

Treatment of Osteomyelitis in the Diabetic Foot

Contribution of conservative surgery

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OBJECTIVE — To compare the duration of healing of foot ulcers with osteomyelitis in diabetic patients treated by medical treatment versus medical treatment associated with conservative orthopedic surgery.

RESEARCH DESIGN AND METHODS — We entered into the study 67 diabetic patients who had a foot ulcer with osteomyelitis without ischemia requiring a peripheral arterial reconstruction. Thirty-two diabetic patients were included in a first historic group from 1986 to 1993, treated by antibiotic therapy, offloading, and wound care. Thirty-two patients were included from September 1993 to March 1995, treated by the same medical treatment and conservative orthopedic surgery.

RESULTS — The healing rate was 57% in the group treated by the medical treatment alone versus 78% in the surgical group ($P < 0.008$). The duration of healing was 462 ± 98 days versus 181 ± 30 days ($P < 0.008$).

CONCLUSIONS — Conservative surgery contributes to an increase in the healing rate of foot ulcers with osteomyelitis compared with a medical treatment alone.

In diabetic patients, delays in healing chronic foot wounds are often related to an underlying osteomyelitis. Other causes can lead to delays in healing chronic foot wounds, such as severe arteriopathy or the lack of proper offloading of a neuropathic wound.

The common mechanism is the loss of sensations due to pure diabetic neuropathy that leads to the formation of hyperkeratosis at pressure points. Repeated pressures lead to fissures and infections of this hyperkeratosis, causing a typical neuropathic ulcer that can evolve into infection of the underlying bone. The current treatment of osteomyelitis in diabetic foot usually relies on long-term antibiotic therapy (1–3). The evolution is often insidious, sometimes leading to amputations or large bone resections (4–6). Some authors have been rec-

ommending treatment with conservative surgery, consisting in bone removal limited to the infected tissues (7–14).

In this study, we analyzed the contribution of conservative surgery to the medical treatment alone. We wanted to know if surgery could significantly reduce the duration of healing and antibiotic therapy among diabetic patients with osteomyelitis limited to the foot. We excluded patients with ischemia requiring immediate peripheral arterial reconstruction.

RESEARCH DESIGN AND METHODS

Since 1986, 67 diabetic patients have been hospitalized in our department and then followed as outpatients by the same team (podiatrist, diabetologist, orthopedic surgeon, vascular surgeon, and nurse). All patients had a

plantar or toe wound with underlying osteomyelitis. The clinical diagnosis of osteomyelitis was made if the ulcer was probed to the bone when exploring the wound (15) and was confirmed by X-ray examination (bone lysis or simple cortical erosion). Patients with severe peripheral vascular disease (evaluated by clinic examination, arterial Doppler ultrasound, transcutaneous oxygen tension [$TcPO_2$], and if necessary arteriography) requiring immediate peripheral vascular bypass were not included in the study.

All patients received a medical treatment including offloading, wound care, and antibiotic therapy after swabbing the ulcer and then after culture results. Culture of anaerobes were not done but when there was a peripheral vascular disease, we used metronidazol or clavulanic acid. The same protocol of antibiotic therapy was initially applied in the 67 patients. The antibiotic therapy was begun after obtaining the cultures with a broad spectrum antibiotic then changed depending on the organisms, sensitivities, and good bone diffusion. We used oral antibiotic when there was no cellulitis or general signs of infection. We used parenteral antibiotic according to the existence of general signs or cellulitis.

The patients were divided in two historic groups. The first group included patients treated between 1986 and 1993 who received the medical treatment alone. The second group included patients treated between September 1993 and March 1995 who received a conservative surgical treatment in addition to the medical treatment. The conservative surgical treatment was defined as a limited resection of the infected part of the phalanx or the metatarsal bone under the wound, with no other resection, associated with a removal of the ulcer site. We started to perform this conservative surgical treatment in September 1993, and the procedure was always done by the same surgeon.

A χ^2 test was used for the comparison of the populations at inclusion and a Student's t test for the comparison of the means. The comparisons at inclusion were

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$TcPO_2$, transcutaneous oxygen tension.

