



# Revolutionizing Sausage Toe Treatment: The Power of Low-Pressure Bandaging in Diabetic Toe Osteomyelitis

## Sosis Parmak Tedavisinde Devrim: Diyabetik Ayak Osteomyelitinde Düşük Basıncılı Bandajlamanın Gücü

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### Abstract

**Aim:** Swollen and reddened toes, often called "sausage toes," are a common symptom of diabetic toe osteomyelitis. This study aimed to evaluate the effectiveness of the bandages for this condition, using a technique previously validated for lymphoedema treatment.

**Material and Method:** Retrospective analysis was conducted at an outpatient clinic involving 94 patients with diabetic foot osteomyelitis that affected their toes. Toe bandages were applied twice weekly using a specially designed 4 cm low-pressure elastic bandage. Clinical remission was defined as the absence of signs of infection in ten months.

**Results:** The study included 60 patients who met the inclusion criteria, with a mean age of  $59.45 \pm 10.43$  years, and 78.3% of them were male. Most lesions were located on the right first toe (30%). A total of 52 patients (86.7%) achieved healing, with a mean healing time of  $13.37 \pm 7.75$  weeks. Previous use of antibiotics for toe osteomyelitis before the study has been associated with a lower healing rate.

**Conclusion:** A literature review reveals no evidence that toe bandages have been used to treat sausage toes. The findings of this study indicate that toe bandages may facilitate a rapid and high rate of healing in cases of sausage toes. This technique's simplicity, affordability, and high success rate make it a valuable addition to standard treatments for sausage toe. The study proposes that further prospective controlled studies be conducted to confirm the findings.

**Keywords:** Diabetic foot osteomyelitis, low-pressure bandaging, sausage toe, toe bandage

### Öz

**Amaç:** Genellikle "sosis parmak" olarak adlandırılan şişmiş ve kızarmış ayak parmakları, diyabetik ayak osteomyelitinin yaygın bir semptomudur. Bu çalışma, daha önce lenfödem tedavisi için onaylanmış bir bandajlama tekniğinin sosis parmak tedavisinde etkinliğini değerlendirmeyi amaçlamıştır.

**Gereç ve Yöntem:** Polikliniğimize ayak parmaklarında diyabetik ayak osteomyeliti ile başvuran 94 hasta retrospektif olarak analiz edildi. Tüm hastaların ayak parmaklarına 4 cm'lik düşük basınçlı elastik bandaj ile haftada iki kez ayak parmağı bandajı uygulandı. Klinik remisyon, on ay içinde enfeksiyon belirtilerinin olmaması olarak tanımlandı.

**Bulgular:** Çalışmaya dahil edilme kriterlerini karşılayan 60 hastanın yaş ortalaması  $59.45 \pm 10.43$  yıl olup, %78.3'ü erkekti. Lezyonların çoğu sağ birinci ayak parmağında (%30) yer almaktaydı. Toplam 52 hastada (%86,7) iyileşme sağlandı ve ortalama iyileşme süresi  $13,37 \pm 7,75$  hafta idi. Çalışmadan önce ayak osteomyeliti için antibiyotik kullanımı daha düşük iyileşme oranı ile ilişkilendirildi.

**Sonuç:** Literatürde ayak parmak bandajlarının sosis parmaklarının tedavisinde kullanıldığına dair bir kanıt bulunamamıştır. Bu çalışmanın bulguları, ayak parmağı bandajlarının sosis parmakta hızlı ve yüksek oranda iyileşmeyi destekleyebileceğini göstermektedir. Bu tekniğin basitliği, ekonomikliği ve yüksek başarı oranı, bu yaklaşımı sosis ayak parmağı için standart tedavilere değerli bir katkı haline getirebilir. Çalışma, bulguların doğrulanması için daha ileri prospektif kontrollü çalışmaların yapılmasını önermektedir.

