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Title: Diabetic foot in type 1 diabetes mellitus

Hajer MARZOUK[1,2], Hamza ELFEKIH[2,3], Farah LOUHICHI[4], Safa AMARA[4,] Wiem SAAFI[2,3], Taieb ACH[2,3], Imen HALLOUL[2,3], Ghada SAAD[2,3], Wided DEBBABI[1,2], Yosra HASNI[2,3], Doaa El Wasly[5]

[1]Department of Endocrinology, Ibn El Jazzar Hospital, Kairouan, Tunisia.

[2]Faculty of Medicine of Sousse, University of Sousse, Tunisia

[3]Department of Endocrinology, Farhat Hached Hospital, Sousse, Tunisia.

[4]The Sousse School of Health Sciences and Techniques, university of Sousse, Tunisia

[5]Department of Internal Medicine and Nephrology, Ain shams University. Cairo, Egypt

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Abreviations:

- DSPN: distal symmetrical polyneuropathy
- PAD: peripheral arterial disease
- IWGDF: International Working Group on the Diabetic Foot
- TM: telemedecine

ABSTRACT :

Background :

Diabetes mellitus is a public health problem. Diabetic foot is one of its major complicati ons and is secondary to neuropathy, arteriopathy, infectious and mechanical foot involve ment. It is a major cause of lower limb amputation and thus of motor disability.

Material and methods

We propose a descriptive study of the main anomalies found in the examination of thefe et in 40 patients with type 1 diabetes.

Results:

The median age of our population was 34.5 years. The average duration of diabetes was 25.35 years. 15% of people have neuropathic pain, and about one third describe the pain as severe. Hallux valgus and claw toes were observed in 35% of patients and a Charcot foot was found in 2 patients.
10% of subjects already had stage 4 arterial disease and 10% had intermittent claudicatio ns.

The results of the care of 3 patients through telemedicine are encouraging. Management was early and further damage was prevented.

Conclusion:

Foot involvement in diabetes mellitus is common and often severe. Early intervention, via telemedicine, could improve outcomes.

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INTRODUCTION:

Diabetes mellitus remains a real public health problem worldwide.
According to the International Diabetes Federation (IDF) in 2019, 463 million adults worldwide were diabetic. The prevalence of diabetes is constantly increasing. In France, for example, the prevalence has continued to increase, from 5.6% in 2015 to 6.30 % in 2022.
Diabetic foot, one of the most serious complications of diabetes mellitus, has serious me ntal, physical and socio-economic consequences. Its management is most of the time complex because it is often the consequence of several neurological, vascular, infectious and biomechanical disorders.
Fortunately, amputations can be prevented if foot lesions are diagnosed early.
Through this study, we wish to share our experience in the management of diabetic feet.

MATERIALS AND METHODS:

We conducted a cross-sectional descriptive study in the diabetology department of Farhat Hached university hospital and department of Endocrinology, Ibn El Jazzar Hospital, Kairouan in Tunisia. Patients with type 1 diabetes mellitus for at least 15 years were recruited after free, informed and signed consent. Our non-inclusion criteria were mainly foot amputees without orthopaedic devices, patients unable to give consent and/or without smartphones.
A total of 40 patients were finally included. Demographic, socioeconomic, medical history, podological examination, shoe inspection and podoscopic exam were noted.
Podological examination includes seven tests: pain assessment, search for any foot deformity, examination of the integuments and appendages, vascular, neurological, joint and muscle examination.
Pain is assessed using DN4 questionnaire, patient description of the pain and palpation of painful points.
The podoscopic examination looks for areas of pathological hyper-pressure that can lead to ulceration.
At the end, we share our first experience of telemedicine (teleconsultation and telemonitoring) for 3 patients with diabetic foot lesions.

STATISTICAL ANALYSIS:

Data were processed by Statistical Package for the Social Sciences (SPSS) software version 20 (SPSS Inc. Chicago, IL, USA).

RESULTS:

The median age of our population was 34.5 years with extremes ranging from 17 years to 55 years; 53% men and 47% women, resulting in a sex ratio of 1.11.
The average duration of diabetes was 25.35 ± 8.92 years [Min = 15 ; Max = 47].
47.5% of subjects were unfortunately unemployed.
Smoking was present in 35% of the population studied. Chronic alcoholism was noted in 7.5%.

Thirty percent of cases (30%) were overweight and 7.5% were obese. A minor amputation was noted in 7.5% of cases.

