

# EPIDEMIOLOGICAL ASPECTS OF FOOT AND ANKLE INJURY IN THE DIABETIC PATIENT

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## ABSTRACT

**Objective:** To identify the epidemiological profile of patients undergoing orthopedic treatment for complications of the feet and ankles due to diabetes, and to try to establish the sequence of events that led to amputation of the limb. **Method:** The medical records of 300 diabetic patients treated from March, 1997 to July, 2006 were systematically reviewed. **Results:** The mean age of the patients was 61 years. Of these, two hundred and seventy three (91%) were diagnosed with type II diabetes, but only 49 (16.3%) had proper medical supervision and control of their glycemia levels. Problems affecting the function of the foot and ankle were found in 405 limbs, with: 102 osteoarticular deformities asso-

ciated with Charcot's neuroarthropathy (34%); 181 chronic ulcers (60.4%); and 97 infected limbs (32.4%). After the average follow-up time, 14 patients (4.6%) died. **Conclusion:** Ulceration of the sole of the foot was the most common complication in our series of patients, the majority of whom were in their seventies, presented type II diabetes, were insulin dependent, and did not have adequate control of glycemia. Loss of sensitivity of the foot, associated with pre-existing deformities, were identified as the main causes of secondary infections culminating in amputation of the limb.

**Keywords:** Epidemiology. Foot injuries. Ankle injuries.

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## INTRODUCTION

Diabetes mellitus is a typical disease of the modern world. The stress caused by the hectic pace of life in large cities, poor eating habits and a sedentary lifestyle are related to the development of obesity, a comorbidity related to this disease. These days we are experiencing a diabetes epidemic that is quickly spreading all over the world and in the vast majority of countries its prevalence ranges between three and five percent of the population.<sup>1</sup> In Brazil the true incidence of the disease in the population is still unknown. It is estimated that there are around eight million diabetics and that at least another three million have not yet had their disease diagnosed.<sup>2</sup>

Diabetes affects all age brackets, yet its incidence increases with age. The improvement in the clinical control of the disease, especially after the development of synthetic insulin, has increased the length of survival of patients.<sup>3</sup> On account of the greater longevity the late-onset complications of the disease are being seen more frequently, including lesions of the foot and ankle. In the United States the most common cause of hospitalization among diabetic

patients is infection of the foot, which has a preexisting ulcer as a route of entry.<sup>4</sup> In our field the treatment of complications associated with injuries on the feet of diabetic patients is usually dealt with by the vascular surgeon. The concept that foot ulcers are caused by circulatory deficit when in actual fact, the main factor implied in the genesis of these lesions is the sensorial deficit associated with peripheral neuropathy, is still widely divulged.<sup>5</sup>

The main goal of our work is to show the epidemiological profile of diabetic patients that approach the orthopedic outpatient sector for treatment of diabetes-related complications involving the feet and ankles, in a typical public university hospital from the largest city in the country. We intend to use this sample to identify the main problems that affect the feet and that are related to the sequence of events culminating in the clinical evolution and in the amputation of the lower limb in diabetic patients, typical of large urban centers of our country, alerting physicians and public health authorities about the need to perform strategic planning in view of the bleak prospects related to the world epidemic of the disease.

All the authors declare that there is no potential conflict of interest referring to this article.

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## CASUISTRY AND METHODS

In the 10-year period between March 1997 and August 2006, we monitored in the specialized outpatient sector of Surgery of the Foot and Ankle in the Orthopedics and Traumatology department of our institution, 300 consecutive patients that sought treatment for complications of the feet caused by diabetes. The data were collected from the medical records and tabulated. The information gathered in the protocols was analyzed with regard to the epidemiological aspects and to the treatment methods employed.

At our hospital the team of professionals involved in the treatment of complications that affect the lower extremities of diabetic patients is formed by orthopedists specialized in reconstructive surgery of the foot and ankle; orthopedic interns in an annual program of specialization in foot and ankle surgery; resident orthopedists and traumatologists; nurses and assistant nurses, with specific training in the treatment of wounds on the feet; plaster technicians trained in the modeling of total contact casts; technicians specialized in the creation of special shoes and insoles, orthoses and prostheses; physiotherapists and social workers. As a tertiary care hospital, we rely on the support of other medical specialties that provide multidisciplinary care, with special emphasis on: clinical medicine, endocrinology, nephrology, ophthalmology, dermatology, cosmetic surgery and vascular surgery.

The outpatient sector works under the supervision of the specialized orthopedists and receives diabetic patients referred for treatment of various lesions, with special emphasis on: fractures and acute dislocations of neuropathic feet and ankles; acquired deformities caused by Charcot's neuroarthropathy sequelae affecting the feet and ankles; pressure ulcers and infections associated with sensorial deficit in the lower extremities.

