

## To Predict the Risk of Lower Limb Amputation in Diabetic Foot Ulcer Patients by Using the DIAFORA Score (Diabetic Foot Risk Assessment Score)

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### Abstract

**Background:** A recently introduced modality is DIAFORA score, for assessing the risk of lower extremity amputation in diabetic foot ulcer patients, which is more accurate as compared to other existing classification systems.

**Aims and Objective:** To predict the risk of lower limb amputation in diabetic foot ulcer patients by using the DIAFORA score (Diabetic foot risk assessment score).

**Materials and Methods:** The study was conducted from 2018 to 2020 on a total of 50 patients with DFUs from OPD, medicine and surgery wards of the MMIMSR, Mullana. Subjects were examined and relevant investigations were sent. The DIAFORA score [3] was calculated for each patient and was categorized into one of the 3 risk groups (low, medium and high). Patients with a score less than 15 were categorized into low risk group, patients with score between 15 and 25 were categorized into medium risk group and patients with score more than 25 were categorized into high risk group for LEA and each subject was followed upto 3 months (91 days) or until LEA/death/recovery of the subject.

**Result:** Mean age of the patients was  $55.82 \pm 14.52$  years. Distribution of study subjects according to the DIAFORA score into high, medium and low risk groups were 17 (34.0%), 10 (20.0%), 23 (46.0%) respectively. Mean DIAFORA score of the low risk group, medium risk group, high risk group was  $7.52 \pm 3.189$ ,  $22.20 \pm 3.120$ ,  $33.76 \pm 3.945$  respectively, statistically significant ( $p < 0.001$ ). DIAFORA score had Area under the receiver operating characteristic (ROC) curve 0.992 (99%) with a p value of 0.0001 (highly significant). DIAFORA score of 23 taken as cut off value for amputation had sensitivity of 91.3%, specificity of 100%, positive predictive value of 100.0% and negative predictive value of 93.1%. Amputation was done in 23 (46.0%) patients whereas rest 27 (54.0%) were recovered. In the amputation group, Peripheral neuropathy, foot deformities, Peripheral Arterial Disease, bone involvement and gangrene were present in 20 (87%), 14 (60.9%), 20 (87%), 18 (78.3%), 23 (100%).

**Conclusion:** We conclude that the recently introduced DIAFORA score model is a reliable predictor of lower extremity amputation amongst patients with Diabetic Foot Ulcer. It has high sensitivity and specificity to predict amputation.

**Keywords:** DFU; LEA; DIAFORA Score; High Risk; Medium Risk; Low Risk

### Introduction

Diabetic foot is a very serious complication of diabetes. It has a global annual incidence of 6.3%. Neuropathy, ischemia, PVD and infection combined result in progression to tissue necrosis which is often rapid and devastating. Diabetes is one of the most common underlying cause of non-traumatic lower extremity amputations (L.E.A.s).

Underlying diabetes-related pathophysiology (neuropathy, peripheral arterial disease (PAD), foot deformity and limited joint mobility), initiating environments (trauma), subsequent infection, and healing complications lead to ulceration and eventually LEA [1]. PAD is the most common cause for lower limb amputation while peripheral neuropathy is most common cause for diabetic foot ulcer.

A timely estimation of the risk of amputation in patients with diabetic foot ulcer is very important as it helps to salvage the limb to reduce the associated high morbidity and mortality, and proper management to salvage the limb.

In the literature numerous classifications were used earlier to estimate the risk of amputation in patients with diabetic foot ulcer such as the Meggitt-Wagner system and TEXAS University Classification. All these have their own pros and cons. The classification system which is most commonly used is Wagner classification system. This system has drawback that it stresses more upon the diabetic foot ulcer characteristics rather than the development and pathogenesis of a diabetic ulcer.

