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ORIGINAL ARTICLE

RECENT DEVELOPMENTS IN THE MANAGEMENT OF CRITICAL LIMB ISCHEMIA

The effect of a multidisciplinary outpatient team approach on outcomes in diabetic foot care: a single center study

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ABSTRACT

BACKGROUND: Recent studies showed no reduction in major amputation rates after introduction of a multidisciplinary team (MDT) approach for the treatment of diabetic foot ulcer. The efficacy of MDTs in the current standard of care is being questioned. This retrospective single-center study evaluated the efficacy of an outpatient MDT approach on limb salvage and ulcer healing in treating diabetic foot ulcers.

METHODS: Patients with a diabetic foot ulcer treated before (2015) and after (2017) implementation of an MDT in a single center were compared. The MDT met weekly and consisted of a vascular surgeon, physiatrist, internist, shoe technician, wound care nurse, nurse practitioner, cast technician, and podiatrist. The primary outcome was limb salvage at 1 year. Secondary outcomes were ulcer healing, amputation-free survival, freedom from any amputation, and overall survival. Multivariable Cox regression models were used to assess predictors for major amputation.

RESULTS: A vascular surgeon treated 104 patients with 148 ulcers in 2015, and the multidisciplinary team treated 133 patients with 188 ulcers in 2017. Limb salvage (90.9% *vs*. 95.5%, P=0.050), freedom from any amputation (56.5% *vs*. 78.0%, P<0.001), and ulcer healing (48.3% *vs*. 69.2%, P<0.001) were significantly lower in the non-MDT group than in the MDT group. Amputation-free survival and overall survival did not differ significantly between the groups. Predictors for major amputation were University of Texas Wound Classification 3D (hazard ratio, 2.8; 95% confidence interval, 1.17-6.45) and being treated in the non-MDT group (hazard ratio, 3.7; 95% confidence interval, 1.25-11.08).

CONCLUSIONS: This retrospective study found an MDT dedicated to diabetic foot care was highly effective in increasing limb salvage and ulcer healing. We advise that such an MDT is an integrated part of the patient's chain-based care.

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KEY WORDS: Diabetic foot; Ulcer; Limb salvage; Wound healing; Amputation; Peripheral arterial disease.

Amputation is the most feared consequence of diabetic foot ulcer and dramatically affects the patient's quality of life.[1, 2] Despite available high-quality care, 1 amputation every 7 minutes is attributable to diabetes.[3] The underlying cause of diabetic foot ulcer is multifactorial.[4] Therefore, in 1981, the concept of a multidisciplinary team (MDT) was formed to prevent amputation by treating diabetic foot ulcer in a multidisciplinary setting.[5] At that time, the effectiveness of the MDT approach became a topic of many studies, which reported significant decreases in amputation rates.[6-10] As a result, many guidelines recommended the MDT approach for the treatment of diabetic foot ulcer.[11, 12] In fact, the most recent National Institute of Health and Care Excellence (NICE)[12] and the International Working Group on the Diabetic Foot (IWGDF)[11, 13] guidelines still base their recommendations on the studies performed back then.

However, the question arises whether these recommendations are still applicable, because the quality of the studies was very low,[12] the studies also included

nondiabetic patients,[14] and because the dedicated MDTs mostly treated hospitalized patients.[7, 10, 15-17] Where the current focus is more on prevention and cost reduction, treating outpatients to prevent hospitalization is becoming increasingly important. Besides that, the studies were performed more than a decade ago, and current best medical treatment and revascularization treatments have significantly improved since then.[18, 19] In fact, recent studies[20, 21] showed no reduction in major amputation rates after the implementation of the MDT, although another recent study did report a significant reduction in major amputation rates.[22]

Therefore, uncertainty remains about the exact role of the MDT in the current standard diabetic foot care. This study evaluated the efficacy of an MDT approach in the current setting for the treatment of outpatients with a diabetic foot ulcer on limb salvage rates and ulcer healing.

Materials and methods

This study was conducted according to the principles of the Declaration of Helsinki and approved by the Institutional Board of Directors (study ID: L 018-063) of the Northwest Clinics, which waived the requirement for informed consent.

Patient selection

The study included all consecutive patients presenting with a new episode of a diabetic foot ulcer to the outpatient clinic at Northwest Clinics, Alkmaar, The Netherlands, between January and December 2015 and between January and December 2017. An MDT dedicated to diabetic foot care was started mid-2016 in our hospital. The initiative to start an MDT was to improve the quality of diabetic foot care and to make diabetic foot care more patient friendly by treating the patients by multiple specialists in 1 appointment. The study time intervals were selected a priori to ensure that all included patients were treated without (non-MDT group) or with an MDT approach (MDT group).

