Wound healing outcomes in a diabetic foot ulcer outpatient clinic at an acute care hospital: a retrospective study

Objective: Patients with diabetic foot ulcers (DFU) have an increased risk of lower extremity amputation. A retrospective chart review of patients with DFUs attending the Foot Treatment and Assessment chiropodist-led outpatient clinic at an inner-city academic hospital was conducted to determine wound healing outcomes and characteristics contributing to outcomes.

Method: We reviewed the complete clinical history of 279 patients with 332 DFUs spanning over a five-year period.

Results: The mean age of patients was 61.5±12.5 years and most patients (83.5%) had one DFU. The majority of wounds (82.5%) were in the forefoot. Overall, 267/332 (80.5%) wounds healed. A greater proportion of wounds healed in the forefoot (82.5%) and midfoot (87.1%) than hindfoot (51.9%; p<0.001). Using a logistic regression model, palpable pedal pulse and use of a total contact cast were associated with better wound healing.

Conclusion: Our findings are the first to demonstrate the benefits of chiropodists leading an acute care outpatient clinic in the management of DFUs in Canada and delivers wound healing outcomes equivalent to or exceeding those previously published.

Declaration of interest: No conflicts of interest to declare.

chiropodist • diabetic foot ulcers • offloading • palpable pulse • wound healing • wound location

More than two million Canadians have diabetes, and that number is projected to grow to 3.7 million by 2019.[1] Diabetes is reaching epidemic proportions, with a concomitant increase in complications associated with the disease, such as diabetic foot ulcers (DFUs) and lower extremity amputations. An estimated 15% of people with diabetes will develop a DFU in their lifetime, and it is a common cause of hospital admission.[2] People with diabetes have an increased risk (x15) of lower extremity amputation.[3] However, up to 80% of major and 70% of minor amputations can be prevented by screening and appropriate management.[4] The treatment of DFUs is complex due to the multifactorial nature of their aetiology. Thus, the assessment and management of DFUs require careful and timely orchestration of clinical triage, local wound care factors, appropriate offloading of the ulcer area, and consideration of various patient factors. A team approach for acute management is purported to prevent the rapid progression to lower extremity amputations.[5]

There is limited data on the impact of chiropodists with advanced training in wound care leading outpatient clinics on the healing of DFUs in Canada. The Foot Treatment and Assessment (FTA) clinic is an outpatient clinic that operates one day a week at an acute care, inner-city, academic hospital. Chiropodists lead and manage the clinic, where the majority of patients present with DFUs without active systemic advancing infection or critical limb ischaemia. Wound severity ranges from superficial non-infected wounds to wounds with infection and ischaemia that probe to bone, University of Texas Classification Grade 3D.[6] Ischaemia was suspected when one or more pedal pulses were absent coupled with other clinical signs and symptoms. These patients were then referred for further vascular arterial studies (i.e., lower extremity arterial duplex scan, ankle-brachial index, and toe brachial index). Patients are referred to the clinic from staff physicians (i.e., family practice, general internal medicine, plastic surgery, orthopaedic surgery, vascular surgery, endocrinology, nephrology, rheumatology, and infectious diseases), and community clinics that form an immediate extension of the multidisciplinary team (MDT). The chiropodists take responsibility for management of the patient with the extended MDT. Following assessment by the chiropodists, a short-term plan is discussed and initiated with the patient and their caregivers. The plan focuses on the aetiology of the wound, ability of the wound to heal, identification of infection and/or ischaemia, off-loading, weight-bearing activity, debridement, local wound care, the patient's primary outcome goal, and overall health management. Further consultation through direct communication with the patient's care team formalises an individualised management plan to address any further health, social issues, or complications.

