

## Research Article

# Diabetic foot: vasculopathy assessment and analysis of risk factors of amputation

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### ABSTRACT

**Background:** Diabetes is a major contributing factor in up to 70% of lower limb amputations. In majority of diabetic patients, the underlying factor contributing to eventual amputation is diabetic foot disease and diabetic foot ulcer. The burden of diabetic foot disease and ulceration is set to increase further due to the co-existence of contributory co morbidities including peripheral vascular disease and peripheral neuropathy.

**Methods:** An observational study was designed to assess the vascular status of diabetic foot patients and the risk factors of lower limb amputation.

**Results:** Diabetic foot ulcers was recorded mostly among males and found to increase with age. Smoking was noted in 87% of the male patients who had diabetic foot ulcers. Gangrene was the major and most common mode of presentation in diabetic foot ulcer patients. The angiopathy should be considered as the major risk factor which leads to major limb amputation, which can be easily detected at the earliest stage by simple clinical examination of peripheral pulses and by arterial Doppler study which is non-invasive.

**Conclusion:** Present study was carried out to assess the vascular status of diabetic foot patients and to assess the prevalence of risk factors due to the lower limb amputation like Ray amputation, below knee amputation, wound debridement. Arterial Doppler, radiography, fundoscopy and neuropathy were done. Based on a study of these results, it was found that vascular status plays a major role in majority of the diabetic patients. Thus, angiopathy in diabetics must be taken into serious considerations and it is suggested that arterial Doppler can be done as a part of clinical examination to combat the major limb amputations.

**Keywords:** Diabetic foot, Vasculopathy, Amputation

### INTRODUCTION

Diabetes is a major contributing factor in up to 70% of lower limb amputations. In majority of diabetic patients, the underlying factor contributing to eventual amputation is diabetic foot disease and diabetic foot ulcer. The burden of diabetic foot disease and ulceration is set to increase further due to the co-existence of contributory co morbidities including peripheral vascular disease and peripheral neuropathy. Lower extremity amputation is twice as common in subjects with diabetes compared with non-diabetic persons, affecting 30% of subjects with diabetes 40 years and older. Foot ulcers cause substantial

emotional, physical, productivity and financial losses. More than 60% of the diabetic foot ulcers have insufficient blood flow due to peripheral vascular disease. The atherosclerotic disease is usually manifested below the popliteal artery and involves one or more of the three lower-leg arteries: the femoral artery, the posterior tibial artery, and dorsalis pedis artery. The ability to revascularise the angiosome where the ulcer is increases the chances for healing. The most costly and feared consequence of a foot ulcer is limb amputation, which occurs 10 to 30 times more often in diabetes than in the general population. Success in treatment and prevention of lower extremity diabetes related complications is

achieved only with a motivated multi-disciplinary approach.

There is an increased prevalence of PVD among individuals with diabetes in both the sexes compared with non-diabetic individuals.<sup>1</sup> In epidemiologic studies, PVD (Peripheral Vascular Disease) is commonly measured as intermittent claudication, the symptom of cramping calf pain introduced by walking and relieved by rest,<sup>1</sup> the absence or marked impairment of at least one major arterial pulse.<sup>2</sup> In those with diabetes, the prevalence of PVD increases with age and duration of diabetes, and is increased in men.<sup>2</sup>

The risk factors of PVD in the general population including hypertension, elevated cholesterol, tobacco use, smoking habits also contribute. PVD increases the risk for ulcer, gangrene,<sup>2,4</sup> abscess and lastly amputation<sup>5</sup> in diabetic patients. Complications affecting the lower limb are among the most common manifestations of diabetes. It was reported that 15% of diabetic patients will eventually suffer from foot ulceration during their life time. These complications are frequent cause of hospitalisation related to foot ulcers. Moreover according to some estimates, the treatment costs of these complications account for approximately 25% of the total hospital costs of diabetes care.

The pathway to diabetic foot ulceration is multifactorial, and it culminates deleterious events such as repetitive or overt trauma in the setting of peripheral arterial disease. The pathway to prevention of these complications relies on early identification, education and implementation of a multidisciplinary management programme. Hence identification of the risk factors in diabetic foot disease remains the major factor in preventing major non-traumatic limb amputations.