Patients were included if they were diagnosed with diabetes, had a new foot ulcer that had not been treated before, and visited the outpatient clinic for ulcer treatment in 2015 or 2017. Patients were excluded if the ulcer was caused after amputation, the patient was lost to follow-up, and an emergency amputation (amputation <24 hours) was necessary. Finally, 238 patients with 336 ulcers were retrospectively analyzed. These patients were grouped according to whether the patient was treated without (non-MDT group) or with (MDT group) the MDT.

Ulcer care in 2015

Patients included in 2015 were treated by a vascular surgeon and a wound care nurse in the Northwest Clinics wound clinic. Most patients were referred by the general practitioner (GP), and some were referred by the attending internist who treated the patient for diabetes.

Before the ulcer was examined, the vascular surgeon always checked for pulses of the dorsalis pedis and of the tibialis posterior artery. If absent, ankle-brachial indices (ABI) and toe pressure measurements were performed. Patients with Rutherford classes 3 to 6 and peripheral arterial disease (PAD; ABI<0.9) were planned for a computed tomography angiography (CTA) scan. The patient was discussed in a team with vascular surgeons and interventional radiologists to check whether the patient was eligible for revascularization and, if so, which procedure would be best.

Besides checking for presence of PAD, the vascular surgeon prescribed antibiotics in case of signs of infection (erythema, swelling, leukocytosis, increased C-reactive protein levels) of the ulcers. Antibiotics were mainly prescribed according to institutional protocol (clindamycin, 600 mg, 3 times daily orally) and sometimes prescribed according to the advice of the microbiologist in case wound culture results were present. The appropriate dressing materials were determined by the vascular surgeon in consultation with the wound care nurse.

Diabetes control was sometimes regulated by the internist but mainly regulated by the GP. When diabetes control was inadequate or the diabetes was not yet regulated by the internist, the vascular surgeon or GP referred the patient to the internist. For special foot and shoe care, the vascular surgeon referred the patient to the physiatrist. It could take 6 to 8 weeks for patients to be seen by the internist or physiatrist.

The decision to amputate was made by the vascular surgeon and mainly based on the severity of the ulcer, possible treatment options, and on the progression of ulcer healing so far.

Multidisciplinary team

Before the MDT was started, the GPs in the vicinity of the hospital were informed about the existence of the team and when a patient should be referred to the team (if the foot ulcer was a plantar or a nonplantar ulcer that was not healed within 2 weeks).

Every Thursday, special diabetic foot consultation hours from 9:00 AM until 12:00 PM were organized in the

outpatient clinic for patients with diabetic foot ulcer. Every member of the MDT was present during the consultation hours. The team consisted of a vascular surgeon, physiatrist, internist, shoe technician, wound care nurse, cast technician, nurse practitioner, and a podiatrist. Patients visiting the consultation hour were referred by their GP. Patient care by the team was according to the national guidelines.[23] In brief, the most important tasks and main responsibilities of the team included wound care, perfusion diagnostics and treatment, infection diagnostics and treatment, provided offloading, control of blood glucose levels, cardiovascular risk management, took care of appropriate footwear, performed foot surgery, provided education, and made an inventory of the level of functioning and of the daily activities that resulted in overloading of the feet.

Patients were examined in a treatment room. Before examination, the wound care nurse removed the dressings and cleaned the ulcer so that the specialists could properly assess the ulcer. Patients were examined by each team member in succession, with the vascular surgeon and physiatrist examining the patient first. The vascular surgeon or nurse practitioner examined the patient for the presence of PAD and determined whether CTA images should be made for potential revascularization. During subsequent appointments, the vascular surgeon checked whether revascularization was necessary based on clinical presentation, ABI status, toe pressure measurements and CTA images. Revascularization included percutaneous transluminal angioplasty or bypass (synthetic or autologous) or femoral endarterectomy in combination with percutaneous angioplasty or a bypass. The vascular surgeon also checked the size and depth of the ulcer each visit to monitor ulcer healing. Wound debridement was performed by the vascular surgeon when necessary. Ulcers that were very deep and extensive were debrided in the operating theater to ensure sterile conditions.

The physiatrist and shoe technician examined the foot for abnormalities (*e.g.*, flat foot, hammer toes, limited joint mobility), locations of abnormal pressure (*e.g.*, callus formation or redness of the skin), indications for peripheral neuropathy (Semmes Weinstein monofilament testing,[24] tuning fork), and provided adequate offloading shoes when necessary. The choice for the appropriate shoe was determined in agreement.

