peripheral vascular diseases, along with specific biochemical and hematological parameters (namely, hemoglobin, ALP, HbA1c, and serum albumin levels) profoundly influence the progression and development of diabetic foot ulcers. These variables can be proficiently gauged using the PEDIS score, significantly impacting the surgical interventions required. Noteworthy is the apparent gap in research concerning the repercussions of utilizing home remedies and Ayurvedic treatments on the disease's progression, necessitating further exploration.

Keywords: Diabetic foot ulcer, Amputation, PEDIS score, Diabetes mellitus.

INTRODUCTION:

Diabetic foot ulcers (DFUs) are a debilitating complication of diabetes mellitus, affecting millions globally. These complex wounds, arising from a synergy of vascular, neurological, and metabolic alterations, pave the way to limb amputations, a dreaded outcome fraught with diminished quality of life, and escalated mortality rates^(1-3^). Understanding the factors associated with amputation among diabetic foot ulcers patients is imperative in curbing the escalation of these adverse outcomes. This study meticulously scrutinizes various potential factors and their underlying mechanisms, to illuminate pathways for strategic interventions. Diabetes mellitus, a burgeoning global health concern, is frequently accompanied by complications that adversely affect the feet, including peripheral neuropathy and peripheral arterial disease, both precursors to DFUs^(4^,5^). It is projected that up to a quarter of individuals with diabetes will develop a foot ulcer in their lifetime, with a substantial fraction proceeding to amputation^(6^). This paints a grim picture of the immense burden that DFUs place not only on the healthcare system but also on the affected individuals, emphasizing the need for preventative strategies. Notably, the genesis and progression of DFUs are governed by a multiplicity of factors, which can be largely segregated into intrinsic and extrinsic categories. Intrinsic factors encompass elements such as age, gender, duration of diabetes, glycaemic control, and the presence of comorbid conditions, which have been substantiated to influence the risk of amputations in DFU patients^(7^,8^). Age, for instance, is a significant determinant, with older individuals

demonstrating an amplified risk, potentially due to the compounded effects of diminished tissue regeneration capacities and co-existing vascular diseases^(9^). Gender, another pivotal determinant, showcases differential risks, with males generally exhibiting higher susceptibility to DFUs and subsequent amputations, a phenomenon possibly linked to differing behavioural patterns and health-seeking behaviours between genders^(10^). Furthermore, the duration of diabetes an unmistakable risk amplifier – propels individuals towards a heightened risk, as sustained hyperglycaemia wreaks havoc on vascular integrity and nerve function, setting the stage for ulcerations and potential amputations^(11^). Precariously, the whirlpool of adverse outcomes does not stop here; glycaemic control emerges as a focal point in the discourse on risk factors. Poor glycaemic control accelerates the journey towards DFUs, nurturing an environment ripe for infection, impaired wound healing, and, consequently, an escalated risk of limb amputation^(12^). On the flip side, extrinsic factors – a confluence of behavioural and environmental aspects – play an instrumental role in determining the fate of DFUs. These encompass elements such as smoking, alcohol consumption, footwear inadequacies, and the quality of healthcare access, each contributing its share to the escalating risk of amputations^(13^,14^). Smoking, a known vascular saboteur, exacerbates peripheral arterial disease, thereby magnifying the risk of ulcerations and subsequent amputations^(15^). In parallel, improper footwear emerges as a silent perpetrator, fostering mechanical stresses and promoting ulcer development, particularly in individuals with already compromised foot mechanics^(16^). Yet, perhaps the most striking aspect of this discussion is the role of healthcare access and quality. The degree of healthcare access can potentially alter the trajectory of DFUs, with early detection and management substantially reducing the risk of amputations^(17^). Hence, strategies aimed at enhancing healthcare access and quality, including patient education and community outreach programs, bear significant potential in mitigating the adverse outcomes associated with DFUs. As we navigate through this intricate web of risk factors, it becomes vividly apparent that the journey from DFUs to amputations is punctuated by numerous intervenable checkpoints. Strategically targeting these checkpoints can potentially revolutionize the management of DFUs, pivoting away from amputations towards preservation of limb function and, consequently, quality of life. As we delve deeper into this narrative, we seek to untangle the complexity surrounding the factors associated with amputations among DFU patients, fostering a future where amputations are no longer a foregone conclusion but a preventable outcome.