## METHODS

- To assess the vascular status in diabetic foot patients.
- To analyse and study the risk factors of lower limb amputation in diabetic foot patients.

### Study design and settings

An observational study was designed to assess the vascular status of diabetic foot patients and the risk factors of lower limb amputation.

### Study period

January and August 2014.

### Subjects

A total of 100 type 2 diabetic patients from our teaching hospital who volunteered for this study were enrolled. Their consent was also taken.

### Ethical considerations

The study was carried out only after obtaining the approval of the institutional ethics committee.

### Data collections

A pretested profoma was used to collect data on age, sex, history of hypertension, history of smoking and duration of diabetes. Ulcers were examined and were graded by Wagner's classification. Also the mode of presentation was noted. Clinically lower limb peripheral pulses (Dorsalis pedis, popliteal, posterior tibial, femoral) and presence of neuropathy were examined. After that they were subjected to arterial Doppler to assess the vascular status. Plain X-ray of foot taken to see joint degeneration, soft tissue infection and vessel calcification.

All patients were managed as per grade of involvement by dressing with or without split skin grafting, wound debridement/drainage followed by wound care with or without local amputation and lower extremity amputation below or above knee as per the case.

### Inclusion criteria

Patients with type 2 diabetes with one or the other forms of diabetic foot lesions were included irrespective of age and sex. Also patients with foot lesions like gangrene of foot chronic indolent ulcers cellulitis and abscess with diabetes were also included.

### Exclusion criteria

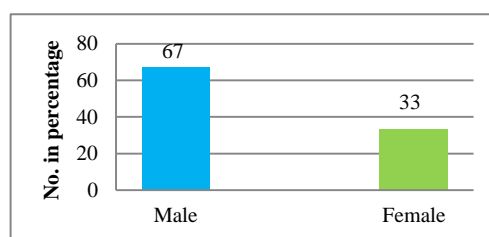
Patients' with foot lesions due to trauma and other ulcers, as well as Coronary Artery Disease (CAD), chronic kidney diseases and associated other co-morbidities were excluded.

## RESULTS

Table 1 shows knowledge of diabetes and foot care.

**Table 1: Knowledge of diabetes and foot care.**

	Frequency	Percent
No	83	83.0
Yes	17	17.0
<b>Total</b>	<b>100</b>	<b>100.0</b>



**Figure 1: Gender.**

There were about 67 males and 33 females in the study (Figure 1).

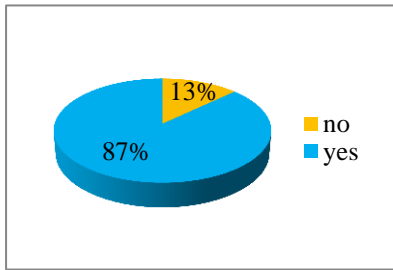


Figure 2: Tobacco use.

Smoking was observed only in male patients. Of the 67 males, 87% are current smokers and the remaining 13% are non-smokers (Figure 2).

Table 2: History of hypertension.

Hypertension	Frequency	Percent
No	79	79%
Yes	21	21%

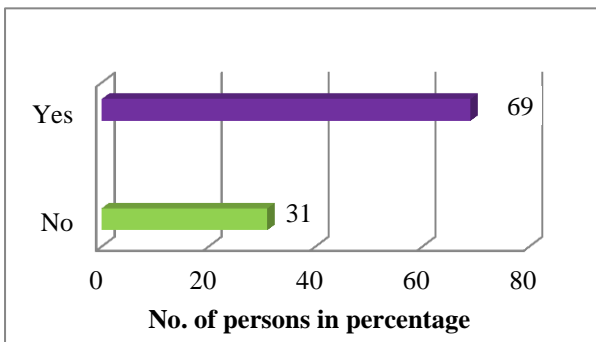


Figure 3: Gangrene.

Of the total patients, 69% of them presented with gangrene (Figure 3).

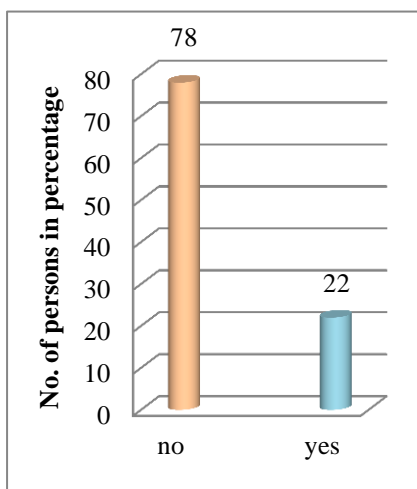


Figure 4: Ulcer presentation.

