Radiographic Abnormalities in the Feet of Diabetic Patients with Neuropathy and Foot Ulceration

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Abstract

Objective: People with diabetic neuropathy are frequently prone to several bone and joint abnormalities. Simple radiographic findings have been proven to be quite useful in the detection of such abnormalities, which might be helpful not only for early diagnosis but also in following the course of diabetes through stages of reconstruction of the ulcerated foot. The present study was designed to identify the common foot abnormalities in south Indian diabetic subjects with and without neuropathy using radiographic imaging.

Methods: About 150 (M:F 94:56) subjects with type 2 diabetes were categorised into three groups: Group I (50 diabetic patients), Group II (50 patients with neuropathy), and Group III (50 diabetic patients with both neuropathy and foot ulceration). Demographic details, duration of diabetes and HbA1c values were recorded. Vibration perception threshold was measured for assessment of neuropathy. Bone and joint abnormalities in the feet and legs of the study subjects were identified using standardised dorsi-plantar and lateral weight-bearing radiographs.

Results: Radiographic findings of the study subjects revealed that those with both neuropathy and foot ulceration and a longer duration of diabetes had more number of bone and joint abnormalities. Subjects with neuropathy alone also showed presence of several abnormalities, including periosteal reaction, osteopenia, and Charcot changes.

Conclusions: The present findings highlight the impact of neuropathy and duration of diabetes on the development of foot abnormalities in subjects with diabetes. Using radiographic imaging can help in early identification of abnormalities and better management of the diabetic foot.

Introduction

Diabetes mellitus has been recognised as one of the leading causes of morbidity and mortality worldwide.1,2 Foot ulcers and amputations are attributed to severe socioeconomic burden, besides causing irreparable physical burden to the diabetic individuals. Assessment and management of risk factors contributing to amputation can play a major role in reducing the rate of amputation. People with diabetes usually present a wide range of bone and joint abnormalities which might be due to various risk factors such as reduced bone mass and renal complications.3–5 Neuropathic changes in the bones and joints also can cause fragmentation and destruction that is characteristic of Charcot fractures.6 Early recognition of bony abnormalities and appropriate treatment may prevent the progression of foot deformity and thereby reduce the morbidity caused due to foot ulceration or re-ulceration. Radiographic findings of such abnormalities are important tools to identify the extent of bone and joint damage that could help in screening the patients at high risk of ulceration and amputation, which could be used as a prediction model as well.7,8 Furthermore, radiographs are beneficial in following the course of diabetes through stages of reconstruction of the ulcerated foot. Several studies have demonstrated the use of radiographic findings to assess bone abnormalities such as traumatic fractures, periosteal reaction, osteopenia, and atrophy of metatarsal;7 Charcot changes;9 metatarsophalangeal arthrodcs;10 and
There is sparse data on radiographic studies of bone abnormalities among people with diabetic foot problems in the Indian population. The present study was done to identify the radiologically determined foot abnormalities in South Indian diabetic patients with and without neuropathy.

**Patients and Methods**

A total of 150 (M:F 94:56) subjects with type 2 diabetes attending a tertiary diabetes care centre were included in this study and were categorised into three groups. Group I consisted of 50 diabetic patients without neuropathy and ulceration. Group II had 50 diabetic patients with neuropathy. In Group III, 50 patients with both neuropathy and foot ulceration were included. Written informed consent was obtained from the study subjects, and the study was approved by the institutional ethics committee. Patients with type 1 diabetes, pregnant and lactating women were excluded. Demographic details and duration of diabetes were recorded for all the patients. Glycosylated haemoglobin (HbA1c) was estimated by high pressure liquid chromatography method using variant turbo machine (BIORAD, USA). Vibration perception threshold (VPT) was measured using Biothesiometer (Bio-medical Instruments Co., Newbury, OH, USA) for all the patients to assess the severity of neuropathy in their feet. Three readings were obtained from each foot on the first metatarsal at different degrees of voltage increase and a mean was taken. Patients with a VPT of > 25 volts were considered to have significant neuropathy. Abnormalities or deformities in the bones and joints of the feet and legs were recorded using radiographic imaging. Standardised dorsi-plantar and lateral weight-bearing radiographs of both feet of each study subject were taken by a single radiographer.

**Statistical analysis**

Mean and standard deviation for continuous variables and proportions for categorical variables are reported. ANOVA was used to test continuous variables and Chi-square test was used to compare categorical variables between the groups. A p value of < 0.05 was considered to be statistically significant. SPSS version 16.0 was used for all statistical analyses.