The internist obtained a deep wound culture, checked the wound culture results, prescribed antibiotics based on wound culture results, if present, gave advice to improve glucose regulation to the patient, the GP's diabetes nurse, or organized glucose regulation at the internal medicine outpatient clinic on a short notice, and took care of secondary prevention of cardiovascular risk factors.

The podiatrist saw the patient if there was callus to be removed and when preventive nail care was deemed necessary by the multidisciplinary team. The cast technician provided plaster when the multidisciplinary team deemed it was necessary.

The wound care nurse redressed the ulcer after every specialist had judged the ulcer. The dressing materials used and ulcer care policy were decided in agreement with the team members.

After patients were seen, the specialists discussed their findings and policy with each other to develop a cohesive plan in a multidisciplinary approach. The decision to amputate was mainly based on the severity of the ulcer, the progression of ulcer healing so far, and the revascularization options, and was made by the vascular surgeon in agreement with the team members.

If patients were hospitalized, all specialists remained involved in the treatment of the diabetic foot ulcer.

Data collection and definitions

Patient demographics, baseline risk factors, ABI and toe pressure measurements, and involvement and treatment recommendations given by all specialists were retrospectively collected. Data were derived from electronic medical records, clinical records, imaging reports, and laboratory reports.

Most patients were seen every week or once every 2 weeks to evaluate ulcer healing. Follow-up was continued until amputation, death, or if complete epithelialization had occurred. If ulcers were completely healed and a new ulcer emerged later at the same spot, the ulcer was analyzed as a new ulcer. If patients had multiple ulcers and died before amputation or ulcer healing occurred, the death was recorded once, and patients were censored for ulcer healing at the time of death. Time to ulcer healing in patients who underwent minor or major amputation was reported as infinite. In patients with more than 1 amputation, only the most proximal amputation level was analyzed.

The primary end point was the difference in the limb salvage rate between non-MDT- and MDT-treated patients within 1 year after the first presentation to the outpatient clinic. The secondary end points were amputation-free survival (AFS), freedom from any amputation, and the ulcer healing rate. Limb salvage was defined as avoidance of major amputation (above the ankle). AFS was defined as avoidance of major amputation or death. Freedom from

any amputation was defined as avoidance of a minor or major amputation. Ulcer healing was defined as complete epithelization of the ulcer without any amputation.

Statistical analysis

To determine whether continuous variables followed a normal distribution, the skewness was used. A skewness of less than -1 or more than 1 was defined as nonnormally distributed. Normally distributed continuous variables are expressed as mean±standard deviation and were compared using independent *t*-tests. Nonnormally distributed data are presented as median and the interquartile range (IQR) and were compared using the Mann-Whitney *U* test. Categorical variables are expressed as number (%) and were compared using the Fisher Exact test. Limb salvage rate, AFS, freedom from any amputation, and the ulcer healing rate were calculated by Kaplan-Meier analysis. The groups were compared using the log-rank test.

Backward stepwise Cox regression was used to identify the predictors of major amputation, with criterion for removal being P>0.10. The model included all recorded risk factors: University of Texas Wound Classification,[25] revascularization procedure, toe pressure <70 mmHg, (non-)MTD group, treated with antibiotics prescribed by the internist, current smoker, kidney disease (glomerular filtration rate <60 mL/min/1.73 m^2), and statin use. The results are noted as hazard ratios (HRs) with corresponding 95% confidence intervals (CIs). Statistical significance was defined as P=0.05. Statistical analysis was performed using SPSS 23 software (IBM, Armonk, NY, USA).

Results

Between 1 January 2015 and 31 December 2015, 104 patients with 148 ulcers were treated in the outpatient clinic by a vascular surgeon. Between 1 January 2017 and 31 December 2017, 133 patients with 188 ulcers were treated in the outpatient clinic by the MDT. Patient characteristics are summarized in Table I and were divided according to whether the patient was treated without (non-MDT group) or with the MDT (MDT group).

Toe pressure was significantly lower in the non-MDT group than in the MDT group (P=0.015). There were no other statistically significant differences in baseline characteristics between the non-MDT and MDT group.

