

## PREVENTION AND TREATMENT OF ULCERATIONS OF THE FOOT IN UNILATERALLY AMPUTATED DIABETIC PATIENTS

KIRSTEN LARSEN, JENS SANDAHL CHRISTIANSEN & BENT EBSKOV

Steno Memorial Hospital, Gentofte and  
Department of Orthopedics, State University Hospital, Copenhagen, Denmark

In unilaterally amputated diabetic patients the prognosis for the remaining leg is poor. Often the patients suffer from diabetic neuropathy, angiopathy and/or arteriosclerosis. Furthermore, the load pattern of the remaining foot is frequently abnormal. In order to assess the extent of the problem, as well as the possibility of preventive care, 20 patients in the outpatient clinic of the Steno Memorial Hospital were followed for a period of 17 months.

Eighteen patients showed signs of peripheral neuropathy and 19 an abnormal load pattern. Following preliminary assessment the dynamic load pattern of the ambulant patients was recorded and their shoes were fitted with a corrective insole made of Rubazote®. In the presence of ulcerations the insoles were continuously modified according to the diminishing size of the ulcer. Supplementary local dressing and systemic antibiotics were administered according to need.

Initially 11 patients had pedal ulcerations, 5 ischemic and 6 neuropathic. All of the neuropathic ulcerations healed during the period of observation and no new ulcerations were seen. Two of the ischemic ulcerations healed whereas the remaining 3 persisted. It is concluded that regulation of the pedal load pattern in unilaterally amputated diabetic patients has a considerable curative and preventive effect.

*Key words:* diabetes mellitus; foot amputation; ischemia; neuropathy; ulceration, prevention, treatment

Accepted 29.viii.81

Whether requiring insulin or not, diabetes mellitus is frequently complicated by late diabetic manifestations, viz. peripheral diabetic neuropathy and angiopathy. Neuropathic ulcers of the foot and insufficient peripheral circulation are frequent causes of lower extremity amputation in diabetics (Kelly & Coventry 1958, Smith & Casingal 1969, Viskum 1969).

In the diabetic patient with unilateral amputation of the lower extremity the prognosis for the remaining extremity is poor (Goldner 1960, Smith & Casingal 1969, Viskum 1969, Ebskov & Josephsen 1980) and the mortality is high (Smith 1956, Whitehouse et al. 1968, Ecker & Jacobs 1970, Editorial 1972, Ebskov & Josephsen

1980). In the unilaterally amputated diabetic the walking pattern will often change and the remaining foot almost invariably becomes deformed. With changes in the configuration of the foot, the gait is altered and new pressure points are created, resulting in ulceration at these points. Such ulcerations represent a serious threat to the survival of the foot because of the risk of infection, gangrene and finally amputation (Kelly & Coventry 1958).

The curative effect of decompression of diabetic neuropathic ulcers has previously been described (Holstein et al. 1976). The present study was initiated to assess the load patterns in the remaining foot of unilaterally amputated diabetic

patients. The effect of relieving abnormal pressure points and/or ulcerations was also investigated.

## PATIENTS

During a 17-month period all unilaterally amputated, diabetic patients seen in the outpatient clinic of the Steno Memorial Hospital were examined and treated in the footclinic. The total number of patients was 24. Four patients who were wheelchair-bound or bedridden were excluded from this study. The material thus comprises 20 patients – 7 females and 13 males (Table 1).

The average age at the onset of diabetes mellitus was 36 years (3–76 years), and the average duration of the disease prior to the initial amputation was 22 years (2–49 years). Four patients were treated with diet and sulfonylurea, and in the remaining 16 patients the condition was controlled with diet and insulin. Only 4 patients had a weight exceeding the ideal weight by more than 15 percent (Table 1). Eighteen patients had symptoms of peripheral neuropathy, defined by con-

comitant loss of the Achilles and/or patellar tendon reflexes and loss of sense of vibration distal to the malleolar level. Four patients had complicating proliferative retinopathy and 6 patients had persistent proteinuria (Albustix®). One patient (No. 4) died prior to the termination of the study.

## METHOD

The 20 patients with retained walking ability were thoroughly examined for malalignment and abnormal configuration of the foot. The presence, location and size of ulcerations were noted and symptoms of peripheral neuropathy (as defined above) were recorded.

