

## Foot Screening for Diabetics

Aziz Nather,<sup>1</sup>FRCS (Edin), FRCS (Glas), MD, Siok Bee Chionh,<sup>2</sup>MRCP, Patricia LM Tay,<sup>1</sup> Zameer Aziz,<sup>1</sup>MB ChB (Dundee), Janelle WH Teng,<sup>1</sup> K Rajeswari,<sup>3</sup> Adriaan Erasmus,<sup>1</sup>B Tech Podiatry (SA), Ajay Nambiar,<sup>1</sup>MRCS (Edin)

### Abstract

**Introduction:** This study aims to evaluate the results of foot screening performed in a study population of 2137 diabetics (3926 feet) screened from 2006 to 2008 by the National University Hospital (NUH) multi-disciplinary team for diabetic foot problems. **Materials and Methods:** A standardised protocol was designed. Foot screening consisted of detailed history taking and clinical examination including assessment for sensory neuropathy by Semmes Weinstein monofilament (SWMF) and neurothesiometer and assessment of vasculopathy by ankle-brachial index (ABI) and total body irradiation (TBI). The foot screening was performed by a trained staff nurse. All patients were classified according to King's College Classification. **Results:** Majority of the patients were in the fifth (27.9%) and sixth (30.0%) decades of life. Two thousand sixty-four had type II diabetes, and only 73 had type I diabetes. Neuropathy was found in 1307 (33.3%) feet based on 5.07 SWMF. Vasculopathy was recorded in 510 (13.0%) and 546 (13.9%) feet based on ABI <0.8 and TBI <0.7. According to King's Classification, 1069 (50.0%) were Stage 1: Normal and 615 (28.8%) were Stage 2: At-Risk. **Conclusion:** Foot screening should be performed as early as possible to detect "At-Risk" feet and prevent the development of diabetic foot complications, thereby further reducing the risk of major amputations.

Ann Acad Med Singapore 2010;39:472-5

**Key words:** "At-Risk" feet, Diabetic foot screening, King's Classification

### Introduction

Prevalence of diabetes is high in Singapore (8.2%).<sup>1</sup> Five per cent to 15% of diabetics developed foot ulcers.<sup>2-4</sup> In fact, the lifetime risk for a person with diabetes of developing a foot ulcer could be as high as 25%.<sup>5</sup> Ulcers if left untreated could lead to major amputations (below and above knee amputations). Pecoraro et al<sup>6</sup> showed that 84% of all lower limb amputations were due to ulceration, 61% due to sensory neuropathy and 46% due to ischaemia. Nather et al<sup>7</sup> found the incidence of major amputations (below and above knee) to be 27.2% in diabetics with foot complications. In Singapore, approximately 700 diabetics undergo lower limb amputations every year as a result of diabetic foot complications.<sup>8</sup> It is therefore very important that all diabetics should have foot screening annually to detect the "foot at risk" early.<sup>9</sup> Such patients could be referred to the podiatrist, orthopaedic surgeon or vascular surgeon for early intervention or monitoring. Ogrin and Sands<sup>10</sup> found that by identifying people at high risk of foot

problems, and managing the risk factors, lower extremity amputations and foot ulcerations could be prevented.

### Materials and Methods

#### Study Population

The study involved 2137 patients (3926 feet) who underwent foot screening at National University Hospital (NUH) from June 2006 to December 2008. Foot screening was conducted by our foot screening staff nurse (Ms K Rajeswari) in the NUH multi-disciplinary team for diabetic foot problems (DFP).

#### Study Protocol

A prospective study was conducted using a standardised protocol designed for foot screening. Informed consent was obtained for each participant. Ethical approval has been obtained from the NUH Ethical Board.

Firstly, a detailed history of the patient was taken. This included the marital status, education level, language of

<sup>1</sup> Department of Orthopaedic Surgery, Yong Loo Lin School of Medicine, National University of Singapore, Singapore

<sup>2</sup> Division of Endocrinology, Department of Medicine, National University Hospital, Singapore

<sup>3</sup> Podiatry Section, Department of Rehabilitation, National University Hospital, Singapore

Address for Correspondence: A/Prof Aziz Nather, Department of Orthopaedic Surgery, Yong Loo Lin School of Medicine, National University of Singapore, Lower Kent Ridge Road, Singapore 119074.