In the non-MDT group, 68 ulcers (45.9%) healed and 65 ulcers (43.9%) required amputation. Eight patients, with all 1 ulcer, died before ulcer healing or amputation occurred. The causes of death were heart and renal failure in 1 patient, progressive ischemia in 1 patient who refused amputation, and unknown in 6 patients. Of these 6 patients, 5 died in a nursing home or at home, and 1 patient died in the hospital from an unknown cause and the family refused autopsy. In 7 patients, with all 1 ulcer, the ulcer did not heal but did not require amputation.

TABLE I.—*Baseline characteristics.*

	Non-MDT	MDT	P value
Patients	104	133	
Wounds	148	188	
Age, years	72.33±11.98	72.43±11.88	0.939
Male sex	99 (66.9)	138 (73.4)	0.228
Medical comorbidities			
Smoking history [a]	51 (39.5)	70 (40.5)	0.648
Current smoking [a]	32 (24.8)	40 (23.1)	1.000
Diabetes type 1	20 (13.5)	23 (12.2)	0.745
Neuropathy [a]	110 (82.1)	135 (84.9)	0.530
Baseline laboratory values			
GFR <60 mL/min/1.73 m^2	68 (46.6)	92 (49.2)	0.659
HbA_{1c}, mmol/mol	54 (44-64)	53 (45-65)	0.506
HbA_{1c}, %	7.1	7.0	
Baseline medications			
Statin	102 (68.9)	127 (67.6)	0.814
Anticoagulation	44 (29.7)	67 (35.6)	0.293
Insulin	94 (63.5)	118 (62.8)	0.910
Vascular status			
TP of affected limb, mmHg	77.87±36.39	92.94±41.81	0.015
UT wound classification			
1A	17 (11.5)	33 (17.6)	0.126
3D	35 (23.6)	31 (16.5)	0.128
Healed ulcers	68 (45.9)	124 (66.0)	<0.001
Total amputations	65 (43.9)	40 (21.3)	<0.001

Continuous data are presented as mean±SD or median (interquartile range) and were compared using the independent *t*-test. Categorical data are presented as number (%) and were compared using the Fisher Exact Test (exact sig. 2-sided). GFR: glomerular filtration rate; HbA_{1c}: hemoglobin A_{1c}; ABI: Ankle Brachial Index; TP: toe pressure; UT: University of Texas.
[a]Rates do not match because of missing values.

In the MDT group, 124 ulcers (66.0%) healed and 40 ulcers (21.3%) required amputation. Eleven patients, all with 1 ulcer, died before ulcer healing or amputation occurred. The causes of death were renal failure and cardiorespiratory diseases in 3 patients, unknown in 4 patients because they died at home or in the nursing home and 4 patients refused amputation and died of deep infection of the diabetic foot ulcer. In 13 patients, with 1 ulcer, the ulcer did not heal but did not require amputation.

Differences as a result of the MDT approach

Specialists such as the physiatrist and internist became more involved in the treatment of foot ulcers, resulting in antibiotic prescriptions to be more based on wound culture results (69% in the non-MDT group *vs*. 89% in the MDT

group, P<0.001), more attention to blood pressure regulation (1% in the non-MDT group *vs*. 13% in the MDT group, P<0.001), and more use of (semi)orthopedic shoes (4% in the non-MDT group *vs*. 27% in the MDT group, P<0.001). Because the internist and physiatrist were already involved, there was no delay between diagnosis and treatment when patients were treated by the MDT. Tables of most of the treatments provided by the internist, vascular surgeon, and physiatrist are presented in the Supplementary Digital Material 1 (Supplementary Table I-III).

Outcome measures

The limb salvage rate in the non-MDT group was significantly lower than in the MDT group after 1 year (90.9% *vs*. 95.5%, P=0.05). A statistically significant increase in freedom from any amputation (minor and major) was seen in the MDT group (56.5% *vs*. 78.0%, P<0.001). The rate of ulcer healing was significantly higher in the MDT group (69.2%) than in the non-MDT group (48.3%, P<0.001). The median time to ulcer healing was 103 days (IQR, 57-182 days) in the non-MDT group and 57 days (IQR, 35-113 days) in the MDT group (P=0.001). There were no significant differences in the AFS rate between the non-MDT and MDT group (84.5% *vs*. 88.8% respectively, P=0.166) and overall survival rate (88.6% *vs*. 90.2% respectively, P=0.701).

Kaplan-Meier analyses of limb salvage, freedom from any amputation, AFS, overall survival, and ulcer healing are shown in Figure 1, 2, 3, 4, 5, respectively.

