

# Clinical Factors affecting Minor Amputation in Diabetic Foot Disease at Tengku Ampuan Afzan Hospital, Kuantan

Zamzuri ZAKARIA, Mustaqim AFIFI, Mohd Ariff SHARIFUDIN

Submitted: 7 Jul 2014  
Accepted: 25 Dec 2014

Department of Orthopaedics, Traumatology and Rehabilitation, Kulliyah (Faculty) of Medicine, International Islamic University Malaysia, 25200 Kuantan, Pahang, Malaysia

## Abstract

**Background:** Diabetic foot disease poses a substantial problem in Malaysian diabetic population. We evaluate the clinical factors affecting minor amputation in diabetic foot disease.

**Methods:** A cross-sectional study enrolling patients admitted to orthopaedic wards of a single tertiary hospital for diabetic foot disease was conducted. Patients who had undergone major amputation or with medical condition above the ankle joint were not included. Clinical data were collected by measurement of ankle brachial systolic index and Semmes-Weinstein 5.07 gauge monofilament test with foot clinical evaluation using King's classification respectively.

**Results:** The total number of patients included was 138, with mean age of 59.7 years (range 29 to 94 years old). Fifty patients (36.2%) had minor amputations. Poor compliance to diabetic treatment, King's classification stage 5, low measures of ankle brachial systolic index, sensory neuropathy, high serum C-Reactive protein and high serum creatinine are significant predictive factors for minor amputation ( $P < 0.05$ ).

**Conclusion:** Identifying these risk factors may help in prevention of minor amputation and subsequently reduce limb loss in diabetic foot.

**Keywords:** amputation, c-reactive protein, creatinine, diabetic foot, foot diseases

## Introduction

Diabetic foot disease is a known complication of diabetes mellitus. In our institution, patients presented with various forms of clinical presentation; majority of them needs admission for further surgical intervention. University of Malaya Medical Centre, Kuala Lumpur conducted a five-day study in 2001, reported a total of 13% of diabetic patients admitted to the orthopaedic wards for diabetic foot problem (1). Amputations, either major or minor, are the common surgical procedures performed for this group of patients. Major amputations refer to any operation performed above the ankle and minor amputations, also known as distal amputations, are surgical procedures performed at the level of ankle and below. The main purpose of amputation is to remove the diseased tissue and maintained the patient's best chance for ambulatory rehabilitation (2). In Kelantan, a two-year review of total number of limb amputation among Kelantanese population reported 66% patients were diabetic and amputation related to diabetic foot conditions (3). In Kuala Lumpur Hospital, 20% of diabetic cases admitted to the orthopaedics wards had major amputation

while 31.7% had minor amputation (4). Minor amputations are important surgical procedures when indicated as it can avoid major amputation such as below or above knee amputation. They give a better quality of life to patients compared with major amputations. This study mainly focused on the clinical factors affecting the minor amputation in diabetic foot disease at Tengku Ampuan Afzan Hospital, Kuantan.

## Methods

This cross-sectional study was carried out at Tengku Ampuan Afzan Hospital, Kuantan, from 1st February 2013 till 31st July 2013. All patients admitted to the orthopaedic wards for diabetic foot disease were enrolled in this study. However, patients who had undergone major amputation or with any medical condition above the ankle joint were excluded. Side of problematic foot was documented and the diabetic foot disease was classified according to King's classification. This classification looks at the clinical features of diabetic foot disease and provide management plan for each stage. Diabetic foot problems are classified according to the severity of the local condition; stage 1: normal foot, stage 2:

high risk, stage 3: ulcerated, stage 4: cellulitis, stage 5: necrotic, and stage 6: requires major amputation (5). Patient's foot was examined thoroughly at the time of admission. Foot was inspected for deformities, presence of callosities, skin conditions and bony abnormalities such as clawing of toes and hallux valgus. Presence of cellulitis, abscess, gangrene and ulcer were documented. For immunopathy, the foot was palpated for tenderness. All bones, joints, and soft tissues were palpated from distal phalanx up to the ankle level.