Email: dosnathe@nus.edu.sg

communication preferred and medical history of diabetes mellitus. Presence of complications and comorbidities of diabetes and social history were recorded. The duration of diabetes and the type of treatment received were also documented.

Examination of the foot was meticulously performed. The foot was examined for the condition of the skin and presence of callosities. A biomechanical assessment was also done including examination for bunions, lesser toe deformities and Charcot joint disease.

Neurological assessment included 10-point Semmes Weinstein (5.07) Monofilament Testing<sup>11</sup> and Vibration Perception Threshold using the Neurothesiometer.

Vascular assessment performed included palpation of foot pulses, ankle brachial index and toe brachial index. Each foot assessed was classified according to King's College Classification.<sup>12</sup> Finally, education on foot care was conducted. A brochure on foot education designed by our NUH Diabetic Foot Team was also given to the patient.

## Results

Figure 1 shows that of the 2137 patients (3926 feet) screened, the majority were referrals from the Division of Endocrinology (1079 patients, 50.5%), other referrals came from the Department of Orthopaedics (227 patients, 10.6%), Division of Renal Medicine (194 patients, 9.1%), Podiatry Section, Department of Rehabilitation (259 patients, 12.1%), and the Department of Medicine (378 patients, 17.7%) at NUH.

Their ages ranged from 12 to 79 years, the average being 56.9 years. The majority were in the fifth and sixth decades of life—27.9% and 30.0%, respectively (Fig. 2). There were 1075 males and 1062 females with a male-to-female ratio of about 1:1. The racial distribution included 1098 Chinese (51.4%), 601 Malays (28.1%), 436 Indians (20.4%) and 2 Eurasians (0.1%).

Two thousand and sixty-four patients (96.6%) had type II diabetes and only 73 (3.4%) had type I diabetes. The duration of diabetes ranged from 1 to 56 years, the average being 10.6 years. Only 34.9% of patients screened had diabetes for 1 to 5 years (Fig. 3).

Hypertension (54.5%) was the most common comorbidity followed by nephropathy (24.0%), ischaemic heart disease (IHD) (14.3%) and cerebrovascular accident (7.2%) (Fig. 4).

Table 1 shows that 10 point 5.07 Semmes-Weinstein monofilament (SWMF) testing indicated loss of protective sensation, that is, sensory neuropathy in 1307 feet (33.3%). Neurothesiometer findings showed loss of vibration perception or sensory neuropathy in 1552 feet (39.5%).

Both pulses were palpable in 2497 feet (63.6%) and 1 pulse palpable in 703 feet (17.9%). Both pulses were not palpable in 711 feet (18.1%).

Ankle-brachial index (ABI) measurements revealed 3019 feet (76.9%) with ABI > 0.8. Vasculopathy taken as ABI < 0.8 and total body irradiation (TBI) < 0.7 was found in 510 feet (13.0%) and 546 feet (13.9%), respectively.

Using King's Classification,<sup>12</sup> 1069 patients (50.0%) were classified as Stage 1: Normal; 615 patients (28.80%) as Stage 2: At-Risk; 212 patients (9.9%) as Stage 3: Ulcerated; 83 patients were found to be in (3.9%) Stage 4; Cellulitic; 11 patients (0.3%) to be in Stage 5: Necrotic and 147 patients (6.9%) classified as Stage 6: Major Amputation (Fig. 5).

Following foot screening, 83 patients (3.90%) were referred to specialists – 75 to podiatrists, 5 to vascular surgeons and 3 to orthopaedic surgeons.

## Discussion

There has been no long-term study conducted in a cohort of diabetic patients to show how foot screening directly benefits the patients in the long-run in reducing the incidence of major lower limb amputation. Such a study should involve a control as a group of patients who did not receive foot screening being followed-up over the same period of time. However, such a study is difficult to perform and would take a long period of observation to complete.

Indeed, no proper study on foot screening has been reported in literature. However, there were some reports in literature where certain aspects of foot screening, such as screening for neuropathy or screening for vasculopathy had been studied.