The objective of this study was to determine wound healing outcomes, as well as to analyse the patient and wound characteristics that contributed to healing of

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Fig 1. Examples of pressure offloading devices used: total contact cast (**a**), custom device (**b**), removable cast walker (**c**), shoe (**d**), healing sandal (**e**), and non-weight bearing (**f**)

Table 1. Demographics for patients who visited the foot treatment and assessment clinic (n=279)

Patient Characteristic	n (%)
Male	194 (69.5%)
Female	85 (30.5%)
Age (years)*	61.5±12.5
HbA1c (%)† (n=226)	7.9±2.7
Duration of diabetes mellitus (years)† (n=243)	16.0±14.0
Saw a foot specialist before clinic visit	114 (40.9%)
Palpable pedal pulses (n=275)	219 (79.6%)
Past or current smoking (n=249)	115 (46.2%)
Previous foot ulceration	229 (82.1%)
Previous lower extremity or foot amputation	79 (28.3%)
Patients with 1 wound only	233 (83.5%)
Patients with 2 wounds	41 (14.7%)
Patients with 3 or more wounds	5 (1.8%)
Total number of wounds	332
Location of wound (n=332)	
Forefoot	274 (82.5%)
Midfoot	31 (9.3%)
Hindfoot	27 (8.1%)
Wound duration at initial clinic visit (weeks)†	4±14.0
Wound area at initial clinic visit (cm^2)†	0.6±2.1

*mean±standard deviation; †median±interquartile range

patients with DFUs who attended the chiropody-led outpatient FTA clinic.

Patients and methods

A retrospective chart review of patients with DFUs who attended the FTA clinic at a large, inner-city, tertiary care, academic hospital between January 2008 and January 2013 was conducted. Patients ≥18 years old with diabetes and the presence of a DFU were included in the study. A diagnosis of diabetes mellitus was explicitly stated in the patient's chart to confirm inclusion in the study. Patients <18 years old and patients without a DFU were excluded. Research Ethics Board approval was obtained before the start of this retrospective chart review.

Demographic data, including both patient characteristics and DFU wound characteristics, were collected from patient charts. Patient characteristics included age, gender, smoking status, presence or absence of pedal pulses, most recent haemoglobin A1c (HbA1c) level, duration of diabetes, any previous DFUs, and any previous foot or toe amputations. Wound characteristics included wound size, location of wound, duration of the wound at the initial clinic visit, and type of pressure offloading device used (see Table 1and Fig 1). Pressure offloading devices were categorised into total contact cast (TCC), removable cast walker (RCW), healing sandal (HS), custom device (CD), shoe, and non-weight-bearing. The referral source, whether or not the patient had seen a foot specialist before the initial clinic visit, and the time to heal the wound were also documented. A healed wound was defined as complete wound closure, observed clinically as skin re-epithelialisation.

Statistics

Statistical analyses employed included Student t-tests for continuous variables, Wilcoxon signed-rank tests for non-parametric continuous variables, and Fisher's exact tests and Chi-squared tests for dichotomous variables. A $p \leq 0.05$ was considered statistically significant. Continuous variables are reported as means and standard deviations (SD) and non-parametric continuous variables are reported as medians with interquartile ranges (IQR). A logistic regression model was built using variables that were found to be

Table 2. Wound healing outcomes

Outcome	Healed n (%)	p-value
Patients with healed wounds	227/279 (81.4%)	
Patients with no healed wounds	52/279 (18.6%)	
Patients with 1 wound only that healed	186/233 (79.8%)	
Patients with 2 wounds and both healed	30/41 (73.2%)	
Patients with 3 or more wounds that all healed	4/5 (80%)	
Gender		0.78
Male patients with 1 or more wounds that healed	157/194 (80.9%)	
Female patients with 1 or more wounds that healed	70/85 (82.4%)	
Location of wound		<0.001
Forefoot wounds healed	226/274 (82.5%)	
Midfoot wounds healed	27/31 (87.1%)	
Hindfoot wounds healed	14/27 (51.9%)	