**Results**

Group I consisted of 50 (M:F 28:22; mean age 47.5 years) diabetic patients without neuropathy, Group II comprised 50 diabetic patients (M:F 34:16; mean age 58.3 years) with neuropathy, and 50 diabetic patients (M:F 32:18; mean age 57.3 years) with both neuropathy and foot ulceration were included in Group III. Groups II and III subjects were older than Group 1 subjects (p < 0.0001). Duration of diabetes was longer in the patients with neuropathy (9.1 ± 6.5 years) and both neuropathy and foot ulceration were included in Group III. Groups II and III subjects were older than Group 1 subjects (p < 0.0001). The glycemic control was also poor in all the three groups, indicated by high HbA1c levels, with no significant difference between the groups. Presence of neuropathy was high in groups II and III, with mean VPT values of 35 ± 6 volts and 41 ± 4 volts, respectively, compared to group I patients (17 ± 2 volts) (Table 1).

**Prevalence of Bone and Joint Abnormalities in the Study Patients**

Figure 1a shows examples of bone abnormalities such as Charcot changes with complete destruction of midtarsal and metatarsophalangeal joints with loss of plantar arch and [B] osteopenia, with thinning of the cortex prominently seen in the 2nd, 3rd, 4th and 5th metatarsals.
of midtarsal and metatarsophalangeal joints. The talo-navicular and calcaneo-cuboidal joints are also destroyed. There is also loss of plantar arch with rocker bottom foot and marked sclerosis. Figure 1B shows osteopenia (thinning of the cortex), which is prominently seen in the 2nd, 3rd, 4th and 5th metatarsals. Figure 2 shows partial dislocation (subluxation) at the metatarsophalangeal joint of the big toe.

Table 2 shows the prevalence of bone and joint abnormalities in the three study groups. Patients with neuropathy and those with both neuropathy and foot ulceration showed several bone and joint abnormalities compared to group I diabetic subjects without neuropathy. Traumatic fracture was observed in 12% of group III patients and 6% of group II subjects, however, the difference was not significant. Prevalence of periosteal reaction (group II vs group III; 10 vs 46%; p < 0.001), osteopenia (28 vs 60%; p < 0.01), erosion (8 vs 28%; p = 0.02), and amputation (2 vs 32%; p < 0.001) was significantly high in the subjects with both neuropathy and ulceration compared to those with neuropathy alone. Atrophic changes (2 vs 16%; p < 0.05) of the metatarsals were also significantly high in group III patients. Penciling was observed in only one patient in group III, while none in the other groups. There was also a significantly high prevalence of infection in group III (54%) subjects compared to the group II patients (14%) (p<0.0001). Juxta-articular exostoses were found in one patient each in groups II and III.

Joint abnormalities including Charcot changes (14 vs 54%; p < 0.0001), osteophytes (2 vs 18%; p = 0.02) and destruction (8 vs 28%; p = 0.02) were also significantly high in the neuropathic ulcer group compared to the neuropathic patients. Joint fragmentation was observed 18% of group III subjects and none in the remaining groups. Joint dislocation was noted in two patients (4%) in group II and four patients (8%) in group III, with no significant difference (Table 2).

Some of the above abnormalities were also noted in group I diabetic subjects with no history of neuropathy and ulceration, such as osteopenia in three patients, infection, atrophic changes, amputation, subchondral sclerosis and osteophyte formation each in one patient. These findings may be attributed to other reasons such as accidental foot injuries and/or improper foot care practices.

**Discussion**

The present investigation revealed the prevalence rates of bone and joint abnormalities assessed by radiographic findings in the diabetic patients. The presence of diabetes per se could not be accounted for the occurrence of bony abnormalities as noted in subjects without neuropathy who had almost negligible prevalence of the abnormalities compared to the other two groups with either neuropathy or with neuropathy and ulceration. However, once neuropathy sets in, the patient becomes highly susceptible to such abnormalities, as shown by the increasing prevalence of various abnormalities in subjects with neuropathy and foot ulceration. However, it is known that people with diabetes have reduced cortical bone mass compared to normal subjects. This was also evidenced in the present study wherein diabetic subjects with neuropathy and those with both neuropathy and ulceration had significantly higher prevalence of osteopenia (28% and 60%, respectively), compared to the diabetic