Smeija et al<sup>13</sup> and Pham et al<sup>14</sup> screened diabetic feet for sensory neuropathy. Smeija et al<sup>13</sup> conducted a study on the reproducibility and accuracy of conventional clinical examination of the diabetic foot for sensory neuropathy using parameters such as pin prick sensation, proprioception testing, vibration perception testing and ankle reflex as compared to SWMF testing. Conventional clinical examination was found to have low reproducibility and accuracy compared to monofilament testing. SWMF was found to be a reproducible and valid test for detecting sensory neuropathy. It is recommended as the screening procedure of choice for foot screening to detect sensory neuropathy. In our protocol, SWMF is also used for screening sensory neuropathy.

In contrast, Pham et al<sup>14</sup> showed that the combination of clinical examination and SWMF Testing is the most sensitive method to identify patients at risk for foot ulceration compared to Vibration Perception Threshold (VPT) and foot pressure measurements.

Shin et al<sup>15</sup> evaluated both neuropathy and vasculopathy

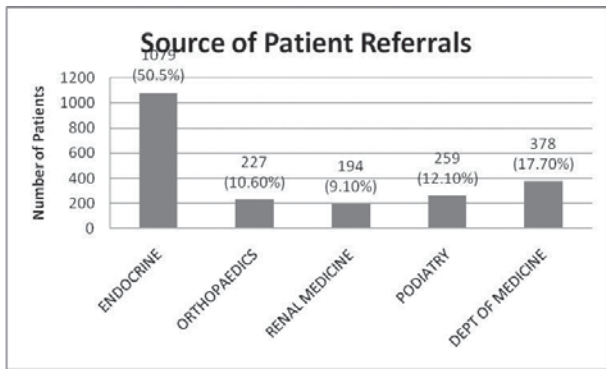


Fig. 1. Source of patient referrals.

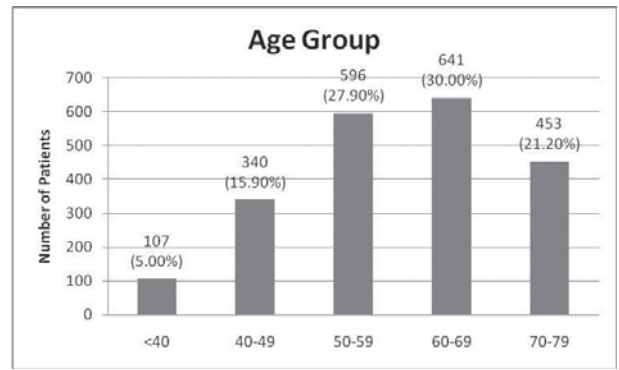


Fig. 2. Age distribution.

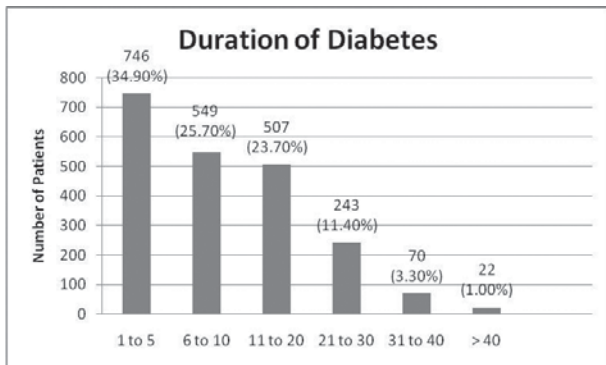


Fig. 3. Duration of diabetes.

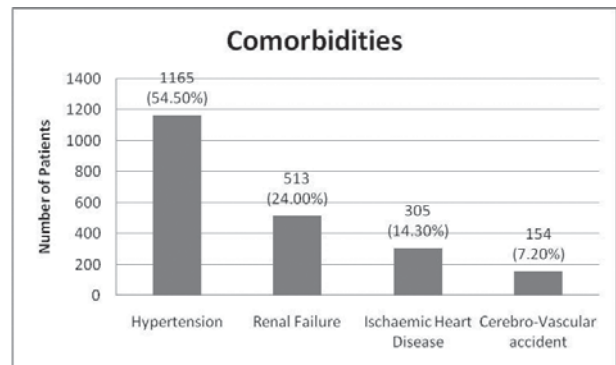


Fig. 4. Results of comorbidities.