### Dynamics of Care and Treatment of Diabetic Patients with Problems in the Feet

In the outpatient sector the initial procedure involving diabetic patients consists of the gathering of information concerning the background of the disease and the brief general clinical exam. The feet and ankles are evaluated in detail in relation to the circulatory state. The distal pulses of the extremity (femoral, popliteal, anterior and posterior tibial) are verified by palpation. We also look at toe perfusion, skin coloration and foot temperature. An examination of the skin of the lower extremities is carefully conducted in search of callosities, cracks, fissures, interdigital mycosis and especially solution of continuity (ulcers). The nails are assessed in terms of the presence of fungal infection (onychomycosis) and ingrown toenail, lesions that function as an entry route for secondary bacterial infection.

The protective sensibility of the skin, especially in areas more subject to pressure, located in the plantar region of the foot (digital pulp of the hallux, region under the head of the I and V metatarsal bones, besides the skin in the heel region), is tested employing Semmes – Weisstein monofilament.

When we verify the presence of ulcers, we perform their mechanical debridement in the actual outpatient sector. Anesthesia is not necessary as in almost all cases, the feet are practically insensitive. Under aseptic conditions, we use a n° 22 scalpel blade to remove the hyperkeratosis that forms around the ulcer. After this, the di-

mensions and the depth of the lesion are gauged and noted down. The ulcers are then classified according to Wagner apud Calhoun<sup>6</sup> and their location is identified in a spreadsheet that is part of the records. We always check for the existence of associated infection. The vast majority of uninfected ulcers are treated with total contact cast (TCC), with weekly changes until complete healing. In the presence of infection in the ulcer bed, the patient is immediately hospitalized and treated with intravenous broad-spectrum antibiotic therapy. Urgent surgery is indicated for debridement with removal of all the infected and devitalized tissue.

In patients that appear with swollen feet, with intense redness and local temperature increase, we always suspect Charcot's arthropathy in activity. A series of plain x-rays of the foot and ankle, in the anteroposterior, lateral and oblique incidences, is usually sufficient for the diagnosis. The classification of the anatomical location<sup>7</sup> and of the evolutionary phase of Charcot's arthropathy are used to direct the treatment, which is essentially perfect with TCC until fracture consolidation. Residual deformities in the feet and ankles, associated with vicious consolidation of the fractures, are usually well tolerated by the patients that present insensitive feet. The accommodation of these deformities in extra-deep special shoes, molded insoles and orthoses is normally sufficient to prevent the appearance of an ulcer under the areas of hyperpressure provoked by the bony prominences. Recurring ulceration frequently located in the plantar and medial region of the midfoot under areas of bony prominences or, more rarely related to joint instability caused by viciously consolidated malleolar fractures, constitute indications of surgical treatment.

## RESULTS

In our casuistry, the mean age of the 129 female patients and 171 male patients was 61 years (ranging from 27 to 95 years).

The vast majority of patients presented type 2 diabetes, present in 273 of the total 300 patients (91%). At the time of the first consultation we verified that only 65 patients (21.7%) regularly attended appointments with the clinical physician for periodic glycemia control. Insulin was used by 116 patients (38.7%) to control the disease. Of these, only 49 (16.3%) regularly visited the clinical physician to control and adjust the dosage of the medication. Sixty-seven of the 116 insulin-dependent patients (57.7%) applied insulin without any parameter of clinical control of the disease.

In our patients the mean body mass index (BMI) totaled 24.4 (variation from 14.7 to 55.6). One hundred thirty patients (43.3%) were overweight (BMI > 25) and 37 patients (12.3%) were obese (BMI > 35).

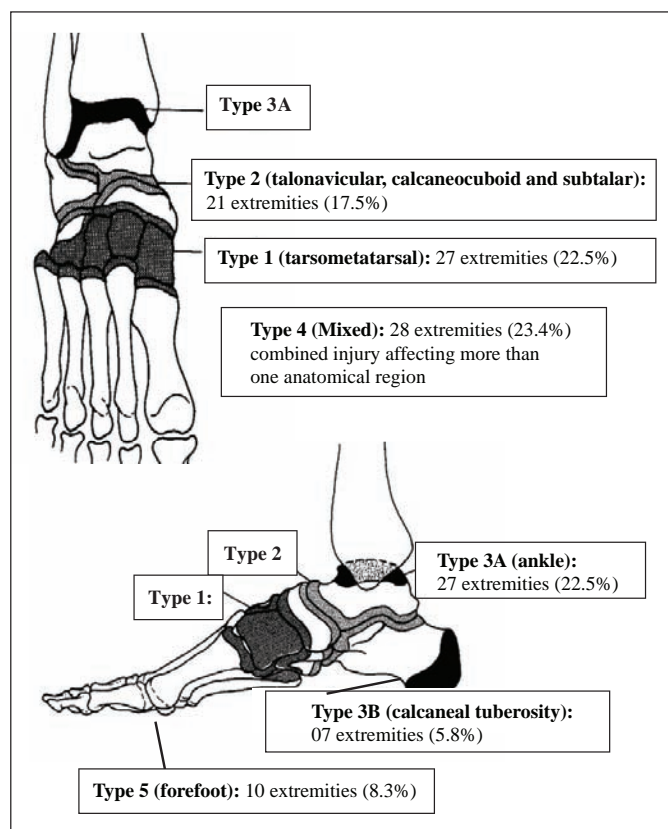
Smoking, a recognized factor of risk for peripheral circulation, was referred to by 70 patients (23.4 %), while chronic alcoholism was reported by 38 patients (12.7%).