Among family histories, we found diabetes in 45% of cases and hypertension in 27.5%. All patients were of course treated with insulin. Human insulin was found in 22.5 % of cases.

1.Pain assessment

The DN4 scale indicated that 15% of diabetic patients had neuropathic pain.

The pain described by patients was in the heel in 10% of cases, and in the metatarsals and toes in 7.5% respectively.

Pain was sudden in 17.5% of cases, progressive in 30% and mechanical in 25%.

32.5% of patients complained of severe pain according to the numeric pain rating scale.[Min = 5; Max = 10]. (table I)

Table I: the main characteristics of pain

		frequency	**pourcentage**
Topography	thigh	1	2,5
	knee	1	2,5
	leg	1	2,5
	calf	2	5
	external malleolus	2	5
	internal malleolus	1	2,5
	ankle	2	5
	dorsum of the foot	1	2,5
	heel	4	**10**
	Foot soles	1	2,5
	Metarsals	3	**7,5**
	toes	3	**7,5**
Pain onset	sudden	7	**17,5**
	Progressive	12	**30**
Trigger factors	walking	4	**10**
	Effort	3	**7,5**
	Standing position	1	2,5
	Wearing shoes	1	2,5
	Rest	1	2,5
Aggravating factors	Prolonged standing position	4	**10**
	Effort	2	5
	walking	3	**7,5**
	Rest	1	2,5
Pain relief	Rest	12	**30**
	Analgesics	2	5
	walking	1	2,5
Rythme	Mechanical	10	**25**
	Inflammatory	6	15
	Mixed	3	7,5

2. Assessent of deformities

Hallux valgus and claw toes were observed in 35% of patients. 25% of patients had hollow feet and 22.5% had flat feet. A retro-calcaneal protrusion was palpated in 12.5% of our participants, and 5% had a protrusion of the styloid of the 5th metatarsal.

A charcot foot was found in 2 patients. (table II)

Table II: Distribution of subjects based on foot deformities

		frequency	pourcentage
Toes	hallux valgus	14	**35**
	claw toes	14	**35**
	quintus varus	4	10
	supradductus	1	2,5
	infradductus	3	7,5
Forefoot	convex	6	15
	triangular	8	**20**
	flat	5	12,5
	normal	21	52,5
Midfoot	flat	9	**22,5**
	cavus	-	-
	hollow	10	**25**
Hindfoot	retro-calcaneal prominence	5	**12,5**
	verticality of the calcaneus	-	-
	navicular bone protrusion	1	2,5
	styloid prominence of M5	2	5
	haglund's disease	-	-

3. Vascular assessment

Skin recoloration time was greater than 4 seconds in 15% of our participants.

The pedal pulse was abolished in 17.5% of patients, the posterior tibial in 15% and the popliteal in 2.5%.(table III)

Table III: Distribution of our subjects based on vascular evaluation

		Frequency	Percentahe
Skin recoloration	≤ 4s	34	85
	> 4s	6	**15**
Pedal pulses	present	33	82,5
	abolished	7	**17,5**
Posterior tibial pulse	present	34	85
	abolished	6	**15**
Popliteal pulse	present	39	97,5
	abolished	1	**2,5**
Intermittent claudication		4	**10**
Trophic disorders	ulceration	4	**10**

	gangrene	-	-
Leriche-Fontene classification	stage 1	2	5
	stage 2	1	2,5
	stage 3	1	2,5
	stage 4	4	**10**

4. Venous and lymphatic assessment:

varicose veins of the lower limbs were found in 45% of patients.
telangiectasias were found in 30% of cases. (table IV)

Table IV: venous and lymphatic assessment

	Frequency	**Percentage**
Varicose veins	17	**42,5**
Varicosities	17	**42,5**
Telengiectasia	12	**30**
Edema	5	**12,5**

5. Examination of shoes

27.5% of patients wore inadequate shoes. Shoe heels were flat in 22.5% and high in 12.5%.
Shoe buttresses were nonresistant and absent in 37.5% and 12.5%, respectively, and combrions were absent in 60% of cases.
10% of our patients did not have shoes.

6. Podographic examination

A podographic examination was carried out for all the patients.
On the right, areas of hyperpressure were found at the forefoot in 17.5% of the cases and at the inner edge in 25% of the cases.
On the left, the areas of hyperpressure were more at the level of the metatarsal heads in 25% of cases and at the level of the back foot in 10% of cases.

7. Grading of podiatric risk according to the IWGDF classification

At the end of our examination, we established the podiatric risk of each patient. Indeed, almost a third of our patients are grade 1 and 7.5% of them are already grade 3.