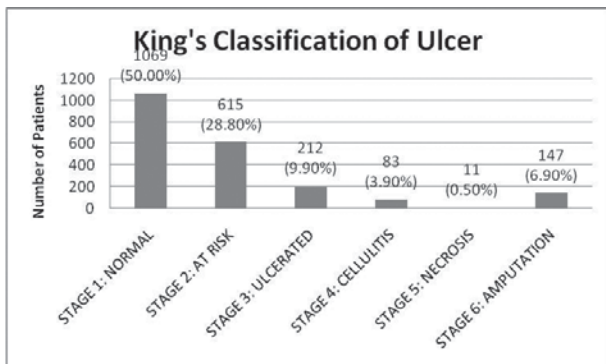


Fig. 5. Results of screening according to King's Classification.

in their foot screening protocol. They found the SWMF and Rydel-Seiffer graduated fork to be useful tools for detecting sensory neuropathy and ABI for detecting vasculopathy.

Khammash et al<sup>16</sup> on the other hand screened diabetic patients for lower limb ischaemia using ABI. They examined 2 cohorts of patients, 100 patients with hypertension and ischaemic heart disease with diabetes and 100 without diabetes. ABI was a useful guide for detecting lower limb ischaemia. In our study, ABI <0.8 and TBI <0.7 was taken as parameters to indicate vasculopathy.

The qualification and experience of the personnel performing the foot screening is a very important consideration. Edelman et al<sup>17</sup> showed that there was

variability in the results of foot screening depending on whether it was performed by primary care providers or performed by foot care providers. They showed that while foot care providers could accurately perform foot screening, primary care providers could not assess foot pulses and could not determine foot deformity adequately. In our protocol, foot screening was carried out by a staff nurse specially trained in foot screening (Ms KRajeswari) who could assess all aspects of foot screening including examining for foot pulses and for foot deformity.

Our results showed that with regard to neuropathy, the incidence of sensory neuropathy (33.0% based on SWMF) was high. Likewise, in our studies, VPT, another modality for sensory neuropathy using the neurothesiometer found a high percentage of patients screened to have sensory neuropathy – 1552 feet (39.5%). With regard to vasculopathy, the incidence of vasculopathy (13.0% based on ABI <0.8 and 13.9% based on TBI <0.7) was likewise quite high. This may be due to the fact that many in our cohort were screened rather late after the onset of diabetes. Only 50% of the patients screened were normal (Stage 1: King's Classification); 28.8% of them were found to have “feet at risk”. Our findings showed that only 34.9% of our patients had diabetes of less than 5 years' duration. The duration of diabetes was 6 to 10 years in 25.7% of the patients and 11 to 20 years in 23.7% of the patients. Moreover, of the

Table 1: Assessment for Neuropathy and Vasculopathy

Explanatory variables	Total feet (n = 3926) No. (%)
Monofilament test	
>8 sites	2505 (63.8)
<8 sites	1307 (33.3)
Not tested	115 (2.9)
Vibration perception threshold	
<25 V	2218 (56.5)
>25 V	1552 (39.5)
Not tested	157 (4.0)
ABI	
>0.8	3019 (76.9)
<0.8	510 (13.0)
<0.4	28 (0.7)
Not tested	370 (9.4)
TBI	
>0.7	2634 (67.1)
<0.7	546 (13.9)
<0.4	327 (8.3)
Not tested	420 (10.7)
Pulses	
2 Pulses	2497 (63.6)
1 Pulse	703 (17.9)
Absent	711 (18.1)
Not tested	16 (0.4)

ABI: ankle-brachial index; TBI: total body irradiation

33% of feet with sensory neuropathy, 295 feet (22.6%) belonged to patients who had diabetes of 1 to 5 years in duration, whilst 1012 feet (77.4%) were from patients who had diabetes of more than 5 years duration. Of the 13.0% of feet with vasculopathy, only 13.5% (59 feet) belonged to patients who had duration of diabetes of 1 to 5 years. However, a high percentage (86.5%; 441 feet) of them belonged to those who had diabetes for more than 5 years. It was not surprising that only 50.0% of the patients were normal (Stage 1: King's Classification). A higher percentage of Stage 1 cases would be seen if our patients are screened early after their onset of diabetes.

