Journal of the
ASEAN Federation of
Endocrine Societies

ORIGINAL ARTICLE

The Impact of Chronic Kidney Disease on Ulcer-Related Outcomes in Hospitalized Diabetic Foot Ulcers: A Retrospective Study from Thailand

Jeeraphan Sripatpong,[1] Sirinate Krittiyawong,[2] Waralee Chatchomchuan,[2]
Ekgaluck Wanothayaroj,[2] Taweesak Srikummoon,[2] Poovasit Klinoubol,[1] Phawinpon Chotwanvirat,[2]
Siriwan Butadej,[1] Soontaree Nakasatien,[1] Thep Himathongkam,[1] Yotsapon Thewjitcharoen[1]

[1]Foot Clinic and Wound Care, Vimut-Theptarin Hospital, Bangkok, Thailand
[2]THEPTARIN Diabetes, Thyroid and Endocrine Center, Vimut-Theptarin Hospital, Bangkok, Thailand

Abstract

Objective. To explore the impact of chronic kidney disease (CKD) on hospitalized patients with diabetic foot ulcers (DFU) at a tertiary diabetes center in Thailand.

Methodology. A retrospective study reviewed hospitalized DFU admissions at Vimut-Theptarin Hospital from 2019 to 2023. Ulcer-related outcomes included complete wound healing at 12 months, major and minor amputations, and 1-year mortality.

Results. A total of 265 DFU admissions from 225 patients were included (male 60.4%; age, 66.7 ± 13.4 years; A1C, 8.2 ± 2.3%, advanced CKD, 26.1%, peripheral arterial disease, 54.7%). Severe DFU (Wagner grade ≥3) comprised 60.0% of all DFUs and almost one-third of patients had prior amputations. Complete healing occurred in 69.8%; major amputation in 4.9%; minor amputation in 30.9%; and 1-year mortality rate after discharge was 11.7%. Advanced CKD (stages 4-5) increased odds of non-healed ulcers (odds ratio OR, 2.69; 95% confidence interval CI, 1.46-4.98; $P = 0.002$) and 1-year mortality rate (21.7% vs 8.4%; $P = 0.004$).

Conclusion. Advanced chronic kidney disease (CKD) is associated with poorer ulcer-related outcomes in hospitalized patients with diabetic foot ulcers (DFU). Proactive foot care and early referral to multidisciplinary teams, particularly for dialysis-dependent patients, remain essential. Despite ongoing advances in DFU management, these patients continue to face higher rates of non-healing ulcers and mortality, underscoring the need for coordinated inter-institutional care and enhanced public education efforts.

Key words: diabetic foot ulcer, chronic kidney disease, Thailand

INTRODUCTION

Diabetic foot ulcer (DFU) causes a significant economic burden on healthcare systems all over the world and is one of the costliest diabetic complications, requiring multidisciplinary expertise from primary care to subspecialties.[1] Approximately 15% - 40% of individuals with diabetes develop a foot ulcer during their lifetime, with up to 10% progressing to lower extremity amputation, resulting in disability, prolonged hospitalization, and premature mortality.[2] Moreover, over 60% of these patients experience DFU recurrence within 5 years, accompanied by 5-year mortality rates of 50% to 70%.[3] The prevalence of co-morbidities is very high in DFU patients leading to increasingly complex wounds which affect the final treatment outcomes.[4-7]

Several studies demonstrated that chronic kidney disease (CKD) is associated with worse outcomes and mortality in DFU patients.[6-10] The presence of CKD accelerates more severe peripheral arterial diseases (PAD) by causing chronic inflammation and promoting a prothrombotic state.[11] A retrospective cohort study from the Netherlands found that DFU patients with advanced CKD had a 10-fold increased risk for major amputation compared to patients who have an estimated glomerular filtration rate (eGFR) of 30-59 ml/min/1.73 m^2.[5] Despite global declines in DFU-related major amputations, CKD prevalence in type 2 diabetes (T2D) has surged with rising life expectancy, though diabetic kidney disease mechanisms remain incompletely understood.[12] In Thailand, T2D is one of the common causes of dialysis.[13] Successful DFU management hinges on coordinated, holistic multidisciplinary care addressing all comorbidities.

eISSN 2308-118x (Online)
Printed in the Philippines

Received: July 10, 2025. Accepted: August 19, 2025.
Published online first: April 12, 2026.
https://doi.org/10.15605/jafes.041.01.5197

Corresponding author: Yotsapon Thewjitcharoen, MD
THEPTARIN Diabetes, Thyroid and Endocrine Center, Vimut-Theptarin Hospital,
3850 Rama IV Road, Phra Khanong, Khlong Toei, Bangkok 10110, Thailand
Tel No.: 066-02-348-7000
E-mail: kamijoa@hotmail.com
ORCiD: https://orcid.org/0000-0002-2317-4041

Over the past 3 decades, our hospital – a tertiary diabetes center in Thailand – has been able to provide comprehensive diabetic foot care to the majority of complex patients referred to us from all over Thailand and neighboring countries. Prior data demonstrated achievement of limb salvage rates exceeding 90% and complete healing rates above 80% through dedicated multispecialty teams.[14] However, advanced CKD reduced complete healing by up to 33%, underscoring the role of comorbidities in this fragile population with DFU as a complex clinical syndrome.[15] More detailed analysis of the relationship between CKD staging and ulcer-related outcomes should be explored to better understand prognostic factors among hospitalized DFU patients. Therefore, this study examines the impact of The Kidney Disease: Improving Global Outcomes (KDIGO) categories for eGFR[16] on outcomes of hospitalized patients with DFU during the period of 2019-2023 at our hospital.

