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Research Article

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The Risk Association Between Foot Complications and Duration in Type 2 Diabetes Mellitus

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Abstract

Background: *Type 2 diabetes mellitus (T2DM) is associated with microvascular and macrovascular complications of which foot complications are considered to have very high prevalence. Diabetic peripheral neuropathy is the primary risk factor for the development of foot ulcers. But before the foot ulcers develop, there are several factors which are linked biomechanically to the high-risk foot. Therefor the objective of the present study was to identify the risk association between foot complications and duration of type 2 diabetes mellitus.*

Methods: *A total 724 T2DM participants were screened and 539 T2DM participants were included the study. The data analysis found with prevalence rate of 67.1% foot complications. Detailed clinical evaluation was performed to identify foot complications (dry skin, callus, fissures, hammer/claw toes, bunions, ingrown nails, fungal infections, Charcot's foot, and ulcers) using Michigan neuropathy screening instrument (MNSI).*

Results: *In the present study we found a statistically significant association between peripheral neuropathy, fissures and callus with duration of T2DM 1-5years (p=0.003), >11years (p=0.015) and 1.5years (p=0.003) respectively.*

Conclusion: *Foot complications like peripheral neuropathy, fissures and callus were associated with duration of type 2 diabetes mellitus duration more than five years.*

Keywords: Type 2 diabetes mellitus, Peripheral Neuropathy, Complications, Ulcer.

Introduction

The two main complications affecting limbs, mainly feet and legs, are diabetic polyneuropathy (DPN) which affects between 30 and 50% of diabetics and diabetic leg and foot ulcers. The lifetime incidence of foot ulcers occurring in DM patients is up to 25%. Diabetic neuropathy is the primary risk factor for the development of diabetic foot ulcers and is implicated in 50–75% of nontraumatic amputations. Peripheral neuropathy can cause tingling, pain (burning or tingling), or weakness in the foot. It can also cause loss of feeling in the foot. DPN involves somatic (leading to sensory loss), motor (leading to atrophy of intrinsic foot muscles) and autonomic nerves (leading to loss of perspiration and skin changes). The high rate of diabetic neuropathy results in substantial morbidity, including recurrent skin manifestations, lower extremity infections, ulcerations and subsequent amputations.

Autonomic neuropathy accounts skin manifestations in T2DM with prevalence ranging from 47.5 – 91.2% [1]. Dry skin is the first and most common among the cutaneous manifestation seen in subjects with T2DM because of uncontrolled blood glucose levels which can alter the blood flow to the skin as well as damage blood vessels and nerves. Decreased blood circulation can lead to changes in the skin collagen altering its texture, appearance and ability to heal. As a result of damage to the autonomic neuropathic system, the skin's endothelial cells gets damaged and this may even reduce its ability to sweat which leads to dry skin, fissure and callus formation as well as a decrease in ability to sense temperature and pressure [2].

Due to loss of sensation on the foot, subjects with DPN presents

with increased plantar pressures superimposing the foot into the very high load [3-5]. Murray et al have reported a 57% risk for ulcer formation at high-pressure points and also the relationship between callus and ulcer locations which may be a consequence of excessive shear forces which was documented in previous studies that friction forces cause hyperkeratosis of the tissues [6]. John et al in 2002 documented that the forefoot is more at risk for callus formation as compared to the rear foot which depended on the severity of peripheral neuropathy and diabetes mellitus.

Methods

After obtaining written informed consent from all the subjects. Detailed clinical evaluation was performed to identify foot complications (dry skin, callus, fissures, hammer/claw toes, bunions, ingrown nails, fungal infections, Charcot's foot, and ulcers) using Michigan neuropathy screening instrument (MNSI).

Michigan neuropathy screening instrument (MNSI): MNSI consists of two components, component 'A' is self-administered questionnaire and component 'B' is examination performed by the therapist.

The MNSI component 'A' questionnaire is self-administered. Responses are added to obtain a total score. 'Yes' responses to questions 1–3, 5–6, 8–9, 11–12, 14–15 are each counted as one point. 'No' responses to questions 7 and 13 each count as one point. Question 4 was considered to be a measure of impaired circulation and question 10 a measure of general asthenia and were not included in the published scoring algorithm. A score of ≥ 7 was considered abnormal and presence of peripheral neuropathy.

