Received: 25 February 2024 | Revised: 12 March 2024 | Accepted: 12 March 2024

DOI: 10.1111/iwj.14859

ORIGINAL ARTICLE

IWJ WILEY

Characteristics and outcomes of diabetic foot ulcers treated with surgical debridement and standardized wound care

Moein Moghaddam Ahmadi[1] | **Mohammad Taghi Ashoobi**[2] | **Zohreh Darabi**[1] | **Hossein Ramezannezhad**[1] | **Mahta Moghaddam Ahmadi**[1]

[1]Poursina Clinical Research Development Unit, Guilan University of Medical Sciences, Rasht, Iran

[2]Razi Clinical Research Development Unit, Razi Hospital, Guilan University of Medical Sciences, Rasht, Iran

Correspondence
Mahta Moghaddam Ahmadi, Poursina Clinical Research Development Unit, Guilan University of Medical Sciences, Rasht. Iran.
Email: moghaddamahmadimahta@gmail.com

Abstract

Diabetic foot ulcers (DFUs) pose a significant clinical challenge, often leading to amputations and hospitalisation. This study aimed to investigate the characteristics and outcomes of DFUs treated with surgical debridement and standardised wound care. This descriptive cross-sectional study focused on diabetic patients with appropriate vascular conditions, as determined by an Ankle Brachial Index >0.9. Based on their infection status, participants were admitted to Poursina Hospital in Rasht, Iran, and subjected to initial supportive measures, antibiotic therapy and surgical debridement. The study incorporated primary treatment with wet bandages, silver spray and fibrinolysin ointment. Statistical analysis employed SPSS 22 software. Most patients were male (54.7%) and under 60 years old (50.7%). Overweight status was prevalent in 69.3% of diabetic ulcer patients, amongst whom 48% underwent wrist debridement. The 64% and 36% of the cases had grade III and grade II Texas index. Moreover, 96% of patients exhibited signs of infection and were classified as Stage Texas B. Reoperation was necessary for 34.7% of patients. The mean hospital stay was 8.5 ± 7.55 days, and the average recovery time was 15.2 ± 15.19 days. Out of 75 patients, 10 were unable to return to limb function due to disability. In this study, around one-third of patients required secondary repair with grafts and flaps. A small number of them were unable to recover because of underlying disability, and the mean recovery time in other cases was 24 days. Future studies should follow up with patients for longer periods to assess long-term therapeutic outcomes and quality of life.

KEYWORDS

debridement, diabetic foot ulcer, infection, Texas index

Key Messages

- Overweight status was prevalent in 69.3% of diabetic ulcer patients, amongst whom 48% underwent wrist debridement. The 64% and 36% of the cases had grade III and grade II Texas index.
- A 96% of patients exhibited signs of infection and were classified as Stage Texas B.
- Reoperation was necessary for 34.7% of patients. The mean hospital stay was 8.5 ± 7.55 days, and the average recovery time was 15.2 ± 15.19 days.