METHODOLOGY

Study design and study population

This retrospective cohort study examined all consecutive hospitalized DFU admissions from 2019 to 2023 at Vimut-Theptarin Hospital (formerly Theptarin Hospital), a private tertiary diabetes center in Bangkok. A dedicated foot clinic, established since 1995, follows uniform guidelines in accordance with international standards to triage the risk of DFU in all people with diabetes. Most hospitalized DFU patients were referral cases from all over Thailand and neighboring countries. DFU was defined as a full thickness wound below the ankle in an individual with diabetes. All hospitalized patients with DFU during the study period were included; exclusion criteria included ulcers above the ankle, absence of diabetes diagnosis, lack of laboratory data on renal function, missing glycated hemoglobin A1C results, and incomplete medical records.

The Wagner classification was used to assess the wound severity based on depth of ulceration and the extent of gangrene.[17] PAD was diagnosed if distal pulses were absent and/or the ankle brachial index (ABI) was <0.9. In patients whose ABI was >1.4 or in those with diagnostic uncertainty, a toe pressure of <55 mmHg or a toe brachial index (TBI) of <0.7 confirmed PAD.

The presence of CKD was defined as having eGFR <90 mL/min/1.73 m^2 with or without albuminuria. The stages of CKD followed standard classification: **Stage 1**: Kidney damage with normal or increased GFR (>90 mL/min/1.73 m^2); **Stage 2**: Mild reduction in GFR (60-89 mL/min/1.73 m^2) **Stage 3a**: Moderate reduction in GFR (45-59 mL/min/1.73 m^2); **Stage 3b**: Moderate reduction in GFR (30-44 mL/min/1.73 m^2); **Stage 4**: Severe reduction in GFR (15-29 mL/min/1.73 m^2); **Stage 5**: Kidney failure (GFR <15 mL/min/1.73 m^2 or dialysis). Renal function was categorized as: no chronic kidney disease (CKD), early-stage CKD (Stages 1–3), and advanced-stage CKD (Stages 4–5). Date of admission was defined as the index date for follow-up.

Sample size calculation

The sample size calculation was based on the study by Bonnet JB et al.,[10] which reported severe DFU in 64.8% of advanced CKD patients versus 24.7% in non-CKD patients. Assuming a two-sided α of 0.05, 80% power, and an approximate 1:1 ratio of advanced CKD to non-CKD patients, the minimum required sample size was 50 admissions. These assumptions provided sufficient statistical power to detect clinically meaningful differences in ulcer-related outcomes between groups.

Outcomes

The primary outcome was the rate of complete wound healing at 12 months post-admission. Secondary outcomes included rates of minor amputation, major amputation, and all-cause mortality at 12 months post-admission. Complete wound healing was defined as the complete epithelialization of the overlying soft-tissue wound within 12 months after admission. Amputations were classified into minor (up to below the ankle level) or major (above the ankle level). Patients who died before achieving wound healing were considered to have non-healing ulcers. This study was approved by the Institutional Review Board Committee of Vimut-Theptarin Hospital (EC No.01-2025).

Statistical analysis

Continuous variables were presented as mean ± SD or median (IQR), as appropriate and categorical variables were presented as proportions. Continuous variables were tested for normality using the Kolmogorov-Smirnov test. If data was not normally distributed, non-parametric tests were applied. Comparisons among different stages of CKD were performed using one-way ANOVA or the Kruskal-Wallis test for continuous variables. Comparisons between healed and non-healed ulcers were conducted using the independent *t-test* or the Mann-Whitney U test for continuous variables, and the Chi-square test for categorical variables. Logistic regression analysis was used to evaluate the association between the transformed variables, clinical binary parameters, and ulcer-related outcomes. Variables with a univariate *P*-value <0.05, together with clinically important predictors (e.g., Wagner grade, PAD, advanced CKD status), were entered into the multivariate logistic regression model. Model diagnostics were performed to assess robustness. Multicollinearity was evaluated using variance inflation factors (VIFs). For further analysis, ulcer-related continuous variables were converted into categorical variables, including A1C (≥9%), age (≥60 years), BMI (≥25 kg/m²), duration of diabetes (≥10 years), and high DFU severity (Wagner score ≥3). Fifteen variables were selected to assess multicollinearity. The type of DFU was excluded from the analysis due to a VIF greater than 2.0, while all other variables had VIF values below 2.0, leaving a total of fourteen variables. Logistic regression was used to evaluate the association between the transformed variables, clinical binary parameters, and ulcer-related outcomes.

A *P*-value <0.05 was considered statistically significant. All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS), version 22.0 (IBM Corporation, Armonk, NY, USA).

RESULTS

Baseline characteristics of the patients

During the 5-year study period (2019–2023), a total of 272 admissions were reviewed; of these, 265 admissions met the inclusion criteria, as shown in Figure 1. A total of 265 DFU admissions from 225 patients were included (male 60.4%, age 66.7 ± 13.4 years, T2D 98.5%, glycated hemoglobin, A1C 8.2 ± 2.3%, advanced CKD 26.1%). DFUs were classified as neuropathic wounds (45.3%) or mixed neuro-ischemic wounds (54.7%). The median length of stay was 7 days (IQR 4, 13 days). Severe DFUs (Wagner grade 3–5) accounted for 60.0% of all DFUs, 63.4% of patients had a previous history of DFU, and 30.9% of patients had prior history of amputation. Patients with dialysis-dependent CKD composed of 13.2% of all patients. The detailed demographic data of DFU classified by non-CKD status, early stages of CKD (Stages 1-3), and advanced stages of CKD (Stages 4-5) were shown in Table 1.