OBJECTIVES:

- The aim of this prospective observational study was To determine the various factors that are influencing Extensive debridement and amputation in diabetic foot ulcers.
- To emphasize the actions that are needed to prevent the progression of disease.
- To draw a protocol from the above factors that can help prevent amputation.

MATERIALS AND METHODS:

Study Setting and Design

This research project utilizes an observational study design, encompassing a target cohort of 140 patients suffering from diabetic foot ulcers (DFUs). The study participants will be selected from individuals who visit the Surgery Department either as outpatients or as admitted cases at M. S. RAMAIAH MEDICAL COLLEGE Hospital and MEMORIAL Hospital between November 2020 and June 2022.

Ethical Considerations:

Prior to the initiation of the study, a detailed review will be conducted and approval sought from the hospital's ethical committee to ensure adherence to ethical standards in research. Furthermore, written informed consent will be acquired from all participants, ensuring their voluntary and informed participation in the study.

Participant Selection:

Inclusion Criteria:

Patients presenting with diabetic foot ulcers, attending the Surgery Department during the study period either as outpatients or admitted cases, will be initially considered for participation in the study.

Exclusion Criteria:

Specific exclusion criteria will be outlined to eliminate candidates who do not fit the objectives of the study. These criteria will be detailed in the full protocol to ensure a focused and coherent study population.

Data Collection:

Primary Data:

Primary data will be systematically collected through structured interviews and clinical evaluations. The data will encompass a variety of parameters including:

Patient Factors: Age, sex, socio-economic status, and education level.

Comorbidities: Existing conditions such as Diabetes Mellitus, Peripheral Vascular Disease (PVD), Hypertension, and Chronic Kidney Disease (CKD).

Wound Factors: Attributes such as infection status, duration, grade, and Ankle-Brachial Pressure Index

(ABPI).
Laboratory Factors: Laboratory results including Fasting Blood Sugar (FBS), Glycated Hemoglobin (HBA1C), Erythrocyte Sedimentation Rate (ESR), Hemoglobin (Hb) levels, serum creatinine, along with culture and sensitivity tests.

Statistical Analysis:

The data obtained will be meticulously analyzed employing the following statistical methods:
Descriptive Statistics: This will include the calculation of mean and standard deviation for continuous variables such as age, sex, socio-economic status, and comorbidities.
Inferential Statistics: Utilizing the Chi-square test of proportion to discern the associations between the likelihood of requiring amputation versus opting for conservative management with respect to various contributing factors.
A p-value of less than 0.05 will be considered indicative of statistical significance, denoting a significant association between the variables analyzed.

Sample Size and Rationale:

The targeted sample size for this study is 140 participants. This estimate was derived utilizing the N master software, drawing upon data from the master thesis by Dr. G. Dinesh Kannan titled 'A study of factors influencing major amputations in the diabetic foot' conducted at Dr. M.G.R medical university, Chennai. In this prior study, 45 out of 81 diabetic patients underwent major amputation. Assuming a similar proportion of patients with diabetic foot ulcers necessitating amputation at our center, and incorporating a relative precision of 15% along with a desired confidence interval of 95%, the requisite number of participants to be enrolled was determined to be 140.
This study aims to employ a robust methodology to scrutinize and analyze the plethora of factors potentially influencing the occurrence of major amputations among individuals suffering from diabetic foot ulcers, thus fostering informed strategies for prevention and management.

RESULTS:

Most of the patients in our study were from fifth and sixth decade, there was male preponderance 3.5:0.5. In our study, 55.7% patients had diabetes for more than 10 years.

Table1: Association between Duration of diabetes with development of diabetic foot ulcer

Duration of Diabetes	Grade2	Grade3	Grade4	Total
5-10years	2	34	3	39
<5years	4	17	2	23
>10years	4	56	18	78
Total	10	107	23	140

Chi-Sq:9.6;p=0.04*;Cramers V=0.18

We found significant association between the duration of diabetes and development of diabetic foot ulcer.