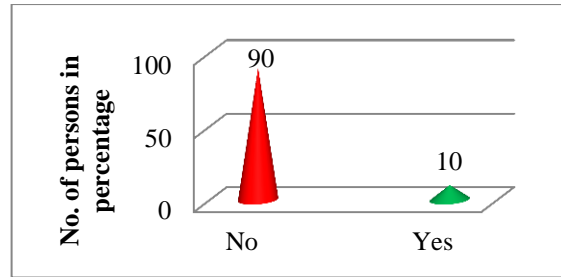


Figure 5: Abscess presentation.

The analysis of mode of presentations from the above three Figures (Figure 3, 4, 5), gangrene form was the most frequently presented form.

Table 3: Wagner grading system.

Grades		Frequency	%	Valid %
Grade 1	Superficial diabetic ulcer	3	3.0	3.0
Grade 2	Ulcer extension involves ligament, tendon, joint capsule/fascia	18	18.0	18.0
Grade 3	Deep ulcer with abscess/osteomyelitis	10	10.0	10.0
Grade 4	Gangrene to portion of fore foot	64	64.0	64.0
Grade 5	Extensive gangrene of foot	5	5.0	5.0
<b>Total</b>		100	100.0	100.0

The ulcers were examined and were graded according to the Wagner's grading system. Grade 4 is the maximum.

Table 4: Peripheral pulses.

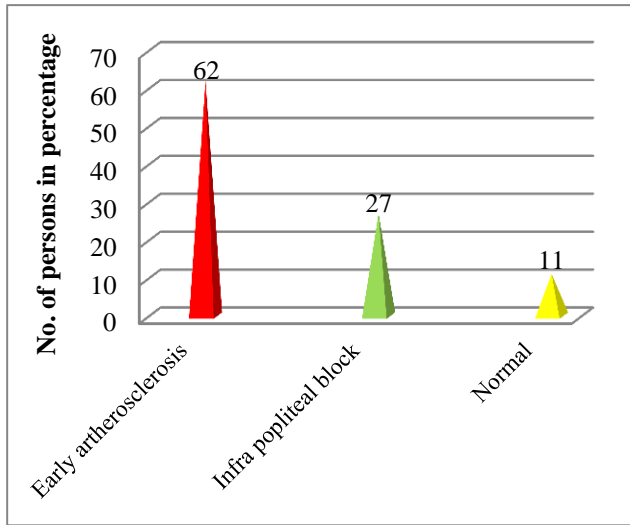
Pulse status	Dorsalis pedis artery 200 (%)	Posterior tibial artery 200 (%)	Popliteal artery 200 (%)	Femoral artery 200 (%)
Yes	145 (72.5)	173 (86.5)	200 (100)	200 (100)
No	65 (27.5)	27 (13.5)	-	-

Pulses were examined on both the legs, in that dorsalis pedis arterial pulse and posterior tibial arterial pulse was absent in 65 and 27 vessels respectively. Also it was noted that they were absent on side of diabetic foot ulcer.

Table 5: X-ray foot.

	Frequency	Percent%
Normal	96	96.0
Osteomyelitis	4	4.0
<b>Total</b>	100	100.0

Almost 96% of the diabetic patients showed normality in the radiography and only 4% presented with osteomyelitis thus it is not much significant.



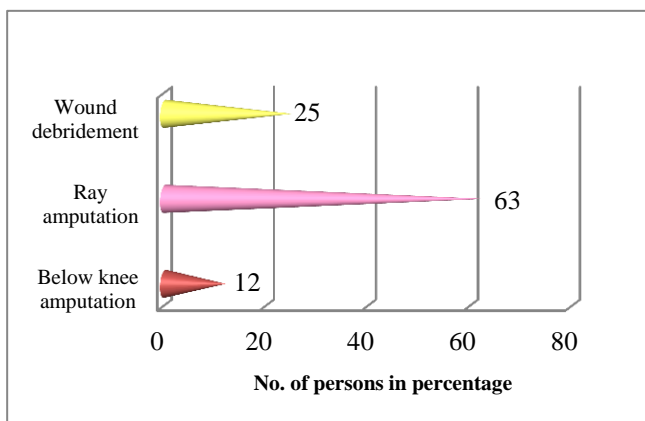
**Figure 6: Arterial Doppler.**

From the above Figure 6 it can be seen that early atherosclerosis and infra popliteal block were 62% and 27% respectively.

