

# Epidemiological Data Regarding Diabetic Foot Risk Factors in India

## Introduction

According to the latest World Health Organization (WHO) report, India leads the world with 31.7 million diabetic subjects and these numbers are expected to increase to a staggering 79.4 million by the year 2030.<sup>1</sup> Diabetes increases the propensity for developing micro and macrovascular complications<sup>2,3</sup>. The term 'diabetic foot' encompasses any foot lesions occurring as a result of diabetes or its complications affecting and approximately affects 15% of all diabetic individuals<sup>4</sup>. The loss of a limb or foot remains one of the most dreaded complications of diabetes and one of the commonest causes for hospitalization of diabetic patients in India<sup>5</sup>. Studies conducted at Dr Mohans' M.V. Diabetes Specialities Centre, Chennai revealed that 50% of the hospital admissions are due to diabetes related foot problems (unpublished observation).

It is remarkable that many of the

principles of etiology, management and prevention of diabetic foot were in fact established by the pioneering work of Paul Brand, while treating plantar wounds in patients with Hansen's disease in India<sup>6</sup>. In many of the developing countries such as India, the morbidity and cost of treating diabetic foot problems is extremely high. This increase could be attributed to several factors including ignorance, poverty, apathy, inadequate facilities for diabetes care and poor socio-economic conditions. The financial burden due to diabetic foot problems is quite staggering. In India, diabetic subjects with foot problems incur very high costs - almost 4 times as compared to the amount spent by a diabetic patient without foot problems<sup>7</sup>. This underscores the need to identify and understand the risk factors leading to diabetic foot in order to reduce complications and also their economic burden.

## Determinants of diabetic foot

The breakdown of the foot has traditionally been considered to be a result of peripheral vascular diseases (PVD), neuropathy and infection. However, there is no direct evidence that infection is a primary cause; rather it occurs after the initial

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ulceration but makes the lesion more serious. In addition to neuropathy and PVD, other more recently recognized risk factors are high foot pressures and the presence of plantar callus. These contributory factors ultimately lead to foot ulceration. There is paucity of reliable population based data as to the prevalence and incidence of diabetic foot problems in developing countries like India. In a clinic-based study conducted in early 1990s, the prevalence of foot ulcers was 3.6%<sup>8</sup>, which is much lower than that reported in the western population<sup>9</sup>. Recently, in a study conducted in 374 South Indian patients who had undergone surgical procedure for foot infection, 50% had grade II, 26.5% grade III and 21.9% grade IV foot ulcers<sup>10</sup>.

## Peripheral vascular disease

Peripheral vascular disease in diabetic patients differs from that in non-diabetic individuals. In non-diabetic individuals the sites of occlusion are more proximal usually

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the infra-renal aorta, iliac and superficial femoral arteries, with sparing of distal vessels whereas in diabetic patients, occlusive lesions occur in more distal vessels such as the tibials and peroneals<sup>11,12</sup>. PVD is a major contributing factor in the pathogenesis of foot ulceration and amputation. McNeely, et al.<sup>13</sup> have shown that PVD (as measured by decreased transcutaneous oxygen tension) is an independent risk factor for diabetic foot lesions.

The prevalence of PVD has been reported to be low among Asians ranging between 3-6%<sup>14-18</sup>. Earlier clinic based reports have suggested that PVD is less common among Indian diabetic patients in the UK<sup>19</sup> and South Africa<sup>20</sup>. Mohan, et al.<sup>14</sup> have reported the prevalence of PVD in South Indian diabetic patients to be 3.9%. In study conducted in 3,010 type 2 diabetic South Indian subjects PVD was present in 4.0%, which included 18 subjects with gangrene and 21 who had undergone amputations<sup>16</sup>. The Chennai Urban Population Study (CUPS), was the first population based study to report on prevalence of PVD and this study reported that the prevalence of PVD was 6.3% among diabetic subjects compared to 2.7% among non-diabetic subjects<sup>15</sup> confirming that

the prevalence of PVD is indeed low in our population, comparative figures in the Western population ranging from 22% to 45%<sup>21-23</sup>. While the low prevalence may be attributed to the sample size, selection criteria and other factors, they could also reflect true differences in prevalence of PVD in different ethnic groups<sup>24</sup>. Other factors explaining the current low prevalence in Indian diabetic patients could be that the age of onset of type 2 diabetes is 10-15 years earlier in Indians and the number of patients above the age of 70 years or with duration of diabetes >30 years is extremely low and the low levels of smoking<sup>25</sup>. As the prevalence of PVD sharply rises above 70 years of age<sup>14,15</sup> we may see an increase in PVD in the next decade or so, with better diabetes care and increased longevity of our diabetic patients. Table 1 provides the prevalence of PVD from various population based studies<sup>15,23,26,27</sup>.