Vasculopathy was evaluated with qualitative and quantitative measures. The foot was examined qualitatively by inspecting skin colour and capillary refill, feel for skin temperature, palpation of all pulses especially dorsalis pedis artery and posterior tibial artery and Doppler analysis. Ankle brachial systolic index (ABSI) measurement was used for quantitative examination. ABSI was measured in supine position with a 12 centimeters occluding cuff placed above the ankle and handheld portable Doppler ultrasound used as the distal sensor at the dorsalis pedis artery (DPA) and posterior tibialis artery (PTA). ABSI was calculated by dividing the highest reading of the ankle pressures at the DPA or PTA, by the brachial systolic pressure of the same side. ABSI is a quick and easy-to-perform clinical evaluation technique. It is routinely performed in clinical practice and produces reliable and reproducible results (5). Sensory neuropathy was examined qualitatively by pinprick test, tendon reflex, vibration sense and position sense of toes with the patient's eyes closed. Quantitative examination was performed using Semmes-Weinstein 5.07 gauge monofilament test. Semmes-Weinstein 5.07 monofilament test is the most useful diagnostic test for diabetic peripheral neuropathy (6). Semmes-Weinstein 5.07 monofilament test was performed by applying 10 gram force on 10 different sites on the foot surface. The monofilament was placed on the surface of foot at right angles to skin and the pressure increased until the filament buckled. Presence of sensation is documented as 1 point. A foot is classified to have sensory neuropathy when patient felt seven sites or less (7).

Blood investigations were taken at the time of admission, which include glycated haemoglobin level (HbA1c), C-reactive protein (CRP), albumin level and serum creatinine level. The treatment of diabetic foot was decided by consultant or specialist in charge of the patient. Types of treatments were grouped as minor amputation and non-amputation.

Minor amputation group includes:

disarticulation of toe (removal of toe at the level of metatarsophalangeal articulation), ray amputation (a toe and part of the corresponding metatarsal bone are amputated), transmetatarsal amputation (amputation of the forefoot at the mid-metatarsal level), Lisfranc disarticulation (hindfoot disarticulation at the tarsometatarsal articulation), Pirogoff's amputation (amputation of the foot through the talotibial articulation with preservation of part of the calcaneus), and Syme's amputation (amputation of the foot through the talotibial articulation with removal of the malleoli of the tibia and fibula).

Non-amputation group treatments include administration of antibiotics, wound dressing, surgical debridement, and incision and drainage. Data collected was analysed using SPSS version 16 (2008). Statistical test used were chi square test, independent sample t test and Mann-Whitney U test. *P* value of less than 0.05 was considered as significant.

## Results

A total number of 138 patients, 57.2% (79/138) men and 42.8% (59/138) women, were enrolled in this study. The age of the patients ranged from 29 to 94 years old (mean age: 59.7 years). Majority of patients (90/138) did not have any other medical comorbidity. Hypertension is the commonest among patients (11.6%). Eight patients (5.8%) had multiple comorbidities. Comorbidities among patients included in this cohort are summarised in table 1. Foot examination revealed 56.5% had left foot problem, 39.9% had right foot problem and 3.6% had bilateral foot problem. Each foot problem was classified according to King's Classification. Thirty-seven percent (51/138) of patients was classified as stage 5, 34% (47/138) as stage 4, and 29% (40/138) as stage 3. The means of other clinical factors are shown in table 2. Fifty patients (36.2%) had minor amputation. The most frequent minor amputation was ray amputation (41/50) followed by transmetatarsal amputation (4/50), toe disarticulation (3/50), and Lisfranc disarticulation (2/50). Clinical factors with increase risk for minor amputation were stage 5 of King's classification, ankle brachial systolic index (ABSI) of less than 0.8, and Semmes-Weinstein monofilament test of 7 and less (Table 3). High level of serum C-reactive protein and serum creatinine also increase the risk for minor amputation with *P* < 0.01 (Table 4). However, multiple linear regression analysis revealed level of serum creatinine as the single significant risk factor for minor amputation in patients with

**Table 1:** Medical comorbidities among diabetic disease patients

| Comorbidities                      | n (%)      |
|------------------------------------|------------|
| Hypertension                       | 16 (11.59) |
| End stage renal failure (ESRF)     | 11 (7.97)  |
| Ischaemic heart disease (IHD)      | 7 (5.07)   |
| Cerebral vascular accident (CVA)   | 2 (1.45)   |
| Gout                               | 2 (1.45)   |
| Chronic obstructive airway disease | 1 (0.72)   |
| Hyperthyroid                       | 1 (0.72)   |
| Multiple comorbidities             |            |
| Hypertension and ESRF              | 4 (2.90)   |
| Hypertension and IHD               | 3 (2.17)   |
| ESRF and IHD                       | 1 (0.72)   |
| Total                              | 48 (34.78) |