The advanced stage of the disease in the patients from our casuistry can be verified with a basis on the presence of the implication of several other organs and systems. The main complications observed in our series were: systemic arterial hypertension in 84 patients (28%); severe vasculopathy, already in treatment by vascular surgery, in 45 patients (15%); cardiopathy, in treatment by cardiologist, in 17 patients (5.6%); severe visual deficit in treatment by ophthalmologist in 18 patients (6%); chronic renal failure in treatment by nephrologist in 11 patients (3.7 %).

## 1 – Charcot's Neuroarthropathy

Deformation in the feet and ankles, caused by Charcot's neuroarthropathy, was verified in 105 of the 300 patients in our series, corresponding to 35% of the total. The mean age of the diabetic patients that developed Charcot's Arthropathy was 60 years (variation from 29 to 82 years). Bilateral lesion occurred in 15 (14.3%) of the 105 patients, totaling the implication of 120 extremities.

The anatomical distribution of the lesions caused by Charcot's neuroarthropathy is shown in Table 1.



**Table 1** – Distribution of Charcot's arthropathy in the patients evaluated

At the time of the first outpatient visit the classification of the evolutionary stage of Eichenholtz apud Brodsky<sup>7</sup> of the 120 extremities with osteoarticular lesions associated with Charcot's neuroarthropathy was as follows: initial phase of bone fragmentation in 74 extremities (61.7%); hypertrophic phase of coalescence in 27 extremities (22.5%) and late phase of sequela in 19 extremities (15.8%).

Conservative treatment with TCC was employed preferentially in the vast majority of extremities with Charcot's neuroarthropathy and evolved satisfactorily in 69 (57.5%) of the 120 extremities affected by the disease. During outpatient monitoring 24 extremities (22.8%) developed ulcers resulting from the formation of bony prominences or of deformity caused by severe joint instability. The location of the ulcers associated with Charcot's neuroarthropathy had the following distribution in the 24 extremities affected: forefoot in five (20.8%); midfoot in 14 (58.4%) and hindfoot in five (20.8%).

To treat the complications resulting from the deformities associated with Charcot's neuroarthropathy it was necessary to perform surgical intervention in 37 of the 120 extremities (30.8%). The surgeries performed consisted of the resection of plantar bony prominences (exostectomy) that provoked recurring ulceration in eight extremities (6.7%); modeling arthrodesis of hindfoot for correction of severe deformity or gross instability in 25 extremities (20.8%); modeling arthrodesis of midfoot for correction of severe rocker-bottom feet caused by accentuated collapse of the medial arch and recurring ulceration in four extremities (3.4%).

The indication of amputations for treatment of Charcot's neuroarthropathy was related to the development of recurring ulcers that suffered secondary infection or complication after attempted reconstructive surgery with modeling arthrodesis. Minor amputations (forefoot or midfoot) or major ones (ankle and leg) were performed in 14 of the 120 extremities (11.7%). Primary amputation of the extremity was indicated when there was extremely severe deformity that ruled out any attempt at reconstruction to align the extremity and obtain plantigrade support of the foot. The distribution of the 14 amputations related to Charcot's arthropathy was as follows: transtibial in five extremities (4.2%); ankle in two extremities (1.7%); midfoot at Chopart's joint level in three extremities (2.5%); forefoot at the tarsometatarsal joint level (Lisfranc) in two extremities (1.7%); forefoot at the transmetatarsal level in two extremities (1.7%).