Table 3. Patient and wound characteristics in healing outcomes

Characteristic	Healed one or more wounds (n=227)	No wounds healed (n=52)	p-value
Age (years), mean±standard deviation	61.1±12.5	63.1±12.3	0.29
HbA1c, %, Interquartile range (IQR)	8.0%, 2.8 (n=181)	7.7%, 2.3 (n=45)	0.39
Duration of diabetes mellitus (years), median, IQR	16.0, 14.0 (n=196)	20.0, 14.0 (n=47)	0.28
Saw a foot specialist before clinic visit, n (%)	95/227 (41.9%)	19/52 (36.5%)	0.48
Palpable pedal pulses	190/224 (84.8%)	29/51 (56.9%)	<0.001
Past or current smoking	93/203 (45.8%)	22/46 (47.8%)	0.81
Previous foot ulceration	183/227 (80.6%)	46/52 (88.5%)	0.18
Previous lower extremity or foot amputation	65/227 (28.6%)	14/52 (26.9%)	0.81
Wound duration at initial clinic visit (weeks), median, IQR	4.0, 11.0	6.0, 18.0	0.53
Wound area at initial clinic visit (cm^2), median, IQR	0.6, 3.8	0.6, 1.8	0.29
Lost to follow-up	0/227 (0%)	19/52 (36.5%)	1.80

statistically significant. A Kaplan-Meier survival analysis was performed to determine the time to heal.

Results

A total of 567 patients visited the FTA clinic between January 2008 and January 2013, of which 279 patients with 332 wounds were included in this study (Table 1). This study excluded 267 patients that did not have wounds, 12 patients <18 years old and nine patient charts were missing. Mean age was 61.5±12.5 years, and 69.5% of patients were male. The majority of patients (83.5%) had only one wound. Most wounds (82.5%) were in the forefoot, the majority of patients (82.1%) had previously experienced a DFU and more than one-quarter (28.3%) had previously undergone a lower extremity or foot amputation. There were 19 patients with a total of 24 wounds (7.2%) who did not return to clinic after their initial visit; for analysis purposes, these wounds were considered to be not healed.

The majority of patients (227/279) had healed wounds at the end of this study. Wound healing outcomes are summarised in Table 2. A total of 65 wounds (19.6%) had not healed at the end of the study period. There were 20 (6.0%) non-healed wounds, in 20 patients, that required amputation of the foot or lower extremity, and seven patients (2.5%) with 7 non-healed wounds died during the study period. The remaining 14 wounds (4.2%) were still undergoing treatment at the study cut-off date. With respect to healed wounds, a significantly greater proportion of wounds healed in the forefoot (82.5%) and midfoot (87.1%) compared with the hindfoot (51.9%; p<0.001).

Table 4. Offloading devices (total n=329) and wound healing outcomes

Type of offloading device	n	Healed n (%)
Custom device, includes custom-made orthotics and footwear	28	24 (85.7%)
Healing sandal, includes open-toe shoes, wound-healing shoes, postsurgical shoes	53	35 (66.0%)
Non-weight bearing, includes wheelchairs, bed rest, non-ambulation	23	17 (73.9%)
Removable cast walkers	141	115 (81.6%)
Shoe, includes regular non-customised footwear and running shoes	30	25 (83.3%)
Total contact cast	54	50 (92.6%)

Palpable pedal pulse was also the only characteristic that differed significantly (p<0.001), where 84.8% of patients with at least one healed wound had a palpable pedal pulse, compared with only 56.9% of patients who had no healed wounds (Table 3).

Offloading DFUs was an integral part of the treatment plan. A total of 329 offloading devices were used in 279 patients (Fig 1). Overall, the most commonly used device was a removable cast walker, in 141 patients (Table 4). The proportion of

Table 5. Association between location of wound, recommended offloading device and wound healing

Wound location	Type of recommended offloading device n (%)						Healed wounds (%)
	Custom device	Healing sandal	Non-weight bearing	Removable cast walker	Shoe	Total contact cast	
Hindfoot	5 (18.5)	7 (25.9)	5 (18.5)	4 (14.8)	4 (14.8)	2 (7.4)	51.9
Midfoot	0 (0)	3 (9.7)	9 (29.0)	7 (22.6)	3 (9.7)	10 (32.3)	87.1
Forefoot	23 (8.5)	43 (15.9)	9 (3.3)	130 (48.0)	24 (8.9)	42 (15.5)	82.5