**Table 2:** Descriptive statistics of clinical factors affecting the minor amputation in diabetic foot disease

| Clinical factors                      | Mean values (Standard deviation) |
|---------------------------------------|----------------------------------|
| Semmes-Weinstein monofilament test    | 7.2 (2.298)                      |
| Ankle brachial systolic index         | 0.84 (0.202)                     |
| Glycated haemoglobin (HbA1c) (mmol/L) | 9.76 (2.974)                     |
| C-reactive protein (mg/L)             | 58.38 (35.72)                    |
| Serum albumin (g/L)                   | 28.17 (4.379)                    |
| Serum creatinine (μmol/L)             | 84.64 (73.833)                   |

diabetic foot disease (Table 5).

## Discussion

Rate of amputation in diabetic foot disease vary between reports. Most of the studies reported rate for major amputation only, with only few reported rate of minor amputation. Minor amputation among diabetic foot disease patients enrolled in this study was 36.2%. However, this figure does not represent the total number of diabetic foot disease patients admitted in Tengku Ampuan Afzan Hospital as patients who had undergone major amputation and lesion above ankle were excluded. In Kuala Lumpur Hospital, almost similar rate for minor amputation was

reported, which was 31.7% (4). However, lower minor amputation rate reported in Taiwan and China were 22.9% and 14.8%, respectively (8,9). High rate of amputation can reflect a higher disease prevalence and poor management of diabetic foot disease.

The aim of amputation surgery is to save the greatest amount of functional limb that will heal. The energy expended when walking with an amputated limb, inversely proportional to the length of the residual limb and number of remaining joints. Patients with minor amputations require less energy to walk than patients with transtibial amputations (10). Minor amputation is undertaken in order to save the limb, whereas major amputation is undertaken when limb salvage is impossible and considered as the endpoint of diabetic foot treatment (11). Major amputation associated with higher treatment cost, poorer prognosis, and higher mortality rate (12). For this reason, minor amputation and the precipitating risk factors was studied to prevent progression towards major amputation.

The King's College Foot Classification was chosen in this study, as it is a simple and practical staging system (5). Each stage of King's College Foot Classification has a specific recommended management plan. Although Wagner classification has been the most widely quoted and utilised system of classification, the classification is a universal wound classification system and not uniquely for diabetic foot disease (6). King's College Foot Classification stage 5 significantly associated with minor amputation in this study. The necrotic or ischaemic stage is considered highest stage in this classification beside stage 6 for unsalvageable foot. Lower measures of ABSI significantly associated with higher risk of minor amputation. ABSI of less than 0.8 indicates lower limb ischaemia. Other studies also reported significant association of low ABSI with major amputation (4,8,14). Adler et al. (15) comparing ABSI between minor and major amputation, showed ABSI of less than 0.8 was not significantly associated with minor amputation although it was a risk factor for major amputation. Peripheral arterial disease greatly increased the risk of major amputation, especially in the diabetic population. Patients, who had undergone minor amputation for underlying peripheral arterial disease, will have higher risk for additional minor amputation or subsequently major amputation. Early referral to a vascular surgeon might prevent the need for major amputation (16).

Sensory neuropathy, as measured by 5.07 Semmes-Weinstein monofilament test was found