A new model has been developed recently to classify subjects of diabetes with active Diabetic Foot Ulcer (DFU) by their risk of Lower Extremity Amputation (LEA) known as the DIAFORA score (Diabetic foot risk assessment) [2]. It has the advantage that it takes into account the risk factors involved in the development of diabetic foot ulcer such as presence of peripheral arterial disease, peripheral neuropathy, history of previous DFUs, multiple DFUs. It is simple and easy to apply in everyday practice and has high sensitivity and specificity and accuracy to predict amputation.

Hence, this study was planned to predict the risk of amputation in patients having diabetic foot ulcer by using DIAFORA score.

### Aims and Objectives

To study the risk of amputation of lower limb in Diabetic foot ulcer patients, by using an assessment tool - called as the DIAFORA score (Diabetic foot risk assessment score).

### Materials and Methods

This study was a prospective study carried out from 2018 to 2020 in which a total number of 50 patients of diabetic foot ulcer were studied, irrespective of type of diabetes, age or sex, at M.M. Institute of medical sciences and research, Mullana, Ambala. All 50 patients were taken from OPD, medical and surgery wards of the hospital were examined and all relevant investigations were sent like CBC, RFT, HbA1C, Fasting Blood sugar, Post prandial blood sugar, Urine Albumin, X-ray Foot, Color Doppler of lower limb, Pus culture and sensitivity.

We recorded important details, risk factors and parameters to calculate the DIAFORA score. DIAFORA score includes 8 variables, which are categorized as foot related variables and diabetic foot ulcer related variables. The foot related variables are diabetic peripheral neuropathy (inability to feel monofilament at  $\geq 1$  of the 4 points), Peripheral arterial disease (none or only 1 pedal pulse is palpable), foot deformity (Foot alteration increasing pressure in  $\geq 1$  sites), previous diabetic foot ulcer/lower extremity amputation and Diabetic foot ulcer related variables are multiple DFUs (1 or more than 1 D.F.U), infection (purulent discharge and any of the local signs), bone involvement (touched with a sterile probe or bone involvement on X-ray) and gangrene (necrosis of tissue (wet/ dry)). Variables had scores 4, 7, 1, 3, 4, 4, 7, 10 respectively.

Patients were then assigned into one of the 3 risk groups (low, medium and high risk). Patients with a score less than 15 were categorized as having low risk, patients with score between 15 and 25 were categorized as having medium risk and those with score more than 25 were categorized as having high risk of lower extremity amputation (L.E.A.).

All the patients with diabetic foot were selected after fulfillment of the inclusion/exclusion criteria into study after obtaining written informed consent.

All selected patients were evaluated using the DIAFORA score and followed up for a period of 3 months (91 days), or either upto lower extremity amputation (L.E.A.) or death of the patient or healing whichever occurred earlier.

**Inclusion criteria**

All the subjects with active Diabetic Foot ulcer (both type 1 and type 2 D.M.).

**Exclusion criteria**

Non-diabetic ulcers and gangrene due to reasons other than diabetes, like non healing decubitus ulcer.

**Statistical methods applied**

Data were described in terms of range, mean ± standard deviation (± SD), median, frequencies (number of cases) and relative frequencies (percentages) as appropriate.

Receiver operator characteristics (ROC) curve was done and cut off value of the DIAFORA score was estimated depending on the specificity and sensitivity. Area under curve (AUC) was measured.

All statistical calculations were done using (Statistical Package for the Social Science) SPSS 21 version (SPSS Inc., Chicago, IL, USA) statistical program for Microsoft Windows.

**Observations and Results**

In our study we found mean age of the patients was 55.82 ± 12.56 years.

Number of males were higher (56%) than the females (44%), (M:F ratio 28:22).

The mean duration of diabetes in diabetic foot ulcer (D.F.U.) patients was 9.07 ± 3.21 years.

The mean HbA1C% of the all DFU patients was 9.94 ± 2.86%.