Table 1—Characteristics of patients at inclusion

	Medical treatment alone	Conservative surgery with medical treatment	P
n	35	32	—
Age	60.3 ± 10	59.4 ± 10.4	>0.74 (NS)
Sex ratio (number of men)	25	29	0.047
NIDDM	26	23	>0.82 (NS)
Diabetes duration	15.6 ± 11.3	18.3 ± 11.6	>0.33 (NS)
HbA _{1c} (%)	7.6 ± 1.9	8.1 ± 1.6	>0.31 (NS)
Retinopathy	24	26	>0.23 (NS)
Renal insufficiency	13	9	>0.43 (NS)
Plasma creatinine (μmol/l)	131 ± 151	172 ± 249	>0.42 (NS)
Ischemic heart disease	6	8	>0.43 (NS)
History of previous foot lesion	22	23	>0.43 (NS)
Plantar wound	14	10	>0.46 (NS)
Toe wound	21	22	>0.46 (NS)
Neuropathy	31	29	>0.78 (NS)
Peripheral vascular disease	19	15	>0.54 (NS)

Data for age, diabetes duration, HbA_{1c}, and plasma creatinine are means ± SD. Peripheral vascular disease does not require immediate bypass.

the demographic data (age and sex), the characteristics of diabetes (insulin-dependent or not; duration; HbA_{1c} at the time of the diagnosis of osteomyelitis), the existence of complications of diabetes (retinopathy, renal insufficiency according to the rate of plasma creatinine, ischemic heart disease, neuropathy, peripheral vascular disease not immediately requiring any revascularization, history of previous foot wound), and the localization of the osteomyelitis (plantar surface or toe).

The primary endpoint was the duration of healing, calculated from the date of onset of the wound until the date of complete healing. Complete healing was defined by 100% epithelialization of the wound. Patients receiving the medical treatment and requiring secondary amputation were considered as failures of the medical treatment, the date of surgery being the date of exit from the study. Patients who received conservative surgery and who were not healed at the end of the study (31 March 1995) were considered as failures of this treatment. Patients who received the medical treatment alone and

who were not healed at the end of the study were considered as failures of the medical treatment. The nonhealing time was then reported. The comparison between the two groups was done using the log-rank test, adjusted for all statistically significant criteria found in the comparison of the two groups at inclusion.

The healing rate and the duration of the antibiotic therapy were also analyzed. We numbered the different levels of bone resection in groups of patients treated with conservative surgery. After a failure of the medical treatment or of the conservative surgery—if there was a secondary surgical

procedure—we numbered the different procedures in both groups. The number of secondary surgical procedures were compared with a χ^2 test.

RESULTS—Sixty-seven patients were included between 10 December 1986 and 31 March 1995. The sex ratio was 13 women (19%) to 54 men (81%). The mean age was 59.9 ± 10.1 years. Thirty-five patients received the medical treatment alone from 10 December 1986 to 1 September 1993, while 32 patients received the association of conservative surgery and medical treatment from 1 September 1993 to 31 March 1995. The characteristics of both groups at inclusion are given in Table 1.

The types of bone resections performed in the conservative surgical treatment are detailed in Table 2.

The rate and duration of healing (Fig. 1) adjusted by sex and the duration of the antibiotic therapy were significantly lower in patients who received conservative surgery along with medical treatment. Results are given in Table 3.

The number of secondary surgical procedures after failure of the initial treatment is significantly higher ($P = 0.004$) in the group treated with medical treatment alone (14/35) compared with the group treated with conservative surgery associated with medical treatment (3/32) (Table 4).

The analysis of the failures of conservative surgery associated with medical treatment shows that 1 patient among 32 required a distal bypass performed after 1 month for an ischemic necrosis in the bone-

Table 2—Conservative surgical treatment

Type of resection	n
Partial toe resection	20
Partial metatarsal resection	12
Total	32

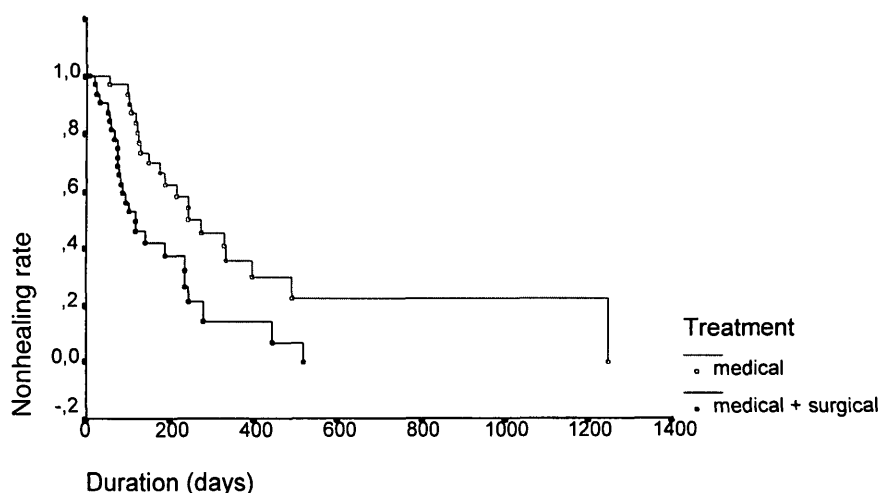


Figure 1—Nonhealing rate.

