Section: General Surgery

Original Research Article

CLINICAL PROFILE, MANAGEMENT, AND OUTCOMES OF DIABETIC FOOT ULCERS ACCORDING TO WAGNER CLASSIFICATION

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ABSTRACT

Background: Diabetic foot ulcer (DFU) is a major complication of diabetes mellitus and a leading cause of lower limb amputation. Early assessment of ulcer severity is essential for selecting appropriate management and improving limb salvage. This study evaluated the clinical profile, management strategies, and outcomes of patients with DFUs according to Wagner classification. **Materials and Methods:** This prospective observational longitudinal study included 55 patients with DFUs admitted to the Department of General Surgery at a tertiary care teaching hospital over 12 months. Demographic details, diabetes history, glycemic status, ulcer characteristics, Doppler findings, management, and outcomes were recorded. Ulcers were graded using the Wagner classification. **Results:** The mean age of participants was 58.78 ± 12.54 years, and 81.82% were male. Type 2 diabetes was present in 96.36% of patients, while 69.09% had poor glycemic control. Most ulcers were Wagner grade 4 (50.91%), followed by grade 3 (27.27%). Spontaneous ulcer development was observed in 74.54% of patients, and multifocal involvement was the most common presentation (38.18%). Doppler evaluation demonstrated progressive distal arterial flow abnormalities suggestive of peripheral arterial disease. Amputation was the most common treatment (49.09%), followed by debridement (41.82%) and conservative management (9.09%). Ray's amputation accounted for 62.96% of all amputations. A significant association was observed between Wagner grade and treatment modality ($p < 0.001$), with higher grades requiring more aggressive surgical intervention. Limb preservation was achieved in 85.45% of patients, and no mortality occurred during hospitalization. **Conclusion:** Advanced Wagner grade ulcers and poor glycemic control were common among patients with DFUs and were associated with increased surgical intervention. Early diagnosis, optimal diabetes control, regular foot surveillance, and timely referral are essential to reduce amputation rates and improve limb salvage.

INTRODUCTION

Diabetic foot ulcer (DFU) is one of the most serious complications of diabetes mellitus (DM) and represents a major public health challenge worldwide. It is associated with substantial morbidity, disability, impaired quality of life, frequent hospitalizations, and considerable healthcare expenditure for patients, families, and healthcare systems. The burden is particularly high in developing countries, where the prevalence of type 2 diabetes continues to rise and neuropathic foot ulcers remain largely preventable through early identification of high-risk individuals, patient education, and regular foot examinations. In India, approximately 10% to 25% of individuals with diabetes develop foot complications during the course of their disease, ranging from simple calluses to severe osteomyelitis and abscess formation.[1] Approximately 15% of patients with diabetes develop a foot ulcer during their lifetime, and nearly 85% of lower limb amputations are preceded by a non-healing ulcer. Diabetic foot complications are the leading cause of diabetes related hospital admissions. Epidemiological studies indicate that nearly 50% of DFUs are primarily neuropathic, 15% are ischemic due to peripheral arterial disease (PAD), and another 15% result from a combination of

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neuropathy and PAD. Even after successful healing, DFUs are characterized by a high recurrence rate, emphasizing the need for long term surveillance and preventive strategies.[2]

The pathogenesis of DFU is multifactorial. Chronic hyperglycemia contributes to peripheral neuropathy, endothelial dysfunction, mitochondrial injury, impaired microcirculation, and defective myelin regeneration, leading to loss of protective sensation and delayed wound healing. Repeated pressure over bony prominences, foot deformities, ill-fitting footwear, and repetitive mechanical stress predispose patients to callus formation, blistering, and ulceration. Because these ulcers are often painless, patients frequently present with advanced disease requiring complex management.