Fig 2. Association between recommended offloading device and location of wound

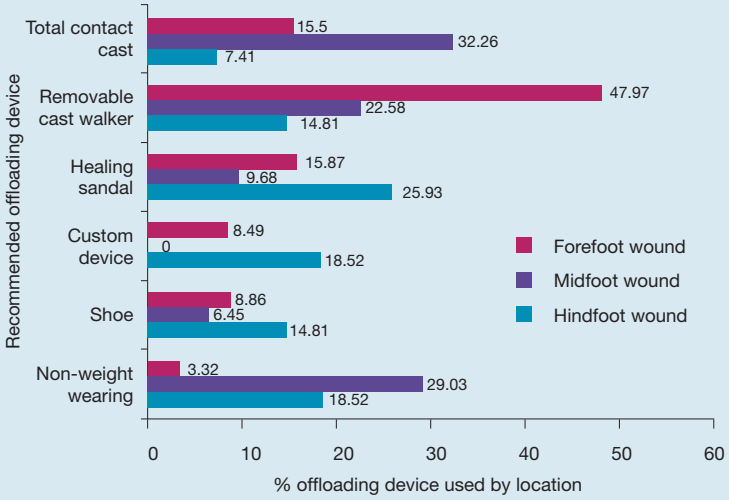
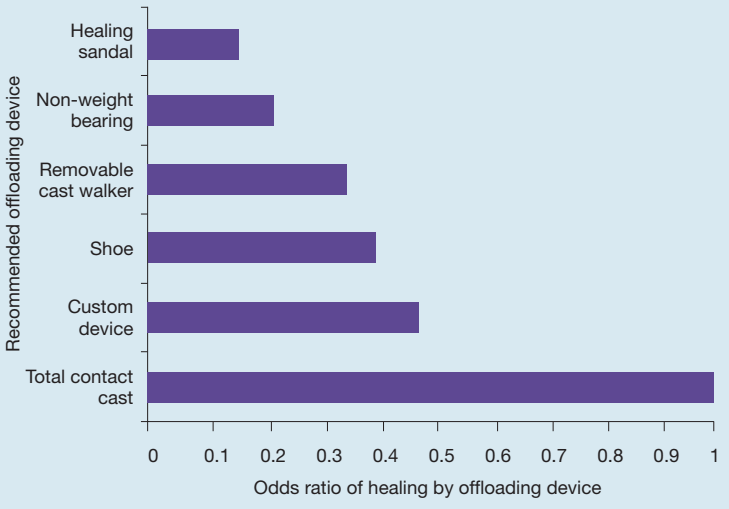


Fig 3. Odds ratio of healing by offloading device, using the total contact cast as the gold standard



successfully healed wounds ranged from 66% for healing sandals to 93% for total contact casts (Table 4). The most commonly used device for forefoot wounds was a removable cast walker (48%), for midfoot wounds was a total contact cast (32%) or non-weight bearing (29%), and for hindfoot wounds was a healing sandal (26%) (Fig 2).

The association between the wound location, the recommended offloading device and wound healing was analysed (Table 5). Patients wearing a total contact cast were most likely to heal their wound (Fig 3). Using a logistic regression model and assigning the proportion of healing in a total contact cast a value of 1.0, the proportion of healing was significantly less with a healing sandal (0.156, p=0.0018) or non-weight-bearing (0.227, p=0.035). Patients wearing a total contact cast also significantly healed foot wounds when compared to a removable cast walker (0.338, p=0.039). The time to wound healing for the different offloading devices was determined with a Kaplan-Meier survival analysis (Fig 4). The median time to wound healing was 13.4 weeks for a custom device and ranged from 11.4 weeks for a total contact cast to 67.9 weeks for non-weight bearing