**Table 2** : Prevalence of bone and joint abnormalities in the study patients

<table>
<thead>
<tr>
<th>Details</th>
<th>Group I (DM)</th>
<th>Group II (DM + neuropathy)</th>
<th>Group III (DM + neuro + ulcer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone abnormalities, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traumatic fracture</td>
<td>-</td>
<td>3 (6)</td>
<td>6 (12)</td>
</tr>
<tr>
<td>Periosteal reaction</td>
<td>-</td>
<td>5 (10)</td>
<td>23 (46)*</td>
</tr>
<tr>
<td>Osteopenia</td>
<td>3 (6)</td>
<td>14 (28)</td>
<td>30 (60)*</td>
</tr>
<tr>
<td>Exostoses</td>
<td>-</td>
<td>1 (2)</td>
<td>1 (2)</td>
</tr>
<tr>
<td>Infection</td>
<td>1 (2)</td>
<td>7 (14)</td>
<td>27 (54)*</td>
</tr>
<tr>
<td>Erosion</td>
<td>-</td>
<td>4 (8)</td>
<td>14 (28)*</td>
</tr>
<tr>
<td>Atrophy of metatarsal</td>
<td>1 (2)</td>
<td>1 (2)</td>
<td>8 (16)*</td>
</tr>
<tr>
<td>Penciling</td>
<td>-</td>
<td>-</td>
<td>1 (2)</td>
</tr>
<tr>
<td>Amputation</td>
<td>1 (2)</td>
<td>1 (2)</td>
<td>16 (32)*</td>
</tr>
<tr>
<td>Joint abnormalities, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charcot changes</td>
<td>-</td>
<td>7 (14)</td>
<td>27 (54)*</td>
</tr>
<tr>
<td>Subchondral sclerosis</td>
<td>1 (2)</td>
<td>1 (2)</td>
<td>2 (4)</td>
</tr>
<tr>
<td>Osteophytes</td>
<td>1 (2)</td>
<td>1 (2)</td>
<td>9 (18)*</td>
</tr>
<tr>
<td>Fragmentation</td>
<td>-</td>
<td>-</td>
<td>9 (18)</td>
</tr>
<tr>
<td>Destruction</td>
<td>-</td>
<td>4 (8)</td>
<td>14 (28)*</td>
</tr>
<tr>
<td>Dislocation</td>
<td>-</td>
<td>2 (4)</td>
<td>4 (8)</td>
</tr>
</tbody>
</table>

*p < 0.05 vs group II*
patients without neuropathy and ulceration (6%). Furthermore, the presence of peripheral neuropathy makes them more susceptible to bone fractures leading to bone and joint abnormalities as reported by several researchers.\textsuperscript{16–18} In addition, the subjects in the present study showed poor vibration sensation as seen by the higher mean VPT values in the group of subjects with neuropathy and foot ulceration, due to sensation loss in their feet, compared to patients without neuropathy.

The most significant findings were observed in the patients with both neuropathy and ulceration who had maximum number of abnormalities. Periosteal reaction, osteopenia, erosion and infection were observed in a significantly higher number of patients with foot ulceration who also had significantly higher prevalence of amputation compared to the other two groups. The significantly high prevalence of periosteal reaction indicates previous traumatic bone injuries and also a response to infection sustained by the patients. It is also important to recognise the fact that presence of such abnormalities as periosteal reaction and sclerosis in patients with neuropathy is due to their loss of pain sensation combined with constant over use of the foot that result in stress and produces abundant sclerosis and disorganised joint. In addition, the high prevalence of Charcot foot changes in these patients also implicates the extent and severity of nerve damage and ulceration.

The significantly greater number of bone and joint abnormalities found in the diabetic patients with both ulceration and neuropathy should, however, elevate the degree of suspicion for such changes in neuropathic diabetic patients with otherwise equivocal clinical findings. In general, the results of this study emphasise the need for heightened suspicion of bony abnormalities in diabetic patients with neuropathy and, in particular, neuropathic foot ulcers so as to reduce morbidity caused by the progression of deformity and subsequent ulceration or re-ulceration.

In conclusion, radiographs can be quite useful in the detection of previously unknown Charcot changes and other abnormalities and in the evaluation of residual bone abnormalities of prior injury, ulceration, and surgery, all of which are frequently poorly recalled by the patient. This can help in better management of such patients to prevent further damage and save the limb from chronic ulceration and amputation.

Acknowledgement

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Conflict of interest

None declared.

References