

Predicting the Risk of Reamputation in Patients Undergoing Lower Extremity Amputation Due to Complications of Diabetes

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ABSTRACT

Objective: Lower extremity amputation (LEA) remains a common intervention for diabetic patients with advanced peripheral vascular disease and foot complications. However, reamputation rates remain high, impacting patient morbidity, rehabilitation, and survival. This study aims to identify clinical and laboratory predictors of reamputation in diabetic patients undergoing LEA and to compare characteristics between those requiring a single surgery and those undergoing additional procedures.

Methods: A retrospective review was conducted on 650 diabetic patients who underwent LEA at a tertiary care center between 2020 and 2025. Patients were grouped as single-operation (Group 1, n=480) or reamputation (Group 2, n=80). Demographic, surgical, and laboratory data were analyzed. Comparative statistics were performed using t-tests, chi-square, and Mann-Whitney U tests with a significance level of $p<0.05$.

Results: Reamputation was required in 14.2% of patients. The most common amputation level was transtibial in both groups. Cigarette use was significantly more frequent in Group 2 (40% vs. 20%, $p=0.001$). Although HbA1C and CRP levels were significantly higher in Group 2 ($p=0.021$ and $p=0.001$, respectively), no significant differences were found in WBC or INR values. Albumin and creatinine levels were significantly worse in Group 2 ($p=0.005$ and $p=0.045$, respectively). A greater proportion of Group 2 patients had an ASA score ≥ 3 (62.5% vs. 45%, $p=0.011$). Amputation side, age, and the frequency of transtibial or transfemoral amputation did not differ significantly between the groups.

Conclusion: Reamputation remains a prevalent issue in diabetic LEA patients. High ASA scores were significantly associated with reoperation risk, underscoring the role of systemic disease burden. While HbA1C levels showed statistical differences, their clinical interpretation remains complex and warrants further prospective analysis. Multidisciplinary preoperative assessment is essential for improving outcomes and minimizing reamputation risk.

INTRODUCTION

Lower extremity amputation is a major surgical intervention often required due to advanced peripheral vascular disease and diabetic complications, resulting in significant disability and reduced quality of life.^[1] Even in cases of minor amputations, such as partial foot procedures, the decision to amputate is a critical point in patient management,^[2] directly impacting rehabilitation potential and long-term health outcomes.^[3]

A key consideration in amputation-level decision-making is the preservation of mobility. This has driven an emphasis on performing the most distal amputation possible,

such as opting for a transtibial (TT) amputation instead of a transfemoral (TF) amputation or attempting a transmetatarsal (TM) amputation rather than a major limb loss. However, the advantages of preserving limb length remain debated due to the high risk of healing failure and the uncertain impact on functional mobility.^[4,5] This is particularly evident in transmetatarsal amputations, where healing failure can reach over 50%, often requiring more proximal revisions such as transtibial amputations.^[6-8] Primary healing failure may necessitate reamputation or prolonged wound management, leading to extended rehabilitation periods, restricted ambulation, and increased mortality risk.^[9]

Despite the critical nature of these decisions,^[10] there re-

mains limited evidence to guide clinicians and patients in accurately assessing the risk of healing failure^[11] and the likelihood of reoperation at different amputation levels.^[12] Recent studies have shown that midfoot amputations, such as Chopart and Lisfranc procedures, can salvage a significant number of non-healing forefoot amputations, achieving long-term functional ambulation^[5] and reducing the need for transtibial amputations in properly selected diabetic patients.^[6] Clinical judgment remains a cornerstone in evaluating these risks, but existing predictive models have limitations.^[1,6,13,14] This underscores the need for a more individualized approach to decision-making, integrating comprehensive data to improve outcome predictions.^[3]

This retrospective study aims to contribute to the understanding of lower extremity amputation outcomes by analyzing a cohort of patients who underwent these procedures at a major urban hospital. The study seeks to identify key factors associated with reoperation rates and compare the outcomes of patients undergoing a single surgery versus those requiring multiple surgical interventions. We hypothesized that patients undergoing distal amputations, particularly transmetatarsal procedures, would demonstrate significantly higher reoperation rates compared to those receiving more proximal amputations, due to increased risk of healing failure.