## 2 – Pressure ulcers

The presence of pressure ulcers was verified in 90 of the 300 patients of our series (30%), totaling 110 extremities affected. The ulcers were classified according to the parameters of Wagner apud Calhoun.<sup>6</sup> We observed zero degree lesions (skin intact with callosity or previous ulcer) in nine extremities (8.2%); degree I lesions (shallow superficial ulcer, not infected) in 57 extremities (51.8%); degree II lesions (deep ulcer exposing tendon or bone with or without superficial infection) in 30 extremities (27.3%) and degree III lesions (deep ulcer with infection) in 14 extremities (12.7%). The distribution of the ulcers in terms of location was as follows: forefoot in 77 extremities (70%); midfoot in 15 extremities (13.6%) and hindfoot in 18 extremities (16.4%). The pressure ulcers, located on the plantar surface of the foot, affected 93 extremities (84.5%). The ulcers caused by extrinsic compression of the inadequate shoe or poorly adjusted orthoses and prosthesis affected 17 extremities (15.5%). In establishing correlation between presence of deformities and ulcer occurrence, we verified that: in the 110 extremities that presented some type of ulcer, 48 lesions (43.6%) were located in the plantar region of the forefoot in association with equinus deformity; 18 lesions (16.4%) were located in the perimalleolar region of the ankle in association with severe instability and deformation of the hindfoot; 15 lesions (13.6%) were located in the midfoot in association with collapse of the medial longitudinal arch caused by Charcot's neuroarthropathy; and 29 lesions (26.4%) were located on the toes in association with claw toe deformities.

Protective sensibility, tested with the Semmes - Weinstein monofilament, was preserved in 14 (12.9%) of the 110 extremities that presented ulcers. The other 96 extremities (87.1%) exhibited varying degrees of hypoesthesia or even complete anesthesia. Based on the clinical exam, vascularization was considered unsatisfactory in 37 (33.7%) of the 110 extremities that presented ulcers. The vast

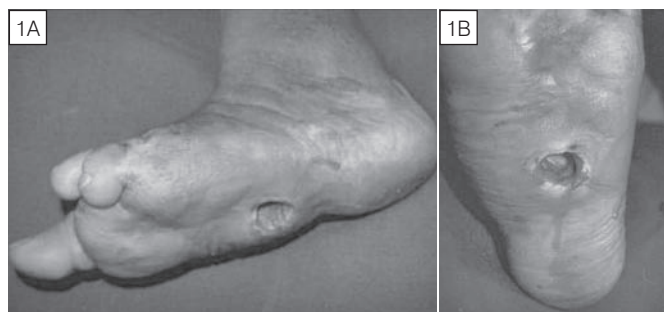
majority of ulcers found on the extremities without protective sensibility were not related to circulatory deficiency. On the other hand, most ulcers that occurred on extremities with circulatory deficiency were not correlated with significant loss of protective sensibility of the affected lower limb.

The treatment of ulcers of neuropathic cause was performed in 81 of the 110 extremities (73.6%) and consisted of the local debridement of the lesion, for surgical removal of all devitalized tissue, followed by occlusive dressing and TCC production. Such procedures were carried out under aseptic conditions in the actual outpatient sector and without the need for anesthesia, since the feet presented insensibility to pain. Due to the presence of deformities on the foot or ankle that caused hyperpressure in the weight bearing area and provoked the recurrence of ulcers always in the same place, it proved necessary to perform some kind of surgery in 29 of the 81 extremities treated in the outpatient sector (35.8%). For correction of equinus deformity, which provoked excessive weight bearing on the forefoot and caused plantar hyperpressure and recurring ulcer in the region under the head of the metatarsal bones, the calcaneal tendon was lengthened in seven extremities (8.6%). Resection of plantar bony prominences in midfoot (ostectomies) was performed in six extremities (7.4%) that exhibited recurring ulceration due to the rocker-bottom feet deformity caused by collapse of the medial arch after sequela of Charcot's neuroarthropathy. In 24 extremities (29.6%) it proved necessary to perform extensive debridement to resect the devitalized and infected tissues. Due to the uncontrollable infection that had the ulcer as its entry route, 18 extremities (22.2%) had to be partially amputated.