1 | INTRODUCTION

Diabetes is a chronic metabolic disorder with a growing global burden.[1] Diabetes prevalence for all age groups worldwide is estimated to rise from 2.8% in 2000 to 4.4% in 2030.[2] Diabetic foot ulcers (DFUs) are one of the most critical chronic complications of diabetes and the leading risk factor for non-traumatic lower-extremity amputations.[3] The global prevalence of DFUs is estimated to be 6.3%.[4] DFUs contribute significantly to patient mortality. Studies have shown that the risk of mortality within 5 years following the development of DFU is substantial, ranging from 43% to 55%.[5] This stark reality emphasises the critical importance of understanding, managing and preventing the complications associated with DFUs. Risk factors for DFUs include prolonged diabetes duration, male gender, poor glycemic control and existing cardiovascular, renal or ocular comorbidities.[6,7] These risk factors highlight the need for tailored and comprehensive approaches to address the unique circumstances of each patient. The pathophysiology of DFUs is complex, often involving a combination of ischemia, neuropathy and infection. These factors contribute to the high morbidity associated with DFUs, including functional decline, hospitalisation and death.[6] Managing DFUs involve a multifactorial approach targeting various aspects of the disease process. Firstly, local wound management plays a pivotal role. This includes meticulous control of exudate and moisture, coupled with advanced wound treatment modalities. The second aspect underscores the importance of addressing infected wounds through debridement, surgical drainage and antibiotic therapy. The third element, mechanical off-loading, is indispensable for mitigating pressure on the affected area. The fourth facet pertains to the restoration of regional perfusion, achieved through revascularization procedures when deemed necessary. Finally, the fifth element emphasises systemic metabolic control and the treatment of comorbidities, reflecting a holistic approach to DFU management.[8] Additionally, surgical debridement is a cornerstone of DFU management, promoting healing by removing necrotic tissue and reducing infection risk.[9] This procedure can be performed using various techniques, each with its advantages and applications. These techniques include sharp/surgical debridement, enzymatic debridement and autolytic debridement. The wound care materials should be chosen based on the wound's characteristics and the patient's needs. Given the multifactorial nature of DFUs, this study aims to contribute to the existing knowledge base by investigating the characteristics and outcomes associated with surgical debridement and standardised wound care. Elucidating these aspects is critical for refining treatment strategies, minimising complications and ultimately improving the quality of life for individuals afflicted with DFUs.

2 | MATERIALS AND METHODS

2.1 | Data source and design

A descriptive cross-sectional study was conducted on diabetic patients with adequate vascular status, as determined by an Ankle Brachial Index (ABI) greater than 0.9. These patients were admitted to Poursina Hospital in Rasht, Iran, and received initial supportive measures and antibiotic therapy. Preoperative interventions included surgical debridement, wet bandaging, silver spray and fibrinolysin ointment application. The definition of surgical debridement is the removal of all necrotic and infected tissue to the point of reaching living tissue. This debridement procedure can include incision, debridement or amputation. The surgical procedure involved surgical debridement of the ulcer and maintaining an open wound bed. The wound was then dressed with a wet bandage, coated with a silver spray for antimicrobial protection and treated with a fibrinolysis ointment to promote granulation tissue formation in preparation for grafting. By utilising the records of these patients, demographic information (age, gender

and body mass index [BMI]), ulcer classification, variables influencing hospital stay duration, reoperation, time needed for tissue preparation in restorative procedures and the restoration of limb function were compiled. The functional recovery time of limb in patients was calculated through interviews and questions (yes or no) about their ability to perform those daily tasks. In this study, BMI in different weight classes, including normal weight <25, overweight (25–29.9), Class 1 obesity (30–34.9), Class 2 obesity (35–39.9) and Class 3 (above 40) were evaluated.

2.2 | Texas classification

Grade:

- Grade 0: Before and after ulcers that are fully epithelialized (from levels A to D)
- Grade 1: Full-thickness skin involvement without tendon, capsule and bone involvement (levels A through D)
- Grade 2: Tendon involvement, capsule without bone involvement (from levels A to D)
- Grade 3: Bone involvement (Levels A to D)