The primary goal of DFU management is rapid wound healing while preserving limb function. Since diabetes affects multiple organ systems, successful treatment requires a multidisciplinary approach involving glycemic optimization, infection control, vascular assessment, wound debridement, pressure offloading, and appropriate wound care. Comprehensive ulcer assessment, including evaluation of ulcer size, depth, location, infection, and vascular status, is essential for planning treatment and monitoring healing. Among several classification systems, the Wagner classification remains the most widely used because it categorizes ulcers according to depth, tissue necrosis, osteomyelitis, and gangrene, thereby facilitating treatment decisions and prognostication. In addition to conventional management, several adjuvant therapies such as negative pressure wound therapy, oxygen therapy, growth factors, acellular biological products, and advanced wound dressings have been investigated to improve healing outcomes.[3]

Previous studies have consistently demonstrated that ulcer severity, poor glycemic control, peripheral neuropathy, and PAD are major determinants of treatment outcomes. Shah et al. reported that most patients presented with Wagner grade 2 ulcers requiring debridement, whereas advanced grades frequently required below knee amputation. Higher HbA1c levels, neuropathy, and PAD were strongly associated with advanced ulcer grades and amputation.[4] Gupta et al. emphasized that patient education and preventive foot care remain the most effective strategies for reducing the burden of diabetic foot disease.[5] Similarly, Akther et al. found that Wagner grade 2 ulcers were the most common presentation, while poor glycemic control, neuropathy, vasculopathy, and inadequate awareness regarding foot care significantly contributed to disease severity.[6] Kumar demonstrated that the Wagner classification effectively guides treatment selection, with lower grade ulcers responding to conservative management and debridement, whereas higher grade lesions frequently require amputation.[7]

The present study was undertaken to evaluate diabetic foot ulcers according to Wagner's classification, assess the management strategies employed at our tertiary care centre, and determine clinical outcomes based on ulcer grade.

MATERIALS AND METHODS

Study design and setting: This observational longitudinal study was conducted in the Department of General Surgery, Himalayan Institute of Medical Sciences, Swami Ram Nagar, Dehradun, over a period of 12 months. Ethical approval was obtained from the Institutional Ethics Committee before commencement of the study, and written informed consent was obtained from all participants prior to enrollment. All patients admitted to the surgical ward with diabetic foot ulcers during the study period and fulfilling the eligibility criteria were considered for inclusion.

Sample size: The sample size was calculated using the formula:

$$n = \frac{Z^2_{(1-\alpha/2)} \times p(1-p)}{d^2}$$

where Z = 1.96 at a 95% confidence level, p = 15% estimated prevalence of diabetic foot based on previous literature, and d = 10% absolute margin of error. The calculated minimum sample size was 50 participants. After accounting for possible non response and dropouts, a total of 55 patients were included in the study.

Study participants: Patients diagnosed with diabetic foot ulcers were eligible for inclusion in the study. Patients presenting with acute traumatic ulcers or those with a history of previous amputation proximal to the ankle joint were excluded. A structured case record form was used for systematic data collection throughout the study.

Clinical evaluation and investigations: After obtaining informed consent, detailed demographic and clinical information was recorded, including age, sex, family history of diabetes mellitus, duration and type of diabetes, and vascular and neurological examination findings. A comprehensive history of the foot ulcer, including onset, duration, progression, and associated symptoms, was obtained. Laboratory investigations included complete blood count, fasting blood glucose, random blood glucose, two-hour postprandial blood glucose, liver function tests, and kidney function tests. Wound swabs were collected under aseptic precautions for microbiological culture and sensitivity testing. Radiological evaluation included plain radiography of the affected foot and Doppler ultrasonography of the lower limb arteries to assess vascular status.

Ulcer assessment and classification: Each patient underwent a detailed examination of the affected foot, and ulcers were classified according to the Wagner classification system. Grade 0 represented a high-risk foot without ulceration, Grade 1 a superficial ulcer without clinical infection, Grade 2 a deeper ulcer with cellulitis but without abscess or osteomyelitis, Grade 3 a deep ulcer associated with abscess formation or bone involvement, Grade 4

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localized gangrene, and Grade 5 gangrene involving the entire foot. This classification was used to determine disease severity and guide management.

Management and follow up: Management was individualized according to the Wagner grade and clinical condition of the patient. Treatment modalities included conservative medical management, surgical debridement, amputation, and reconstructive procedures such as split skin grafting where indicated. Patients were clinically evaluated at admission, between days 5 and 7 after initiation of treatment, and again at the time of hospital discharge to assess wound healing, treatment response, and clinical outcome.