**Table 6: Presence of neuropathy.**

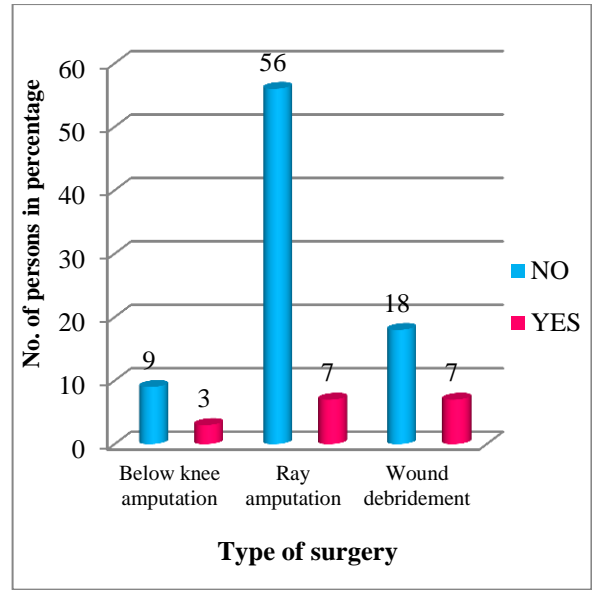
	Frequency	Percent
Absent	22	22.0
Present	78	78.0
<b>Total</b>	<b>100</b>	<b>100.0</b>

Peripheral neuropathy was present in 78% of the patients presented with diabetic foot ulcers (Table 6).



**Figure 7: Type of surgery.**

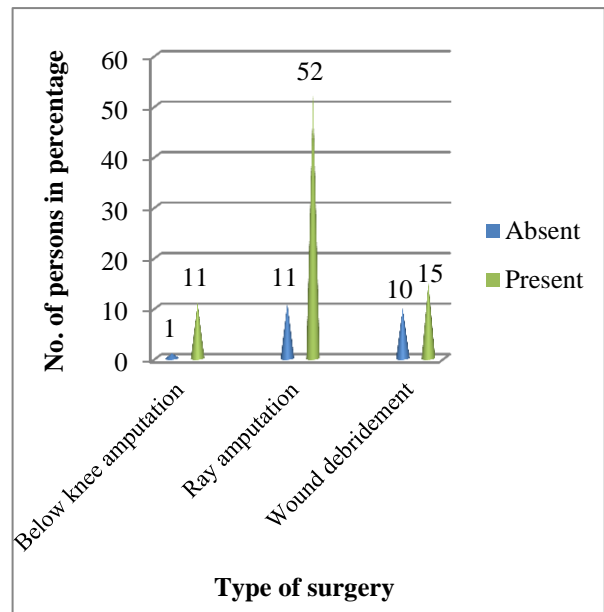
Treatment modalities were followed in which wound debridement was done in 25% of patients, ray amputation and below knee amputation in 63% and 12% respectively (Figure 7).



**Figure 8: Comparison of surgery & knowledge.**

Of the 100 cases only 17 had some knowledge on diabetic foot care and 87 had nil or sub-optimal knowledge it is compared with surgery and depicted in Figure 8.

In those 56 members with no knowledge about diabetic foot care went in for ray amputation.



**Figure 9: Surgery & neuropathy.**

A comparison between surgery and neuropathy is drawn and observed that patients presenting with peripheral neuropathy went in for ray amputation.

About 63 members out of 78 underwent amputations (Figure 9).