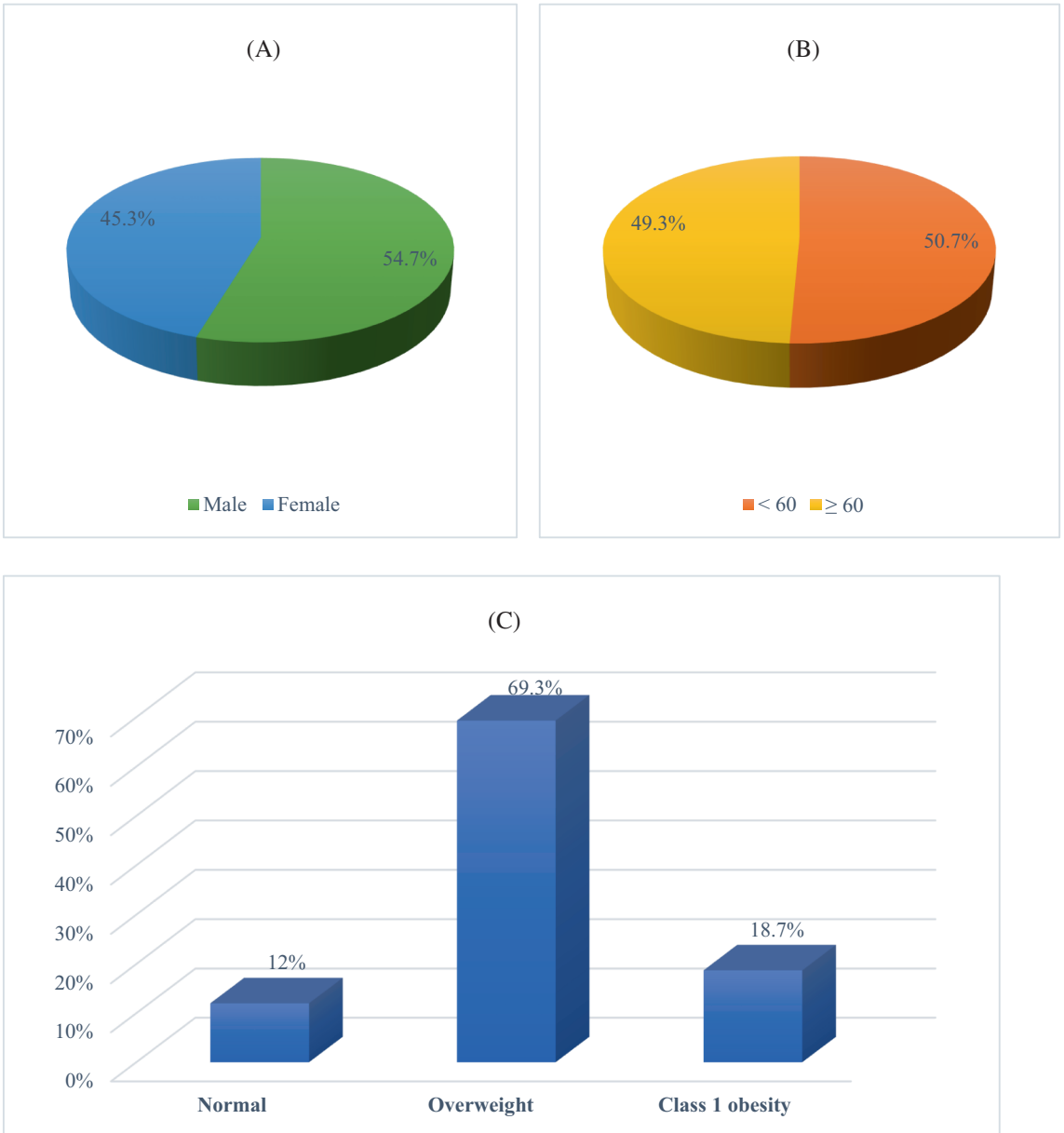

FIGURE 1 Evaluation of demographic characteristics of patients with diabetic ulcers. (A) Frequency distribution of gender. (B) Frequency distribution of age group. (C) Frequency distribution of BMI categories.

Stage:

- A: Non-infectious
- B: Infectious
- C: ischemic
- D: Infectious and ischemic

Seventy-five samples were calculated based on the Lenselink et al.[10] study and the following formula: the sample size was evaluated, considering the need for reoperation $p = 0.56$ and the value of d (0.2 value of p) with 95% confidence.

$$n = \frac{Z_{1-\frac{\alpha^2}{2}}}{d^2} pq.$$

2.3 | Statistical analysis

The collected data were encoded and entered into SPSS 22 software. Mean and standard deviation were used to describe quantitative variables, and numbers and percentages were used for qualitative variables.

TABLE 1 Evaluation of some indexes of diabetic ulcers in patients with diabetic ulcers ($N = 75$).

Variables	Status	Number	Percentage
Debridement	Mild	29	38.7
	Moderate	36	48
	Severe	10	13.3
Grade Texas	I	0	0
	II	27	36
	III	48	64
Stage Texas	Ischemic (A)	3	4
	Infection (B)	72	96
Requires reoperation	Yes	26	34.7
	No	49	65.3

TABLE 3 Evaluation of hospital length of stay (days) in patients with diabetic ulcers ($N = 75$).