Statistical analysis

Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 20. Continuous variables were expressed as mean ± standard deviation or median with interquartile range, as appropriate, while categorical variables were presented as frequencies and percentages. Student's *t* test was used for comparison of continuous variables, whereas the Chi square test or Fisher's exact test was applied for comparison of categorical variables. A *p* value of less than 0.05 was considered statistically significant.

RESULTS

The mean age of the study participants was 58.78 ± 12.54 years, with a median age of 62 years (IQR: 48–68 years) and an age range of 35 to 80 years. More than half of the participants (50.91%) were older than 60 years, followed by 36.36% aged 41–60 years and 12.73% aged 40 years or younger. Most participants were male (81.82%), while females accounted for 18.18% of the study population. Type 2 diabetes was present in 96.36% of patients, whereas only 3.64% had type 1 diabetes. Smoking or tobacco use was reported by 58.18% of participants, while 41.82% had no history of smoking or tobacco use. [Table 1]

Table 1: Baseline demographic and clinical characteristics of the study population (n = 55)

Variable	Domain	Value
Age (years)	Mean ± SD	58.78 ± 12.54
	Median (IQR)	62 (48–68)
	Range	35–80
Age group n (%)	≤40 years	7 (12.73)
	41–60 years	20 (36.36)
	>60 years	28 (50.91)
Gender n (%)	Male	45 (81.82)
	Female	10 (18.18)
Type of diabetes n (%)	Type 1	2 (3.64)
	Type 2	53 (96.36)
Smoking/Tobacco use n (%)	Yes	32 (58.18)
	No	23 (41.82)

The mean duration of diabetes was 9.78 ± 7.13 years, with a median duration of 9 years (IQR: 5–12 years) and a range of 1 to 42 years. The mean duration of diabetic foot ulcer was 31.71 ± 41.04 days, with a median duration of 20 days (IQR: 10–30 days) and a range of 3 to 240 days. The mean HbA1c level was 9.32 ± 2.40%, with values ranging from 6.10% to 15.00%. Poor glycemic control was observed in 69.09% of patients, while 21.82% had fair glycemic control and only 9.09% had good glycemic control. Nearly half of the patients (49.09%) had irregular diabetic follow up, 36.36% had regular follow up, and 14.55% had no previous follow up. Before admission, 69.09% of patients were receiving oral hypoglycemic agents, 9.09% were on insulin therapy, 10.91% were using alternative medicine, and 10.91% were not taking any treatment. Most patients (92.73%) had no previous surgery on the affected limb, while 3.64% had undergone incision and drainage, 1.82% had previous debridement, 1.82% had previous amputation, and 1.82% had undergone a procedure by an unqualified practitioner. [Table 2]

Table 2: Disease characteristics, glycemic status and previous management (n = 55)

Variable	Domain	Value
Duration of diabetes (years)	Mean ± SD	9.78 ± 7.13
	Median (IQR)	9 (5–12)
	Range	1–42
Duration of DFU (days)	Mean ± SD	31.71 ± 41.04
	Median (IQR)	20 (10–30)
	Range	3–240
HbA1c (%)	Mean ± SD	9.32 ± 2.40
	Range	6.10–15.00
Glycemic control n (%)	Good	5 (9.09)
	Fair	12 (21.82)
	Poor	38 (69.09)
Frequency of diabetic follow up n (%)	None	8 (14.55)
	Irregular	27 (49.09)
	Regular	20 (36.36)
Treatment before admission n (%)	Oral hypoglycemic agents	38 (69.09)

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	Insulin	5 (9.09)
	Alternative medicine	6 (10.91)
	No medication	6 (10.91)
Previous surgery (same limb) n (%)	None	51 (92.73)
	Debridement	1 (1.82)
	Incision and drainage	2 (3.64)
	Amputation	1 (1.82)
	Self/unqualified procedure	1 (1.82)