Ulcer-related outcomes

Complete healing was achieved in 69.8% of all admissions. Major amputations were performed in 4.9% and minor amputations in 30.9%. The 1-year mortality rate was 11.7%. The most common causes of death were sepsis (46.9%), cardiovascular events (28.1%), and cancer (9.4%). Comparison of the clinical characteristics of the healed (including minor amputations) and non-healed patients were demonstrated in Table 2. When stratified by the severity of CKD, patients with advanced CKD had unfavorable outcomes in all ulcer-related outcomes as shown in Figure 2. Complete healing rates decreased from 75.9% for non-CKD patients to only 50.7% in patients with advanced stages of CKD (*P*-value = 0.021). Patients with advanced stages of CKD had higher 1-year mortality rate compared with those in the early stages of CKD (21.7% vs. 8.4%, *P*-value = 0.004). Ulcer-related outcomes stratified by type of ulcers and renal status were shown in Figure 3. Complete healing rate was higher in neuropathic ulcers compared with neuro-ischemic ulcers in all stages of renal function. Among advanced CKD patients with neuro-ischemic ulcers, complete healing rate was only 43.4%. Ulcer-related outcomes stratified by severe DFU (Wagner grade ≥3) across renal function groups are presented in

Table 1. Demographic data of hospitalized diabetic foot ulcer (DFU) classified by estimated glomerular filtration rate (eGFR) for the Kidney Disease: Improving Global Outcomes (KDIGO) staging system

	Total admissions (N = 265)	No CKD (N = 29, 10.9%)	Early CKD (N = 167, 63.0%)	Advanced CKD (N = 69, 26.1%)	*P*-value
Age (years)	66.7 ± 13.4	61.1 ± 13.5	66.6 ± 13.2	69.3 ± 13.1	**0.022** [a]
Male (%)	60.4%	62.1%	61.7%	56.5%	0.748 [b]
BMI (kg/m²)	24.5 (21.5, 27.4)	23.9 (20.1, 26.8)	24.7 (21.7, 27.8)	24.3 (21.3, 26.3)	0.432 [c]
T2D (%)	98.5%	93.1%	98.8%	100.0%	**0.034** [b]
Duration of DM (years)	20.0 (11.0, 28.0)	10.0 (2.0, 25.0)	20.0 (11.0, 29.0)	21.0 (12.0, 29.5)	**0.013** [c]
A1C (%)	7.7 (6.5, 9.5)	8.3 (6.8, 9.7)	8.0 (6.8, 10.0)	7.0 (6.0, 8.3)	**0.005** [c]
Serum creatinine (mg/dL)	1.2 (0.3, 2.1)	0.6 (0.5, 0.8)	1.0 (0.4, 1.4)	4.4 (2.4, 6.7)	**<0.001** [c]
eGFR (mL/min/1.73 m²)	57.0 (26.5, 87.0)	98.0 (93.5, 113.5)	67.0 (47.0, 86.0)	12.0 (7.0, 22.0)	**<0.001** [c]
Length of stay (days)	7 (4, 13)	7 (4, 10)	7 (4, 12)	9 (4, 17)	0.541 [c]
Type of DFU					**<0.001** [b]
Neuropathic	45.3%	69.0%	50.3%	23.2%	
Mixed	54.7%	31.0%	49.7%	76.8%	
Charcot foot (%)	7.9%	3.4%	8.4%	8.7%	0.637 [b]
Ischemic Heart Disease (%)	27.9%	13.8%	24.0%	43.5%	**0.002** [b]
Stroke (%)	8.3%	6.9%	10.2%	4.3%	0.322 [b]
Severe DFU (Wagner grades 3–5) (%)	60.0%	51.7%	58.7%	66.7%	0.329 [b]
Previous DFU (%)	63.4%	58.6%	56.3%	82.6%	**0.001** [b]
Previous Amputation (%)	30.9%	24.1%	32.3%	30.4%	0.674 [b]
Diabetic Retinopathy (%) *					0.121 [b]
No DR	26.1%	47.4%	27.0%	11.8%	
Mild NPDR	3.9%	0.0%	5.0%	2.9%	
Moderate to Severe NPDR	19.0%	15.8%	20.0%	17.6%	
PDR	51.0%	36.8%	48.0%	67.6%	
Active smoking (%)	8.7%	3.4%	9.6%	8.7%	0.465 [b]
Wound location (%)					0.089 [b]
Toe	45.3%	34.5%	46.1%	47.8%	
Forefoot	40.8%	41.4%	42.5%	36.2%	
Heel	7.5%	20.7%	5.4%	7.2%	
Ankle	3.8%	0.0%	4.2%	4.3%	
Midfoot	1.9%	3.4%	1.8%	1.4%	
Whole foot	0.7%	0.0%	0.0%	3.1%	

* Available data 153/265 (57.7%)

[a] One-way ANOVA; [b] Chi-square test; [c] Kruskal-Wallis test

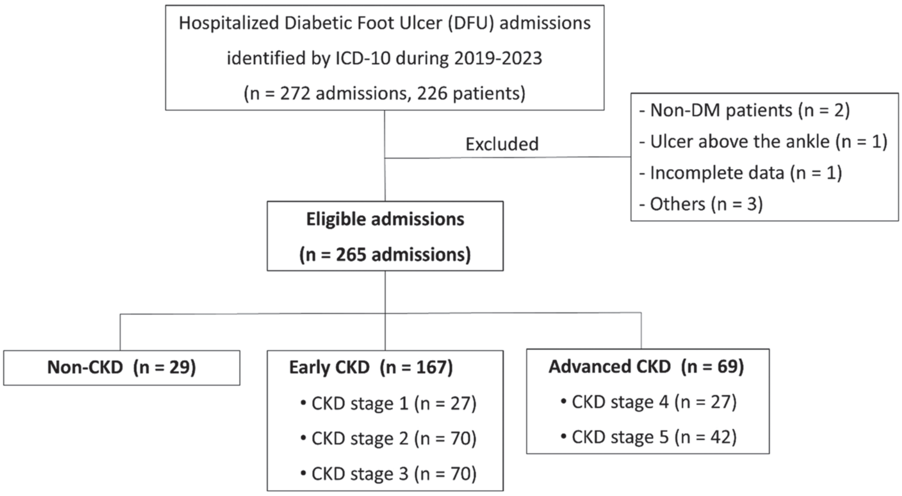

Figure 1. Study flowchart of patient selection.