The peripheral circulation was assessed by comparing the Doppler blood pressure recording at ankle level, with the systolic blood pressure as recorded on the upper arm with conventional auscultatory technique. If the latter pressure exceeded the systolic ankle pressure by more than 20 mmHg the peripheral blood pressure was considered decreased and in such patients ulcerations of the foot were classified as ischemic, whereas the

Table 1. Sex and age distribution at the onset of diabetes mellitus and at the time of unilateral lower extremity amputation

No.	Sex	Age at onset of D.M.	Age at L.E. amputation	B.W./I.W. %	Clinical findings at the time of amputation			
					Antidiabetic treatment	Peripheral neuropathy	Proliferative retinopathy	Nephropathy
1	M	48	50	134	16 I	+	-	-
2	M	14	61	96	30 I	+	-	-
3	M	58	85	101	20 I	+	-	+
4	M	15	57	88	30 I	+	+	-
5	M	27	55	85	88 I	+	-	-
6	M	22	65	107	22 I	+	-	-
7	F	76	82	105	S	+	+	-
8	F	3	52	85	36 I	+	+	+
9	F	11	50	74	18 I	+	-	-
10	F	51	60	141	S	+	-	-
11	M	16	23	109	36 I	-	-	-
12	M	60	62	114	S	+	-	+
13	M	22	50	108	64 I	+	-	+
14	M	51	58	81	22 I	-	-	-
15	M	44	62	114	S	+	-	-
16	F	45	58	148	48 I	+	-	-
17	F	5	50	71	22 I	+	+	-
18	M	39	59	102	24 I	+	-	+
19	M	45	60	100	14 I	+	-	+
20	F	50	69	125	26 I	+	-	-

D.M.: Diabetes mellitus

I.W.: Ideal weight

L.E.: Lower extremity

I: Insulin – figures indicate units/24 h.

B.W.: Body weight

S: Sulfonylurea

remaining ulcerations were considered neuropathic (Yao et al. 1970, Nielsen et al. 1973).

In order to localize the pedal pressure points the shoe was mounted with an interchangeable insole, made of leather (1 mm) covered by a light, thermoplastic material (1 mm Plastozote®) ("interim insole"). One to three weeks later the functional footprint was recorded and a new insole was produced with suitable excavations corresponding to the abnormal pressure points. In the presence of abnormal varus or valgus loading of the foot the insole was further modified by a corrective module made from a soft, pressure-resistant material (3–5 mm Rubazote®), carefully adjusted to balance the foot. Following another 1 to 4 weeks the skin of the foot was re-assessed and if satisfactorily decompressed, the insole was covered by soft leather for durability ("permanent insole"). If ulcerations were present at the initial examination of the patient, the interim insole with properly adjusted excavation(s) was successively replaced by new insoles, the shaping of which corresponded to the decreasing size of the ulceration(s), the aim being to ensure a constantly optimal deloading of the sores.

Necrotic ulcerations were treated locally with dressings with chloramine (0.1 percent) b.i.d. and the patients were seen in the clinic at least once a week to check for infection and excise necrotic tissue. Bacterial cultures and resistance patterns were checked repeatedly and systemic antibiotics administered as indicated. Neuropathic ulcerations without necroses were dressed q. 24 hours with Bactigras®, and seen biweekly in the foot clinic.

The status of the diabetes mellitus was checked once a month in patients with ulcerations; in the remaining patients it was checked once every 3 months.

## RESULTS

All 20 patients with retained walking ability showed some degree of abnormal alignment and loading of the remaining foot (Table 2). Seventeen of the patients had peripheral neuropathy (Table 2), corresponding well with available information on their pre-amputation status (Table 1).

Eleven patients had abnormally lowered blood pressure at the ankle level of the remaining leg – and in 8 of these ischemia was recorded as the main indication for the previous, unilateral amputation. In only 2 out of 9 patients with normal ankle blood pressure had ischemia led to the first amputation (Table 2).

At the initiation of the study 11 patients had ulcerations of the foot, 5 of these being classified

as mainly ischemic and the remaining 6 as neuropathic (Table 2). Following treatment 2 ischemic ulcerations healed whereas 3 persisted. All neuropathic ulcerations healed with the described treatment. During the 17 months of the study no new ulcerations of the feet were seen.