Variables	Status	Number	Mean ± SD
Gender	Male	41	8.34 ± 5.6
	Female	34	9.14 ± 5.54
Age (year)	<60	38	8.97 ± 5.71
	≥60	37	8.43 ± 5.44
BMI	Normal	9	6.33 ± 1.87
	Overweight	52	8.75 ± 6.23
	Class 1 obesity	14	10.07 ± 3.89
Debridement	Mild	29	8.13 ± 5.38
	Moderate	36	8.86 ± 5.81
	Severe	10	9.8 ± 5.43
Grade Texas	II	27	6.74 ± 4.19
	III	48	9.81 ± 5.9
Stage Texas	Ischemic (A)	3	7 ± 4.35
	Infection (B)	72	8.77 ± 5.61

TABLE 4 Evaluation of time required for tissue preparation for healing (day) in patients with diabetic ulcers ($N = 27$).

Variables	Status	Number	Mean ± SD
Gender	Male	15	15 ± 15.08
	Female	12	15.58 ± 16
Age (year)	<60	15	15.73 ± 14.68
	≥60	12	14.66 ± 16.44
BMI	Normal	2	7.5 ± 4.94
	Overweight	20	16.7 ± 17.3
	Class 1 obesity	5	12.6 ± 4.27
Debridement	Mild	12	16.16 ± 17.6
	Moderate	14	14.64 ± 14.03
	Severe	1	13 ± 0
Grade Texas	II	9	10.55 ± 4.61
	III	18	17.6 ± 18.04
Stage Texas	Ischemic (A)	1	36 ± 0
	Infection (B)	26	14.46 ± 14.9

TABLE 2 Evaluation of Texas Grade by Stage Texas in patients with diabetic ulcers (N = 75).

Stage Texas	A		B		Total	
Grade Texas	Percentage	Number	Percentage	Number	Percentage	Number
II	33.3	1	36.1	26	36	27
III	66.7	2	63.9	46	64	48
Total	100	3	100	72	100	75

3 | RESULTS

In this study, 75 diabetic patients who underwent debridement were evaluated. The mean and median age of patients was 59.98 ± 9.63 and 59 years, in the 40–88 age range, and more than half were male. The body mass index of patients was 27.9 ± 2.3 kg/m^2, and more than half of patients with diabetic ulcers were overweight (69.3%). Besides, 18.7% of patients were class 1 obesity, and none of the patients were class 2 or 3 obesity (Figure 1). In terms of diabetic ulcer indexes, patients with diabetic ulcers with debridement of the wrist (moderate), toes (mild), legs and thighs (severe) were 48%, 38.7% and 13.3%, respectively. According to the Texas index, 64% of patients had grade III, 36% had grade II and grade I was not observed. Most patients (96%) had Stage Texas B infection, and only 4% had Stage Texas A infection (Table 1). According to Table 2, out of 72 patients in stage B, most (63.9%) were in grade III (Table 2). The mean and median duration of hospitalisation were 8.7 ± 5.55 and 7 days, respectively. Table 3 reports the hospital length of stay and duration (days) in diabetic ulcer patients according to some demographic characteristics and ulcer indicators. Of the 75 patients undergoing debridement, 27 (36%) required secondary repair with grafts and flaps. The mean and median repair duration were 15.2 ± 15.19 and 10 days. Also, the minimum and maximum repair times were 4 and 65 days, respectively. Evaluation of time required for tissue preparation for healing (day) in patients with diabetic ulcers according to some demographic characteristics and ulcer indicators (Table 4). Out of 75 patients, 10 patients could not restore limb function due to disability, and from 65 samples, the mean recovery time of limb function was

TABLE 5 Evaluation of limb function recovery time (day) in patients with diabetic ulcers ($N = 65$).