8. Telemedicine in the management of diabetic feet

a/Patient 1

The patient was 32 years old and had type 1 diabetes for 16 years. The patient was a regular sportsman. He had a first teleconsultation because he had a lesion on his left foot. It was a superficial ulcerated lesion on the medial border of the left foot, caused by unsuitable footwear. The lesion had already been evolving for about a week, but was initially neglected by the patient. The lesion initially consisted of a phlycthene which was subsequently ruptured.

The lesion had been evolving for around ten days. The patient sent us photos of the lesion. (photo 1)

There were no signs of local infection. We ordered an X-ray of the foot and, fortunately, there were no obvious images of osteitis.

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After examining the photos, we recommended off-loading the foot, washing with saline and initial application of a modern tulle gras dressing.
We monitored the lesion closely, at least weekly at first, until complete healing.

b/Patient 2

The patient was 52 years old and presented with a hyperkeratotic skin lesion on the external border of the right foot.
The patient had an initial teleconsultation. Photos of the lesion were sent to us by smartphone. Mechanical stripping of the hyperkeratotic margins, daily dressings and total discharge of the lesion were recommended. Weekly teleconsultations were continued until total healing of the lesion (photos 3 and 4).

c/Patient 3

Mrs. R, 20 years old, presented via teleconsultation for pain in the right hallux with edema, redness and discharge of pus. Upon viewing the photos, the diagnosis was clear; Ms. R suffers from an ingrown toenail at an advanced a nd complicated stage of paronychia.
In this case, the patient was advised to present to the emergency room to decide on possible surgical management.
Teleconsultation allowed us to identify the pathology, to propose a management and abo ve all to give advice on the nature of the pathology in order to avoid complications.
(photo 5).

DISCUSSION:

The DN4 scale indicated that 15% of our diabetic patients had neuropathic pain. 32.5% of patients complained of severe pain according to the numeric pain rating scale.[Min = 5; Max = 10].
The distal symmetrical polyneuropathy (DSPN) is the most typical presentation and can affect up to 90% of patients [1].
This polyneuropathy is associated with a heavy morbidity and mortality and is one of the main causes of the ulcers observed in diabetic feet [2,3].
The diagnosis of this disorder is often delayed because it is often silent. Most patients pr esent only when pain appears. This is present in 10 to 26% of the population [4,5,6].
The mechanism of peripheral neuropathy is still not well elucidated. Several theories we re advanced. It may involve changes in calcium and sodium channels distrubition and expression, altered neuro-peptide expression and loss of spinal inhibitory control [7].
Evaluation of the deformities showed that hallux valgus and claw toes were found in 35% of the cases each. Foot deformities are quite common in litterature and may affect up to 44.5% of patients with type 1 diabetes in a large Canadia n study [8].

Charcot foot is an advanced stage of diabetic foot deformities and was found in 2 patients. Charcot neuropathic osteoarthropathy, commonly referred to as the Charcot foot, is a condition affecting the bones, joints, and soft tissues of the foot and ankle. The pathogenesis of this complication remains unclear. However, it is known that local a nd uncontrolled inflammation plays a predominant role.Diabetic neuropathy is the main

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cause of Charcot foot. However, it is essential not to omit other etiologies. Theseetiologi es include toxins (ethanol, drug related), infection (leprosy), spinal cord and nerve roots (tabes dorsalis, trauma, syringomyelia) and a number of other conditions (Parkinson's disease, HIV, sarcoidosis, rheumatoid disease, and psoriasis) [9].

The classic rocker-bottom foot represents a severe chronic deformity typical for this condition [10,11,12].

The incidence of this complication is highly variable in the literature and varies from 0.1 to 29%. Likewise, its prevalence varies from 0.08 to 13% [13,14].

This disparity in results is probably explained by the size of the sample, which is often s mall.

A larger and more recent Swedish observational study included 3449 subjects. The incidence varied from 228 to 287 new Charcot foot cases per year (range 67–92 for subjects with type 1 and 113–180 for subjects with type 2 diabetes) with a relative incidence between 6.4 and 9.5 per 10,000 subjects with diabetes (12.1–17.6 for type 1 and 5.6–7.9 for type 2 diabetes; two-sample test, $P < 0.001$). The prevalence increased, from 0.55% in 2006 to 0.79% in 2016 [15].

In another large study investigators reported a prevalence of 0.56% but without specifying the type of diabetes [16].