Risk groups	N	Mean DIAFORA score	Std. Deviation	95% Confidence Interval for Mean		Minimum	Maximum	F	p-value
				Lower Bound	Upper Bound				
Low	23	7.52	3.189	6.14	8.90	3	14	286.47	0.001
Me- dium	10	22.20	3.120	19.97	24.43	15	25		
High	17	33.76	3.945	31.74	35.79	26	40		
Total	50	19.38	12.282	15.89	22.87	3	40		

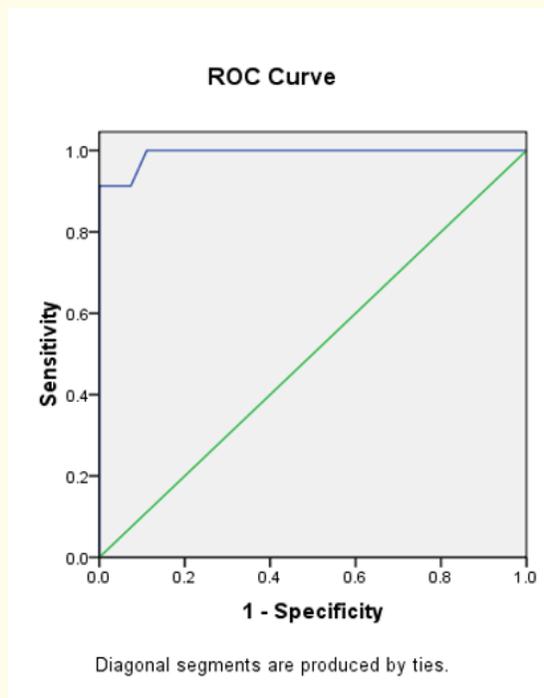
**Table 1:** Mean DIAFORA score of the study participants in different risk groups.

As table 1 shows that mean the DIAFORA score of low risk group was the lowest (7.52), medium risk group was in the middle (22) and of high risk group was the highest (33.76). This correlation was statistically significant (p value 0.001)

Amputation done	Amputation risk groups						Chi-square value	p-value
	Low (n = 23) (Mean = 7.52)		Medium (n = 10) (Mean = 22.20)		High (n = 17) (Mean = 33.76)			
No	23	100.0%	4	40.0%	0	0.0%	40.338	0.001
Yes	0	0.0%	6	60.0%	17	100.0%		
Total	23	100.0%	10	100.0%	17	100.0%		

**Table 2:** Correlation between amputation and risk of amputation (Calculated by DIAFORA score).

As table 2 shows none (0%) of the D.F.U. patients were amputated in the low-risk group, 60.0% were amputated in the medium risk group and all (100%) D.F.U. patients were amputated in the high-risk group (p value < 0.001).



**Figure 1:** Area under the curve.

AUC is 0.992 (99%) with a p value of 0.0001 (highly significant) implying that DIAFORA score is a strong predictor of risk of amputation.

DIAFORA score of 23 taken as cut off value for undergoing amputation had 91.3% sensitivity, 100% specificity, 100.0% positive predictive value and 93.1% negative predictive value.

Peripheral Neuropathy, Foot deformity, Peripheral arterial disease (P.A.D.), previous D.F.U., multiple D.F.U., bacterial infection, gangrene, osteomyelitis was found in 33 (66.0%), 17 (34.0%), 23 (46.0%), 22 (44%), 15 (30%), 34 (68%), 26 (52%) and 19 (38%) patients respectively.

## Discussion

There are various risk factors which contribute in the development of a diabetic foot ulcer. Some of the general factors are uncontrolled hyperglycemia of long duration, old age, peripheral vascular disease and some of the local causes are structural foot deformity, peripheral neuropathy, repeated trauma due to ill fitting foot-wear, callus, limited joint mobility, prolonged elevated pressure etc.