Backward elimination Cox regression analysis showed

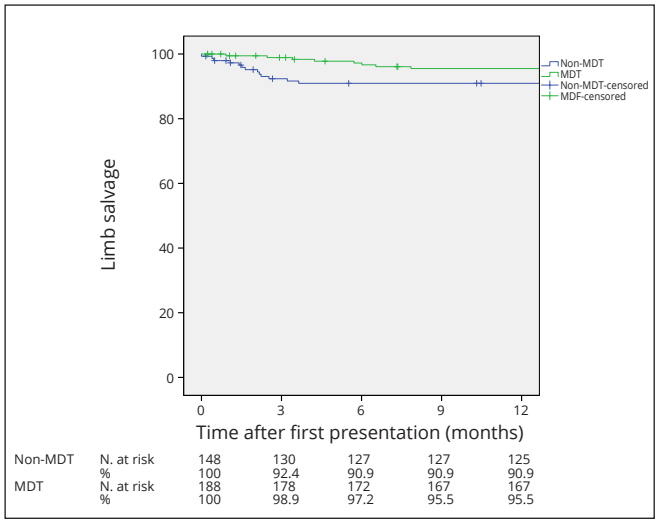

Figure 1.—Limb salvage rate.

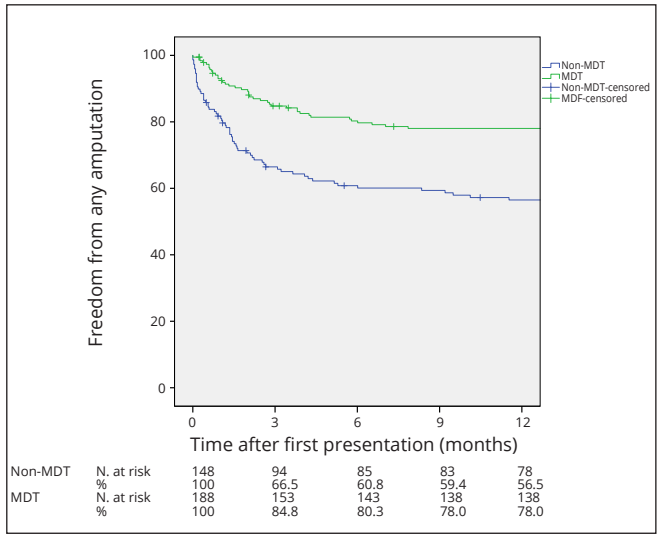

Figure 2.—Freedom from any amputation.

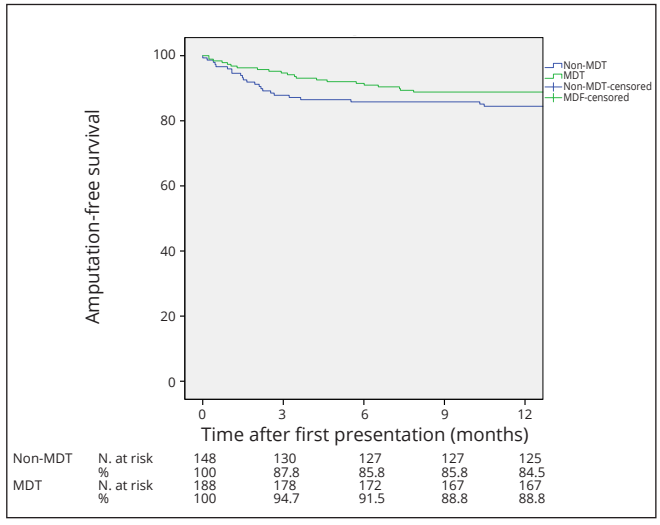

Figure 3.—Amputation-free survival.

University of Texas Wound Classification 3D (HR, 2.8; P=0.020) and treatment in the non-MDT group (HR, 3.7; P=0.018) were the only statistically significant predictors for major amputation (Table II).

Discussion

Treatment of diabetic foot ulcer by a multidisciplinary team is recommended worldwide.[26, 27] However, these recommendations were based on low-quality studies[7, 10, 12, 14, 15, 28] that were performed many years ago. With

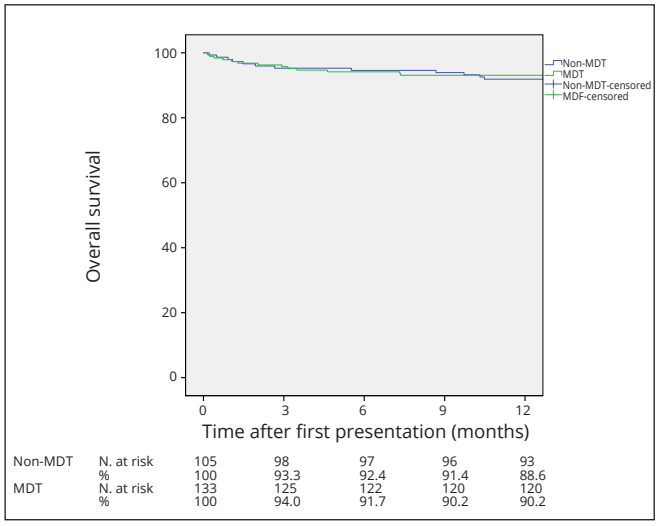

Figure 4.—Overall survival.