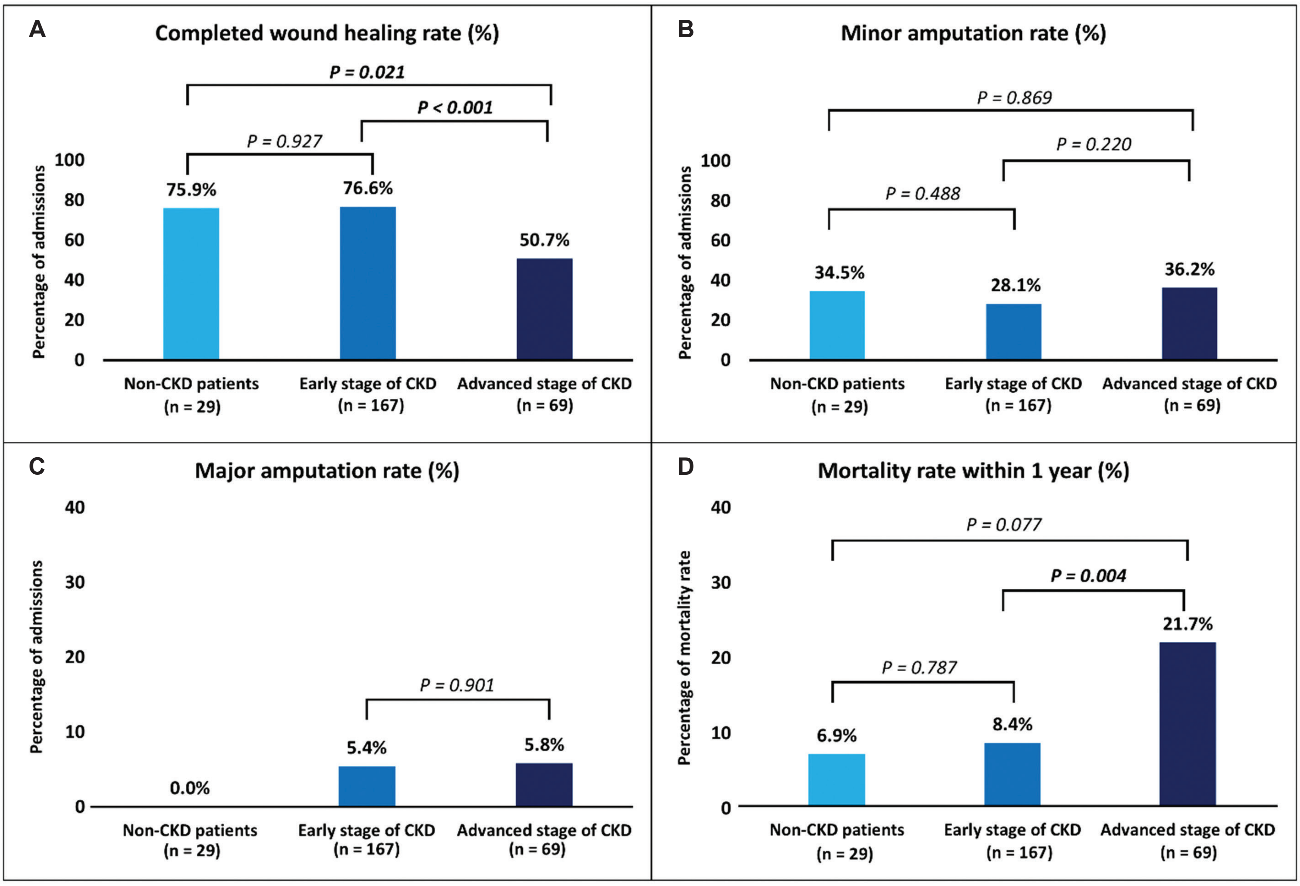

Figure 2. Ulcer-related outcomes stratified by renal status. **(A)** Completed wound healing rate. **(B)** Minor amputation rate. **(C)** Major amputation rate. **(D)** Mortality rate within 1 year.

Figure 4. Advanced renal dysfunction with severe DFU was associated with unfavorable ulcer-related outcomes in terms of complete healing and minor amputation rates, but differences in in major amputation rate and mortality rate were not statistically significant.

Results of univariate and multivariate logistic regression analysis of the complete healing rate are demonstrated in Table 3. More advanced Wagner's grades (≥3) were found more in non-healed group than healed group (70.0% vs. 55.7%, *P*-value 0.029) but this factor did not reach statistically significant levels after multivariate analysis as shown in Table 3. According to multivariate analysis for associated factors to predict non-healed ulcers, patients with advanced stages of CKD had increased odds of having a non-healed ulcer (Odd ratio 2.69, 95% Confidence Interval: 1.46-4.98, *P*-value = 0.002).

Comparisons with our previous published data

Compared with our previously published data from 2009 to 2013[14] and from 2014 to 2018,[15] the rates of ischemic ulcers and/or neuro-ischemic ulcers, advanced CKD, and severity of DFU increased in this study period (2019-2023) as shown in Table 4. Major amputation rate slightly increased from 4.2% to 4.9% but minor amputation rate markedly rose from 18.7% to 30.9%.