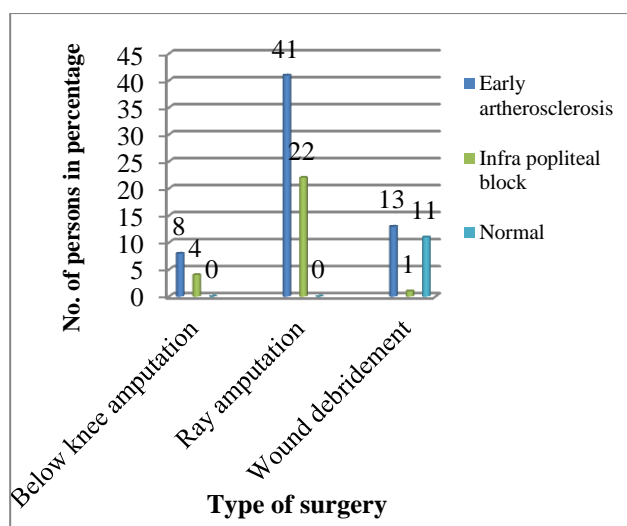


Figure 10: Surgery & arterial Doppler.

Table 7: Arterial Doppler and surgery.

Doppler findings	Total	Amputation (Ray & below knee)
Early atherosclerosis	62	49
Infra popliteal block	27	26
Normal	11	0

Has a significance P (0.001)

## DISCUSSION

The diabetic foot is defined as any foot pathology that results directly due to the diabetic state or its long term complication. Peripheral vascular disease increases the risk of developing foot ulcers and contributes to poor healing.<sup>6</sup> Peripheral vascular disease is common among patients with diabetes who may also suffer from peripheral neuropathy and foot deformities, which increases the risk of developing ulcers. Diabetic foot is described by the WHO as the foot of diabetic patient that has the potential risk of pathologic consequences including infection, ulceration or destruction of deep tissues associated with neurologic abnormalities, various degrees of peripheral vascular disease or metabolic complications of the diabetes in the lower limb.

Diabetic angiopathy is reported to be the most frequent cause of morbidity and mortality in diabetic patients.<sup>7</sup> Macroangiopathy manifests as a diffuse multi segmental involvement involving the lower limb vessels and is also associated with compromised collateral circulation. This is considered as an atherosclerotic obstructive disease of large vessels, which leads to peripheral arterial disease of the lower extremities. Only little is known about the biology of PAD in individuals with diabetes, but it is felt that the vascular changes observed with other manifestations of atherosclerotic disease are applicable to patients with both peripheral arterial disease and diabetes.

In a case control study of 112 hospitalised diabetic patients by Peters et al.,<sup>8</sup> peripheral arterial disease was independently associated with the 5.5 fold increased risk for diabetic foot. Microangiopathy results in capillary basal membrane thickening, altered nutrient exchange, tissue hypoxia and microcirculation ischemia. There has been an evidence of diabetic foot as early as the ancient Egyptian time with discovery of mummies with prosthetic toes. Pryce reported a case of foot ulcer associated with diabetes in 1887.

Lack of attention to foot hygiene and use of poorly fitting foot wear are the major factors that are preventable in the development of infection. Diabetic foot infection may be fungal infection of nail to severe necrotising limb or life threatening infections. Early diagnosis and prompt definitive treatment may be delayed due to lack of foot sensation, patient's poor eye sight, poor judgement by physician. Abrasion, rashes and loss of skin integrity can be the initiating factor in the development of diabetic foot infection. Usually it is seen that 60% foot infections started in web spaces, 30% in nails and 10% were secondary to punctures. The clinical presentation of a diabetic ranges from acute cellulitis to life threatening necrotising fasciitis.

Debridement has to be meticulous and often repeated debridement is necessary.<sup>9</sup> Treatment priorities are 1) aggressive treatment of infections 2) diagnosis of ischemia and evaluation for possible revascularisation 3) relief of pressure to the wound 4) improvement of the wound environment with debridement dressing and advanced care treatments. Treatment of a complicated diabetic foot ulcer can involve many pathways. After a complete ulcer evaluation including measurements, x ray studies, fundoscopy, arterial Doppler can be done.

About 2.5% of diabetic men and women will develop a foot ulcer each year.<sup>10</sup> The diabetic foot syndrome is a severe complication of diabetes as it often leads to limb amputation with consequent negative effects on the quality of life<sup>11</sup> and productivity of the affected patient. In our study, more males (67%) presented with diabetic foot lesions, which is consistent with findings of other studies.<sup>12,13</sup> This may be due to engagement of more males in manual labour often without wearing protective shoes. The high incidence of patients without any formal education in this study is a reflection of the general level of literacy in the country and has a direct bearing on the ability of the patient to understand and practice diabetic foot care education programmes. Only 17% of the patients were aware of the diabetic foot care protocol.