MATERIALS AND METHODS

All procedures involving human participants were conducted in accordance with institutional and national ethical standards, as well as the 1964 Helsinki Declaration and its subsequent amendments. Ethical approval for this study was obtained from the local ethics committee (Approval No: 2025/010.99/15/4).

This retrospective observational study was conducted at the Orthopedics and Traumatology Clinic of Kartal Dr. Lütfi Kırdar City Hospital Hospital. It included patients who underwent lower extremity amputation between 2020 and 2025. Patients were categorized into two groups: Group 1 (single-surgery), comprising those who underwent a single surgical procedure, and Group 2 (reoperation), comprising those who underwent one or more additional surgical amputations. Debridement procedures—defined as surgical removal of necrotic or infected soft tissue without further bone resection—were not considered reoperations in this study.

The study evaluated demographic, surgical, clinical, and laboratory parameters, including age, amputation level, side, presence of diabetes mellitus and vascular disease, creatinine, HbA1C, albumin, white blood cell (WBC) count, international normalized ratio (INR), and ASA score (≥ 3 vs. <3).

Inclusion criteria were: Age ≥ 18 years, confirmed amputation surgery within the specified period, and availability of diagnosis through hospital records. Exclusion criteria included missing or inaccessible data, concurrent orthope-

dic or systemic surgical procedures, and loss to follow-up.

Patients excluded from the study were as follows: 30 With traumatic amputations (16 upper, 14 lower extremity), 20 with upper extremity amputations due to vascular causes, 8 with chronic osteomyelitis, 6 with congenital anomalies, and 26 with insufficient clinical data. After exclusions, a total of 560 patients who underwent lower extremity amputation due to non-traumatic causes, predominantly vascular disease, were included in the final analysis (Fig. 1).

Surgical reports, radiological imaging, clinical anamnesis, and laboratory results were reviewed retrospectively. Data was extracted from the hospital's electronic health record system. Statistical analyses were performed using SPSS software. Continuous variables were analyzed using the independent t-test or Mann-Whitney U test, and categorical variables using the chi-square or Fisher's exact test, as appropriate. A p-value <0.05 was considered statistically significant.

RESULTS

Out of 560 patients included in the study, 480 were classified into Group 1 (Single-surgery), and 80 into Group 2 (Re-operation). The mean age was slightly higher in Group 2 (68.1 ± 10.9 years) compared to Group 1 (65.4 ± 11.2 years), although this difference did not reach statistical significance ($p=0.124$).

There was a significant difference in the distribution of right-sided amputations between the two groups, with 60% in Group 1 and 45% in Group 2 ($p=0.021$). The proportion of patients with ASA scores of 3 or higher was also significantly higher in Group 2 (62.5%) than in Group 1 (45%) ($p=0.011$).

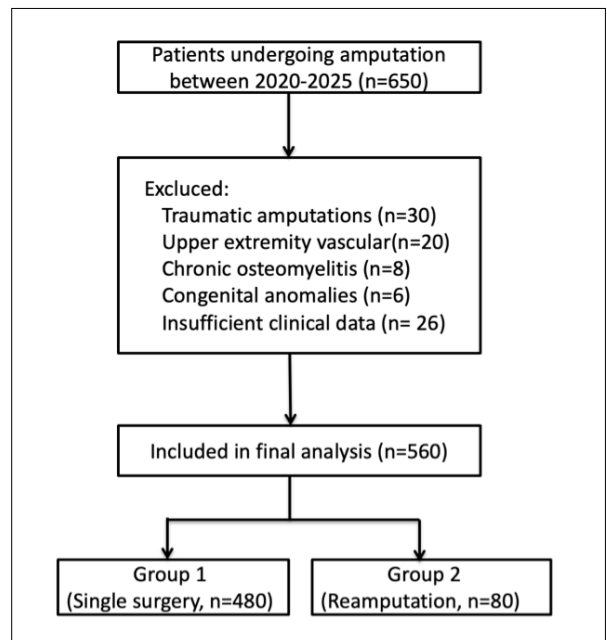


Figure 1. Flowchart.



Figure 2. Pre-and postoperative clinical photographs of a 64-year-old non-smoking diabetic patient who underwent transmetatarsal amputation for forefoot gangrene. Laboratory parameters were consistent with Group 1 (non-reamputation group), including normal albumin and creatinine levels and controlled HbA1C. Favorable wound healing is evident in the early postoperative period, consistent with the patient's low predicted risk for revision surgery.