During the Michigan neuropathy screening instrument (MNSI) component 'B' examination, the subject's foot was inspected for dry skin, callus, fissures, hammer/claw toes, bunions, ingrown nails, fungal infections, Charcot's foot, and ulcers. Any foot with any abnormality was given a score of 1. In addition, each foot was inspected for ulcers, and any foot with an ulcer was given a score of 1. Ankle reflexes was also elicited; if present, the reflex was designated as present with reinforcement and was scored as 0.5. If the reflex was absent, it was scored as 1. Vibration sensation was evaluated as described for the VPT. Vibration sensation was scored as present if the subject was able to feel the vibration within 8 mV and scored as 0.5 if the subject was able to sense the vibration between 15 and 24 mV; if the subject was not able to feel the vibration or feel the vibration above 25 mV, a score of 1 was given. The total potential score on the MNSI is 8 points and in the published score algorithm, a score ≥2.5 is considered to indicate the presence of peripheral neuropathy.

Results

A total of 724 T2DM subjects were screened and 539 T2DM subjects were included based on inclusion and exclusion criteria. The mean age of T2DM subjects was 54.71 ± 9.68 years. Mean Body mass index (BMI) was 24.19 ± 3.33kg/m2. Duration of diabetes was categorized based on the severity of T2DM, 129 subjects had diabetes duration from 1-5years, 171 subjects diabetes duration was from 6-10 years, 124 subjects were with diabetes duration 11-15 years and 115 subjects had diabetes duration more than 16years.

Continuous variables were summarized using mean and standard deviation and categorical variables were expressed as frequency and percentage. (Table 1)

Table 1: Demographic and clinical characteristics of type 2 diabetes mellitus subjects

PARAMETERS	Mean ± SD	N (%)
Age (years)	54.71 ± 9.68	
BMI (kg/m2)	24.19 ± 3.33	
Gender	Male	372 (69.0%)
	Female	167 (31.0%)
Duration of diabetes (Years)	1-5 years	129 (23.9%)
	6-10 years	171 (31.7%)
	11-15 years	124 (23.0%)
	>16 years	115 (21.3)
Medications	OHA	46 (86.5%)
	Insulin	56 (10.4%)
	OHA + Insulin	56 (10.4%)
Co-Morbidities	Smoking	243 (45.1%)
	Alcoholism	213 (39.5%)
	Obesity	85 (15.8%)
	Hypertension	245 (45.5%)
	IHD	49 (9.1%)

In the present study we found a statistically significant association between peripheral neuropathy, fissures and callus with duration of T2DM 1-5years (p=0.003), >11years (p=0.015) and 1.5years (p=0.003) respectively. Fissure was 1.86 times more likely to be associated with duration of T2DM 11-15years and 2.18 times risk association with duration of T2DM >15years. Whereas callus and peripheral neuropathy was 0.465, 0.458 times more likely to be associated with duration of T2DM 6-10 years respectively (p=0.003). (Table 2)

Table 2. Association of foot complications and duration of type 2 diabetes mellitus