**Table 3:** Categorical factors associated with risk of minor amputation in diabetic foot disease patients.

| Factors                         |                               | Minor amputation<br>n (%) | Non amputation<br>n (%) | P value <sup>a</sup> |
|---------------------------------|-------------------------------|---------------------------|-------------------------|----------------------|
| Gender                          | Male                          | 30 (60%)                  | 49 (55.7%)              | 0.622                |
|                                 | Female                        | 20 (40%)                  | 39 (44.3%)              |                      |
| Race                            | Malay                         | 45 (90%)                  | 78 (88.6%)              | 0.866                |
|                                 | Chinese                       | 2 (4%)                    | 3 (3.4%)                |                      |
|                                 | Indian                        | 3 (6%)                    | 4 (4.5%)                |                      |
|                                 | Others                        | 0 (0%)                    | 3 (3.4%)                |                      |
|                                 |                               |                           |                         |                      |
| Level of education              | Nil                           | 6 (12%)                   | 16 (18%)                | 0.506                |
|                                 | Primary                       | 16 (32%)                  | 22 (25%)                |                      |
|                                 | Secondary                     | 23 (46%)                  | 36 (40.9%)              |                      |
|                                 | Tertiary                      | 5 (10%)                   | 14 (15.9%)              |                      |
| Marital status                  | Married                       | 30 (60%)                  | 66 (75%)                | 0.159                |
|                                 | Single                        | 1 (2%)                    | 2 (2.3%)                |                      |
|                                 | Widow                         | 19 (38%)                  | 20 (22.7%)              |                      |
| Smoking                         | Yes                           | 18 (36%)                  | 28 (31.8%)              | 0.616                |
|                                 | No                            | 32 (64%)                  | 60 (68.2%)              |                      |
| Diabetic treatment              | Oral hypoglycemic agent (OHA) | 24 (48%)                  | 42 (47.7%)              | 0.479                |
|                                 | Insulin                       | 20 (40%)                  | 29 (33%)                |                      |
|                                 | Combined                      | 6 (12 %)                  | 17 (19.3%)              |                      |
| Compliant to diabetic treatment | Yes                           | 22 (44%)                  | 60 (68.2%)              | 0.005                |
|                                 | No                            | 28 (56%)                  | 28 (31.8%)              |                      |
| Foot involved                   | Left                          | 29 (58%)                  | 49 (55.7%)              | 0.740                |
|                                 | Right                         | 20 (40%)                  | 35 (39.8%)              |                      |
|                                 | Bilateral                     | 1 (2%)                    | 4 (4.5%)                |                      |
| Age group                       | ≥ 60 years                    | 27 (54%)                  | 45 (51.1%)              | 0.746                |
|                                 | < 60 years                    | 23 (46%)                  | 43 (48.9%)              |                      |
| Income group                    | < RM 1000                     | 40 (80%)                  | 61 (69.3%)              | 0.173                |
|                                 | ≥ RM 1000                     | 10 (20%)                  | 27 (30.7%)              |                      |
| Body mass index (BMI)           | < 25                          | 14 (28%)                  | 27 (30.7%)              | 0.884                |
|                                 | ≥ 25                          | 36 (72%)                  | 61 (69.3%)              |                      |
| ABSI                            | < 0.8                         | 29 (58%)                  | 18 (20.5%)              | < 0.001              |
|                                 | ≥ 0.8                         | 21 (42%)                  | 70 (79.5%)              |                      |
| Monofilament test               | ≤ 7                           | 34 (68%)                  | 30 (34.1%)              | < 0.001              |
|                                 | > 7                           | 16 (32%)                  | 58 (65.9%)              |                      |
| King's classification           | Stage 3                       | 1 (2%)                    | 39 (44.3%)              | < 0.001              |
|                                 | Stage 4                       | 1 (2%)                    | 46 (52.3%)              |                      |
|                                 | Stage 5                       | 48 (96%)                  | 3 (3.4%)                |                      |

<sup>a</sup>  $\chi^2$  test.

**Table 4:** Numerical factors associated with minor amputation in diabetic foot disease patients.

|                                       | Minor amputation<br>mean (SD) | Non amputation<br>mean (SD) | P value              |
|---------------------------------------|-------------------------------|-----------------------------|----------------------|
| Age (years)                           | 59.84 (11.56)                 | 59.62 (10.74)               | 0.910 <sup>a</sup>   |
| Duration of diabetes mellitus (years) | 11.26 (5.85)                  | 10.85 (6.42)                | 0.712 <sup>a</sup>   |
| HbA1c level (mmol/L)                  | 10.18 (2.62)                  | 9.52 (3.15)                 | 0.209 <sup>a</sup>   |
| C-reactive protein (mg/L)             | 68.28 (28.67)                 | 56.58 (53.31)               | < 0.001 <sup>b</sup> |
| Serum albumin (g/L)                   | 27.08 (4.31)                  | 28.79 (4.32)                | 0.015 <sup>b</sup>   |
| Serum creatinine (μmol/L)             | 125.94 (98.57)                | 61.17 (39.68)               | < 0.001 <sup>b</sup> |