### Neuropathy

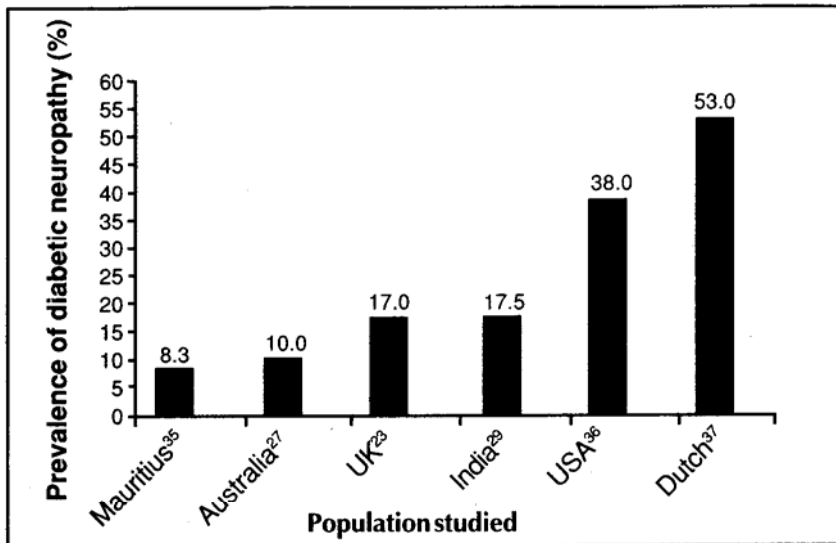
Neuropathy is one of the commonest complications of diabetes. Sensory, autonomic and motor neuropathy contributes to the pathogenesis of neuropathic foot. Diabetic peripheral neuropathy, which increases with the duration of

diabetes, leads to impaired sensations in the lower limb making the foot vulnerable to trauma due to mechanical, chemical and thermal factors leading to end-stage complications of foot ulceration and amputation. Motor neuropathy leads to foot deformity due to loss of proprioception and muscle atrophy, while dry fissured skin offering portals of entry for microorganisms in autonomic neuropathy is one of the important contributory factors for foot infection<sup>28</sup>. In India infection plays an important part in the pathogenesis of neuropathy.

The overall prevalence of neuropathy in the CUPS using biothesiometry was 7.7%, while it was 5.8%, 14.7% and 17.5% in those with NGT, IGT and diabetes, respectively<sup>29</sup>. In a large clinic based study of 1,000 type 2 South Indian diabetic subjects, the prevalence of neuropathy again based on biothesiometry, was found to be 19.1%.<sup>30</sup> The prevalence of neuropathy in India however, appears to be lower than that reported in Europeans. This may be due to the lower mean age of the diabetic subjects in India<sup>31,32</sup>, the lower sensitivity of the biothesiometry and the shorter duration of diabetes in our subjects<sup>32</sup>. Most of the diabetic

Reference	Year	Place	Category	Prevalence of PVD (%)
Walters, et al. <sup>23</sup>	1992	East Dorset, UK	Diabetes	20.2
Beks, et al. <sup>26</sup>	1995	Amsterdam, Netherlands	NDD KD	15.1 20.9
Premalatha, et al. <sup>15</sup>	2000	Chennai, India	NDD KD	3.5 7.8
Tapp, et al. <sup>27</sup>	2003	Australia	NDD KD	6.9 13.9

NDD: Newly detected diabetes, KD: Known diabetes.



**Figure 1.** Prevalence of diabetic neuropathy in type 2 diabetic subjects in different populations.

foot problems in India are neuropathic and infective, rather than vascular in origin as seen in developed countries<sup>33</sup>. The prevalence of peripheral neuropathy was as high as 27.5% in the South Indian type 2 diabetic patients<sup>16</sup>. Among the young diabetic patients in North Eastern India, peripheral neuropathy was found to be common in patients with fibrocalculous pancreatic diabetes (43.5%)<sup>34</sup>. Prevalence of diabetic neuropathy in type 2 diabetic subjects are presented in Figure 1.<sup>23,27,29,35-37</sup>

In India, diabetic patients with neuropathy who live in rural areas are more prone to foot ulcers than those who live in urban areas for various reasons including rodent bites (individuals in rural areas often sleep in huts, farm houses or outdoors on the farm, where rodents are common), barefoot walking, sociocultural practices, inadequate facilities for diabetes care and low patient education<sup>33</sup>.