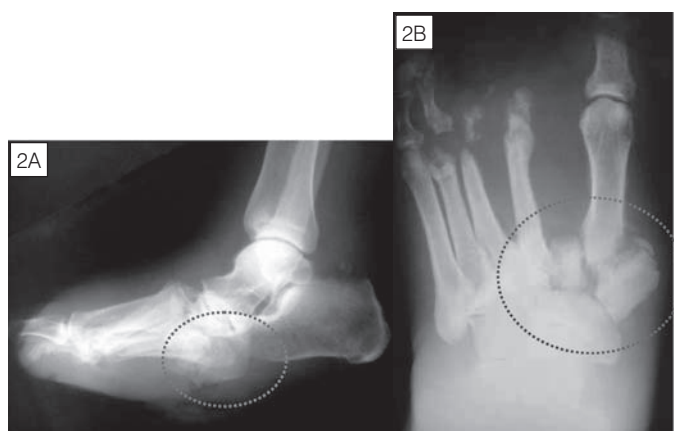
### 3 – Infection

The incidence of infection in the extremities was observed in 69 of the 300 patients from our casuistry (incidence in 23% of the patients). The infection was bilateral in nine patients, totaling 78 infected extremities. The distribution of infections, according to their location, was as follows: forefoot in 51 cases (65.4%); midfoot in 19 cases (24.4 %); hindfoot in eight cases (10.2%). In correlating the occurrence of infection with the presence of ulcer or deformity due to Charcot's neuroarthropathy, we verified that: in 23 extremities (29.5%) the infection was preceded by ulcer and in 16 extremities (20.5%) the infection occurred in feet with sequela of Charcot's neuroarthropathy. In correlating the occurrence of infection with the presence of ulcer and deformity due to Charcot's neuroarthropathy, we verified that this association occurred in 12 extremities (15.4%). The sequence shown in Figures 1 to 6 illustrates the treatment performed with one of the patients from our series that exhibited peripheral neuropathy in advanced stage, loss of protective sensibility of the feet and developed deformities associated with Charcot's neuroarthropathy. In this case the plantar bony prominence on an insensitive foot was directly responsible for the appearance of ulcer that underwent secondary infection and almost occasioned the amputation of the extremity.

All the patients with diagnosis of infection in the extremity were hospitalized and treated with emergency surgery. According to the extent of infection, abscess drainage and debridement of the devitalized tissues were performed in 35 extremities (44.8%), as the infection was exclusively restricted to the soft parts. In these cases the wounds were left open to granulate by second intention and the



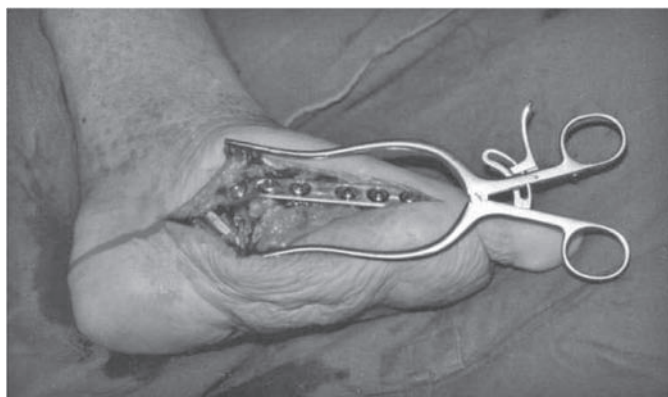
**Figure 1** – Side (1a) and sole (1b) of the foot with infected plantar ulcer caused by bony prominence in diabetic patient with peripheral neuropathy and loss of protective sensibility. The patient presented previous amputation of the central toes due to complication of the disease.



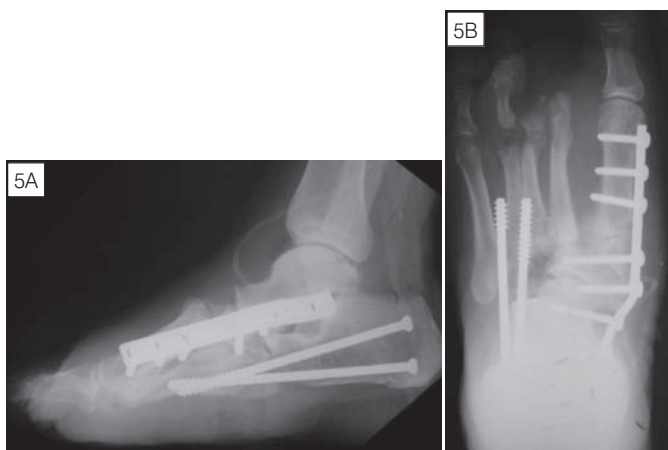
**Figure 2** – Lateral (2a) and dorsoplantar (2b) incidences of the foot. The deformities with arch collapse and plantar prominence of the cuboid bone (circle 2a) and dislocation of the tarsometatarsal joint with medial bony prominence of the intermediate wedge (circle 2b). Deformities caused by Charcot's neuroarthropathy.



**Figure 3** – Area of plantar incision made for debridement of the wound, removal of the devitalized tissue and complete resection of the infected cuboid.



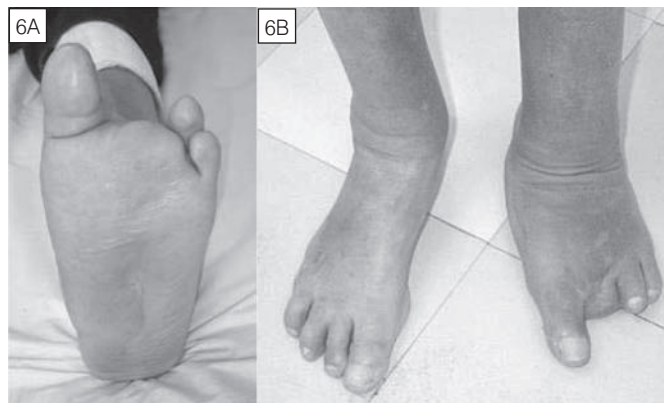
**Figure 4** – Longitudinal incision on the foot. Bone stabilization of the midfoot obtained after removal of the joint cartilage of the bones of the medial column and internal fixing with plate and screws.