Variables	Status	Number	Mean ± SD
Gender	Male	38	27.47 ± 20.7
	Female	27	19.48 ± 16.19
Age (year)	<60	38	26.71 ± 23.29
	≥60	27	20.55 ± 10.8
BMI	Normal	4	21.75 ± 12.8
	Overweight	48	24.18 ± 19.4
	Class 1 obesity	13	24.76 ± 21.4
Debridement	Mild	27	13.88 ± 7.05
	Moderate	33	28.93 ± 20.44
	Severe	5	48 ± 25.6
Grade Texas	II	24	16.41 ± 8.77
	III	41	28.68 ± 22.18
Stage Texas	Ischemic (A)	3	15.66 ± 8.14
	Infection (B)	72	24.56 ± 19.57

TABLE 6 Evaluation of patients with diabetic ulcers that needed reoperation ($N = 75$).

		Requires reoperation				
		Yes		No		
Variables	Status	Number	Percentage	Number	Percentage	Number
Gender	Male	17	41.5	24	58.5	41
	Female	9	26.5	25	73.5	34
Age (year)	<60	17	44.7	21	55.3	38
	≥60	9	24.3	28	75.7	37
BMI	Normal	1	11.1	8	88.9	9
	Overweight	18	34.6	34	65.4	52
	Class 1 obesity	7	50	7	50	14
Debridement	Mild	8	27.6	21	72.4	29
	Moderate	15	41.7	21	58.3	36
	Severe	3	30	7	70	10
Grade Texas	I	0	0	0	0	0
	II	3	11.1	24	88.9	27
	III	23	47.9	25	52.1	48
Stage Texas	Ischemic (A)	0	0	3	100	3
	Infection (B)	26	36.1	46	63.9	72

24.15 ± 19.25 days, with a minimum recovery time of 7 days and a maximum of 120 days. Table 5 shows the duration of recovery of limb function (day) in patients with diabetic ulcers according to some demographic characteristics and ulcer indicators. In this study, out of 75 patients undergoing debridement, 26 patients (34.7%) required reoperation. Table 6 reported the need for reoperation regarding some indicators of diabetic ulcers in patients with diabetic ulcers.

4 | DISCUSSION

Due to the high prevalence of diabetes and its diabetic ulcers, we decided to study the results of primary surgical debridement, wet bandage, silver spray and fibrinolysin ointment in treating diabetic patients with appropriate vascular status. According to the results of the present study, more than half of the patients were men. Moreover, in similar studies on diabetic foot, the prevalence has been reported to be higher in men.[11,12] Men appear to be more likely than women to develop diabetes due to their association with risk factors for atherosclerosis.[13,14] Consistent with previous studies, our findings showed that more than half of the cases involved patients under 60 years old.[15,16] The highest percentage of patients with diabetic ulcers had debridement of the wrist (moderate), toes (mild), legs and thighs (severe). The toes are the most common ulcer site in Larijani's study.[12] Given the high prevalence of ischemia in the extremities and frequent microtrauma to the toes, especially from improper shoe pressure and nail grip, this statistic is justified for debridement ulcer sites.[17] Also, we showed that the time required for ulcer healing after surgery in the proximal and distal areas had the lowest and highest values, respectively. In diabetic patients, the blood supply to distal parts is at its lowest, whilst it is highest in the proximal areas. This suggests that an increased blood supply to the proximal areas may enhance the speed of ulcer healing.[18] In contrast, further investigations showed that about one-third of patients required reoperation and secondary repair with grafts and flaps. In the Lenselink et al.[10] study, 56% of patients required additional surgery and 30% needed amputation.[10] In another study, a few patients had an ulcer at the surgical site after a surgical intervention, such as amputation or debridement, or after CABG to remove the graft, and needed secondary repair.[19] Consequently, surgical manipulations in the lower extremities of diabetic patients should be avoided as much as possible due to the high risk of ulcers. Statistical results showed that the average length of stay in the hospital was 8 days, and the mean recovery time was 24 days. In multiple types of research, the mean length of hospital stay varied between 14.3, 21.4, 26.6, 41.05 and 44.5.[11,20] Reducing hospitalizations in patients despite admitting patients with higher degrees of foot ulcers can be a therapeutic success. About three-quarters of patients with diabetic ulcers were also overweight. This confirms the importance of obesity in developing DFUs compared to other studies. Accordingly, being overweight is considered an independent risk factor for DFUs.[21–23] In the present study, 96% of patients had an infection, and Stage Texas B and only 4% had Stage Texas A. Approximately two-thirds and one-third of patients had grade III and grade II Texas index, respectively. Lenselink et al.[10] determined that infection was identified as one of the main risk factors for relapse and amputation.[10] A study by Fagila et al. showed that delayed debridement in patients with ulcers associated with abscess formation led to increased amputation levels.[24]