<sup>a</sup>Independent-Samples t test.<sup>b</sup>Mann-Whitney U test.**Table 5:** Associated factors of minor amputation in diabetic foot disease patients

| Variables                             | SLR <sup>a</sup>        |         | MLR <sup>b</sup>      |         |
|---------------------------------------|-------------------------|---------|-----------------------|---------|
|                                       | <sup>b</sup> (95% CI)   | P value | <sup>b</sup> (95% CI) | P value |
| Age (years)                           | 0.000 (−0.007, 0.008)   | 0.113   | —                     | —       |
| Duration of diabetes mellitus (years) | 0.002 (−0.011, 0.016)   | 0.712   | —                     | —       |
| HbA1c level (mmol/L)                  | 0.017 (−0.010, 0.045)   | 0.209   | —                     | —       |
| C-reactive protein (mg/L)             | 0.001 (0.000, 0.003)    | 0.153   | —                     | —       |
| Serum albumin (g/L)                   | −0.021 (−0.039, −0.002) | 0.027   | —                     | —       |
| Serum creatinine (μmol/L)             | 0.003 (0.002, 0.004)    | < 0.001 | 0.003 (0.002, 0.004)  | < 0.001 |

<sup>a</sup>Simple Linear Regression.<sup>b</sup>Multiple Linear Regression.

to have significant association with higher risk of minor amputation. Other studies also had a significant association of sensory neuropathy with amputation (8,14,15). Semmes-Weinstein monofilament test is an inexpensive, accurate, reliable and practical modality for physicians to identify patients with higher risk of developing ulcers or require amputation. Feng et al. (16) reported diabetic patients with positive Semmes-Weinstein monofilament test have 1.5 to 15 times higher risk for major amputation compared with patients with negative monofilament test result.

Blood investigations that significantly associated with minor amputation in this study were high serum CRP and high serum creatinine. Xiang et al. (9) reported high serum CRP was significantly associated with amputation but not serum creatinine level. Serum CRP increases in response to inflammation, infection, trauma and tissue necrosis, malignancies, and autoimmune disorders, hence, it is not specific. However, it can be used as a guide to help in managing diabetic foot disease and monitor the disease progression

since rapid decrease of serum CRP will indicate good response towards treatment. Serum creatinine is important in assessing the renal function. High serum creatinine is associated with chronic renal disease. Furthermore, patients with coexisting diabetes mellitus and end stage renal disease have greater risk for foot ulceration and subsequent lower extremity amputation. Individuals with chronic renal disease are highly predisposed to major amputation because of the presence of classical risk factors for peripheral vascular disease. Other specific risk factors include chronic inflammation, malnutrition, fluid retention, alterations in the renin-angiotensin system, hyperhomocysteinaemia, abnormal mineral metabolism, lipoprotein imbalances, and oxidative stress (1,17).

## Conclusion

It is shown from this study that King's classification stage 5, low measures of ankle brachial systolic index (ABSI), and sensory



neuropathy, are significant predictive factors for minor amputation among diabetic foot disease patients in Tengku Ampuan Afzan Hospital, Kuantan. Blood investigations like serum CRP and serum creatinine can predict minor amputation if it is significantly high. Identifying these risk factors may help in prevention of minor amputation and subsequently reduce limb loss in diabetic foot disease patients.

## Acknowledgement

The authors wish to thank the staff of the Department of Orthopaedic, Traumatology and Rehabilitation, International Islamic University Malaysia, and Department of Orthopaedics, Tengku Ampuan Afzan Hospital, Kuantan for their contribution and support in conducting the research.

## Conflict of Interest

None.

## Funds

This research was financially supported by the Research Management Center (RMC) of the International Islamic University Malaysia, through Endowment Fund B (EDW-B1-252-0730).

## Authors' Contribution

Conception and design, final approval of the article, obtaining of funding: ZZ

Analysis and interpretation of the data, provision of study materials or patient: MA

Drafting of the article: ZZ, MAS

Critical revision of the article for the important intellectual content: MAS

Administrative, technical or logistic support: MA, MAS

## Correspondence

Dr Mohd Ariff Sharifudin  
MBBS (IIUM), MMed (Ortho) (USM)  
Department of Orthopaedics  
Traumatology and Rehabilitation, Kulliyyah (Faculty) of Medicine  
International Islamic University Malaysia  
Jalan Sulatn Ahmad Shah  
25200 Kuantan  
Pahang, Malaysia  
Tel: +609-570 6131  
Fax: +609-514 4451  
Email: ariffs@iium.edu.my