DISCUSSION

The present study demonstrates the impact of advanced CKD on various outcomes of hospitalized DFU patients. These findings were consistent with previous studies reporting higher odds of amputation and an increase in resource utilization due to prolonged length of stay among CKD patients with DFU.[4-10] Co-existing advanced CKD with the presence of PAD were the main drivers of these poor ulcer-related outcomes. Most patients with complicated DFUs at our center presented late for appropriate treatment. Longer delays before evaluation by diabetic foot specialists contributed to greater DFU severity.[18] Moreover, PAD has become an increasingly common cause of DFU, adversely affecting healing rates and amputation-free survival.[19] PAD prevalence is higher in the elderly, and increases exponentially with aging of the population.[20]

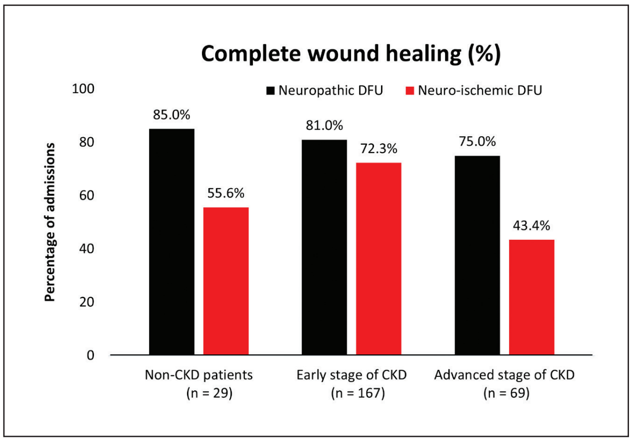

Figure 3. Ulcer-related outcomes stratified by type of ulcers.

Table 2. Clinical characteristics of patients with healed (including minor amputations) versus non-healed ulcers

	Healed ulcer (N = 185, 69.8%)	Non-healed ulcer (N = 80, 30.2%)	*P*-value
Age (years)	65.3 ± 13.1	69.9 ± 13.5	**0.008** [a]
Male (%)	62.7%	55.0%	0.239 [b]
BMI (kg/m²)	24.9 (22.3, 28.1)	23.4 (20.1, 25.5)	**0.001** [c]
T2D (%)	97.8%	100.0%	0.416 [b]
Duration of DM (years)	19.5 (11.0, 27.0)	20.0 (10.0, 30.0)	0.490 [c]
A1C (%)	7.9 (6.7, 9.7)	7.3 (6.0, 9.1)	**0.048** [c]
Serum creatinine (mg/dL)	1.1 (0.8, 1.8)	1.5 (0.9, 3.3)	**0.014** [c]
eGFR (mL/min/1.73 m²)	61.0 (36.0, 87.5)	42.5 (16.3, 86.8)	**0.015** [c]
Severe DFU (Wagner grades 3–5) (%)	55.7%	70.0%	**0.029** [b]
Wound location (%)			0.074 [b]
Toe	46.0%	43.7%	
Forefoot	43.2%	35.0%	
Heel	5.4%	12.5%	
Ankle	3.2%	5.0%	
Mid Foot	2.2%	1.3%	
Whole Foot	0.0%	2.5%	

[a] Independent t-test; [b] Chi-square test; [c] Mann-Whitney U test

Table 3. Factors associated with non-healed diabetic foot ulcer by logistic regression analysis

Variables	Univariate analysis			Multivariate analysis		
	Odds	*P*-value	95% CI	Odds	*P*-value	95% CI
Male	1.38	0.240	0.81 - 2.34			
A1C ≥9%	0.70	0.262	0.38 - 1.30			
Age ≥60 years	1.65	0.105	0.90 - 3.04			
BMI ≥25 kg/m²	0.46	0.006	0.26 - 0.80	0.57	0.070	0.31 - 1.05
Duration of DM ≥10 years	0.67	0.225	0.35 - 1.28			
Presence of Charcot foot	0.70	0.509	0.25 - 1.99			
Presence of IHD	1.77	0.048	1.00 - 3.12	1.02	0.943	0.53 - 1.99
Presence of PAD	2.73	<0.001	1.56 - 4.80	1.38	0.391	0.66 - 2.90
Previous Amputation	1.20	0.516	0.69 - 2.11			
Wagner grade ≥3	1.86	0.030	1.06 - 3.25	1.37	0.304	0.75 - 2.52
Wound site at heel	2.50	0.051	0.99 - 6.27			
Advanced CKD	3.17	<0.001	1.78 - 5.64	**2.69**	**0.002**	**1.46 - 4.98**
Severe DR	1.54	0.301	0.68 - 3.47			
Active Smoking	0.62	0.359	0.22 - 1.73			