Most of our patients (69%) presented with foot gangrene. Even though a few studies have given similar results,<sup>14</sup> most other studies have identified foot ulcer as the most common presentation of diabetic foot syndrome.<sup>15,16</sup> The high incidence of foot gangrene may be due to a number of factors including seeking alternative medical care where irritant topical agents were applied to the affected

foot, self-medication, ignorance, and poverty, with consequent delay in presentation to hospital for appropriate medical care.<sup>17</sup> The average interval between the occurrence of foot lesions and presentation in hospital was about 2 weeks, the longest being 1 months. There was considerable delay in presenting to the hospital because of lack of knowledge about the diabetic foot consequence and attempting native treatment which eventually fails.

Lower limb amputation was carried out in 75% of the patients, with type 2 diabetic patients. This is comparable to findings of another study<sup>24</sup> in which 80% of the major amputations were performed on type 2 diabetic patients. This tends to suggest a higher tendency for lower limb amputations in type 2 diabetes. However, a study in Taiwan recorded low rates.<sup>18</sup> These variations require further study on sociology and clinical aspects.

The most common major lower limb amputation carried out in this study was below knee amputation probably due to late presentation of our patients. In other studies in developed countries, most of the amputations were minor amputations around the foot.<sup>12,13,19</sup> The high rate of major amputations in this study places even greater burden, economic and social, on the affected patients as many of them are unable to acquire limb prosthesis to ensure full rehabilitation.

Peripheral neuropathy, as found in 78% of the patients, and peripheral vascular disease(89%), as determined by the absence of palpable peripheral arterial pulsations and arterial Doppler study, were closely associated with a higher risk of lower limb amputations. This is in keeping with the findings of other studies.<sup>19,20-22</sup> This underscores the need for intensive diabetic foot care in patients with these lesions as a means of preventing the occurrence of foot lesions and consequent lower limb amputation.

Several factors predispose diabetic patients to developing a diabetic foot disease, including neuropathy, vasculopathy and immunopathy. Peripheral neuropathy occurs early in the pathogenesis of diabetic foot complications and is considered to be the most prominent risk factor for diabetic foot ulcers. Diabetic angiopathy is also reported to be the most frequent cause of morbidity and mortality in diabetic patients. Macroangiopathy manifest as a diffuse multisegmental involvement typically involving the infrapopliteal vessels and is also associated with compromised collateral circulation. In our study also about 27% of cases had infrapopliteal block and 62% cases had early atherosclerotic changes, which clearly say that 89% cases of diabetic foot diseases have vascular changes. Hence peripheral arterial disease can be considered as an independent risk factor and always advisable to evaluate the arterial system in cases of diabetic foot disease at early stages and implement the preventive measures to stop the evolving atherosclerotic changes to complete vessel block which may eventually lead to a major limb amputation. Calle-Pascual et al.

reported that 100% of the major amputations in their series were associated with peripheral vascular disease.<sup>23</sup>

Even though the neuropathy has been the initiating factor for the diabetic foot disease in association with secondary infection, the vascular component should be considered as the major factor for wound healing and also the deciding factor for limb amputation because once the infrapopliteal vessel blockade occurs the progression of collaterals development is very low and even though if collaterals develops that vessel also goes for atherosclerotic changes. The Arterial reconstruction and free omental grafts will not give better results. Hence diabetic angiopathy should be taken into serious consideration and initial evaluation; proper preventive measures should be implemented to avoid major limb amputations.

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*Ethical approval: The study was approved by the institutional ethics committee*