Most patients had Wagner grade 4 ulcers (50.91%), followed by grade 3 (27.27%). Grade 2 and grade 5 ulcers were each observed in 9.09% of patients, while grade 1 ulcers were the least common, accounting for 3.64% of cases. The majority of ulcers developed spontaneously without any recognizable injury (74.54%), whereas 25.46% were associated with trauma. The left foot was more commonly affected (54.55%) than the right foot (43.64%), and bilateral involvement was seen in 1.82% of patients. The most common ulcer location was a combination of multiple sites (38.18%), followed by the digits and heel (14.55% each), dorsum of the foot (12.73%), whole foot (10.91%), and plantar aspect (9.09%). Examination of the contralateral limb showed that most patients (78.18%) had a normal limb, while 7.27% had discoloration and another 7.27% had a previous amputation. Grade 1 ulcer was present in 3.64% of patients, whereas healed ulcer and not applicable findings were each observed in 1.82% of patients. [Table 3]

Table 3: Clinical profile of diabetic foot ulcers (n = 55)

Variable	Domain	n (%)
Wagner grade	Grade 1	2 (3.64)
	Grade 2	5 (9.09)
	Grade 3	15 (27.27)
	Grade 4	28 (50.91)
	Grade 5	5 (9.09)
Mode of injury	Spontaneous	41 (74.54)
	Traumatic	14 (25.46)
Laterality	Right	24 (43.64)
	Left	30 (54.55)
	Bilateral	1 (1.82)
Location	Digits	8 (14.55)
	Plantar	5 (9.09)
	Dorsum	7 (12.73)
	Heel	8 (14.55)
	Combination	21 (38.18)
	Whole foot	6 (10.91)
Contralateral limb	Normal	43 (78.18)
	Discoloration	4 (7.27)
	Grade 1 ulcer	2 (3.64)
	Healed ulcer	1 (1.82)
	Previous amputation	4 (7.27)
	Not applicable	1 (1.82)

USG Doppler findings for the femoral artery showed triphasic flow in 60.00% on both right and left sides. Biphasic flow was observed in 29.09% on the right and 38.18% on the left, while monophasic flow was noted in 10.91% on the right and 1.82% on the left. For the popliteal artery, triphasic flow was recorded in 50.91% bilaterally. Biphasic flow was seen in 34.55% on the right and 36.36% on the left, monophasic flow in 12.73% bilaterally, and absence of flow in 1.82% on the right side only. In the anterior tibial artery, triphasic flow was found in 43.64% on the right and 41.82% on the left. Biphasic flow occurred in 40.00% bilaterally, monophasic flow in 10.91% on the right and 14.55% on the left, and absence of flow in 5.45% on the right and 3.64% on the left. Regarding the posterior tibial artery, triphasic flow was observed in 41.82% bilaterally. Biphasic flow was present in 30.91% on the right and 27.27% on the left, monophasic flow in 21.82% on the right and 25.45% on the left, with absence of flow noted in 5.45% bilaterally. For the dorsalis pedis artery, triphasic flow was detected in 36.36% on the right and 32.73% on the left. Biphasic flow was recorded in 20.00% on the right and 27.27% on the left, monophasic flow in 34.55% on the right and 27.27% on the left, and absence of flow in 9.09% on the right and 12.73% on the left. [Figure 1-2]

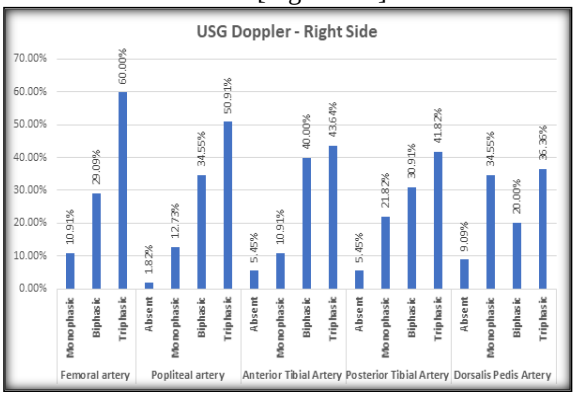

Figure 1: USG Doppler artery of Left side (n = 55)