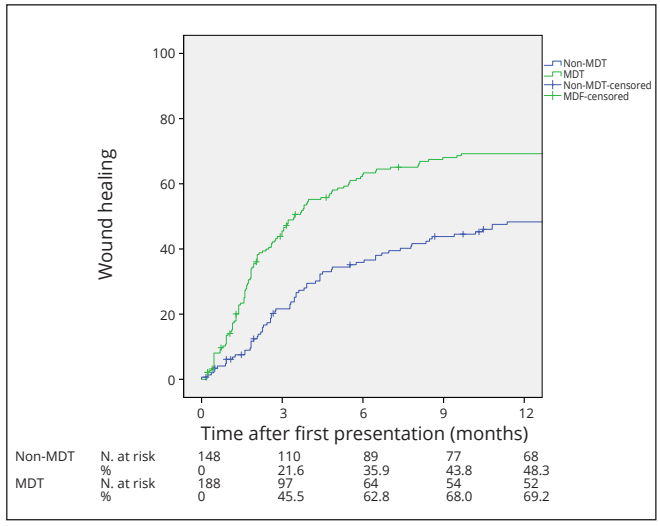

Figure 5.—Ulcer healing.

TABLE II.—*Backward elimination Cox regression analysis for predictors of major amputation.*

Major amputation	HR	95% CI	P value
UT wound classification 3D	2.751	1.17-6.45	0.02
Non-MDT group	3.724	1.25-11.08	0.018

HR: Hazard ratio; CI: confidence interval; UT: University of Texas.

the developments in health care and the conflicting results reported by recent studies,[20-22] the efficacy of the MDT in the current setting became unclear.

The concept of the MDT was started in 1981[5] and was a topic of many studies thereafter. One of the much-debated topics was and still is the composition of the MDT.[29-31] Even the NICE guidelines[12] and IWGDF guidelines[11, 13] differ in their recommendations about the composition of the MDT. One of the reasons for this difference could because no studies were performed that compared the efficacy of the MDT with different team members. It is therefore not clear which composition works best and whether a specialist has added value to the team or not. In addition, not all required specialists are available in every hospital.[29]

The MDTs described in the many studies that have been published on this approach differ in composition, and comparing these studies could possibly answer this question; however, comparing the results of these studies is difficult because of the difference in patient populations. Some MDTs treat inpatients[7, 21, 32-37] and others treat outpatients.[8, 20, 22, 28, 38, 39] Some studies also included nondiabetic patients[8, 9, 14, 39] or neuropathic ulcers only.[28] Therefore, no conclusion can be made about which MDT works best and which specialists have to be involved.

In addition, specifically appointing a specialist who must be a member of the MDT is difficult because the work performed by specialists differs around the world. For example, endovascular procedures can be performed by interventional cardiologists,[40] vascular surgeons,[41] or interventional radiologists,[40] and foot surgery can be performed by an orthopedic surgeon,[21, 42] podiatrist,[39] general surgeon, or vascular surgeon.[43] To overcome this problem, the NICE guidelines[12] recommended specialists with skills in specific areas of diabetology, podiatry, diabetes specialist nursing, vascular surgery, microbiology, orthopedic surgery, biomechanics and orthoses, interventional radiology, casting, and wound care. The IWGDF guidelines[11, 44] recommend the same specialists, except do not recommend a specialist with skills on interventional radiology, casting, and wound care. Thus, the MDTs around the world can consist of different specialists, but all with skills in the same area.

It is certain that the MDT members should have the knowledge and skills in treating diabetes, infection, PAD, abnormal foot pressure, and foot deformities. Each clinic should decide which specialists would be best to take care of these problems in their clinic. Another solution could be that the recommended MDT members will be reported in the national guidelines that are representative for the situation in a particular country.