Figure 3. Postoperative clinical photographs of a 68-year-old diabetic patient with a prior history of 1st–3rd toe amputations and poor wound healing. The plantar and dorsal ulcers exhibit persistent tissue necrosis and purulent discharge. Laboratory values and clinical course were consistent with the Group 2 cohort (reamputation group), including hypoalbuminemia, elevated creatinine, and a likely ASA score ≥ 3 . These findings suggest a high risk for further proximal amputation.

Regarding amputation level, foot-level amputations were significantly more frequent in Group 1 (32%) than in Group 2 (15%) ($p=0.004$), as illustrated by the clinical examples of a well-healed transmetatarsal amputation (Fig. 2) and a non-healing, infected stump requiring revision (Fig. 3). No statistically significant differences were observed between the groups in terms of transtibial (51% vs. 60%, $p=0.172$) or transfemoral amputations (17% vs. 25%, $p=0.093$).

Cigarette use was notably more prevalent in Group 2, with 40% of patients reporting active smoking, compared to 20% in Group 1 ($p=0.001$).

Laboratory values showed significant differences between the groups. Group 2 had lower mean albumin levels (2.8 ± 0.5 g/dL vs. 3.2 ± 0.6 g/dL, $p=0.005$), higher HbA1c values ($8.1 \pm 1.5\%$ vs. $7.4 \pm 1.2\%$, $p=0.021$), and higher CRP levels (18.7 ± 6.3 mg/L vs. 12.3 ± 5.1 mg/L, $p=0.001$). Creatinine levels were also significantly higher in Group 2 (1.3 ± 0.4 mg/dL vs. 1.1 ± 0.3 mg/dL, $p=0.045$).

No significant differences were observed between the groups for WBC counts ($p=0.331$) or INR values ($p=0.080$) (Table I).

Table I. Demographics, clinical and laboratory parameter comparison by group

Parameter	Group 1 (n=480)	Group 2 (n=80)	p-value
Age (years)	65.4 $\pm$ 11.2	68.1 $\pm$ 10.9	0.124
Side - Right (%)	288 (60%)	36 (45%)	0.021*
ASA ≥ 3 (%)	216 (45%)	50 (62.5%)	0.011*
Amputation Level - Foot (%)	154 (32%)	12 (15%)	0.004*
Amputation Level - Transtibial (%)	245 (51%)	48 (60%)	0.172
Amputation Level - Transfemoral (%)	81 (17%)	20 (25%)	0.093
Cigarette Use (%)	96 (20%)	32 (40%)	0.001*
Albumin (g/dL)	3.2 $\pm$ 0.6	2.8 $\pm$ 0.5	0.005*
HbA1C (%)	7.4 $\pm$ 1.2	8.1 $\pm$ 1.5	0.021*
CRP (mg/L)	12.3 $\pm$ 5.1	18.7 $\pm$ 6.3	0.001*
Creatinine (mg/dL)	1.1 $\pm$ 0.3	1.3 $\pm$ 0.4	0.045*
WBC ($\times 10^9$ /L)	7.9 $\pm$ 2.2	8.4 $\pm$ 2.5	0.331
INR	1.05 $\pm$ 0.11	1.12 $\pm$ 0.15	0.080

Values are presented as mean $\pm$ standard deviation or frequency (%), as appropriate. Group 1 includes patients who underwent a single surgical amputation; Group 2 includes patients who required one or more additional surgical amputations (excluding debridement). Significant differences ($p<0.05$) are indicated with an asterisk (*). ASA: American Society of Anesthesiologists score; HbA1C: glycated hemoglobin; CRP: C-reactive protein; WBC: white blood cell count; INR: international normalized ratio.