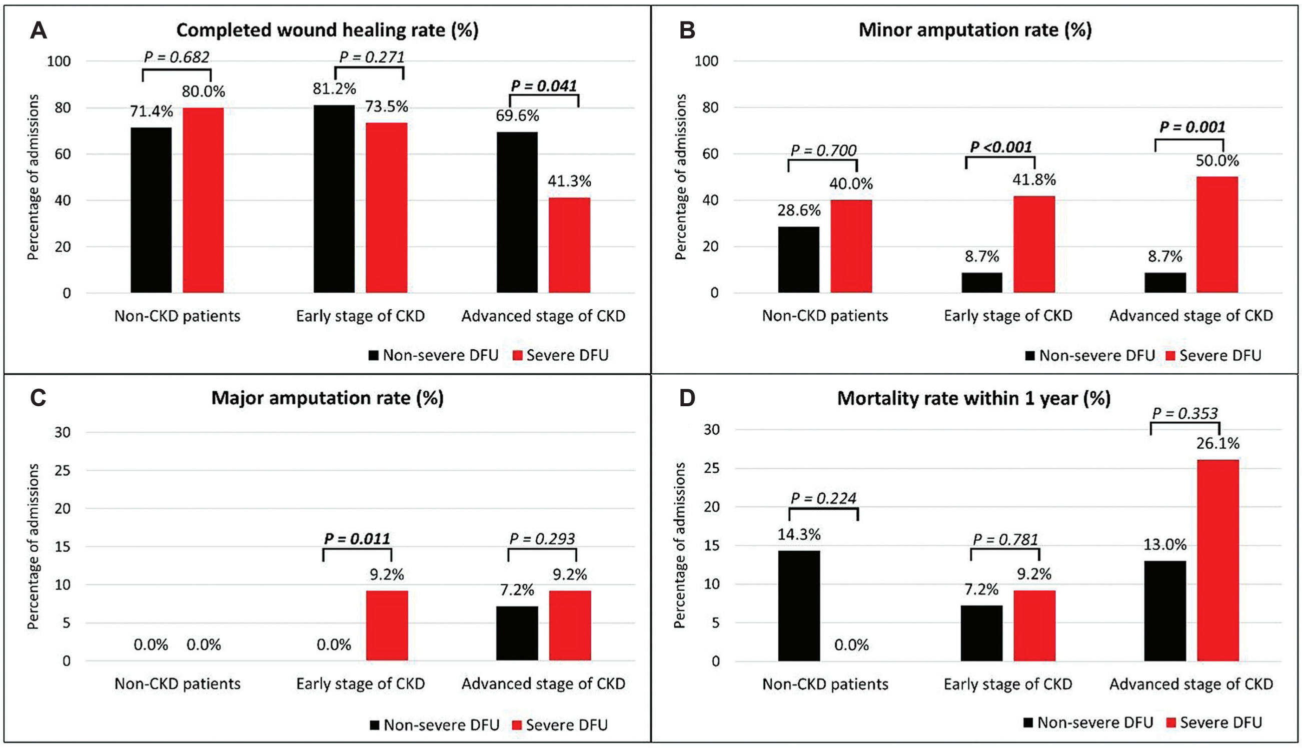

Figure 4. Ulcer-related outcomes stratified by severe diabetic foot ulcer (Wagner grade ≥3) in each renal status. **(A)** Completed wound healing rate. **(B)** Minor amputation rate. **(C)** Major amputation rate. **(D)** Mortality rate within 1 year.

Table 4. Comparison of clinical characteristic data and ulcer-related outcomes for this study period (2019-2023) with our previous published studies in 2009-2013 and 2014-2018

Study period	2009-2013* (N = 262)	2014-2018# (N = 350)	2019-2023 (N = 265)	*P*-value
Age (years)	65.6 ± 11.9	65.4 ± 13.4	66.7 ± 13.4	0.416
Duration of DM (years)	17.2 ± 9.9	18.8 ± 11.5	20.0 ± 10.9	0.017
A1C (%)	8.9 ± 2.4	8.6 ± 2.3	8.2 ± 2.3	0.003
PAD (%)	43.1%	62.0%	54.7%	<0.001
Advanced CKD (%)	18.5%	27.0%	26.1%	**0.029**
Major Amputation (%)	4.2%	4.6%	4.9%	0.927
Minor Amputation (%)	18.7%	22.3%	30.9%	**0.003**
Non-healing rate (%)	17.9%	26.6%	30.2%	**0.004**
Dead within 1 year (%)	5.7%	12.0%	11.7%	**0.021**

*J Clin Transl Endocrinol. 2014;1:187-91. # BMC Endocr Disord. 2020;20:89.

Previous studies have reported that beyond ulcer severity, several factors – particularly the renal function – are important predictors of amputation risk.[9,21,22] Our findings indicate that advanced renal dysfunction is associated with unfavorable ulcer-related outcomes, independent of DFU severity. These results highlight the importance of recognizing advanced renal impairment as a key risk factor for poor outcomes, even in patients who present with less severe DFU at initial evaluation.

Identifying individuals at risk for foot ulceration is the first step to prevent the vicious cycle of DFU.[23] The latest International Working Group on the Diabetic Foot (IWGDF) guideline designated end-stage renal failure as the highest podiatric risk category for worse outcomes.[24] This update in the IWGDF underscores the relationship between DFU and CKD. Patients receiving dialysis still have significantly greater odds ratio of undergoing major amputation even after adjusting for the presence of PAD.[25,26] It has been postulated that dialysis treatment itself might decrease tissue oxygenation and blood flow to the foot.[27] Therefore, active annual foot ulcer screening and prompt referral to a multidisciplinary diabetic foot team should be emphasized in people with diabetes who are on dialysis. Delayed referral to multidisciplinary care and the lack of a dedicated follow-up pathway can lead to lower extremity amputations. The national diabetes foot care audit in England reported that more than 10% of patients who did not self-present were not seen for 2 months or more after initial healthcare contact.[28] Our center, a referral facility for complex DFU cases for three decades, has also observed the continuing trend of delayed hospital presentation in several patients. More efforts are required to educate patients with high-risk foot if the ulcer develops to improve the future outcomes.