Patients with diabetes must receive foot screening as soon as possible. In this way we could reduce the rate of the development of diabetic foot complications. We strongly recommend that foot screening be performed once diabetes is diagnosed.

Our findings showed that 28.8% were classified as Stage 2, that is, "At-Risk". Indeed, 83 patients (3.9%) of

our total number receiving foot screening needed referral for specialist care to podiatrists, vascular surgeons or orthopaedic surgeons. By performing foot screening earlier in patients, the number of patients requiring referral for specialist care could be reduced.

## Conclusion

Foot screening should be performed as early as possible in diabetics to detect "At-Risk" feet and prevent the development of diabetic foot complications. In this way, the risk of major amputations (below and above knee) could be further reduced.

## REFERENCES

1. Ministry of Health, Singapore. Details of National Health Survey Findings. Singapore: Ministry of Health, 2004.
2. Kumar S, Ashe HA, Parnell LN, Fernando DJ, Tsigos C, Young RJ, et al. The Prevalence of Foot Ulceration and its correlates in Type 2 Diabetic Patients: A Population-Based Study. *Diabet Med* 1994;11:480-4.
3. Harris MI, Hamman RF, editors. National Diabetes Data Group: Diabetes in America. Washington DC: NIH Publication US Government Printing Office, 1985;85-1468.
4. Reiber GE. The epidemiology of diabetic foot problems. *Diabet Med* 1996;13:S11.
5. International Working Group on the Diabetic Foot. Epidemiology of Diabetic Foot Infections in a Population-Based Cohort. Proceedings of the International Consensus on the Diabetic Foot; 2003 May 22-24; Noordwijkerhout, The Netherlands.
6. Pecoraro RE, Reiber GE, Burgess EM. Pathways to diabetic limb amputation, basis for prevention. *Diabetes Care* 1990;13:513-21.
7. Nather A, Chionh SB, Chan YH, Chew JLL, Lin CB, Neo SH, et al. Epidemiology of diabetic foot problems and predictive factors for limb loss. *J Diabetes Complications* 2008;22:77-82.
8. Ministry of Health, Singapore. Epidemiology and Disease Control Division. Annual Report 2001. Singapore: Ministry of Health, 2001.
9. Rathur HM, Boulton AJM. The neuropathic diabetic foot. *Nat Clin Pract Endocrinol Metab* 2007;3:14-25.
10. Ogrin R, Sands A. Foot assessment in patients with diabetes. *Aust Fam Physician* 2006;35:419-21.
11. Nather A, Neo SB, Chionh SB, Liew SCF, Sim EY, Chew JLL. Assessment of sensory neuropathy in diabetic patients without diabetic foot problems. *J Diabetes Complications* 2008;22:126-31.
12. Edmonds ME, Foster AVM. *Managing the Diabetic Foot*. 2nd ed. London: Blackwell, 2005.
13. Smieja M, Hung DL, Edelman D, Etchells SE, Cornuz J, Simel DL. Clinical examination for the detection of protective sensation in the feet of diabetic patients. *J Gen Intern Med* 1999;14:418-24.
14. Phum H, Armstrong DG, Harvey C, Harkless LB, Giurini JM, Veves A. Screening technique to identify people at high risk for diabetic foot ulceration – a prospective multicenter trial. *Diabetes Care* 2000;23:606-11.
15. Shin JB, Seong YJ, Lee SH, Park JR. Foot screening technique in a diabetic population. *J Korean Med Sci* 2000;15:78-82.
16. Khammash MR, Obeidat KA, El-Qarqas EA. Screening of hospitalized diabetic patients for lower limb ischaemia: is it necessary? *Singapore Med J* 2008;49:110-3.
17. Edelman D, Sanders LJ, Pogach L. Reproducibility and accuracy among primary care providers of a screening examination for foot ulcer risk among diabetic patients. *Prev Med* 1998;27:274-78.