In the present study, the team members met the recommendation of the NICE guidelines, except for the diabetes specialist nurse and interventional radiologist. However, patients attending the outpatient foot clinic with Ruther-

ford classes 3-6 and PAD disease were evaluated in a team with vascular surgeons and interventional radiologists to discuss whether the patient was eligible for revascularization and which procedure would be best for the patient. Besides that, no recommendations are made in the NICE guidelines regarding the role of the GPs. In this study, GPs were educated before the MDT started in 2017 about when a patient with a diabetic foot ulcer should be referred to the MDT and, therefore, the GP's might have been more educated and focused on ulcer patients than before the introduction of the MDT. This could have contributed to the higher wound healing and freedom from any amputation rates of the patients treated by the MDT.

The efficacy of the MDT has been evaluated in many studies over the years. However, the applicability of these studies in the current setting is being questioned, mainly because of the change and improvements in standard care. In 1986, Edmonds *et al.* described that 10 ulcers healed by in-hospital bed rest.[6] In the current setting, a patient will not be hospitalized for offloading. Instead, appropriate footwear or plaster can be applied for offloading.[42]

In addition, the revascularization strategies in the past were limited.[45] The 2005 the American College of Cardiology (ACC) and American Heart Association (AHA) guidelines recommended that critical limb ischemia patients with necrosis of weightbearing portions of the foot or refractory ischemic rest pain should be evaluated for primary amputation.[46] These recommendations were omitted in the 2011 ACC/AHA guidelines, and new recommendations were added.[47] The decision to perform endovascular or surgical revascularization was determined by the life expectancy. If a critical limb ischemia patient had a life expectancy of less than 2 years in whom an autogenous vein conduit was not available, PTA would be a reasonable option to perform as the initial procedure. For CLI patients with a life expectancy more than 2 years, bypass was recommended as the initial therapy.[47]

In the 2016 ACC/AHA guidelines, new recommendations were added about the angiosome concept, evaluation of lesion characteristics, and that an inline flow to the foot should be created.[48] The recommendation of type and use of medical treatment by the ACC/AHA has also changed over the years. Because of all these changes and improvements, the results of the MDT studies that have been performed in the past are no longer applicable to the current standard care.

To truly evaluate the efficacy of the MDT in current practice, patients visiting the clinic for standard wound care should be compared with patients visiting the clinic with a modern MDT. Nine studies[20, 21, 33-36, 38, 42, 49] have been published since 2009 that evaluated the efficacy of the MDT this way and included patients with diabetes only. A summary of the studies is listed in Table III.[20, 21, 33-36, 38, 42, 49] Interestingly, seven[20, 21, 34-36, 38, 42] of the nine studies are of poor quality according to the Methodological Index for Non-Randomized Studies (MINORS) Score.[50] This is because studies did not report inclusion or exclusion criteria[20, 34] or the method of statistical analysis performed,[20] or because studies did not include similar groups or did not report baseline characteristics of the groups.[34, 35, 42] Most studies were retrospectively analyzed. Only 1 study was prospective with contemporary groups and the only study to report loss to follow-up.[49] In that study, the patients treated by the MDT were compared with patients treated by regular care in another hospital. The percentage of major amputations of patients treated by an MDT was statistically significantly lower than in the non-MDT group (4.7% *vs*. 21.7%, P<0.001).

The study periods in 2 studies, by Bailie *et al.*[20] and by Plusch *et al.*,[38] were recent (2012-2016), and the results of the MDT-treated outpatients are comparable with the present study. The study by Plusch *et al.* found no statistically significant difference in the percentage of total minor and major amputations between patients who were treated with and without an MDT.[38] This could be explained by the fact that there were more severe ulcers in the MDT group because of a no-wait policy of urgency referrals. In this way, the more severe ulcers were over-represented in the MDT group. In the study by Bailie *et al.*, the percentage of major amputation was increased to 8% when patients were treated by the MDT.[20] An explanation for the increase is that the wounds were more severe, and 80% of the major amputations occurred because the patients were in such a severe state that treatment by the MDT was limited.[20] The other recent study, by Kim *et al.*, also reported an increase in major amputation rates after treatment by the MDT.[21] The explanation for this increase was also because of the more severe ulcers in the MDT group.[21]

It is interesting that the most recent studies about this subject all report no decrease in major or total amputations after the implementation of the MDT. All studies explained that this was due to the more severe ulcers that patients were presenting with. Compared with the present study, the severity of the presented ulcers decreased (P=0.128) after implementation of the MDT. This could be explained by the fact that the GPs were informed about the MDT and when to refer a patient to the team. This procedure was not described by the other recent studies and