**Figure 5** – Dorsoplantar (5a) and lateral incidences (5b), immediately after surgery for plantar removal of the infected cuboid, medial removal of the prominent intermediate wedge and arthrodesis of the midfoot fixed with plate and screws for correction of collapse of the medial plantar arch and of the deformity caused by the tarsometatarsal dislocation.

patients remained in hospital for intravenous antibiotic therapy until the infection was controlled, which occurred after two weeks, on average. In the presence of osteomyelitis, the treatment consisted of the complete removal of the infected bone. Therefore 43 partial or complete amputations of the extremity were performed for treatment of the profound infections that affected the bones, totaling incidence of 55.2% in our casuistry. The distribution of the location in which the amputations were performed in our series, is as follows: transfemoral amputation in one extremity (2.3%); transtibial amputation in 10 extremities (23.3%); Syme's amputation (ankle disarticulation) in two extremities (4.6%); amputation at Chopart's joint (talonavicular and calcaneocuboid) in two extremities (4.6%); amputation at Lisfranc's joint (tarsometatarsal) in four extremities (9.3%); transmetatarsal amputation in an extremity (23%); radius amputation (metatarsus and corresponding toes) in 12 extremities (27.9%); and amputation of toes in 11 extremities (25.7%).

Septicemia, triggered from a focal point of infection located on the distal extremity, was the cause of 18 of the 19 deaths recorded



**Figure 6** – (6A) Dorsoplantar (6B) and medial, (6C) aspects/views of the left foot 28 months after surgical treatment of infected plantar ulcer in the midfoot. The plantigrade position of the foot and the absence of recurring ulceration after the removal of the plantar and medial bony prominences. In this case it was possible to avoid amputation of the extremity through urgent measures, reconstruction of the bone architecture and stabilization of the foot.

in our series. The partial or complete amputation of the infected extremity was performed as an attempt to contain the infection, in 10 of the 18 patients that evolved to death (52.6%).

#### 4 – Necrosis and ischemia

In twenty-four of the 300 patients of our casuistry, totaling 8%, we observed necrosis of ischemic cause implicating the lower extremity. All told, 27 extremities were affected by some degree of partial or generalized focal necrosis. The most common locations of ischemic tissue necrosis were: forefoot level in 12 extremities (44.5%); midfoot level in five extremities (18.5%); hindfoot and ankle level in 10 extremities (37.0%). Twenty-six of the 27 extremities affected by ischemic tissue necrosis were operated. The surgeries performed were as follows: extensive removal of the devitalized tissue in nine extremities (34.6%) and partial or complete amputation of the extremity in 15 cases (57.7%). The levels of amputation performed were: forefoot in eight cases (53.3%); midfoot in five cases (33.4%); transtibial in two cases (13.3%).

Prior to the development of the severe ischemia that triggered the tissue necrosis we could observe, based on the data available in the medical records, that 17 (70.8%) of the 24 patients had a past record and clinical signals of previous severe ischemia (decreased or absent peripheral pulses, reduction of the tissue perfusion of the

extremity, complaints of chronic pain in the feet when walking short distances, previous monitoring by the vascular surgeon). Three of the 24 patients (12.5%) had already previously undergone surgery in an attempt at revascularization of the extremity or amputation due to chronic ischemia.

## DISCUSSION

In the last twenty years diabetes has become a highly prevalent disease in the world population, and its incidence has been assuming alarming epidemic proportions.<sup>8</sup> In the United States this phenomenon became a motive of great concern among the authorities responsible for medical care planning, particularly due to the expenditures involved in the treatment of the disease.<sup>9</sup> The severe sequelae resulting from the chronicity of the disease are highly incapacitating and involve problems of locomotion due to implication of the feet.<sup>9</sup>

The loss of protective sensibility involves mainly the region of the feet and ankles, caused by chronic inflammation of the nerves (peripheral neuropathy).<sup>8</sup> The exact mechanism that causes this to occur has not yet been established. Theories propose that the buildup of sorbitol<sup>9</sup>, an intermediate substance in the metabolism of glucose, is deposited in the myelin sheath and interferes in nerve conduction. Whatever the exact mechanism that leads to peripheral neuropathy, the fact is that the greater the time elapsed since diagnosis of the disease, the higher the incidence of complications related to progressive loss of sensation in the feet.<sup>10</sup>

The appearance of ulcers in the feet that present loss in protective sensibility is related to the presence of contact areas where there is excessive pressure.<sup>11</sup> Claw toe deformity and bony prominences located mainly in the plantar region increase the risk of these lesions in insensitive feet. Protective measures that include daily inspection of the feet and ankles, besides the use of appropriate stockings, insoles and shoes are known to reduce the risk of ulceration.<sup>12</sup>

In our casuistry advanced peripheral neuropathy was present in the vast majority of diabetic patients that developed problems and complications related to the foot and ankle. These patients were in the seventh decade of life and exhibited type II diabetes without adequate glycemia control. The occurrence of pressure ulcer was one of the main complications that affected the feet of these patients. The association between pressure ulcer and loss of protective sensibility caused by peripheral neuropathy, was found frequently in our casuistry.

