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Research Article

Effects of a Multidisciplinary Therapeutic Approach to "Diabetic Foot" Complications: A Single-Center Pilot Study from Turkey

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Abstract

Objectives: The prevalence of diabetes mellitus is rapidly increasing in society. Every year, millions of people suffer from diabetic foot complications. This study was conducted to evaluate the effectiveness of a multidisciplinary approach in diabetic foot treatment.

Methods: A total of 85 cases with diabetic foot complications were analyzed in the study. Besides, we evaluated patients' personal information, any morbidity, the consultations they asked for while planning their treatment, the surgical options they preferred, the SINBAD and PEDIS scores they had when they were admitted to the hospital, and how these scores related to each other.

Results: The number of male patient was higher (66, 77%) and the average age of all patients was 67.4 (40-93) years. The frequency of chronic ischemic heart disease was found to be 96% among the patients and also 51 patients (60%) underwent peripheral vascular interventional angiography. Wound debridement was performed on 38 patients (44%), and various levels of amputations were conducted on 47 patients. While 39 of the patients received hyperbaric oxygen therapy (HBOT) and 34 received vacuum-assisted wound closure (VAC) system treatment.

Conclusion: This single clinical study demonstrates that a multidisciplinary approach is an effective strategy for treating diabetic foot complications.

Keywords: Diabetic foot, complication, multidisciplinary approach

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Diabetes mellitus (DM) is rapidly becoming a significant public health issue in society. Consequently, diabetic complications are also increasingly prevalent worldwide. The prevalence of the disease has doubled in the last 20 years, and it is estimated that by the year 2045, approximately 693 million adults worldwide will be affected by the disease.[1]

Each year, diabetes-related foot ulcers affect an estimated 18.6 million people worldwide. These ulcers are initially seen as clinical manifestations in 80% of patients who have lower extremity amputations due to diabetes. Studies have associated diabetic foot ulcers with an increased risk of mortality.[2] A patient with a diabetic foot ulcer has a risk of mortality within 5 years that is 2.5 times higher compared to a diabetic patient without a diabetic foot ulcer.[3]

This study was conducted to evaluate the effect of a multidisciplinary approach in diabetic foot treatment. Effective management of diabetic foot treatment is important to reduce the risk of amputation, improve the quality of life of patients, and reduce the impact of all these financial and moral burdens.

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A multidisciplinary approach can facilitate the provision of individualized and comprehensive care to patients by bringing together various healthcare professionals. This one-center study looked at the effects of multidisciplinary team care on clinical outcomes for diabetic foot patients.

Methods

This study was conducted between August 2016 and August 2023 (7 years) as a single center in the orthopedics and traumatology outpatient clinic of a tertiary healthcare institution. A total of 85 cases of diabetic foot complications (DFCs) were included in the study, all of which were evaluated, followed up on, and treated by a single orthopedics and traumatology physician.

The demographic information of the patients, such as their admission dates, age, and gender, was recorded. Concomitant conditions such as chronic ischemic heart disease and chronic kidney failure were noted in these patients diagnosed with diabetes mellitus.

In the management of patients' treatments, consultations were sought from various specialties such as infectious diseases, endocrinology, nephrology, and cardiology. The preferred surgical treatment options (debridement, finger amputation, foot amputation, below-knee amputation, above-knee amputation) were recorded, along with the supportive treatment systems accompanying surgical treatment (peripheral vascular interventions, HBOT, VAC).

By evaluating the clinical conditions and laboratory parameters of all patients, SINBAD scores and PEDIS scores were calculated.[4] The SINBAD score system is a simple and fast system that measures only clinical examination findings (Table 1).[5] The PEDIS Score was modified based on the Infectious Diseases Society of America/IWGDF (IDSA/IWGDF) Classification for Diabetic Foot Disease Assessment.[6] The IDSA/IWGDF classification (Table 2) assesses the severity of infection in four degrees based on the clinical findings of the patient. The PEDIS score evaluates five separate parameters out of a total of 12 points (Table 3).