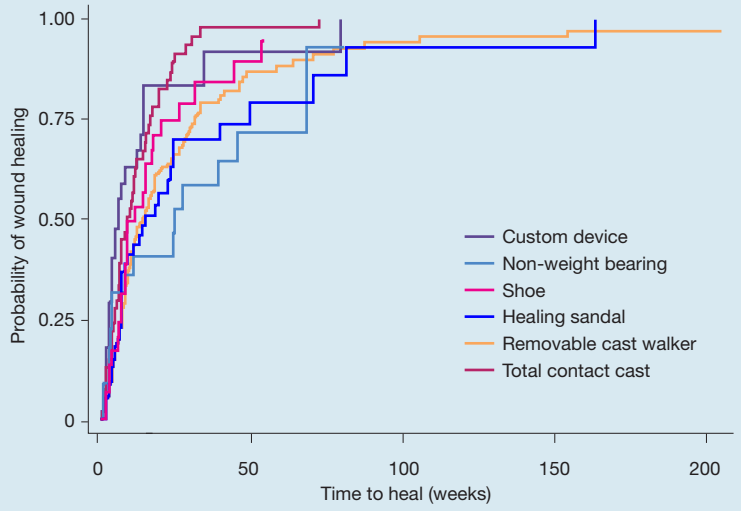
Discussion

When high-risk foot issues are detected, there is a scarcity of MDTs that include chiropodists with advanced wound training to coordinate and manage people with DFUs. Once a limb-threatening complication is identified by a chiropodist in clinic, a team approach for acute management will be rapidly enabled to mitigate the risk of lower extremity amputation.

In our retrospective review of 332 wounds in 279 patients treated at a large, inner-city, hospital-based clinic over a five-year period, 81% of DFUs without active systemic advancing infection or critical limb ischaemia were successfully healed to wound closure. The 81% rate of complete wound closure of DFUs in our study compares well with other studies.[7–10] In an analysis of 1088 patients with DFUs treated at 14 diabetic foot centres across Europe, up to 79.8% of ulcers had healed after one year.[7] In 449 patients with DFUs treated at a specialist multidisciplinary foot clinic, 68.3% of all ulcers healed within one year.[8] Ogrin et al. recently reported 69% of 83 patients with DFUs receiving care from an interprofessional diabetes foot ulcer team healed in an average of 7.35 weeks.[9] Taylor et al. reported 80% of 917 neuropathic or neuroischaemic DFUs treated at a hospital vascular surgery service were healed or functionally healed (i.e., did not require further follow-up), with a mean time to healing of 29–33 weeks.[10]

At our FTA clinic, most patients presented with DFUs without active systemic advancing infection or critical

Fig 4. Kaplan-Meier survival curve for time to wound healing (i.e., complete wound closure), stratified by offloading device



limb ischaemia and wound severity ranged from superficial non-infected wounds to University of Texas Classification Grade 3D, i.e., wounds with infection and ischaemia that probe to bone.[6] For continuity of care, these DFUs were managed by the chiropodist in close collaboration with the MDT members outside the FTA clinic.

Our clinic was able to achieve an 81% healing rate in even the most difficult to heal foot wounds due to several significant findings. The presence of palpable pedal pulses, location of wound, and the usage of recommended offloading devices were associated with a greater likelihood of wound healing in our study. Our findings compare well with other previously mentioned studies; however, the specific role of the chiropodist/podiatrist on their teams is not well-defined.

In our study, the presence of palpable pedal pulses was significant where 85% of patients with at least one healed wound had a palpable pedal pulse. The assessment of peripheral arterial disease (PAD) in patients with DFUs is important in order to determine whether arterial insufficiency will affect the outcome of wound healing. Underlying PAD is present in up to 50% of people with a DFU.[11] Palpation of pedal pulses in both the posterior tibial and dorsalis pedis arteries is a specific and reproducible tool for determining the presence of PAD in the foot.[12–14] In a prospective evaluation of 1000 patients with DFUs, PAD, defined by the absence of palpable pedal pulses, was determined to be a strong predictor of impaired wound healing,[15] which can increase the risk for amputation.[11,16]

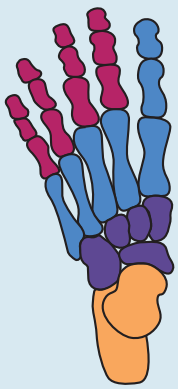
Our study also demonstrated that a midfoot or forefoot wound location was associated with a greater likelihood of healing when compared with a hindfoot location. This significant finding is in agreement with a study of 449 patients with DFUs by Ince et al.,[8] who found that ulcers of the midfoot and hindfoot were less likely to heal than those of the forefoot. Pickwell et al. also reported lower rates of wound healing in the midfoot (73.7%) and hindfoot (64.7%) compared with the toes (79.8%).[7] Wounds located on the midfoot and hindfoot are more difficult to offload, which will impede healing. This is particularly true in patients with diabetes and Charcot foot deformity, which causes midfoot and hindfoot architecture collapse.