The presence of ulcer in the feet and ankles and the deformities associated with Charcot's neuroarthropathy were the main motives that led the patients to seek medical care in our outpatient clinic. In the presence of insensitive feet in association with preexisting deformities (hollow foot, varus foot, equinus foot, hallux valgus, claw or hammer toes, prominence of the metatarsal heads, among others) or plantar bony prominences caused by sequela of Charcot's neuroarthropathy there is fertile soil for the appearance of areas of hyperpressure located in the region of the foot where it rests on the ground.<sup>13</sup> The persistent compression of the skin interposed between the bony prominence and the ground or tight shoe provokes local tissue ischemia and triggers the occurrence of focal necrosis with ulcer formation. The lack of protective sensibility prevents the patient from promptly identifying the start of this process which, in a patient with preserved sensation, would provoke intense pain.<sup>14</sup>

The forefoot, particularly the region located under the head of the metatarsals, was the most frequent site of the pressure ulcers, totaling 70% of our series. We verified that the retraction of the posterior musculature of the leg, especially the triceps surae, was related to equinus deformity and resulted in excessive weight bearing of the forefoot during gait, favoring the appearance of ulcers located in this region. The lengthening of the Achilles tendon (calcaneal tendon) was a useful and necessary measure to reduce the recurrence of ulcers in the forefoot.

The combination of pressure ulcer and deformity caused by Charcot's neuroarthropathy was frequent in our casuistry, particularly in the presence of bony prominences located in midfoot in association with collapse of the medial arch. In situations like this, besides the treatment with TCC to allow ulcer healing, it was also necessary to take steps to prevent its relapse with the use of a molded insole and special extra-deep shoes. Selected cases were submitted to surgery for resection of overly exuberant plantar bony prominences. In very specific situations, when the foot deformities were highly accentuated, we endeavored to reestablish plantigrade support, performing reconstruction of the osteoarticular architecture. More extensive surgery was performed on these feet for realignment and stabilization by means of modeling arthrodesis. For correction of bony wedge deformities, of appropriate size and location, these were resected and after adequate realignment the foot was fixed internally with plate and screws. Bone graft was used to fill bone cavities and to assist in the obtainment of foot alignment.

Unstable deformities located in the hindfoot, mostly associated with the sequela of malleolar fractures in association with osteoarticular destruction and disarrangement caused by Charcot's neuroarthropathy, received special treatment. Unstable deformities in varus or valgus could not be accommodated or stabilized with orthoses to allow the weight bearing of the extremity without the formation of zones of friction and pressure ulcers in the malleolar regions. In these cases, in particular, it proved necessary to reconstruct the hindfoot by means of resection of the malleoluses, removal of bony wedges and tibiototalcalcaneal arthrodesis fixed by means of intramedullary metallic nails or plates and screws. Bone graft was almost invariably used to fill bone cavities and to assist in the obtainment of hindfoot alignment.

What draws attention in our series is the fact that approximately one third of the patients that approached our outpatient service for treatment presented problems related to Charcot's neuroarthropathy. Although they had sought medical care in several different places, 62% of these patient exhibited the disease still in activity, had never been adequately diagnosed as suffering from osteoarticular deformity in fragmentation phase<sup>15</sup> and had not been immobilized with TCC either. We consider that the lack of adequate diagnosis might be related to problems of familiarity of health professionals with this specific disease of the feet and ankles in diabetic patients with peripheral neuropathy. We believe it is essential to create a program geared toward educating and providing guidance to health professionals in relation to this problem, so that both early identification and adequate treatment of Charcot's neuroarthropathy can prevent further complications of the disease.

The secondary infection of pressure ulcers located on the sole of the feet was the main cause that led to partial or complete amputation of the extremity. Preceding the infection, we noticed

that the frequency of pressure ulcers associated with preexisting deformities was high, affecting 39 extremities (50%). This once again characterized the well-known equation that establishes a direct relationship between acquired deformity, localized increase of pressure in area of weight bearing or friction with the shoe, feet with significant sensorial deficit and development of ulcers.<sup>15</sup> We verified that in the 78 extremities that developed infection, 43 required some kind of amputation. This high frequency of amputations to treat infected extremities (approximately 55% in our series) stresses the need to prevent and to treat ulcers before these undergo secondary infection. In this manner the morbidity of the disease can be effectively reduced.