Table 1. SINBAD score in evaluation of diabetic foot

Category	Definition	Score (Range: 0-6)
Site	Forefoot	0
	Midfoot and hindfoot	1
Ischemia	Pedal blood flow intact: at least one people pulse	0
	Clinical evidence of reduced pedal flow	1
Neuropathy	Protective sensation intact	0
	Protective sensation lost	1
Bacterial Infection	None	0
	Present	1
Area ulcer	Ulcer <1 cm^2	0
	Ulcer ≥1 cm^2	1
Depth	Ulcer confined to skin and subcutaneous tissue	0
	Ulcer reaching muscle, tendon or deeper	1

Statistical Analysis

The suitability of the data for normal distribution was examined with the Shaphiro Wilk Test. Relationships between categorical variables were analyzed with the Pearson Chi-Square Test. Relationships between numerical variables were analyzed using the Spearman Correlation Coefficient Test. If the correlation coefficient is between 0.8 and 1, it indicates a very strong relationship; if it takes values between 0.6 and 0.8, it indicates a strong relationship; if it is between 0.4 and 0.6, it indicates a moderate relationship; and if it is between 0.2 and 0.4, it indicates a weak relationship. In descriptive statistics, median IQR=(Q3-Q1) is given for numerical variables, and number and percentage values are given for categorical variables. Data analysis was performed using the SPSS version 24.0 statistical program (Statistical Package for the Social Sciences, IBM Corporation, Armonk, New York, United States). A p-value of less than 0.05 was considered statistically significant.

Results

It was observed that the male gender was numerically superior (66/85, 77%) and the average age of the patients was 67.4 (40–93) years. The frequency of chronic ischemic heart disease was found to be 96.5% (82/85), while the frequency of chronic kidney failure was 16.5% (14/85) among the patients.

Throughout their treatments, an internal medicine specialist kept track of each patient's blood sugar regulation. During treatment, 48.2% of patients (41/85) were consulted with an infectious diseases specialist and received antibiotic treatment based on culture-antibiogram results. 95.3% of patients (81/85) were consulted with a cardiology specialist, assessed for ischemic heart disease, and initiated necessary treatments. A total of 51 patients (60%, 51/85) underwent peripheral vascular interventional angiography.The average CRP value at the time of admission was 64.2.When considering the preferred surgical procedures for patients, it was observed that debridement was performed on 38 patients (44%). The overall amputation rate in the cases of this study was calculated at 56% (47/85). When subgroups were created based on the levels of amputation, it was observed that 22 patients underwent finger amputation, 8 patients underwent foot amputation, 9 patients under-

Table 2. CDSA/IWGDF Classification in diabetic foot

Clinical manifestations	Infection severity	PEDIS Grade (Range: 1-4)
Wound lacking purulence or any manifestations of inflammation	Uninfected	1
Presence of ≥2 manifestations of inflammation (purulence, or erythema, tenderness, warmth, or induration), but any cellulitis/erythema extends ≤2 cm around the ulcer, and infection is limited to the skin or superficial subcutaneous tissues; no other local complications or systemic illness	Mild	2
Infection (as above) in a patient who is systemically well and metabolically stable but which has ≥1 of the following characteristics: cellulitis extending >2 cm, lymphangitic streaking, spread beneath the superficial fascia, deeptissue abscess, gangrene, and involvement of muscle, tendon, joint or bone	Moderate	3
Infection in a patient with systemic toxicity or metabolic instability (e.g. fever, chills, tachycardia, hypotension, confusion, vomiting, leucocytosis, acidosis, severe hyperglycaemia, or azotaemia)	Severe	4

Table 3. PEDIS score in evaluation of diabetic foot

Category	Clinical Manifestations	Score (Range: 0-12)
Perfusion	No peripheral arterial disease	0
	Peripheral arterial disease, no critical limb ischemia	+1
	Critical limb ischemia	+2
Extent	Skin intact	0
	<1 cm^2	+1
	1–3 cm^2	+2
	>3 cm^2	+3
Depth	Skin intact	0
	Superficial	+1
	Fascia, muscle, tendon	+2
	Bone or joint	+3
Infection	None	0
	Surface	+1
	Abscess, fasciitis, and/or septic arthritis	+2
	Systemic inflammatory response syndrome	+3
Sensation	Sensation intact	0
	Loss of sensation	+1

went below-knee amputation, and 8 patients underwent above-knee amputation procedures. When patients are analyzed in terms of supportive treatment systems accompanying surgical treatment, it was observed that 39 patients (45%) received HBOT and 34 patients (40%) received VAC systems (Table 4).

SINBAD scores and PEDIS scores were calculated at the time of patients' admission to determine the severity of infection and necrosis in their extremities (Tables 5 and Table 6). The distribution of the cases in terms of gender and other clinical characteristics was compared according to the surgical procedure applied (Table 2). It was determined that gender, VAC, and HBOT distributions were statistically