Table 3—Rates and duration of healing and duration of the antibiotic therapy

	Medical treatment alone	Conservative surgery associated with medical treatment	P
n	35	32	—
Healing rates	57 (20)	78 (25)	<0.008
Duration of healing (days)	462 ± 98	181 ± 30	<0.008
Duration of antibiotic therapy (days)	246.9 ± 232	111 ± 121	<0.007

Data are means ± SD, % (n), or n.

resection zone. His initial TcPO₂ was 30 mmHg. Two patients required a new resection of phalangeal bone because of recurrent osteomyelitis after conservative surgery. The analysis of the secondary surgical procedures after failure of the initial treatment in both groups is given in Table 4.

CONCLUSIONS — We compared two types of treatment in 67 diabetic patients with foot ulcer with osteomyelitis, without indication for peripheral arterial reconstruction. The first treatment was medical alone and the second treatment was the same medical treatment associated with an orthopedic conservative surgical treatment. The healing time was significantly shorter in the patients treated with conservative surgery along with the medical treatment compared with the patients who received the medical treatment alone. The duration of the antibiotic therapy was significantly shorter and the healing rate was significantly higher for the patients treated with conservative surgery along with the medical treatment. The higher number of failures in the group treated with medical treatment alone could be explained by the extension of the osteomyelitis or the development of a chronic osteomyelitis. It led to a secondary bone resection that likely was larger than would have been required had conservative surgery been performed from the start of the diagnosis of osteomyelitis.

Although both groups were historic and not randomized, there were no significant differences between both groups at inclusion for demographic parameters outside sex. This difference has been taken into account in the statistical analysis by adjustment for sex. The medical treatment, particularly the strategy of the antibiotic therapy, and the team, except the introduction of the orthopedic surgeon from September 1993, were the same during the entire study. We did not do a bone biopsy for culturing in both groups. The

antibiotic therapy was not changed after the bone resection in the group treated by conservative surgery.

Analysis of the failures of conservative surgery associated with the medical treatment showed we had in one case underestimated the level of vascular disease of the foot, despite having done a thorough clinical examination and an arterial Doppler ultrasound and TcPO₂ measurement. The TcPO₂ was 30 mmHg in this patient. This patient had a distal bypass which allowed the healing of the wound. It seems to be necessary to do a repeated measurement of the transcutaneous oxygen pressure in addition to clinical examination and arterial Doppler ultrasound. If the degree of ischemia is uncertain (when the TcPO₂ is ~30 mmHg), arteriography seemed to us to be the best investigation to avoid a failure of the orthopedic conservative surgery. The wound healing failure exposed a recurrence of the osteomyelitis or a secondary infection and necrosis in case of vascular insufficiency (16).

Our study showed the efficacy of the medical treatment was improved by the limited resection of the infected bone. It seemed to us unnecessary to perform larger bone resections. In performing a limited resection of the infected bone, the extension of the osteomyelitis was prevented and the risk of cellulitis as well. The poor penetration of antibiotics in infected bone tissues could explain their poor effi-

cacy in osteomyelitis. The development of a sequestrum, creating a nonvascularized zone, made it even more difficult for the antibiotics to penetrate. The resection of this bone, not easily reached by the antibiotics, could accelerate the healing. The conservative surgery allowed a decrease in the duration of the medical treatment (antibiotics and offloading). By shortening healing times, the duration of antibiotic therapy was shortened as well, so that the tolerance to antibiotics would be increased (the tolerance to long-term antibiotic therapy often being problematic), and the risk of emergence of resistant strains would be decreased. The risk of toxicity of antibiotics was decreased as well. The compliance of those patients treated with conservative surgery was also increased, since the healing time was shorter and as a consequence, the offloading period was shorter as well.

The bone saved with this conservative method allowed patients to maintain an optimal function of the foot. The partial preservation of a toe or a limited metatarsal head resection could prevent secondary deformities resulting from larger bone resections. The limited bone resection allowed us to keep a volume and an appearance of the foot almost as good as normal. The shoe fitting was normal. This nonmutilating surgery seemed to be psychologically acceptable.

Our study showed that the conservative surgery could be performed for the treatment of osteomyelitis of the diabetic foot with neuropathy and without severe peripheral vascular disease. The absence of recurrences of the osteomyelitis and of secondary static problems of the feet should be verified by a long-term follow-up of these patients, which would confirm the efficacy of this conservative surgery.

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Table 4—Analysis of secondary surgical procedures after failure of the initial treatment

	Medical treatment alone	Conservative surgery associated with medical treatment
n	35	32
Toe amputations	9	2
Transmetatarsal amputations	3	0
Below-knee amputations	2	0
Distal bypasses	0	1
Total of surgical procedures	14	3

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