In addition to the neurological evaluation, arterial involvement was investigated. The pedal pulse was abolished in 17.5% of patients, the posterior tibial in 15% and the popliteal in 2.5%.

10% of subjects already had stage 4 arteriopathy according to the Leriche-Fontaine classification.

50% of diabetics with foot ulcer have arteriopathy [17]. Peripheral arterial disease PAD is under-diagnosed and so under-treated. Its main symptom is intermittent claudication.

Intermittent claudication was present in 10% of subjects.This symptom attributable to PAD, occurred in about 1.5% of the cohorts in the Framingham Heart Study. The prevalence in men was higher [18].

Diabetes mellitus is a clear risk factor for PAD [19,20].

It is useful to specify that the incidence of arterial disease varies according to the method used for diagnosis (palpation of pulses, search for intermittent claudication or ankle brachial index) [21,22].

7.5% of subjects had a grade 3 according to the IWGDF classification. According to a meta-analysis of risk factors for amputation in diabetic foot IWGDF grades 3 and 4 were found as predictors of amputation (OR: 1.7 and 2.5) [23].

Amputation usually occurs when patients do not seek medical care promptly.

To facilitate access to care and to detect and treat injuries quickly, we proposed to set up a telemedicine platform. The results were good with the first 3 patients, giving the hope of generalizing this method in the management of diabetic foot.

According to a recent meta-analysis, treating diabetic foot ulcer via telemedicine TM could be at least as effective as to face-to-face attendance. The results were as follows: (a) healing rate OR was 1.35, in favor of TM ($p = 0.4$), (b) time to heal with means of 73 ± 24.1 days and 83.5 ± 28.4 days, for the TM and control group, respectively ($p = 0.35$), c) the amputation rate OR was 0.48 ($p = 0.007$) in favor of the TM group, d) the mortality

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rate OR was 1.66 (p = 0.2), and e) a trend for lesser cost than face-to-face group (p = 0.4) [24].

Digital photography was found to be a valid, reliable, and feasible method for assessing and monitoring diabetic foot ulcers according to a systematic review [25].

Another meta-analysis enrolling 1876 patients with diabetic foot ulcers concluded that telemedicine is non-inferior to standard care: time to healing of wound within 12 months (mean difference: -0.07, 95% CI: -0.31-0.17), the incidence of amputation (RR: 0.73, 95% CI: 0.54-1.00), and all-cause mortality (RR: 0.99, 95% CI: 0.42-2.37) [26].

CONCLUSION:

Foot lesions are common in type 1 diabetes mellitus.

Therefore, lesions should be screened to treat them early and prevent amputations. Our f irst experience in telemedicine is encouraging and we hope to generalize this technique i n the management of diabetic feet.

LIMITS OF OUR STUDY:

The main limitation of our study is the small sample size.

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Authors did not use any financial sources to conduct this study. They declare no conflict of interest in conducting the study and preparation of this manuscript.

PHOTOS :

Photo 1

Photo 2

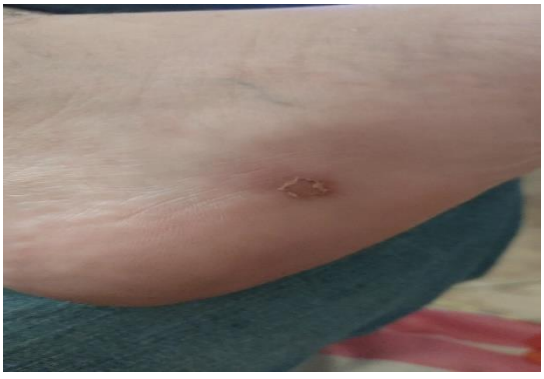

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Photo 3

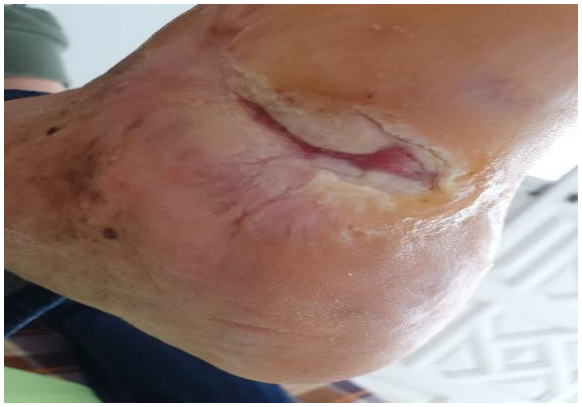

Photo 4

Photo 5

Photo 6

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