The mistaken concept that lists ischemia as the main cause of complications related to the lower extremities of diabetic patients needs to be reviewed. In our series of 300 patients, only 24 (27 extremities) presented problems primarily related to ischemia, ischemic necrosis and gangrene due to arterial insufficiency, totaling incidence of 8%. We believe that careful clinical evaluation of blood perfusion through the clinical exam (palpation of peripheral pulses, checking of capillary refill, foot coloration and temperature assessment) in association with supplementary exams (Doppler ultrasonography and mainly transcutaneous oximetry of digital pulp)<sup>16</sup> should always be performed for the screening of diabetic patients. In the presence

of peripheral circulation considered deficient, the vascular surgeon should be consulted, yet the management of the global treatment of the extremity needs to be allocated to a physician specialized and trained in the treatment of diseases of the foot and ankle. This physician should be familiarized with techniques for treatment of wounds on insensitive feet and be able to provide instructions on making plaster casts of the total contact type and molded orthoses, besides performing specialized surgical procedures, such as: osteoarticular reconstructions, correction of specific deformities (claw toes, hallux valgus, hollow foot, flat foot, etc.) and performing functional amputations, overseeing patient rehabilitation.<sup>16</sup>

## CONCLUSION

In our casuistry the vast majority of diabetic patients that presented problems and complications related to the foot and ankle suffered from peripheral neuropathy in advanced stage, were in their seventies and presented type 2 disease without adequate control of glycemia. The recurring ulceration on the sole of the feet was a frequent complication and was directly related to the loss of the protective sensibility in association with preexisting deformity or deformity resulting from Charcot's neuroarthropathy. The main complication that led to amputation of the extremity was the secondary infection of the pressure ulcers.

## REFERENCES

1. Medvei VC. History of endocrinology. Lancaster: MTP Press; 1982.
2. Sherwin RS Diabetes melito. In: Goldman L, Bennet JC, editores. *Cecil: Tratado de medicina interna*. 21ª ed. Rio de Janeiro: Guanabara Koogan; 2002. p. 1391-413.
3. Bloomgarden ZT, Karmally W, Metzger MJ, Brothers M, Nechemias C, Bookman J et al. Randomized, controlled trial of diabetic patient education: improved knowledge without improved metabolic status. *Diabetes Care*. 1987;10:263-72.
4. Boulton, AJ. The diabetic foot: epidemiology, risk factors and the status of care. *Diabetes Voice*. 2005;50:5-7.
5. Abbott CA, Vileikyte L, Williamson S, Carrington AL, Boulton AJ. Multicenter study of the incidence of and predictive risk factors for diabetic neuropathic foot ulceration. *Diabetes Care*. 1998;21:1071-5.
6. Calhoun JH, Cantrell J, Cobos J, Lacy J, Valdez RR, Hokanson J et al: Treatment of diabetic foot infections: Wagner classification, therapy and outcome. *Foot Ankle*. 1988;9:101-6.
7. Brodsky JW, The diabetic foot. In: Coughlin MJ, Mann RA, editors. *Surgery of the foot and ankle*. Eichenholtz classification; 7th ed. St Louis: Mosby; 1999. p 895-969.
8. Guyton GP, Saltzman CL. An Instructional Course Lecture, American academy of orthopaedic Surgeons. The diabetic foot. *J Bone Joint Surg Am*. 2001;83:1083-96.
9. Pinzur MS, Slovenkai MP, Trepman E. Guidelines for diabetic foot care. The 29. Diabetes Committee of the American Orthopaedic Foot and Ankle Society. *Foot Ankle Int*. 1999;20:695-702.
10. Coughlin MJ, Mann RA, Brodsky JW. *Surgery of the foot and ankle*. 8th. St Louis: Mosby; 2007.
11. Frykberg RG. Epidemiology of the diabetic foot: ulcerations and amputations. *Adv Wound Care*. 1999;12:139-41.
12. Laing P. Diabetic foot ulcers. *Am J Surg*. 1994;167:S31-6.
13. Boyko EJ, Ahroni JH, Stensel V, Forsberg RC, Davignon DR, Smith DG. A prospective study of risk factors for diabetic foot ulcer. The Seattle Diabetic Foot Study. *Diabetes Care*. 1999;22:1036-42.
14. Brower AC, Allman RM. Pathogenesis of the neurotrophic joint: neurotraumatic vs neurovascular. *Radiology*. 1981;139:349-54.
15. Smith DG, Boyko EJ, Ahroni JH, Stensel VL, Davignon DR, Pecoraro RE. Paradoxical transcutaneous oxygen response to cutaneous warming on the plantar foot surface: a caution for interpretation of plantar foot TcPO2 measurements. *Foot Ankle Int*. 1995;16:787-91.
16. Frykberg RG, Armstrong DG, Giurini J, Edwards A, Kravette M, Kravitz S, et al. Diabetic foot disorders. A clinical practice guideline. For the American College of Foot and Ankle Surgeons and the American College of Foot and Ankle Orthopedics and Medicine. *J Foot Ankle Surg*. 2000;(Suppl.):1-60.