TABLE III.—*Published studies since 2009 comparing the percentage of major amputations after treatment with and without the MDT.*

Studies	Study period		Patient treatment		MDT members	In-/outpatients	MA MDT (%)	MINORS Score
	SC	MDT	SC (n)	MDT (n)				
Alexandrescu *et al.* (2009)[42]	2001-2005	2005-2008	86	97	Diabetologist, vascular surgeon, orthopedic surgeon, podiatrist, radiologist, plastic surgeon, psychologists, infection specialist, nurses, orthotics, general practitioner	Not reported	10.3	14
Aydin *et al.* (2010)[34]	1992-1996	2002-2007	147	74	Not reported	Inpatient	14.9	12
Bailie *et al.* (2017)[20]	2014-2015	2015-2016	NR	NR	Vascular surgeon, orthopedic surgeon, plastic surgeon, diabetes and endocrinology physicians, interventional radiologists, microbiologists, podiatrists, surgical appliance team, vascular scientists, diabetes specialist nurses	Outpatient	19.0	11
Cahn *et al.* (2014)[36]	2010-2010	2011-2011	93	101	Orthopedic surgeon, endocrinologist, nurse	Inpatient	19.0	15
Kim *et al.* (2018)[21]	2002-2011	2012-2015	229	109	Endocrinologist, podiatric surgeon, vascular interventionalist	Inpatient	14.7	15
Nather *et al.* (2010)[35]	2002-2003	2003-2007	61	878	Endocrinologist, orthopedic surgeon, infectious diseases, vascular surgeon, podiatrist, wound care nurse, foot care nurse, foot screening nurse, case manager	Inpatient	19.6	13
Plush *et al.* (2015)[38]	2012-2013	2012-2013	116	40	NR	Outpatient	20.0	15
Weck *et al.* (2013)[49]	2000-2007	2000-2007	560	684	NR	Both	4.7	18
Yesil *et al.* (2009)[33]	1999-2002	2002-2008	137	437	Endocrinologist, orthopedist, plastic and vascular surgeons, infectious diseases, rehabilitation specialist, radiologist, diabetes nurse, wound care nurse, footwear technician	Inpatient	12.6	17
Present study	2015-2015	2017-2017	148	188	Internist, vascular surgeon, physiatrist, shoe technician, podiatrist, wound care nurse, nurse practitioner, cast technician	Outpatient	4.3	18

SC: standard care; MDT: multidisciplinary team; MA: major amputation; MINORS: Methodological Index for Non-Randomized Studies; NR: not reported.

emphasizes the importance of treating ulcers in an early stage and incorporating all care givers in the chain-base care for these ulcer patients.

The current study demonstrated the added value of the MDT in treating outpatients with diabetes in a currently considered standard of care setting, and limb salvage rates were higher when patients were treated by the MDT. The increase in limb salvage rates and ulcer healing rates of patients who were treated by the MDT could be explained by the chain-based care and by differences that the MDT created: the education of GPs, antibiotics prescribed by the internist based on wound culture results, attention to blood pressure regulation, and the use of (semi)orthopedic shoes by patients. In addition, because all specialists were present at the same time, there was no unnecessary delay in diagnosis or treatment.

Because the vascular surgeon was present in the treatment of patients with and without the MDT and used the same treatment protocols in both periods, the influence of the vascular surgeon on the outcome could not be analyzed. However, the influence of the vascular surgeon should not be undervalued. A previous study described an increased risk for major amputation in nonrevascularized patients.[39] In addition, a systematic review demonstrated improved limb salvage rates in patients with a diabetic foot ulcer undergoing revascularization compared with the results of medically treated patients.[51] Multiple studies also showed improved ulcer healing rates in revascularized ulcers.[52-54] Evidently, revascularization is essential for increasing limb salvage and ulcer healing rates. Not only the internist and physiatrist but also the vascular surgeon are indispensable as members of the MDT.

Limitations of the study

This study has several limitations. First, because of the retrospective nature of the study, selection bias cannot be ruled out, and the influence of unknown confounders is hard to estimate. Second, the toe pressures in the 2017 group were better than in the 2015 group, which could have biased the results. However, toe pressure was not found to be a predictor of major amputation, and therefore, the influence of the difference in toe pressure between the groups on the results is limited. Third, the duration of follow-up is limited to 1 year because the team was introduced in mid-2016.

Conclusions

In this retrospective study a multidisciplinary team dedicated to diabetic foot care was highly effective in increasing limb salvage and ulcer healing. We advise that such an MDT is an integrated part of the patient's chain-based care.

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