DISCUSSION

Reamputation rates in patients undergoing lower extremity amputation (LEA) due to diabetes and peripheral vascular disease have been reported to range from 20% to 60%, depending on the initial amputation level and individual patient factors.^[9,13,15] Distal amputations, including transmetatarsal (TMA) and transtibial (TT) levels, are often preferred to preserve joint function and prosthetic potential. However, these procedures carry a significant risk of wound healing failure—up to 56% non-healing rates have been reported following TMAs—often necessitating conversion to more proximal levels.^[6,8] This underscores the importance of careful preoperative evaluation and individualized decision-making, especially in diabetic patients with multiple comorbidities.^[4] Recent studies report that only 38% of patients undergoing below-knee amputation (BKA) achieve both wound healing and functional ambulation, while nearly one-quarter ultimately require revision to an above-knee level.^[16] In our study, most reamputations occurred following foot-level or transtibial procedures, which is consistent with this existing literature.^[7,8] Although the distribution of amputation levels between groups was not statistically significant, the observed trends reflect the inherent vulnerability of distal procedures. Studies by Seçkin et al.^[7] and Antony et al.^[8] similarly found high revision rates within five years in patients undergoing distal amputations.

Several patient-related risk factors were significantly associated with reamputation. Smoking was notably more prevalent in the reamputation group (40% vs. 20%, $p=0.001$), reinforcing its known adverse effects on endothelial function, tissue oxygenation, and wound healing. This finding is consistent with Acar and Kacira, who identified smoking as a strong independent predictor of reamputation in diabetic foot patients.^[1,15] Van Helm et al.^[17] and O'Brien et al.^[13] also emphasized that smoking, malnutrition, alcohol use, and physical inactivity are frequently underaddressed in perioperative care, despite their substantial contribution to complications and reoperation. Given that these factors are modifiable, aggressive preoperative counseling and support should be prioritized to improve outcomes.

Systemic health status was another important determinant. A significantly higher proportion of patients in the reamputation group had an ASA score ≥ 3 (62.5% vs. 45%, $p=0.011$), reflecting a greater systemic disease burden. This finding is in line with the NSQIP framework, which recognizes ASA classification and hypoalbuminemia as robust preoperative risk indicators.^[11,12,18-21] While ASA scoring is a general measure, it remains useful for surgical risk stratification, particularly in resource-constrained settings.

Biochemical parameters further supported the relationship between systemic status and reamputation risk. Albumin levels were significantly lower and creatinine levels significantly higher in the reamputation group, implicating poor nutritional and renal function in impaired healing. These findings are consistent with earlier reports linking hypoalbuminemia and renal insufficiency to poor tissue integrity and increased infection risk.^[6,7] Seçkin et al.^[7] also

emphasized nutritional optimization in patients at risk for revision surgery. Inflammatory burden, as reflected by elevated CRP levels, was another predictor of reamputation. Anwander et al.^[14] reported that CRP >100 mg/L was associated with early surgical failure in diabetic foot syndrome. In contrast, WBC count and INR did not significantly differ between groups, suggesting that chronic inflammation, rather than acute infection or coagulopathy, may be more relevant in this population.

Metabolic control also appeared to influence outcomes. HbA1C was significantly higher in the reamputation group (8.1% vs. 7.4%, $p=0.021$), reinforcing the role of glycemic status in wound healing. While HbA1C remains a somewhat debated predictor, it remains biologically plausible that poor glycemic control compromises microvascular perfusion, immune function, and tissue repair. Essien and Zucker-Levin similarly reported that patients with chronic kidney disease and peripheral neuropathy had significantly higher odds of subsequent amputations.^[22]

Despite identifying several significant predictors, no single factor fully accounted for reamputation risk, reinforcing the multifactorial nature of wound healing. Comprehensive preoperative assessment—including metabolic, nutritional, inflammatory, and functional status—is essential. Anwander et al.^[14] and the AMPREDICT model have demonstrated the value of multifactorial predictive tools incorporating a range of clinical variables and interactions to generate individualized reamputation risk profiles.^[3,10] Emerging technologies may enhance this process. For instance, Mert et al.^[23] demonstrated that ChatGPT-4o achieved 83.3% agreement with expert surgical teams in determining appropriate amputation levels in diabetic foot ulcer patients, particularly for distal procedures.

Finally, although our study focused on preoperative factors, postoperative management also plays a critical role in outcomes. Fujii et al.^[24] found that patients used only 27% of their prescribed opioids post-discharge, with little guidance on safe disposal. For high-risk patients such as diabetic amputees—who often face polypharmacy, altered pain thresholds, and increased susceptibility to complications—tailored discharge protocols are essential. As Yip et al.^[25] noted, perioperative complications such as infection or trauma may influence surgical success more than baseline characteristics.