**Anahtar Kelimeler:** Diyabetik ayak osteomyeliti, düşük basınçlı bandajlama, sosis parmak, ayak parmağı bandajı



## INTRODUCTION

Diabetes mellitus (DM) is a significant disease with high morbidity and mortality rates, affecting 2.5-3% of the global population.<sup>[1]</sup> The lifetime risk of developing a diabetic foot ulcer (DFU) is estimated to be between 10% and 25%. DFU is a common and significant complication in diabetic patients, with 14% to 24% of infections resulting in amputation. Notably, 85% of non-traumatic amputations are attributed to DFU.<sup>[2]</sup>

Osteomyelitis is an infection-related inflammatory disease of the bones. In order to reach a clinical diagnosis of osteomyelitis, imaging, and laboratory results are typically used to support the initial hypothesis. However, microbial cultures and bone biopsies must be conducted to reach a definitive diagnosis. The infection usually starts as soft tissue ulcers and spreads to the underlying bone tissue.<sup>[3]</sup> Bone infection in a diabetic foot requires more extended therapy and more surgeries, leading to higher recurrence rates, amputation risk, and lower treatment success. The eradication of diabetic foot osteomyelitis represents a significant challenge in efficacy and cost-effectiveness. The social burden associated with this condition is considerable, and the financial implications regarding the consumption of health resources are substantial. Patients with diabetic foot osteomyelitis have a high rate of amputation and hospitalization.<sup>[4]</sup>

The most effective method for treating osteomyelitis in diabetic patients involves removing infected and necrotic tissues, using systemic antibiotics, and closely monitoring and caring for the patients. A distinctive deformity known as 'sausage toe' can be observed in cases of osteomyelitis affecting the toes. This refers to a non-pitting, red toe swelling, which is considered a clear sign of osteomyelitis. It can be posited that this swelling is a consequence of inflammation in well-circulated feet and is, therefore, less likely to occur in cases of poor foot circulation.<sup>[5]</sup> The successful treatment of sausage toe with antibiotic therapy alone was reported in 20% of cases, while conservative surgery was successful in 58% of cases. Amputation was required in 45.8% of cases.<sup>[6]</sup>

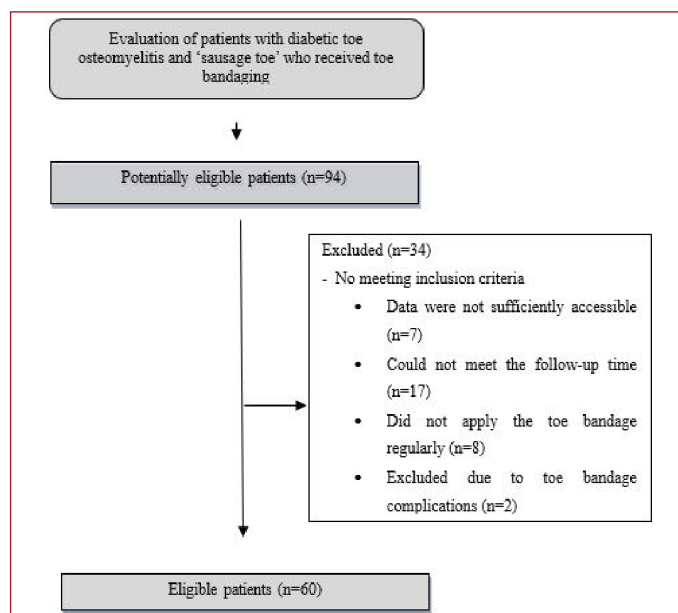
Compression bandaging has been a standard recommendation for treating edema affecting the extremities. Furthermore, toe bandaging is an accepted component of multilayer lymphedema bandaging, and its use in venous hypertension and lymphedema has been documented.<sup>[7]</sup> The application of a toe bandage results in increased pressure within the subcutaneous tissues, reduced fluid entering the interstitial spaces, and decreased capillary filtration. Compression increases lymph flow and venous return, thereby reducing edema volume. Furthermore, it increases microcirculation, which may facilitate wound healing and soften thickened or hardened tissues.<sup>[8]</sup> This method, effective in lymphedema, may also prove similarly effective in toe osteomyelitis in diabetic patients presenting with edema-swelling despite their distinct etiology.

This study aimed to demonstrate the efficacy of toe bandage application with a technique that is safe in treating lymphedema in the literature, which may be significantly helpful in treating diabetic foot osteomyelitis developing in the toes.

## MATERIAL AND METHOD

The study was initiated after approval from the ethics committee of Kayseri City Hospital with approval number 10.09.2024/173. The current study was conducted at the hyperbaric medicine outpatient clinic of Kayseri City Hospital. All procedures were carried out following the ethical rules and the principles of the Declaration of Helsinki.