## References

1. Ooi CG, Haizee HN, Kando DV, Lua GW, Phillip H, Chan SP, Ismail IS, Rokiah P, Zaini A, Hew FL. Diabetes mellitus in a Malaysian teaching hospital: prevalence of diabetes mellitus and frequency of testing for hypercholesterolaemia, proteinuria and HbA1c. *Med J Malaysia*. 2002;**57**(2):195–200.
2. Margolis DJ, Allen-Taylor L, Hoffstad O, Berlin JA. Diabetic neuropathic foot ulcers and amputation. *Wound Repair Reg*. 2005;**13**(3):230–236. doi: 10.1111/j.1067-1927.2005.130303.x.
3. Yusof MI, Sulaiman AR, Muslim DAJ. Diabetic foot complications: a two-year review of limb amputation in a Kelantanese population. *Singapore Med J*. 2007;**48**(8):729–732.
4. Harwant S, Doshi HK, Moissinac K, Abdullah BT. Factors related to adverse outcome in inpatients with diabetic foot. *Med J Malaysia*. 2000;**55**(2):236–241.
5. Jain AKC, Joshi S. Diabetic foot classifications: review of literature. *Med-Science*. 2013;**2**(3):715–721. doi: 10.5455/medscience.2013.02.8069.
6. Nather A. Diabetic foot problems. 1st ed. Singapore (SG): World Scientific Publishing Co. Pte. Ltd; 2008.
7. Kamei N, Yamen K, Nakanishi S. Effectiveness of Semmes-Weinstein monofilament examination for diabetic peripheral neuropathy screening. *J Diabetes Complications*. 2005;**19**(1):47–53. doi: 10.1016/j.jdiacomp.2003.12.006.
8. Sun JH, Tsai JS, Huang CH, Lin CH, Yang HM, Chan YS, et al. Risk factors for lower extremity amputation in diabetic foot disease categorized by Wagner classification. *Diabetes Res Clin Pract*. 2012;**95**(3):358–363. doi: 10.1016/j.diabres.2011.10.034.
9. Xiang L, Ting X, Yuzhen W, Hongbin G, Zhiguo L, Yufeng J, et al. Incidence, risk factors for amputation among patients with diabetic foot ulcers in a Chinese tertiary hospital. *Diabetes Res Clin Pract*. 2011;**93**(1):26–30. doi: 10.1016/j.diabres.2011.03.014.
10. Philbin TM, Berlet GC, Lee TH. Lower-extremity amputations in association with diabetes mellitus. *Foot Ankle Clin*. 2006;**11**(4):791–804. doi: 10.1016/j.fcl.2006.06.012.
11. Jeffcoate WJ, van Houtum WH. Amputation as a marker of the quality of foot care in diabetes. *Diabetologia*. 2004;**47**(12):2051–2058. doi: 10.1007/s00125-004-1584-3.
12. Vamos EP, Bottle A, Majeed A, Millet C. Trends in lower extremity amputations in people with and without diabetes in England, 1996–2005. *Diabetes Res Clin Pract*. 2010;**87**(2):275–282. doi: 10.1016/j.diabres.2009.11.016.
13. Nather A, Bee CH, Huak CY, Chew JLL, Lin CB, Neo S, et al. Epidemiology of diabetic foot problems and predictive factors for limb loss. *J Diabetes Complications*. 2008;**22**(2):77–82. doi: 10.1016/j.jdiacomp.2007.04.004.

14. Adler AI, Ahroni JH, Boyko EJ, Smith DG. Lower-extremity amputation in diabetes: the independent effects of peripheral vascular disease, sensory neuropathy, and foot ulcers. *Diabetes Care*. 1999;**22**(7):1029–1035. doi: 10.2337/diacare.22.7.1029.
15. Nerone VS, Springer KD, Woodruff DM, Atway SA. Reamputation after minor foot amputation in diabetic patients: risk factors leading to limb loss. *J Foot Ankle Surg*. 2013;**52**(2):184–187. doi: 10.1053/j.jfas.2012.11.015.
16. Feng Y, Schlosser FJ, Sumpio BE. The Semmes Weinstein monofilament examination is a significant predictor of the risk of foot ulceration and amputation in patients with diabetes mellitus. *J Vasc Surg*. 2011;**53**(1):220–226. doi: 10.1016/j.jvs.2010.06.100.
17. Kaminski M, Frescos N, Tucker S. Prevalence of risk factors for foot ulceration in patients with end-stage renal disease on haemodialysis. *Intern Med J*. 2012;**42**(6):120–128. doi: 10.1111/j.1445-5994.2011.02605.x.