This study has several limitations, including its retrospective design and incomplete data on factors such as diabetes duration, vascular imaging, or postoperative infection. Nevertheless, it draws on a large, real-world cohort and provides valuable insight into the clinical and systemic predictors of reamputation in diabetic LEA patients.

Conclusion

In conclusion, reamputation remains a significant concern in diabetic patients undergoing lower extremity amputation. Careful selection of the initial amputation level and preoperative risk stratification are essential. In our study, ASA ≥ 3 status was significantly associated with reamputation, while HbA1C, although statistically different, war-

rants further investigation to clarify its clinical relevance. Future prospective studies are needed to better define the interplay of metabolic, vascular, and systemic factors contributing to reamputation risk.

Ethics Committee Approval

The study was approved by the Kartal Dr. Lütfi Kırdar City Hospital Ethics Committee (Date: 30.04.2025, Decision No: 2025/010.99/15/4).

Informed Consent

Retrospective study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: E.E., H.Y.; Design: O.F.S., H.Y.; Supervision: E.E., O.F.S.; Materials: E.E., O.F.S., H.Y.; Data collection and/or processing O.F.S., H.Y., E.E.; Data analysis and/or interpretation were performed: E.E., H.Y., O.F.S.; Literature search: H.Y., O.F.S., E.E.; Writing: E.E., O.F.S.; Critical review H.Y., O.F.S., E.E.

Conflict of Interest

None declared.

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Diyabete Bağlı Komplikasyonlar Nedeniyle Alt Ekstremitte Ampütasyonu Uygulanan Hastalarda Reampütasyon Riskinin Öngörülmesi

Amaç: Diyabete bağlı komplikasyonlar nedeniyle alt ekstremitte amputasyonu (AEA) uygulanan hastalarda reamputasyon gereksinimini öngören klinik ve laboratuvar parametreleri belirlemek ve tek cerrahi geçiren hastalar ile ek cerrahi girişim geçiren hastaların özelliklerini karşılaştırmak.

Gereç ve Yöntem: 2020–2025 yılları arasında üçüncü basamak bir sağlık merkezinde AEA uygulanan 650 diyabetik hasta retrospektif olarak incelendi. Hastalar, yalnızca bir cerrahi geçirenler (Grup 1, n=480) ve tekrar cerrahi uygulananlar (Grup 2, n=80) olmak üzere iki gruba ayrıldı. Demografik, cerrahi ve laboratuvar verileri analiz edildi. Karşılaştırmalı istatistiksel analizler t-testi, ki-kare ve Mann–Whitney U testi ile yapıldı; anlamlılık düzeyi $p<0.05$ olarak belirlendi.

Bulgular: Hastaların %24.1'inde reamputasyon gerekti. En sık uygulanan amputasyon seviyesi her iki grupta da transtibialdi. Sigara kullanımı Grup 2'de anlamlı derecede daha sık görüldü (%40 ve %20, $p=0.001$). HbA1C ve CRP düzeyleri Grup 2'de daha yüksek saptandı (sırasıyla, $p=0.021$ ve $p=0.001$), ancak WBC ve INR açısından anlamlı fark yoktu. Albümin ve kreatinin düzeyleri Grup 2'de anlamlı olarak daha kötüydü ($p=0.005$ ve $p=0.045$). ASA skoru ≥ 3 olan hasta oranı Grup 2'de anlamlı şekilde daha yüksekti (%62.5 ve %45, $p=0.011$). Amputasyon tarafı, yaş ve transtibial veya transfemoral amputasyon sıklığı açısından gruplar arasında fark yoktu.

Sonuç: Diyabetik hastalarda reamputasyon önemli bir sorun olmaya devam etmektedir. Yüksek ASA skorları, sistemik hastalık yükünü yansıtarak reoperasyon riskini öngörmeye önemli olabilir. HbA1C düzeyleri istatistiksel olarak farklı olsa da, klinik anlamı için ileriye dönük çalışmalara ihtiyaç vardır. Multidisipliner preoperatif değerlendirme, sonuçları iyileştirmek ve reamputasyon riskini azaltmak açısından kritik önemdedir.

Anahtar Sözcükler: Alt ekstremitte amputasyonu; ASA skoru; diyabetik ayak; reamputasyon; risk faktörleri; yara iyileşmesi.