The sample size was calculated to be 51 using G\*Power version 3.1.9.7 (2020) from the University of Düsseldorf, Germany (for Windows 10), with a 95% power (beta) and a 0.05 type I error rate (alpha). The medical records of 94 patients admitted to our outpatient clinic between November 2022 and August 2024 who met the criteria for diabetic foot osteomyelitis in the toes, as defined by the American Infectious Diseases Society of Infectious Diseases,<sup>[9]</sup> were reviewed. These criteria included the presence of non-pitting red swelling of the toe and the use of a toe bandage for treatment. In the study context, the patient follow-up and treatment records were evaluated retrospectively. Patients who were followed up in our outpatient clinic for ten months were included in the evaluation, excluding those with missing information (**Figure 1**). A consent form detailing the risks of toe bandaging was obtained from all patients.



**Figure 1.** Study flow diagram

Toe bandages were not applied to patients who presented with circulatory disorders in the lower extremities. Ankle-brachial index (ABI) measurements were conducted to exclude lower extremity circulatory disorders in patients scheduled to receive a toe bandage. A normal ABI range is between 0.9 and 1.3, indicating adequate blood flow. An ABI less than 0.9 suggests varying degrees of arterial insufficiency, while an ABI greater than 1.3 may indicate arterial stiffness or calcification. A toe bandage was applied to patients with an ABI result between 0.9 and 1.3.

Furthermore, patients exhibiting signs of toe circulatory disorders, including pale and cyanotic foot skin color, loss of skin hair, skin thinning, decreased skin temperature, and absence of foot pulse, were excluded from the toe bandage application.

Age, gender, height, and body weight were extracted from the medical records. Body mass index (BMI), comorbidities, medications, and previous osteomyelitis treatments were also documented. The patient's medical history was recorded, including details of the wound's location, results of any cultures taken from the wound or bone, hemogram, C-reactive protein (CRP) level in the blood, sedimentation rate, HbA1C value, and the time taken for the toe to heal. This information was obtained from the hospital's automation system and the national digital health system.

The patients were provided with the standard of wound care, which included the application of a toe bandage twice weekly in the case of sausage toe. For control, the toe was re-examined only on the day following the initial application of the bandage, and the toe was monitored with bandaging throughout the study. The bandaging was performed using a 4 cm elastic bandage with low pressure, specially produced for the toes. The technique used was in accordance with the standard procedure described in the literature, with the bandage fully grasping the fingertip and extending downwards to ensure no gaps were present.<sup>[7]</sup> The toe and nail tips were left open to monitor any discoloration or circulatory disorders that may arise (Figure 2). This was done twice a week. Clinical remission was defined as the complete absence of clinical findings of infection in the follow-up period (Figure 3). The failure criteria included recurrent, persistent, progressive infection, ischemia, necrosis, and amputation.



Figure 2. The application of a toe bandage to the sausage toe



Figure 3. A-D, patients recovering with toe bandage application

### Statistical Analysis

The data collected in this study were analyzed using the Statistical Package for the Social Sciences (SPSS 25) from IBM Corporation, Chicago, IL, USA. The analysis aimed to evaluate demographic factors, the rate of recovery, and the factors influencing recovery in patients with sausage toes. Normality was assessed using the Kolmogorov-Smirnov test. Descriptive statistics were obtained using the Chi-square test. Pearson's correlation test was applied to assess correlations in normally distributed data, while Spearman's rho test was used for non-normally distributed data. A p-value of less than 0.05, with a 95% confidence interval,

was considered statistically significant. The differences between independent groups—specifically demographic factors of recovered and non-recovered patients, as well as disease- and treatment-related factors—were compared using a t-test. One-way ANOVA was employed to compare more than two groups, particularly to investigate the impact of antibiotic usage (none, single, or multiple) on recovery and recovery time.

## RESULTS

The study included 60 patients who met the inclusion criteria. The mean age of the patients included in the study was  $59.47 \pm 10.40$  years; 21.7% were female, and 30.0% of the lesions were located on the right first toe (**Table 1**).