## DISCUSSION

In unilaterally amputated diabetics the prognosis is poor, both *quo ad vitam* (Smith 1956, Whitehouse et al. 1968, Ecker & Jacobs 1970, Editorial 1972, Ebskov & Josephsen 1980) and as far as the survival of the remaining lower extremity is concerned (Goldner 1960, Smith & Casingal 1969, Viskum 1969, Ebskov & Josephsen 1980).

In diabetics with neuropathy and/or ischemia abnormal alignment of the foot leads to abnormal loading which subsequently carries a serious risk of pressure-induced necroses. We found abnormal pressure points in the remaining foot of all 20 patients with retained walking ability. Whether this was also the case in the previously amputated foot, we do not know, and we also do not know whether the abnormal loading had been present before the onset of diabetes or had developed under adverse conditions with ill-fitting footwear, neuropathy or following changing load patterns consequent to unilateral amputation. There is, however, some reason to believe that the latter cause may be a significant one because it augments the risk of pressure-induced ulceration of the remaining foot.

In the present study we found that conservative treatment had a very good effect on primarily neuropathic ulcerations of the foot, in as much as all ulcerations healed. Conversely the primarily ischemic lesions were to a large extent unresponsive to such treatment although in some (two) patients the ulcerations did actually heal.

It is reasonable to assume that unilaterally amputated diabetic patients with pathologically decreased ankle blood pressure may retain some walking ability provided ulcerations of the remaining foot are prevented. This would indicate a thorough evaluation at regular intervals, per-

Table 2. Indication for unilateral lower extremity amputation, given together with observation period and results from the present study

No.	Durat. of obs. (months)	Indication for amput.	Level of amput.	Ankle pressure* mm Hg	Neuropathy**	Ankle deformity	Ulcerations/ start***	Ulcerations/ end****
1	5	trauma	crus	0	+	varus	-	-
2	5	ischemia	crus	-50	+	varus	+ (I)	+
3	3	neuropathy/ infection	crus	-70	+	varus	+ (I)	+
4	1	ischemia	Symes	-85	+	valgus	+ (I)	+
5	16	neuropathy/ infection	femur	15	+	valgus	+ (N)	-
6	39	"	Symes	+10	+	valgus	+ (N)	-
7	33	ischemia	crus	-110	+	valgus	-	-
8	14	neuropathy/ infection	crus	50	+	valgus	+ (N)	-
9	7	ischemia	crus	-80	+	valgus	-	-
10	11	ischemia	crus	-105	+	valgus	-	-
11	7	trauma	Symes	0	-	valgus	-	-
12	3	neuropathy/ infection	crus	30	+	valgus	+ (N)	-
13	13	"	Symes	15	+	valgus	-	-
14	2	ischemia	femur	-120	-	varus	-	-
15	14	ischemia	crus	-70	+	valgus	-	-
16	8	ischemia	crus	-10	+	valgus	+ (N)	-
17	5	ischemia	crus	150	+	valgus	+ (N)	-
18	3	trauma	femur	-75	+	valgus	-	-
19	7	ischemia	crus	-130	-	varus	+ (I)	-
20	1	neuropathy/ infection	crus	-110	+	varus	+ (I)	-

\* Difference between ankle pressure on remaining leg and arm pressure.

\*\* Peripheral neuropathy on remaining leg.

\*\*\* Ulcerations of remaining leg at onset of observation period.

\*\*\*\* Ulcerations of remaining leg at the end of observation period.

I: Primarily ischemic.

N: Primarily neuropathic.

mitting early discovery of abnormal pressure points and rational correction in due time.

The functional footprint, impressed on the interim insole, yields sufficient information about the intimate interaction between foot and shoe. It differs from the passive footprint and plaster cast by including the dynamic relationship between osseous prominences of the foot and the influences of heel height and the transverse dimension of the footwear.

Previously described electric pressure transducers (Bauman & Brand 1963, Stokes et al. 1977) mounted in the shoe or in special slipper-socks do not incorporate these advantages, and moreover are cumbersome.

It is essential to inform the patient that new shoes require a fresh functional assessment, particularly if the patient has previously had neuropathic ulcerations of the foot. In addition, the motor neuropathy may cause collapse and changing load patterns of the foot within a very short span of time, again necessitating frequent re-evaluation and often new insoles and even new shoes. If the shoes are handmade the patient as well as the shoemaker should for the same reasons be warned that it may frequently be necessary to produce a new last.

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Correspondence to: Jens Sandahl Christiansen, M.D., Steno Memorial Hospital, DK 2820 Gentofte, Denmark.