In our clinic, wound location is an important consideration in choosing the type of offloading device to effectively offload pressure from the wound site. The selection of different devices is dependent on whether the DFU is located on the forefoot, midfoot, and hindfoot (Fig 5). The type of offloading device chosen by the chiropodist requires consultation with the patient and/or the patient's family. Factors taken into consideration when selecting the appropriate offloading device include the wound location, wound condition (i.e., active infection that requires daily treatment), skin integrity around the wound, the patient's balance, gait and mobility, the patient's lifestyle (e.g., working, driving, use of stairs, activities of daily living), condition of the contralateral limb (i.e., healthy, active wound, amputated), and the patient's ability to come to the clinic for follow-up.

The type of offloading device used contributed to our wound healing rate of 81%. When comparing offloading devices, the use of a total contact cast was associated with a greater likelihood of wound healing. A total contact cast is a custom moulded, minimally padded fibreglass cast that is changed weekly. It is indicated for DFUs with adequate arterial perfusion, well managed infection, and/or severe structural deformity of the forefoot, midfoot and hindfoot. A total contact cast is contraindicated in patients with unmanaged active infection, poor blood flow, unstable gait or balance, cognitive impairment, or poor adherence due to possible iatrogenic injury or impact on activities of daily living.

Strengths of this study were demonstrated by the ability to follow patients for an extended period in a team-based environment led by chiropodists. This study

Fig 5. Recommended offloading devices based on wound location



Lesser toes	• Short removable cast walker • Healing sandal with solid rocker sole • Custom device + shoe
1st ray & metatarsal heads	• Total contact cast • Tall removable cast walker ± insole modification
Midfoot	• Total contact cast ± modification • Tall removable cast walker with insole modification
Hindfoot	• Total contact cast with modification • Healing sandal with insole modification • Non-weight bearing

involved a large sample size (n=332 wounds) evaluated at a single centre over a five-year period, which permitted follow-up of 163 weeks for the longest time to wound healing. Wound healing was defined as complete wound closure, rather than 'functional' healing.[10] We also were able to capture detailed patient demographics and multiple patient factors.

Limitations

This study was limited by the quality of data recorded in patient charts. Our clinic had several chiropodists over the five-year study period, and each clinician's charting style differed somewhat in details. Future studies could include prospective data collection and logistic regression models to capture wound severity and time to heal.

Conclusion

This study demonstrated that a chiropody-led FTA clinic facilitated complete wound healing in most patients with DFUs. In addition, this model of care delivery enabled timely triage and appropriate patient access to specialised medical and surgical services in the hospital setting. The clinic focused on patient-centred care and the implementation of best practices. The presence of palpable pedal pulses, wound location, and use of a total contact cast were associated with a greater likelihood of wound healing. The appropriate selection and use of offloading devices is essential in the successful healing of DFUs. Clinic personnel spend substantial time with patients to involve them in the choice of offloading device, and many factors are considered when fitting a device. We believe such patient-driven care contributed to the high wound healing rate observed in this study and supports the role of the chiropodist within a hospital-based multidisciplinary team in the management of patients with DFUs and prevention of lower extremity amputations. **JWC**

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Reflective questions

- What are the barriers in building a multidisciplinary team (MDT) to manage diabetic foot ulcers? How would you overcome these barriers?
- What aspects should be considered when selecting an offloading device for a patient with a diabetic foot ulcer?
- How do clinicians outside a hospital setting build a model of care delivery that includes timely access to specialised medical and surgical services when warranted?

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