## REFERENCES

1. Kannel WB, McGee DL. Diabetes and glucose tolerance as risk factors for cardiovascular disease. The Framingham study. *Diabetes Care.* 1979;2:120-6.
2. Melton LJ III, Macken KM, Palumbo PJ, Elveback LR. Incidence and prevalence of clinical peripheral vascular diseases in a population based cohort of diabetic patients. *Diabetes Care.* 1980;3:650-4.
3. Delbridge L, Apple Burg M, Reeve TS. Factors associated with the development of foot lesions in the diabetic. *Surgery.* 1983;93:78-82.
4. Okuyama M, Nagai K, Miyazaki S, Kosaka J, Kamikubo K, Miura K, et al. Diabetic gangrene-analysis of 487 cases. *Tohoku J Exp Med.* 1983;141:583-6.
5. Tan MH, Gwee HM, Yeo PPB, Lim P, Bose K. Diabetic amputees in Singapore. *Tohoku J Exp Med.* 1983;141:576-82.
6. Singh N, Armstrong DG, Lipsky BA. Preventing foot ulcers in patients with diabetes. *JAMA.* 2005;293(2):217-28.
7. Joseph WS, LeFrock JL. The pathogenesis of diabetic foot infections immunopathy, angiopathy. *J Foot Surg.* 1987;26:7-11.
8. Peters EJ, Lavery LA, Armstrong DG. Diabetic lower extremity infection: influence of physical, psychological and social factors. *J Diabetes Complications.* 2005;19:107-12.
9. Lipsky BA, Pecoraro RE, Larson SA, Hanley ME, Ahroni JH. Outpatient management of

- uncomplicated lower extremity infections in diabetic patients. *Arch Intern Med.* 1990;150:790-7.
10. Moss SE, Klein R, Klein B. The prevalence and incidence of lower extremity amputation in a diabetic population. *Arch Intern Med.* 1992;152:610-3.
  11. Teichmann J, Sabo D. Epidemiology and classification of diabetic foot syndrome. *Orthopäde.* 2009;38:1139-48.
  12. van Houtum WH, Lavery LA, Harkless LB. The impact of diabetes-related lower-extremity amputations in the Netherlands. *J Diabetes Complications.* 1996;10:325-30.
  13. Resnick HE, Carter EA, Sosenko JM, Henly SJ, Fabsitz RR, Ness FK, et al. Incidence of lower-extremity amputation in American Indians: the Strong Heart Study. *Diabetes Care.* 2004;27:1885-91.
  14. Nather A, Bee CS, Huak CY, Chew JL, Lin CB, Neo S, et al. Epidemiology of diabetic foot problems and predictive factors for limb loss. *J Diabetes Complications.* 2008;22:77-82.
  15. Pendsey SP. Understanding diabetic foot. *Int J Diabetes Dev Ctries.* 2010;30:75-9.
  16. Udosen AM, Ikpeme IA, Etiuma A, Egor S. Major amputations at the University of Calabar teaching hospital, Calabar, Nigeria. *Nigir J Surg Sci.* 2004;14:60-3.
  17. Pendsey S, Abbas ZG. The Step-by-step program for reducing diabetic foot problems: a model for the developing world. *Curr Diabet Res.* 2007;7:425-8.
  18. Tseng CH. Prevalence of lower-extremity amputation among patients with diabetes mellitus: is height a factor? *Can Med Ass J.* 2006;174:319-23.
  19. Aksoy DY, Gürlek A, Cetinkaya Y, Oznur A, Yazici M, Ozgür F, et al. Change in the amputation profile in diabetic foot in a tertiary reference centre: efficacy of team working. *Exp Clin Endocrinol Diabetes.* 2004;112:526-30.
  20. Mayfield JA, Reiber GE, Nelson RG, Greene T. A foot risk classification system to predict diabetic amputation in Indians. *Diabetes Care.* 1996;19:704-9.
  21. Del Aguila MA, Reiber GE, Koepsell TD. How does provider and patient awareness of high-risk status for lower-extremity amputation influence foot-care practice? *Diabetes Care.* 1994;17:1050-4.
  22. Nather A, Bee CS, Huak CY, Chew JL, Lin CB, Neo S, et al. Epidemiology of diabetic foot problems and predictive factors for limb loss. *J Diabetes Complications.* 2008;22:77-82.
  23. Calle-Pascual AL, Garcia-Torre N, Moraga I, Diaz JA, Duran A, Moñux G, et al. Epidemiology of non-traumatic lower-extremity amputation in area 7, Madrid, between 1989 and 1999: a population-based study. *Diabetes Care.* 2001;24(9):1686-9.
  24. Solomon S, Afghan AM, Gopie P, Noel J, Rahman R, Richardson R, et al. Taking the next step in 2005, the year of the diabetic foot. *Prim Care Diabetes.* 2008;2:175-80.

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