Table 4. General characteristics of cases with diabetic foot

	n (%)	M [IQR]
Gender		
Male	66 (77.6)	
Female	19 (22.4)	
Age		67 [14]
CRP		42.9 [80.8]
SINBAD Score		4 [3]
PEDIS Score		9 [6]
Surgical Procedure		
Debridement	38 (44.7)	
Finger amputation	22 (25.9)	
Foot amputation	8 (9.4)	
Below knee amputation	9 (10.6)	
Above knee amputation	8 (9.4)	
Chronic Ischeamic Heart Disease		
Yes	82 (96.5)	
No	3 (3.5)	
Chronic Renal Failure		
Yes	14 (16.5)	
No	71 (83.5)	
Vacuum Assisted Closure (VAC)		
Yes	34 (40)	
No	51 (60)	
Hyperbaric Oxygen Therapy (HBOT)		
Yes	39 (45.9)	
No	46 (54.1)	
Infectious Diseases Consultation		
Yes	41 (48.2)	
No	44 (51.8)	
Cardiology Consultation		
Yes	81 (95.3)	
No	4 (4.7)	
Peripheral Vascular Intervention		
Yes	51 (60)	
No	34 (40)	

M: Median and IQR: Interquartile range [IQR:Q3–Q1] (n=85); CRP: C-reactive protein.

Table 5. SINBAD score results for all cases with diabetic foot

SINBAD score	n	Percentage (%)
1	7	8
2	10	12
3	14	17
4	13	15
5	13	15
6	28	28
Total	85	100

Table 6. PEDIS score results for all cases with diabetic foot

PEDIS score	n	Percentage (%)
3	3	4
4	7	8
5	12	14
6	6	7
7	6	7
8	4	5
9	11	13
10	7	8
11	10	12
12	19	22
Total	85	100

significantly different between surgery types ($p<0.05$). Debridement operations were encountered in 89.5% (n=34), finger amputation in 63.6% (n=14), below-knee amputation in 77.8% (n=7), and above-knee amputation in 87.5% (n=7). It was observed that the rate was significantly higher in men compared to women ($p=0.035$). It was observed that the frequency of VAC application in patients with foot amputation and finger amputation (63.6% and 75%, respectively) was statistically significantly higher ($p=0.005$). Similarly, it was observed that the frequency of HBOT application in patients with foot amputation and finger amputation (63.6% and 62.5%, respectively) was statistically significantly higher ($p=0.018$) (Table 7).

The relationships of the cases with SINBAD Score, PEDIS Score, age, CRP and surgical procedure were examined. A positive, moderate, and statistically significant relationship was detected between the surgical procedure and CRP values ($r=0.471$; $p<0.001$). A strong positive, statistically significant relationship was detected between the surgical procedure and SINBAD values ($r=0.879$; $p<0.001$). As the SINBAD score increases, an increase in the amputation level is expected. A strong positive, statistically significant relationship was detected between the surgical procedure and PEDIS scores ($r=0.882$; $p<0.001$). As the PEDIS score increases, the amputation level is expected to increase. A moderate, statistically significant relationship was detected between CRP values and SINBAD and PEDIS scores ($p<0.001$) (Table 8).

Discussion

DFCs are becoming a significant public health concern, given the increasing prevalence of diabetes worldwide. In some cases, it is overlooked that DFC may be life-threatening.[7] Delaying appropriate and timely treatment can result in severe infections accompanied by rapidly progressing skin and tissue necrosis, often associated with significant systemic symptoms. In such situations, initiating treatment as quickly as possible not only reduces the risk of permanent damage to the patient but also lowers mortality. Patients often seek care at multiple healthcare centers, wasting time before receiving the correct treatment. Consequently, what could have been a manageable pathology with early interventions turns into a complex problem threatening the patient's life. [8] Based on this information, our study has drawn conclusions regarding the effects of a multidisciplinary treatment approach on diabetic foot complications.

While the SINBAD score was <5 in only 15% of the patients who underwent amputation, this score was calculated as <5 in all patients who underwent wound debridement. In a previous study, it was reported that in the amputated patient group, 28.9% had a SINBAD score of <5.[8] To ensure the continuation of patients' lives and minimize potential disability, the preservation of maximum limb reserves should be the goal for these patients. In patients with DFC, impaired circulation must be revascularized, and advanced wound care and healing techniques must be used. In our study, revascularization was achieved by performing a peripheral vascular angiographic procedure in patients who were suitable for the procedure and accepted the procedure in order to restore the impaired extremity circulation of the patients (51/85, 60%). HBOT was administered to 45% of patients (39/85), and VAC was used in 40% of patients (34/85) to promote advanced wound care and accelerate healing. We attribute the completion of treatment with wound debridement in 44% of our patients to the success of this strategy.