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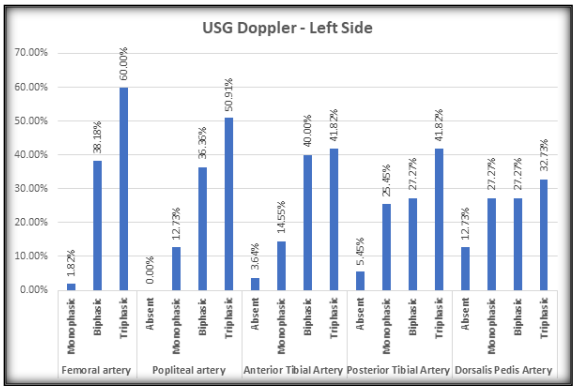

Figure 2: USG Doppler artery of Left side (n = 55)

Amputation was the most common management modality, performed in 49.09% of patients, followed by debridement in 41.82%, while 9.09% were managed conservatively. Among the 27 patients who underwent amputation, Ray's amputation was the most frequently performed procedure (62.96%), followed by below knee amputation (29.63%) and forefoot amputation (7.41%). No patient required above knee amputation. Reconstructive procedures included split skin grafting in 20.00% of patients, flap coverage in 5.45%, and secondary suturing in 1.81%. At the final follow up, 85.45% of patients retained a functional limb, whereas 14.55% experienced limb loss and were fitted with a prosthesis. [Table 4]

Table 4: Management of diabetic foot ulcers according to Wagner grade

Variable	Domain	n (%)
Overall management	Conservative	5 (9.09)
	Debridement	23 (41.82)
	Amputation	27 (49.09)
Type of amputation (n=27)	Ray's	17 (62.96)
	Forefoot	2 (7.41)
	Below knee	8 (29.63)
	Above knee	0
Reconstruction	Split skin graft	11 (20.00)
	Flap	3 (5.45)
	Secondary suturing	1 (1.81)
Final outcome	Functional limb	47 (85.45)
	Limb loss with prosthesis	8 (14.55)

There was a significant association between Wagner grade and the management modality ($p < 0.001$). All patients with Wagner grade 1 ulcers were managed conservatively (100%). Among patients with grade 2 ulcers, 40.00% received conservative treatment and 60.00% underwent debridement. Most grade 3 ulcers were managed with debridement (86.67%), while 6.67% each were treated conservatively or required amputation. In grade 4 ulcers, amputation was performed in 75.00% of patients, whereas 25.00% underwent debridement. All patients with Wagner grade 5 ulcers (100%) required amputation. The need for surgical intervention, particularly amputation, increased progressively with higher Wagner grades. [Table 5]

Table 5: Association between Wagner grade and management modality

Wagner grade	Conservative	Debridement	Amputation	p value
Grade 1	2 (100)	0	0	<0.001
Grade 2	2 (40)	3 (60)	0	
Grade 3	1 (6.67)	13 (86.67)	1 (6.67)	
Grade 4	0	7 (25)	21 (75)	
Grade 5	0	0	5 (100)	

DISCUSSION

The present study evaluated the demographic profile, clinical characteristics, management, and outcomes of 55 patients with diabetic foot ulcers (DFUs) treated at a tertiary care center. The findings highlight that DFUs predominantly affected older adults with long standing type 2 diabetes, poor glycemic control, and advanced ulcer grades, resulting in a high requirement for surgical intervention.

The mean age of the study population was 58.78 ± 12.54 years, with more than half of the patients older than 60 years. Similar findings have been reported by Sreeja et al,[8] who observed a mean age of 57.62 years with most patients belonging to the sixth decade of life. Boopathy et al,[9] Singaraddi et al,[10] Yadav et al,[11] and Bhaskar Patil et al,[12] also reported that DFUs were more common among patients older than 50 years. Increasing age is associated with prolonged diabetes duration, peripheral neuropathy, and vascular disease, all of which contribute to ulcer development.

Male predominance was observed in the present study, with males accounting for 81.82% of cases. Similar male predominance has been reported by Sreeja et al,[8] Boopathy et al,[9] Singaraddi et al,[10] and Bhaskar Patil et al.[12] Most patients had type 2 diabetes (96.36%), and more than half were smokers or tobacco users. Bhaskar Patil et al,[12] similarly identified type 2 diabetes, tobacco use, and smoking as important factors associated with diabetic foot disease, while Sreeja et al,[8] also reported a high prevalence of previous diabetic foot ulcers and peripheral vascular disease.