DFU complicated with PAD is highly prevalent among CKD patients and revascularization by angioplasty or bypass surgery in advanced tertiary centers are often needed in these patients. CKD patients tended to have PAD with characteristic lesions that significantly reduce long-term patency rate after revascularization such as long vascular segments, serious calcification, poor collateral circulation, and more involvement of small vessels under the knee.[20] Recently, transcatheter arterialization of the deep veins – a percutaneous approach that creates an artery-to-vein connection for delivery of oxygenated blood by means of the venous system to the ischemic foot has emerged to as a promising therapy in patients with no-option chronic limb threatening ischemia.[29] This advanced intervention, however, was not yet available in our center. Poor glycemic control is associated with worse outcomes following revascularization and optimal glycemic management including nutritional intervention, is very important factors to aid wound healing process in patients with complex DFU.[30]

Several limitations may have influenced our results. First, the retrospective design limits the generalizability of our findings to populations with different demographics and health care systems.. Various confounding factors like socioeconomic status, location of ulcers, smoking status, and other co-morbidities were not considered in our study due to incomplete data. Economic constraints were the main hindrance for patients with low socio-economic capacity from achieving the best results. Second, the use of a single definition of chronic kidney disease (CKD), based solely on estimated glomerular filtration rate (eGFR) without incorporating other markers of kidney damage, may have led to misclassification of CKD status. Third, consistent with prior studies, we classified patients who died within 12 months of admission as having non-healing ulcers; however, some of these patients may have died from unrelated causes after complete wound healing had been achieved. Fourth, we did not apply correction methods for multiple testing which could affect the significance level in our data. Fifth, our analysis was conducted at the level of hospital admissions rather than individual patients. Although repeated admissions represented only 17.7% of the sample and largely corresponded to distinct DFU episodes with differing severity and management, the non-independence of observations could affect the validity of our results. Given the relatively small sample size and sparse clustering, attempts to employ mixed-effects or generalized estimating equation models risked non-convergence or unstable estimates. Therefore, we performed admission-level analysis while explicitly acknowledging this methodological limitation. Finally, the presence of PAD might be underreported from inherent limitations of ABI in patients with calcified vessels.

CONCLUSION

Our data is consistent with other studies reporting an increase in morbidity and mortality in CKD patients who develop DFU. It is important to maintain a proactive approach to foot care and early referral for DFU in patients with advanced CKD, especially if the patients are on dialysis. Despite continuous improvements in DFU management, advanced CKD patients still had unfavorable ulcer-related outcomes and increased mortality. Coordinated care between institutes and better efforts at public education are required to improve future outcomes.

Acknowledgments
The authors express their gratitude to the staff at the THEPTARIN Diabetes, Thyroid and Endocrine Center (TDTEC) and Foot Clinic and Wound Care, Vimut-Theptarin Hospital, Bangkok, Thailand for their dedicated and compassionate patient care. We also acknowledge the meticulous proofreading and editing provided by Dr. Tinapa Himathongkam and Professor Rajata Rajatanavin. Parts of this manuscript has previously been presented as a poster at IDF World Diabetes Congress 2025 at Bangkok, Thailand.

Statement of Authorship
All authors certified fulfillment of ICMJE authorship criteria.

CRediT Author Statement
JS and YT: Conceptualization, Software, Formal analysis, Data Curation, Visualization; **JS, SN, SB, and PC:** Methodology, Validation, Investigation, Writing – original draft preparation; **JS and SN:** Resources, Project administration; **SK, WC, EW, TS, PK, and PC:** Writing – review and editing; **YT:** Writing – review and editing; **TH:** Supervision, Funding acquisition.

Data Availability Statement
Datasets analyzed in the study are under license and not publicly available for sharing.

Author Disclosure
The authors declared no conflict of interest.

Funding Source
None.

References

1. Armstrong DG, Boulton AJM, Bus SA. Diabetic foot ulcers and their recurrence. N Engl J Med. 2017;376(24):2367-75. PMID: 28614678 DOI: 10.1056/NEJMra1615439
2. Hoffstad O, Mitra N, Walsh J et al. Diabetes, lower-extremity amputation, and death. Diabetes Care. 2015;38(10):1852-7. PMID: 26203063 DOI: 10.2337/dc15-0536
3. Morbach S, Furchert H, Gröblinghoff U et al. Long-term prognosis of diabetic foot patients and their limbs: Amputation and death over the course of a decade. Diabetes Care. 2012;35(10):2021-7. PMID: 22815299 PMCID: PMC3447849 DOI: 10.2337/dc12-0200
4. Wolf G, Müller N, Busch M et al. Diabetic foot syndrome and renal function in type 1 and 2 diabetes mellitus show close association. Nephrol Dial Transplant. 2009;24(6):1896-901. PMID: 19131351 DOI: 10.1093/ndt/gfn724
5. Otte J, van Netten JJ, Woittiez AJJ. The association of chronic kidney disease and dialysis treatment with foot ulceration and major amputation. J Vasc Surg. 2015;62(2):406-11. PMID: 25937604 DOI: 10.1016/j.jvs.2015.02.051
6. Bonnet JB, Sultan A. Narrative review of the relationship between CKD and diabetic foot ulcer. Kidney Int Rep. 2021;7(3):381-8. PMID: 35257052 PMCID: PMC8897302 DOI: 10.1016/j.ekir.2021.12.018
7. Salim M. Clinical outcomes among patients with chronic kidney disease hospitalized with diabetic foot disorders: A nationwide retrospective study. Endocrinol Diabetes Metab. 2021;4(3):e00277. PMID: 34277993 PMCID: PMC8279616 DOI: 10.1002/edm2.277