4.1 | Limitations

We acknowledge that our study has certain limitations that should be considered. Firstly, the cross-sectional nature of the study design restricts our ability to establish causal relationships between the interventions and outcomes. Additionally, the reliance on retrospective data from medical records may introduce biases and limit the completeness of information. The sample size, although calculated based on previous studies, may still be considered relatively small, affecting the generalizability of our findings.

4.2 | Implications for future study

This study provided valuable data on DFUs treated with surgical debridement and standardised wound care. However, future research should focus on long-term outcomes like recurrence and amputation rates to get a more complete picture. Cost-effectiveness analysis and using larger, more diverse populations would also strengthen the generalizability of the findings. Finally, employing standardised tools to assess functional recovery would provide more objective data.

5 | CONCLUSION

As a result of this study, about one-third of patients required secondary repair with grafts and flaps. A small number of patients were unable to recover limb function due to disability. Furthermore, the average time to return limb function was 24 days.

FUNDING INFORMATION

The present research was part of an MD thesis, which the research deputy of the Guilan University of Medical Sciences supported. The authors received no financial support for this article's research, authorship and/or publication.

CONFLICT OF INTEREST STATEMENT

Each author has contributed substantially to the conception and design of the study or acquisition of data or analysis and interpretation of data, drafting the article or revising it critically for important intellectual content. Each author has seen and approved the contents of the submitted manuscript. None of the authors has any personal or financial conflicts of interest.

DATA AVAILABILITY STATEMENT

The data and materials supporting this study's findings are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

The present research was part of an MD thesis, which the research deputy of the Guilan University of Medical Sciences supported. Also, this research was approved by the Ethics Committee of Guilan University of Medical Sciences (IR.GUMS.REC.1398.160).