Table2: Association of diabetic neuropathy with development of Diabetic foot ulcer

Diabetic neuropathy	Grade2	Grade3	Garde4	Total
No	**6**	**43**	**12**	**61**
Yes	**4**	**64**	**11**	**79**
Total	**10**	**107**	**23**	**140**

Chi-Sq:2.8; p=0.3;CramersV=0.12

Although 56% of patients had diabetic neuropathy, we did not find any significant association between diabetic neuropathy and diabetic foot ulcer. Most of the patients (38.6%) had wound duration longer than 30 days followed by37.1% of patients had wound duration between 15-30 days.

Table3:AssociationofDurationofwoundwithprocedure

Duration of wound	Procedure1	Procedure2	Procedure3	Procedure4	Total
15-30days	36	7	8	1	52
7-15days	23	0	3	1	27
<7days	7	0	0	0	7
>30days	11	11	19	13	54
Total	77	18	30	15	140

Chi-Sq: 50.7; p=0.0001*; Cramers V=0.34

- Procedure1=Debridement + Rays amputation
- Procedure 2 = Transmetatarsal + tarsometatarsal + Midtarsal + Syme's amputation
- Procedure3=Below knee amputation + transcondylar Amputation
- Procedure4=above knee amputation
- Above table signifies that duration of wound significantly influences the procedure, wound longer than 30 days or more required higher level of amputation such as below knee amputation and above knee amputation (significant pvalue).
- 87.1% of patients had deranged HbA1c.

Table 4: Association of Glycated haemoglobin (HbA1c) with development of diabetic foot ulcer

HbA1c	Grade2	Grade3	Grade4	Total
Deranged	4	96	22	122
Normal	6	11	1	18
Total	10	107	23	140

Chi-Sq:21.9;p=0.001*; Cramers V=0.39

There is significant association between the deranged HbA1c and the development of diabetic foot ulcer.

Table 5: Association of PEDISSCORE with PROCEDURE

PEDISSCORE	Procedure1	Procedure2	Procedure3	Procedure4	GrandTotal
GRADE2	10	0	0	0	10
GRADE3	67	16	20	4	107
GRADE4	0	2	10	11	23
Grand Total	77	18	30	15	140
Chi-Sq:62.6;p=0.0001*;Cramers V=0.47					

Pedisscore predicts the risk of amputation and mortality in diabetic foot ulcers 76% patients belonged to pedisgrade 3 of which of which 47.1 percent underwent procedure 1 (debridement/rays amputation or both), 14.2% of them underwent procedure 3, Pedisscore with association with procedure had significant p value.

Table 6: Association of hemoglobin with development of Diabetic foot ulcer

Hemoglobin	Grade2	Grade3	Grade4	Total
Deranged	2	59	18	79
Normal	8	48	5	61
Total	10	107	23	140

ChiSq:9.9; p=0.05*; Cramers V=0.23

Hemoglobin level determines the wound healing. We found the significant association between low levels of hemoglobin and development of diabetic foot ulcer.

Table7: Association of ALP with development of diabetic foot ulcer

ALP	Grade2	Grade3	Grade4	Total
Deranged	0	48	21	69
normal	10	59	2	71
total	10	107	23	140

Chi-Sq:26.8; p=0.0001*;Cramer'sV=0.43

We found significant association between deranged alkaline phosphatase and development of diabetic footulcer.
Prior to admission for surgical intervention out of 140 patients87 patient had undergone ayurvedic/herbal treatment prior to admission.

Table 8: Association of ayurvedic treatment with the procedure

Ayurvedic/Herbal	Procedure1	Procedure2	Procedure3	Procedure4	Total
No	39	6	5	3	53
Yes	38	12	25	12	87
Total	77	18	30	15	140

Patient prior to admission, who had undergone ayurvedic treatment were 87 (63.1%), out of which most of the patient had either gone debridement and rays amputation (27.14%) and below knee amputation (17.85%). 60% of the patient who presented with diabetic foot ulcer to hospital, were undergoing treatment based on homeremedies and over the counter medication and ointments for local application without counseling to any doctor, in our study.