As a result of the groupings made, it was observed that there was a predominance in male individuals affected by DFC (77%) and in the male gender ratio of amputated patients (32/47, 68%), in line with the literature.[9-11]

Current literature data have reported various values related to the amputation rate above the ankle level for patients with DFC. In our study, amputations above the ankle level were performed in approximately 20% of our patients, which is in close alignment with these reported values.[9,12]

Some studies have reported that the age group with the highest incidence of diabetic foot complications is be-

Table 7. Comparison of demographic and clinical characteristics of cases by surgical procedure

	Surgical Procedure					
	Debridement	Finger amputation	Foot amputation	Below knee amputation	Above knee amputation	
	n (%)	n(%)	n (%)	n (%)	n (%)	P
Gender						
Male	34 (89.5)	14 (63.6)	4 (50)	7 (77.8)	7 (87.5)	0.035
Female	4 (10.5)	8 (36.4)	4 (50)	2 (22.2)	1 (12.5)	
Chronic Isch. Heart Disease						
Yes	37 (97.4)	21 (95.5)	8 (100)	8 (88.9)	8 (100)	0.688
No	1 (2.6)	1 (4.5)	0 (0)	1 (11.1)	0 (0)	
Chronic Renal Failure						
Yes	6 (15.8)	5 (22.7)	2 (25)	1 (11.1)	0 (0)	0.587
No	32 (84.2)	17 (77.3)	6 (75)	8 (88.9)	8 (100)	
VAC						
Yes	10 (26.3)	14 (63.6)	6 (75)	3 (33.3)	1 (12.5)	0.005
No	28 (73.7)	8 (36.4)	2 (25)	6 (66.7)	7 (87.5)	
HOT						
Yes	19 (50)	14 (63.6)	5 (62.5)	2 (22.2)	0 (0)	0.018
No	19 (50)	8 (36.4)	3 (37.5)	7 (77.8)	8 (100)	
Infectious Diseases Consultation						
Yes	15 (39.5)	9 (40.9)	4 (50)	7 (77.8)	6 (75)	0.131
No	23 (60.5)	13 (59.1)	4 (50)	2 (22.2)	2 (25)	
Cardiology Consultation						
Yes	35 (92.1)	21 (95.5)	8 (100)	9 (100)	8 (100)	0.718
No	3 (7.9)	1 (4.5)	0 (0)	0 (0)	0 (0)	
Peripheral Vascular Intervention						
Yes	22 (57.9)	13 (59.1)	7 (87.5)	7 (77.8)	2 (25)	0.097
No	16 (42.1)	9 (40.9)	1 (12.5)	2 (22.2)	6 (75)	

The p value was obtained from the Pearson Chi square test.

Table 8. Correlation between surgical procedure and age, CRP, SINBAD, PEDIS scores of the cases with diabetic foot

	Age	CRP	SINBAD score	PEDIS score
Surgical Procedure				
r	-0.020	0.471**	0.879**	0.882**
p	0.853	<0.001	<0.001	<0.001
Age				
r		0.125	0.046*	0.040*
p		0.255	0.675	0.716
CRP				
r			0.486**	0.525**
p			<0.001	<0.001
SINBAD score				
r				.935**
p				<0.001

r: Spearman Correlation Coefficient (n=85); C-reactive protein; **The correlation coefficient is significant at the 0.01 level; *The correlation coefficient is significant at the 0.05 level.

tween the ages of 45 and 64.[13,14] In our study, the average age was found to be 67.4 (40–93).

In previous studies, it was stated that a high CRP value during hospital admission for patients with diabetic foot complications was a predictive factor for major amputation.[15,16] In our study, the average CRP value was calculated as 36.8 in patients who underwent debridement, while the average CRP value in patients who underwent amputation was 86.3.

Consistent with the literature, we think that a multidisciplinary approach throughout the treatment of patients is a necessity to increase treatment success.[17-19]

Limitations

The limitations of this study include that it was single-center and included a relatively small patient sample. As a result, caution is advised when assessing the applicability of the findings to larger and more diverse patient populations, and the generalizability of the results should be approached with care.

Conclusion

This single-center pilot study shows that a multidisciplinary treatment approach may yield positive results in the management of diabetic foot complications in Turkey. A comprehensive evaluation of patients developing diabetic foot complications was made possible through collaboration among various healthcare professionals, and this approach has proven to provide a potential improvement in clinical outcomes. However, conducting studies that include larger sample groups and evaluate long-term results will help us better understand the effectiveness of this approach. This study highlights the importance of considering a multidisciplinary approach in the treatment of diabetic foot complications, emphasizing it as a significant strategy to be considered.

Disclosures

Ethics Committee Approval: The authors declared that the research was conducted according to the principles of the World Medical Association Declaration of Helsinki, "Ethical Principles for Medical Research Involving Human Subjects." This clinical study protocol was approved by the Ethics Committee of Biruni University (Permit number: 2023/83-28). Informed consent was received from the patients or their legal representatives.

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