Foot complications	Duration of T2DM (years)	N (%)		Odds Ratio 95% CI (lower, upper)	p - value
		YES	NO		
Peripheral Neuropathy	1-5	44 (34.1)	85 (65.9)	--	
	6-10	74 (43.3)	97 (56.7)	0.458 (0.273, 0.768)	0.003
	11-15	58 (46.8)	66 (53.2)	0.675 (0.420, 1.086)	0.105
	>16	61 (53.0)	54 (47.0)	0.778 (0.468, 1.294)	0.333
Dry Skin	1-5	91 (70.5)	38 (29.5)	--	
	6-10	127 (74.3)	44 (25.7)	1.205 (0.723, 2.009)	0.474
	11-15	95 (76.6)	29 (23.4)	1.368 (0.780, 2.400)	0.275
	>16	92 (80.0)	23 (20.0)	1.670 (0.923, 3.023)	0.090
Fissure	1-5	45 (34.9)	84 (65.1)	--	
	6-10	52 (30.4)	119 (69.6)	0.816 (0.501, 1.328)	0.412
	11-15	62 (50.0)	62 (50.0)	1.867 (1.127, 3.093)	0.015
	>16	62 (53.9)	53 (46.1)	2.184 (1.304, 3.656)	0.003
Callus	1-5	47 (36.4)	82 (63.6)	--	
	6-10	36 (21.1)	135 (78.9)	0.465 (0.278, 0.778)	0.003
	11-15	51 (41.1)	73 (58.9)	1.219 (0.735, 2.023)	0.444
	>16	40 (34.8)	75 (65.2)	0.930 (0.550, 1.573)	0.788
In Growing Nails	1-5	15 (11.6)	114 (88.4)	--	
	6-10	9 (5.3)	162 (94.7)	0.422 (0.179, 0.998)	0.050
	11-15	11 (8.9)	113 (91.1)	0.740 (0.326, 1.680)	0.472
	>16	20 (17.4)	95 (82.6)	1.600 (0.777, 3.296)	0.202
Hammer Toes	1-5	6 (4.7)	123 (95.3)	--	
	6-10	6 (3.5)	165 (96.5)	0.745 (0.235, 2.367)	0.618
	11-15	11 (8.9)	113 (91.1)	1.996 (0.715, 5.573)	0.187
	>16	9 (7.8)	106 (92.2)	1.741 (0.600, 5.050)	0.308
Ulcer	1-5	8 (6.2)	121 (93.8)	--	
	6-10	7 (4.1)	164 (95.9)	0.646 (0.228, 1.829)	0.410
	11-15	8 (6.5)	116 (93.5)	1.043 (.379, 2.871)	0.935
	>16	5 (4.3)	110 (95.7)	0.688 (0.218, 2.164)	0.522
Fungal Infection	1-5	5 (3.9)	124 (96.1)	--	
	6-10	11 (6.4)	160 (93.6)	1.705 (0.577, 5.035)	0.334
	11-15	8 (6.5)	116 (93.5)	1.710 (0.544, 5.378)	0.359
	>16	3 (2.6)	112 (97.4)	0.664 (0.155, 2.843)	0.581
Bunions	1-5	3 (2.3)	126 (97.7)	--	
	6-10	5 (2.9)	166 (97.1)	1.265 (0.297, 5.393)	0.751
	11-15	6 (4.8)	118 (95.2)	2.136 (0.522, 8.734)	0.291
	>16	5 (4.3)	110 (95.7)	1.909 (0.446, 8.171)	0.383

Discussion

Studies reported that the foot complications are associated with several risk factors like obesity, peripheral vascular diseases and uncontrolled blood glucose levels, duration of diabetes mellitus, HbA1c and age. Whereas, duration of T2DM is considered to be the most common risk factor [7-10].

In the present study, stepwise multivariate analysis was performed to find the risk association between the duration of T2DM and foot complications and we found foot complications like fissures and callus were highly associated with T2DM duration more than six years. Similar to our study, a study by Rao et al documented that the prevalence of peripheral neuropathy and autonomic neuropathy increases as the duration of T2DM increases. In their study, out of 51 subjects with peripheral neuropathy, 7 subjects had <5years duration and 44 subjects had >5years duration of diabetes. Autonomic neuropathy was seen in 8 subjects with <5years duration and 24 subjects with duration >5years [8]. In the present study, we found a significant risk association between peripheral neuropathy, fissures, and callus with duration of T2DM 1-5years (p=0.003), >11years (0.015) and 1.5years (0.003) respectively. Fissure was 1.86 times more likely to be associated with duration of T2DM 11-15years and 2.18 times risk association with duration of T2DM >15years. Whereas callus and peripheral neuropathy was 0.465, 0.458 times more likely to be associated with duration of T2DM 6-10 years respectively (p=0.003).

Even though we didn't find much association other than fissures, in a study by M Oe et al, documented a correlation between fissures and autonomic neuropathy, authors reported that decreased perspiration due to autonomic neuropathy can lead to dry skin and fissure development in subjects with a long duration of diabetes mellitus. Since the plantar skin does not have sebaceous glands, dryness is more likely. Decreased perspiration due to autonomic neuropathy decreases stratum corneum moisture content, which in turn can lead to fissures [11]. In another study by Rao et al., 2015 reported among 51 T2DM subjects, peripheral neuropathy was observed in 7 subjects with duration of T2DM <5years and 44 subjects had >5years. Autonomic neuropathy was observed in 8 subjects with duration of T2DM <5years and 24 subjects with duration >5years. It is made clear that as the duration of diabetes mellites increases, it is more likely to develop a foot complication which includes peripheral neuropathy and secondary complications due to peripheral neuropathy.

Conclusion

In the present study we found that, foot complications like peripheral neuropathy, fissures and callus were associated with duration of type 2 diabetes mellitus duration more than five years. Therefore, early screening for musculoskeletal and foot complications should be incorporated in routine diabetes evaluation to detect early changes and prevent the progression of the complications.

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