**Table 1. Demographic data and examination results of the participants**

Variable	Mean±SD	Median	Min-max
Age (years)	59.45±10.43		
Height (cm)	170.21±8.76		
Weight (kg)		82.00	60-148
BMIa (kg/m <sup>2</sup> )		26.80	20.20-51.20
	<b>n</b>	<b>%</b>	
<b>Gender</b>			
Male	47	78.3	
Female	13	21.7	
<b>Location</b>			
Right 1 <sup>st</sup> toe	18	30.0	
Right 2 <sup>nd</sup> toe	7	11.7	
Right 3 <sup>rd</sup> toe	5	8.3	
Right 4 <sup>th</sup> toe	2	3.3	
Right 5 <sup>th</sup> toe	1	1.7	
Left 1 <sup>st</sup> toe	14	23.3	
Left 2 <sup>nd</sup> toe	9	15.0	
Left 3 <sup>rd</sup> toe	2	3.3	
Left 4 <sup>th</sup> toe	1	1.7	
Left 5 <sup>th</sup> toe	1	1.7	
<b>Previous Osteomyelitis Treatment (Antibiotics)</b>			
No	28	46.7	
Yes	32	53.3	

BMI – Body mass index

Out of 60 patients, four were amputated, and four did not heal during the study period. 52 (86.7%) patients were successfully healed. The mean healing time of the healed patients was  $13.37 \pm 7.75$  weeks. Previous use of antibiotics for toe osteomyelitis was associated with a lower healing rate (**Table 2**).

**Table 2: Factors affecting the healing process with the application of toe bandages**

Variable	Healed	Not healed	p
Age	59.17±10.33	61.38±11.34	0.581 <sup>β</sup>
Gender			0.503*
Woman	12	1	
Male	40	7	
Height	170.37±8.77	169.00±7.10	0.677 <sup>β</sup>
Weight	81.00 (60.00-148.00)	82.50 (70.00-117.00)	0.459*
BMI	26.80 (20.20-51.20)	28.55 (26.20-40.00)	0.107*
Previous osteomyelitis treatment			0.039*
Yes	25	7	
No	27	1	
Hb	13.47±1.63	13.51±2.09	0.950 <sup>β</sup>
WBC	8.38 (4.09-19.45)	9.92 (6.56-16.99)	0.123*
CRP	13.9 (1.3-243.3)	12.7 (5.7-331.0)	0.350*
ESR	19.0 (1.0-75.0)	14.5 (3.0-95.0)	0.761*
HbA1c	8.85±1.82	10.00±2.64	0.123 <sup>β</sup>

BMI: body mass index; Hb: haemoglobin, WBC: white blood cells; CRP: c-reactive protein; ESR: erythrocyte sedimentation rate; HbA1c: haemoglobin A1C  
\*Mann Whitney U test, <sup>β</sup>Independent sample test

Of the 52 healed patients, 13 were not using antibiotics, 26 were using single antibiotics, and 13 used combined antibiotics with toe bandage application. The administration of single or combined antibiotics did not result in a statistically significant difference in the healing rate ( $p:0.128$ ) (One-way ANOVA). Antibiotics used in combination with toe bandaging in patients included ciprofloxacin, fusidic acid, amoxicillin + clavulanic acid, trimethoprim + sulfamethoxazole, ceftriaxone, and rifampicin. The type of antibiotic was not found to be effective in healing ( $p:0.078$ ) (One-way ANOVA). In addition, in patients who received antibiotics and were healed, it was determined that the antibiotic administered was unrelated to the healing duration ( $p:0.144$ ) (One-way ANOVA).

In two patients, discoloration was observed as a consequence of the application of bandages. The bandaging was stopped to prevent damage to the skin. The patients were subsequently excluded from the study, as they had not been subjected to toe bandaging. The follow-up with the patients revealed that no permanent damage related to toe bandaging had occurred.

## DISCUSSION

This study presents a highly efficacious solution to the problem of sausage toe, a prevalent but understudied phenomenon among individuals with diabetes mellitus. Despite the lack of information on sausage toe in the existing literature, there is no evidence to suggest using alternative methodologies for treating this condition, except for antibiotics and conservative surgical procedures.<sup>[6]</sup> The 86.7% recovery rate observed in our study, compared with the 54.2% reported by Yammine et al.<sup>[6]</sup> proves that the toe

bandage technique is an effective intervention for sausage toe in diabetic patients. Using a toe bandage, an effective and reliable technique in this study seems to be a valuable addition to the current treatment methods in this area.