### Infection

Foot infection is the most common infectious complication in patients with diabetes mellitus and is the common initiating event

that results in lower extremity amputation. Diabetic foot infection constitutes ~10% of diabetes-related hospital admissions<sup>38</sup>. It may be non-limb threatening or limb threatening, but is well documented that diabetic foot infections are polymicrobial in nature<sup>39-41</sup>. They result from an interplay of neuropathy, ischemia and metabolic alterations<sup>42</sup> reducing the defense mechanism. In diabetic neuropathy, dry skin can result in cracks, which allows the colonization of harmful bacteria, precipitating life-threatening infection<sup>43</sup>. Most of these amputations are the consequences of infections caused by ulcerations of the foot that are not recognized or treated in an appropriate and timely manner<sup>44</sup>.

As foot has several compartments, which are interlinked, infection can spread from one part into another and lack of pain allows the patient to continue ambulation further, facilitating the spread. In addition, soft tissues in the foot including plantar aponeurosis, tendons, muscle sheaths and fascia cannot resist infection. Recurrence of foot infection was common among

South Indian type 2 diabetic subjects and was related to the presence of PVD and neuropathy<sup>10</sup>.

### Foot pressure abnormalities

Foot deformities resulting from neuropathy, abnormal biomechanics, congenital disorders or prior surgical intervention may result in high focal foot pressures<sup>45,46</sup> leading to vulnerable areas on the foot predisposing to ulcerations. These areas are primarily located plantarly, although medial and dorsal ulcerations may occur from footwear irritation. Such deformities might include prior partial foot amputations, prominent metatarsal heads, hammertoes, Charcot arthropathy or hallux valgus. High foot pressure combined with features related to autonomic neuropathy can lead to callus formation, which act as a foreign body and cause tissue damage and foot ulceration.

The non-enzymatic glycosylation of collagens leads to stiffness of the ligaments and is associated with restrictions in the range of motions of the joints of foot and ankle (limited joint mobility [LJM]) causing abnormally high plantar foot pressures<sup>47</sup>. LJM contributes to the abnormal mechanisms in the diabetic foot often leading to limitations in the range of motion of feet that are rigid, firm and dry. Fernando, et al.<sup>48</sup> have shown that LJM contributes to foot ulceration in the susceptible neuropathic foot and that abnormal plantar foot pressures alone do not lead to foot ulceration. A study conducted in South Indian diabetic patients reported that diabetic patients had higher prevalence of LJM and plantar pressure than control subjects and among the diabetic patients, those with neuropathy and

history of plantar ulceration had higher LJM and plantar pressure compared to non-neuropathic subjects<sup>49</sup>. In addition, forefoot to rearfoot plantar pressure ratio >2 was found to be associated with neuropathy, LJM and ulceration<sup>50</sup>. LJM and plantar pressures have been reported to be higher in European patients than in Asian patients<sup>51</sup>.

### Other risk factors

Diabetic patients with other microvascular complications, particularly nephropathy at all stages, have an increased risk for foot ulceration<sup>52</sup>. However, the most at-risk group of both ulceration and amputation are those diabetic individuals with a past history of any foot lesion<sup>53</sup>.

### Conclusion

Neuropathy, vascular insufficiency, infection and deformities threaten the diabetic foot and the overall functional well-being of the diabetic patient calling for prevention and effective management at the initial stages of disease. Although foot problems in diabetes cannot be eradicated completely, the opportunity exists to diagnose and treat diabetic foot conditions effectively, to increase awareness, educate and motivate patients to care for their feet, to minimize complications and to decrease healthcare costs. In India, intensive treatment regimens combined with patient education on the prevention of foot amputations are helpful in preventing newer problems and surgery in diabetic foot disease<sup>54</sup>. Thus, effective preventive strategies for diabetic foot problems are the only approach to achieve the goal of reduction of major limb amputation by 50% as proposed in the St. Vincent's declaration<sup>55</sup>.

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