8. Gershater MA, Löndahl M, Nyberg P et al. Complexity of factors related to outcome of neuropathic and neuroischaemic/ischaemic diabetic foot ulcers: A cohort study. Diabetologia. 2009;52(3):398-407. PMID: 19037626 DOI: 10.1007/s00125-008-1226-2
9. Vadiveloo T, Jeffcoate W, Donnan PT et al. Amputation-free survival in 17,353 people at high risk for foot ulceration in diabetes: A national observational study. Diabetologia. 2019;62:1038-47. PMID: 30171278 PMCID: PMC6223842 DOI: 10.1007/s00125-018-4723-y
10. Bonnet JB, Szwarc I, Avignon A et al. Renal function is highly associated with podiatric risk in diabetic patients. Clin Kidney J. 2023;16(11):2156-63. PMID: 37915919 PMCID: PMC10616501 DOI: 10.1093/ckj/sfad106
11. Game FL, Selby NM, McIntyre CW. Chronic kidney disease and the foot in diabetes--is inflammation the missing link? Nephron Clin Pract. 2013;123(1-2):36-40. PMID: 23752138 DOI: 10.1159/000351813
12. Koye DN, Magliano DJ, Nelson RG et al. The Global Epidemiology of Diabetes and Kidney Disease. Adv Chronic Kidney Dis. 2018;25(2): 121-32. PMID: 29580576 PMCID: PMC11000253 DOI: 10.1053/j.ackd.2017.10.011
13. The Nephrology Society of Thailand. Clinical practice recommendations for evaluation and management of chronic kidney disease in adults 2022 (revised edition). https://www.nephrothai.org/wp-content/uploads/2023/03/CKD-guideline-2565-revised-edition.pdf
14. Thewjitcharoen Y, Krittiyawong S, Porramatikul S et al. Outcomes of hospitalized diabetic foot patients in a multi-disciplinary team setting: Thailand's experience. J Clin Transl Endocrinol. 2014;1(4): 187-91. PMID: 29159100 PMCID: PMC5685051 DOI: 10.1016/j.jcte.2014.10.002
15. Thewjitcharoen Y, Sripatpong J, Krittiyawong S et al. Changing the patterns of hospitalized diabetic foot ulcer (DFU) over a 5-year period in a multi-disciplinary setting in Thailand. BMC Endocr Disord. 2020;20:89. PMID: 32571283 PMCID: PMC7310152 DOI: 10.1186/s12902-020-00568-7
16. Kidney Disease: Improving Global Outcomes (KDIGO) CKD Work Group. KDIGO 2024 Clinical Practice Guideline for the Evaluation and Management of Chronic Kidney Disease. Kidney Int. 2024;105(4S): S117-314. PMID: 38490803 DOI: 10.1016/j.kint.2023.10.018
17. Wagner FW Jr. The dysvascular foot: A system for diagnosis and treatment. Foot Ankle. 1981;2(2):64-122. PMID: 7319435 DOI: 10.1177/107110078100200202
18. Ugwu E, Adeleye O, Gezawa I et al. Predictors of lower extremity amputation in patients with diabetic foot ulcer: Findings from MEDFUN, a multi-center observational study. J Foot Ankle Res. 2019;12:34. PMID: 31223342 PMCID: PMC6570910 DOI: 10.1186/s13047-019-0345-y
19. Barnes JA, Eid MA, Creager MA et al. Epidemiology and Risk of Amputation in Patients With Diabetes Mellitus and Peripheral Artery Disease. Arterioscler Thromb Vasc Biol. 2020;40:1808-17. PMID: 32580632 PMCID: PMC7377955 DOI: 10.1161/ATVBAHA.120.314595
20. Kullo IJ, Rooke TW. CLINICAL PRACTICE. Peripheral Artery Disease. N Engl J Med. 2016;374(9):861-71. PMID: 26962905 DOI: 10.1056/NEJMcp1507631
21. Miyajima S, Shirai A, et al. Risk factors for major limb amputations in diabetic foot gangrene patients. Diabetes Res Clin Pract. 2006; 71(3):272-9. PMID: 16139385 DOI: 10.1016/j.diabres.2005.07.005
22. Hurley L, Kelly L, et al. A prospective study of risk factors for foot ulceration: The West of Ireland Diabetes Foot Study. QJM. 2013; 106(12):1103-10. PMID: 24072752 DOI: 10.1093/qjmed/hct182
23. Boyko EJ, Ahroni JH, Cohen V, et al. Prediction of diabetic foot ulcer occurrence using commonly available clinical information: The Seattle Diabetic Foot Study Diabetes Care. 2006;29(6):1202-1207 PMID: 16731996 DOI 10.2337/dc05-2031
24. Bus SA, Lavery LA, Monteiro-Soares M, et al. Guidelines on the prevention of foot ulcers in persons with diabetes (IWGDF 2019 update) Diabetes Metab Res Rev. 2020;36(Suppl 1):e3269 PMID: 32176451 DOI: 10.1002/dmrr.3269
25. Margolis DJ, Hofstad O, Feldman HI. Association between renal failure and foot ulcer or lower-extremity amputation in patients with diabetes Diabetes Care. 2008;31(7):1331-1336 PMID: 18390800 PMCID: PMC2453658 DOI: 10.2337/dc07-2244
26. Orimoto Y, Ohta T, Ishibashi H, et al. The prognosis of patients on hemodialysis with foot lesions J Vasc Surg. 2013;58(5):1291-1299 PMID: 23810259 DOI: 10.1016/j.jvs.2013.05.027
27. Lavery LA, Lavery DC, Hunt NA, Fontaine J, Lavery RD. Does the start of dialysis initiate a period of increased risk of ulceration or amputation? J Am Podiatr Med Assoc. 2018;108(1): 1-5. PMID: 29547031 DOI: 10.7547/16-056
28. Health and Social Care Information Centre. National Diabetes Foot Care Audit Report 2014-2016. England and Wales; 2016. https://digital.nhs.uk/data-and-information/publications/statistical/national-diabetes-footcare-audit/national-diabetes-foot-care-audit-2014-2016
29. Shishehbor MH, Powell RJ, Montero-Baker MF, et al. Transcatheter arterialization of deep veins in chronic limb-threatening ischemia. N Engl J Med. 2023;388(3):1171-80. PMID: 36988592 DOI: 10.1056/NEJMoa2212754
30. Moore ZE, Corcoran MA, Patton D. Nutritional interventions for treating foot ulcers in people with diabetes. Cochrane Database Syst Rev. 2020;7(7):CD011378. PMID: 32677037 PMCID: PMC7388930 DOI: 10.1002/14651858.CD011378.pub2