Diabetic foot osteomyelitis requires prolonged treatment. In our study, the average healing time for healed patients was  $13.37 \pm 7.75$  weeks, compared to  $15.8 \pm 9.7$  weeks in a study of patients with diabetic foot osteomyelitis.<sup>[10]</sup> This suggests that the toe bandage method may shorten the healing time.

In the two case reports regarding sausage toe published in the literature, one reported successful treatment with antibiotics alone,<sup>[11]</sup> while the other reported success with conservative surgery combined with antibiotic therapy.<sup>[12]</sup> The presence of a sausage toe deformity should be a cause for concern in routine clinical practice. Evidence suggests that DFUs in patients are associated with suboptimal and inappropriate antibiotic therapy and infections caused by highly resistant pathogens.<sup>[13]</sup> We obtained wound or bone cultures from all patients in our study and adjusted antibiotic treatment according to the results of these cultures. Accordingly, no statistically significant difference was observed between the antibiotics already administered. We found that using antibiotics before presented to us was associated with a lower healing rate. This may reflect a higher incidence of failure due to latent chronic osteomyelitis and highly resistant pathogens.

The bandaging technique applied in this study may also prove effective in treating dactylitis, a condition characterized by a swollen, sausage-shaped finger or toe associated with various rheumatological disorders.<sup>[14]</sup> This represents a particularly challenging problem with few treatment options. In this case, flexor tenosynovitis, surrounding diffuse peri tendinous inflammation and soft tissue edema, is typically responsible for the 'sausage digit' appearance. High-resolution MRI has also shown that bone marrow edema, synovitis, and bone erosion can occur.<sup>[15]</sup> Similar findings are also seen in diabetic foot osteomyelitis<sup>[16]</sup> and sausage toe.<sup>[5,6]</sup> The findings of this study have the potential to provide a solution to the issue under investigation and to form the basis for further research in this field.

It is crucial to ensure that this risky treatment is administered correctly. In our study, we left the fingertips of patients who underwent toe bandaging uncovered and conducted a follow-up examination the next day. If unexpected symptoms such as discoloration, pain, or numbness occurred, we advised removal of the bandage. The toe was then carefully examined at least twice a week. Serious adverse events such as skin necrosis, nerve damage, or thromboembolic events resulting from compression therapy are rare when compression is applied correctly and contraindications are taken into consideration.<sup>[17]</sup> However, it is essential to always keep in mind that toe bandaging can be a risky treatment.

The sample size may need to be bigger to assess the success of this method reliably and in a generalizable manner. Moreover,

the retrospective study design and the absence of a control group may restrict the assessment of treatment outcomes. Future studies must be conducted using a prospective, controlled design.

## CONCLUSION

Diabetic toe osteomyelitis is a prevalent, challenging, and costly condition. Toe bandaging is an effective and fundamental technique for managing a range of toe-related problems. The results of our study indicate that this technique may facilitate healing, help prevent infection, and control edema in cases of sausage toes, as well as in lymphoedema and venous hypertension. Applying and using the correct materials correctly for optimal results is essential.

A literature review revealed no evidence that the toe bandages had been used to treat sausage toes. The findings of our study indicate that the incorporation of low-pressure bandage therapy into the conventional treatment regimen results in a rapid and high rate of healing in sausage toe. Demonstrating the efficacy of this inexpensive and reliable treatment, which will be added to standard treatments, will attract the attention of many medical centers worldwide, and further studies on this subject will be encouraged. It is thought that learning this valuable method by the clinics interested in this work may prevent major complications in many patients with sausage toe, shorten the treatment time, and increase the treatment rates.

## ETHICAL DECLARATIONS

**Ethics Committee Approval:** The study was carried out with the permission of Kayseri City Hospital Ethics Committee (Date: 10.09.2024, Decision No: 173).

**Informed Consent:** Informed consent was obtained from all individual participants included in the case.

**Referee Evaluation Process:** Externally peer-reviewed.

**Conflict of Interest Statement:** The authors have no conflicts of interest to declare.

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