ORCID

Mahta Moghaddam Ahmadi https://orcid.org/0009-0005-1585-3764

REFERENCES

1. Sun J, Hu W, Ye S, Deng D, Chen M. The description and prediction of incidence, prevalence, mortality, disability-adjusted life years cases, and corresponding age-standardized rates for global diabetes. *J Epidemiol Glob Health*. 2023;13(3):566-576.
2. Wahidin M, Achadi A, Besral B, et al. Projection of diabetes morbidity and mortality till 2045 in Indonesia based on risk factors and NCD prevention and control programs. *Sci Rep [Internet]*. 2024;14(1):5424. doi:10.1038/s41598-024-54563-2
3. Lin C-W, Armstrong DG, Lin C-H, et al. Nationwide trends in the epidemiology of diabetic foot complications and lower-extremity amputation over an 8-year period. *BMJ Open Diabetes Res Care*. 2019;7(1):e000795.
4. Zhang P, Lu J, Jing Y, Tang S, Zhu D, Bi Y. Global epidemiology of diabetic foot ulceration: a systematic review and meta-analysis. *Ann Med*. 2017;49(2):106-116.
5. Robbins JM, Strauss G, Aron D, Long J, Kuba J, Kaplan Y. Mortality rates and diabetic foot ulcers: is it time to communicate mortality risk to patients with diabetic foot ulceration? *J Am Podiatr Med Assoc*. 2008;98(6):489-493.
6. Kalish J, Hamdan A. Management of diabetic foot problems. *J Vasc Surg*. 2010;51(2):476-486.
7. Hsu L, Li L, Poon LY. Analysis of risk factors of infection in diabetic foot patients. *Int Wound J*. 2024;21(1):e14411.
8. Roth-Albin I, Mai SHC, Ahmed Z, Cheng J, Choong K, Mayer PV. Outcomes following advanced wound Care for Diabetic Foot Ulcers: a Canadian study. *Can J Diabetes [Internet]*. 2017;41(1):26-32. https://www.sciencedirect.com/science/article/pii/S1499267116300259
9. Dayya D, O'Neill OJ, Huedo-Medina TB, Habib N, Moore J, Iyer K. Debridement of diabetic foot ulcers. *Adv Wound Care*. 2022;11(12):666-686.
10. Lenselink E, Holloway S, Eefting D. Outcomes after foot surgery in people with a diabetic foot ulcer and a 12-month follow-up. *J Wound Care*. 2017;26(5):218-227.
11. Moxey PW, Gogalniceanu P, Hinchliffe RJ, et al. Lower extremity amputations—a review of global variability in incidence. *Diabet Med [Internet]*. 2011;28(10):1144-1153. doi:10.1111/j.1464-5491.2011.03279.x
12. Larijani B, Heshmat R, Bahrami A, et al. Effects of intravenous Semelil (ANGIPARSTM) on diabetic foot ulcers healing: a multicenter clinical trial. *Daru*. 2008;16:35-40.
13. Nordström A, Hadrévi J, Olsson T, Franks PW, Nordström P. Higher prevalence of type 2 diabetes in men than in women is associated with differences in visceral fat mass. *J Clin Endocrinol Metab*. 2016;101(10):3740-3746.
14. Madonna R, Balistreri CR, De Rosa S, et al. Impact of sex differences and diabetes on coronary atherosclerosis and ischemic heart disease. *J Clin Med*. 2019;8(1):98.
15. Kirkman MS, Briscoe VJ, Clark N, et al. Diabetes in older adults. *Diabetes Care*. 2012;35(12):2650-2664.
16. Deshpande AD, Harris-Hayes M, Schootman M. Epidemiology of diabetes and diabetes-related complications. *Phys Ther*. 2008;88(11):1254-1264.
17. Soler EP, Ruiz VC. Epidemiology and risk factors of cerebral ischemia and ischemic heart diseases: similarities and differences. *Curr Cardiol Rev*. 2010;6(3):138-149.
18. Clemens MW, Attinger CE. Functional reconstruction of the diabetic foot. *Semin Plast Surg*. 2010;24(1):43-56.
19. Siddiqi M. Saphenous vein harvest wound complications: risk factors, identification, prevention, and management. *Chronic Wound Care Manag Res*. 2016;3:147-156.
20. Bagher A, Afshari M, Darvish Nezhad F, et al. Lower limb amputation in patients with diabetic foot ulcer: a 22 year review. *Iran Red Crescent Med J*. 2006;1(8):21-24.
21. Janmohammadi N, Moazzezi Z, Ghobadi P, Haddadi R, Montazeri MA. Evaluation of the risk factors of diabetic foot ulcer and its treatment in diabetic patients, Babol, north of Iran. *IJEM*. 2009;11(2):121-219.
22. Hajtalebi H, Khani Iurigh H, Hajtalebi H. Investigating the treatment status of 10 patients with second and third degree diabetic foot ulcers based on the therapeutic protocols of Iranian traditional medicine in Bojnurd from 2015-2016. *Asian J Clin Case Reports Tradit Altern Med [Internet]*. 2017;1(3-4):55-64. https://www.ajcrtam.ir/article_27587.html

23. Jalilian M, Ahmadi Sarbarzeh P, Oubari S. Factors related to severity of diabetic foot ulcer: a systematic review. *Diabetes Metab Syndr Obes*. 2020;13:1835-1842.
24. Faglia E, Clerici G, Caminiti M, Quarantiello A, Gino M, Morabito A. The role of early surgical debridement and revascularization in patients with diabetes and deep foot space abscess: retrospective review of 106 patients with diabetes. *J Foot Ankle Surg off Publ Am Coll Foot Ankle Surg*. 2006;45(4):220-226.

How to cite this article: Moghaddam Ahmadi M, Ashoobi MT, Darabi Z, Ramezannezhad H, Moghaddam Ahmadi M. Characteristics and outcomes of diabetic foot ulcers treated with surgical debridement and standardized wound care. *Int Wound J*. 2024;21(4):e14859. doi:10.1111/iwj.14859