Table 9: Associationofhomeremedywithprocedure

Homeremedy for wound	Procedure1	Procedure2	Procedure3	Procedure4	Total
No	29	8	13	6	56
Yes	48	10	17	9	84
Total	77	18	30	15	140

Chi-sq:0.46;p=0.9;CramersV=0.05

There found to be significant association homeremedy with procedure. Most of them underwent debridement.
In our study, male patients constituted around 87%.

Table10:Association of gender with grading of diabetic foot ulcer

GENDER	Grade2	Grade3	Grade4	Total
Female	0	15	3	18
Male	10	92	20	122
Total	10	107	23	140

Chi-sq:1.6;p=0.4;cramersV=0.16

From the above table we can in for that though male patients constituted 87%, there was no significant association between the gender and grading of diabetic foot ulcer.

Frequency of socioeconomic status

Socioeconomic status	Percentage
Upper class	0
Upper middle	29(20.7%)
Lower middle	54(38.6%)
Upper lower	52(37.1%)
Lower class	5(3.5%)

In our study, patients belonging to lower middle class constituted around 38.6%.

Table 11: Association between socioeconomic status and development of diabetic foot ulcer

Socioeconomic	Grade2	Grade3	Grade4	Total
Lower	3	2	0	5
Lower	2	39	13	54
Upper lower	1	42	9	52
Upper	4	24	1	29
Total	10	107	23	140

Chi-sq:31.6;p=0.0001*; Cramers V=0.33

There was significant association between the socioeconomic class belonging to lower classes to the development of diabetic foot ulcer especially of Grade 3. 52.9% patients were smokers in our study.

Table12: Association between smoking and development of diabetic foot ulcer

Smoking	Grade2	Grade3	Grade4	Total
No	4	55	7	66
Yes	6	52	16	74
Total	10	107	23	140

Chi-Sq:3.6; p=0.1; Cramers V=0.15

In our study, we did not find any significant association between smoking and development of

diabetic foot ulcer although smoking is considered as risk factor for diabetic foot. In our study, only 21.4% patients were alcoholics. In the literature, alcohol (particularly higher life time consumption) and psychosocial behavior contributes to development of diabetic foot ulcer. 63.6% patients had associated peripheral vascular disease. Only 3% of patients had associated osteomyelitis. Only 20.7% patients had deranged albumin. Albumin signifies nutritional status of the patient and helps in wound healing. 97% of patients had active wound site infection. 70% of patients had history of previous amputation/debridement. Various procedures were done. Among that 81% of patients underwent debridement and 45% of patients underwent rays amputation. Out of 140 of our patients who had undergone debridement or amputation at any level, 84 patients (65%) had to undergo minor or major debridement redebridement due to localized spread of infection. 70% of patient who had undergone debridement or lower level of amputation, did not require higher level of amputation and only 16.4% of patient required reamputations such as rays amputation for adjacent spread of infection to other toesor higher level of amputation following primary surgery.

Table 13: Cumulative summary of factors associated with amputation and debridement

FACTORS	AMPUTATION	DEBRIDEMENT
AGE	50-60years	40-50years
GENDER	Male (108) (85.7%)	Male (14)
DURATION OFDIABETES	<5years- 19(15%) 5-10years-35(27.7%) >10years- 72(57%)	<5years- 4(28.5%) 5-10years-4(28.5%) >10years-6(42.8%)
ALCOHOLCONSUMTION	26(20.3%)	4(28.5%)
SMOKER	65(51.5%)	9(64.2%)
PVD	50(39.6%)	1(7.14%)

DISCUSSION:

In this study, we embarked on an analytical journey to investigate and quantify the various factors influencing the onset and development of diabetic foot ulcers (DFUs) in patients visiting the M. S. Ramaiah Medical College Hospital and Memorial Hospital over a specified period. The data harvested from the 140 participants has brought to light some compelling findings which are discussed herewith. Our study substantiates the considerable role that the duration of diabetes plays in the development of diabetic foot ulcers. A significant majority, constituting 55.7% of the patients had a history of diabetes spanning over a decade, aligning with other research findings which delineate prolonged diabetes as a dominant precursor for DFUs [18]. The chi-square test result, which stood at 9.6 with a p-value of 0.04, indicates a statistically significant relationship between the duration of diabetes and the gravity of foot ulcers. This concurs with other literature emphasizing the direct proportional relationship between the severity of foot ulcers and the length of time the individual has had diabetes [19]. Interestingly, while the prevalence of diabetic neuropathy was noted in a sizable proportion of patients (56%), our study did not find a significant association with the development of DFUs (p=0.3, Cramers V=0.12). This contrasts slightly with some earlier research which established neuropathy as a pivotal factor in the onset of DFUs [20]. This discrepancy warrants further investigation to delineate the complexities surrounding neuropathy and DFU interrelation. The study brings to light a notable trend where patients who had wounds for over a month necessitated more severe surgical interventions, including above-knee and below-knee amputations, highlighting the crucial aspect of timely medical intervention in managing DFUs effectively. These findings mirror the conclusions drawn by several studies that indicate the detrimental effects of delayed treatment, escalating the severity of the condition [21].

The glycated hemoglobin levels (HbA1c), which were deranged in a vast majority (87.1%) of the patients, significantly correlated with the development of diabetic foot ulcers (p=0.001, Cramers V=0.39). Elevated levels of HbA1c have been widely documented as an indicator of poor glycemic control, potentially leading to DFUs [22]. This, paired with the significant association observed between low hemoglobin levels and DFU development (p=0.05, Cramers V=0.23), echoes the broader consensus in the medical fraternity regarding the influence of these parameters on wound healing capabilities [23].

The socioeconomic backdrop of the patients surfaced as a crucial element influencing the development of

DFUs, predominantly affecting individuals from lower socioeconomic strata (p=0.0001, Cramers V=0.33). Literature often showcases the socio-economic factors as key determinants in the prevalence and management of DFUs [24]. In our study, the lower middle class constituted the largest segment of the affected population (38.6%), an observation which mirrors wider trends highlighting the burden of DFUs on economically marginalized communities [25].

Surprisingly, smoking, despite being acknowledged as a substantial risk factor for DFUs, did not exhibit a significant association in our study (p=0.1, Cramers V=0.15). This finding is somewhat at odds with numerous studies that have underscored the detrimental impacts of smoking on vascular health and wound healing [26]. Gender distribution in our study, with a high male preponderance (87%), did not significantly influence the grading of DFUs, a finding concurrent with some literature which suggests that while men are more prone to developing DFUs, the severity isn't significantly influenced by gender [27]. Several patients had resorted to alternative forms of treatment like Ayurvedic remedies before seeking medical intervention, which might indicate a potential area for public health intervention to encourage earlier hospital consultations. Furthermore, the study highlighted the gravity of re-debridement in managing DFUs, indicating a complex clinical course requiring vigilant monitoring and intervention.

In summation, our study showcases a multifaceted and intricate interplay of various factors influencing the prevalence and progression of diabetic foot ulcers. While it resonates with existing literature in several aspects, it also brings to light new perspectives, encouraging a deeper exploration into this pressing healthcare issue.

CONCLUSIONS:

Our study has contributed valuable insights into the factors influencing the onset and development of diabetic foot ulcers in the demographic investigated. It reinforces the significance of stringent glycemic control, timely medical intervention, and socio-economic support in managing DFUs effectively. Based on the insights gleaned, we recommend an intensified public health initiative focusing on early detection and intervention, coupled with an educational campaign targeting communities at higher risk, to ameliorate the adverse outcomes associated with diabetic foot ulcers. Furthermore, the study indicates avenues for more in-depth research into the complexities surrounding neuropathy and DFU interrelation, and the implications of alternative treatments that are being sought by patients. Through collaborative efforts, incorporating multidisciplinary approaches and community engagement, it is plausible to envision a future where the prevalence and severity of diabetic foot ulcers are substantially diminished.

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