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The mean duration of diabetes was 9.78 years, reflecting the chronic nature of the disease before ulcer development. The mean ulcer duration was 31.71 days, indicating delayed presentation for medical care. Similar observations were reported by Boopathy et al,[9] where most patients had diabetes for more than five years and presented with ulcers of one to three months duration. Delayed presentation increases the risk of infection, tissue loss, and need for surgical intervention.

Poor glycemic control was common in the present study, with a mean HbA1c of 9.32% and 69.09% of patients demonstrating poor glycemic control. These findings are consistent with Singaraddi et al,[10] who also reported elevated HbA1c levels in most patients, and Abhirup et al,[13] who found that the majority of patients had HbA1c values above 8%. Poor glycemic control impairs wound healing, promotes infection, and increases the risk of ulcer progression. Nearly half of the patients had irregular diabetic follow up, while most were receiving oral hypoglycemic agents, suggesting that inadequate long term diabetes management may have contributed to ulcer development.

Most ulcers were classified as Wagner grade 4, followed by grade 3, indicating that many patients presented with advanced disease. The majority of ulcers developed spontaneously and involved multiple sites, with the left foot being more frequently affected. Similar findings regarding ulcer characteristics have been reported by Sreeja et al,[8] Boopathy et al,[9] Singaraddi et al,[10] and Bhaskar Patil et al,[12] although Boopathy et al,[9] reported a higher proportion of lower Wagner grades. The advanced ulcer grades observed in the present study likely reflect delayed presentation and poor glycemic control.

Arterial Doppler assessment demonstrated progressive reduction in normal triphasic flow from proximal to distal arteries, particularly in the tibial and dorsalis pedis arteries, suggesting significant peripheral arterial disease in many patients. Comparable findings were reported by Abhirup et al,[13] who observed frequent involvement of the anterior and posterior tibial arteries. Doppler examination is valuable for identifying vascular compromise and planning limb salvage procedures.

Surgical treatment was required in most patients. Amputation was performed in 49.09% of cases, while 41.82% underwent debridement and only 9.09% were managed conservatively. Ray's amputation was the most common amputation procedure. Similar observations were reported by Sreeja et al,[8] who identified gangrene as a major predictor of amputation. These findings emphasize the importance of early diagnosis and timely intervention to reduce limb loss.

A significant association was observed between Wagner grade and treatment modality. Lower grade ulcers were managed conservatively or with debridement, whereas higher grade ulcers increasingly required amputation. All grade 5 ulcers underwent amputation, while 75% of grade 4 ulcers required limb removal. Similar trends were reported by Abhirup et al,[13] and Seth et al,[14] who demonstrated that increasing ulcer severity was associated with higher amputation rates and poorer healing outcomes.

Despite the severity of disease, 85.45% of patients retained a functional limb at discharge, while 14.55% experienced limb loss requiring prosthetic rehabilitation. No mortality was recorded during the study period. McDermott et al,[15] reported substantially higher long term recurrence, amputation, and mortality rates, highlighting the importance of continued follow up after discharge. Seth et al,[14] also reported increased readmissions and poorer outcomes among patients with severe diabetic foot infections.

The strengths of this study include comprehensive clinical evaluation, standardized Wagner grading, vascular assessment using Doppler ultrasonography, and assessment of treatment outcomes in a real-world tertiary care setting. However, the study was limited by its single center design, relatively small sample size, and absence of long term follow up, which limits assessment of ulcer recurrence, functional recovery, and mortality. Larger multicenter studies with longer follow up are required to better evaluate long term outcomes and optimize management strategies for patients with diabetic foot ulcers.

CONCLUSION

Diabetic foot ulcers predominantly affected older male patients with long standing type 2 diabetes and poor glycemic control. Most patients presented with advanced Wagner grade ulcers, requiring surgical management, particularly amputation. Higher ulcer grades were significantly associated with more invasive treatment, emphasizing the importance of early diagnosis and timely intervention. Despite the severity of disease, limb preservation was achieved in most patients. Regular diabetic follow up, optimal glycemic control, smoking cessation, routine foot examination, and early referral to specialized care are essential to reduce ulcer severity, prevent amputations, and improve clinical outcomes in patients with diabetic foot ulcers.

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