In our study we found mean age of the patients was  $55.82 \pm 12.56$  years. The mean age of patients who submitted to amputation was  $56.1 \pm 14.44$  years. Monteiro-Soares, *et al.* [2], Monteiro-Soares, *et al.* [3], Prompers, *et al.* [4], Husers, *et al.* [5] also observed similar results.

The number of males were higher (56%) than the females (44%), (M:F ratio 28:22). Moreover, 74% males and 26% females underwent amputation (p value 0.024). Ugwu, *et al.* [6] also observed the same.

Diabetic peripheral neuropathy is a major etiological factor for Diabetic Foot Ulcers. Peripheral neuropathy is associated with absence of perceived trauma which is the basic reason behind development of diabetic foot ulcerations. In our study Peripheral Neuropathy was found in 66.0% patients with DFU, out of them 87% underwent amputation, (p value 0.006) i.e. statistically significant. Ugwu, *et al.* [6], Yesil, *et al.* [7] showed similar findings.

HbA1c is useful for monitoring long term serum glucose regulation. We found that mean HbA1C% of the all DFU patients was  $9.94 \pm 2.86\%$  and of the amputated patients was  $11.6 \pm 2.71\%$ .

In a diabetic patient, once an ulceration develops, arterial insufficiency will result in prolonged healing and contributes to an elevated risk for L.E.A. We found that P.A.D. was present in 46% patients, out of them 87% underwent amputation, (p value < 0.001) i.e. P.A.D. is a strong predictor of amputation. Sayiner, *et al.* [8], Pemayun, *et al.* [9] had same results.

Long standing diabetes leading to development of peripheral neuropathy and this leads to recurrent trauma and mechanical changes of the foot, leading to the development of diabetic foot deformities. In the present study foot deformity was found in 34.0% patients. Foot deformity showed significant correlation with amputation (p value 0.001). Reiber GE, *et al.* [10] reported foot deformity in 63% patients.

Infections of D.F.U occur repeatedly due to long standing hyperglycemia and poor wound healing. In the present study bacterial infection was seen in 68% of the patients and out of them 82.6% underwent amputation, (p value 0.067). Ugwu, *et al.* [6], Nather, *et al.* [11] showed similar findings.

Gangrene is the most dreaded complication of diabetic foot. It can occur as a result of a deep seated infections, P.A.D. or impaired micro-circulation. We found that 52% patients had gangrene and all (100%) patients who developed gangrene underwent amputation, which was statistically significant (p value < 0.001). Shatnawi, *et al.* [12] observed similar findings.

We found that 38% patients had bone involvement, out of them 78.3% underwent amputation which was statistically significant (p value < 0.0001). Uysal, *et al.* [13] also concluded the same.

History of previous diabetic foot ulcer patient did not show statistically significant correlation with amputation.

We found that 30% patients had multiple D.F.U.s and out of those 26.1% underwent amputation (0.577). Multiple diabetic foot ulcer patients did not show statistically significant correlation with amputation (p value > 0.05).

As figure 1 shows DIAFORA score model had an area under the ROC curve of 0.992 (99%) implying that DIAFORA score was a very strong predictor of LEA, which was statistically significant ( $p$  value  $< 0.001$ ). DIAFORA score cut off value 23 has a high sensitivity, specificity, PPV and NPV and accuracy to predict amputation.

We observed that male gender, peripheral neuropathy, foot deformity, peripheral arterial disease, bone involvement, presence of gangrene, mean DIAFORA score, were statistically significantly higher in the amputated group as compared to non-amputated group (all had  $p$  value  $< 0.05$ ).

### Conclusion

DIAFORA score is a significantly strong predictor of lower extremity amputation in Diabetic foot ulcer patients. Although many conventional scoring systems are known but a recently introduced DIAFORA score classification system is simple, easy to remember and easy to apply in everyday practice and has high sensitivity and specificity and accuracy to predict amputation. It should be adopted more widely in routine clinical practice to reduce the morbidity and mortality in diabetic foot ulcer patients.

### Conflict of Interest

None.

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