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Original Research

Predictors of Lower Extremity Amputation and Reamputation in the Diabetic Foot

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ABSTRACT

In the present study, we aimed to identify the comorbidities that would be predictive of requiring lower extremity amputation or reamputation for diabetic foot wounds. We performed a retrospective review of 132 consecutive patients who had undergone lower extremity amputations (110 patients) or reamputations (22 patients) for diabetic wounds from January 2013 to March 2016. We used multivariate logistic regression to calculate the odds ratios (ORs) for amputation and reamputation for various comorbidities. The ORs of undergoing amputation were greatest for adult males (OR 5.12, 95% confidence interval [CI] 1.56 to 13.04; $p = .05$) and those with longer term diabetes (OR 4.22, 95% CI 2.01 to 12.95; $p = .05$), wound infection (OR 3.94, 95% CI 1.04 to 9.00; $p = .05$), diabetic neuropathy (OR 3.53, 95% CI 1.07 to 9.11; $p = .05$), and a positive history of smoking (OR 3.04, 95% CI 1.55 to 9.89; $p = .05$). Similarly, the ORs of undergoing reamputation were greatest for adult males (OR 4.06, 95% CI 1.02 to 12.08; $p = .05$) and those with longer term diabetes (OR 3.67, 95% CI 1.94 to 11.42; $p = .05$), wound infection (OR 3.12; 95% CI 0.9 to 8.32; $p = .05$), diabetic neuropathy (OR 3.01, 95% CI 0.92 to 8.54; $p = .05$), and a positive history of smoking (OR 2.89, 95% CI 1.09 to 9.42; $p = .05$). The early identification of these comorbidities could help determine which patients are most likely to require amputation or reamputation.

Of patients with diabetes, 12% to 25% are at risk of diabetic foot ulcers throughout their life, and these wounds often lead to high morbidity rates, poor quality of life, prolonged hospital stays, high treatment costs, and high rates of lower extremity amputation (1–5). Diabetic foot ulcers account for 40% to 60% of nontraumatic lower extremity amputations, and the incidence of major (above the foot) amputations ranges as high as 0.5 to 5 per 1000 diabetic persons (1–3,6–9).

The challenges for clinicians caring for patients with lower extremity diabetic wounds include deciding whether and when to perform an amputation and determining the appropriate level of the amputation. A sometimes greater challenge involves addressing these same issues when considering reamputation. A variety of tests and classification systems have been described to help with this process (10–16). From a clinical standpoint, knowledge regarding the predictors of the need for reamputation could also be especially helpful.

During a 3-year period at our institution, we encountered a large number of patients with diabetic wounds requiring amputation or reamputation. In the present study, we used retrospective data about these patients to identify the comorbidities that were most predictive of their need for amputation or reamputation.

Patients and Methods

We performed a retrospective review of the records of 132 consecutive patients who had undergone lower extremity amputation or reamputation as a result of diabetic wounds at Konya Necmettin Erbakan University Meram Medical Faculty Hospital from January 2013 to March 2016. Two surgeons (E.A., B.K.K.) performed all record reviews and surgeries. All the patients provided written informed surgical consent. The institutional review board approved our study protocol, and the study was conducted in accordance with the principles of the Declaration of Helsinki.

Type 2 diabetes mellitus had been previously diagnosed in all the patients. We collected data regarding the demographic and clinical characteristics of the patients, including age, gender, cigarette smoking history, duration of diabetes, diabetic comorbidities (nephropathy, neuropathy), general comorbidities (peripheral artery disease, hypertension, hyperlipidemia, malignancy), leukocytosis, wound infection status, and culture microorganism and antibiogram results. We also recorded the side and level of the amputation or reamputation. Also, for those undergoing reamputation, we determined the interval between the amputation and reamputation and whether the reamputation was ipsilateral or contralateral.

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Our institution classifies diabetic ulcers according to the depth of the wound using the Wagner-Meggitt classification (15–19). It consists of 6 wound grades: grade 0, intact skin; grade 1, superficial ulcer; grade 2, deep ulcer to tendon, bone, or joint; grade 3, deep ulcer with abscess or osteomyelitis; grade 4, forefoot gangrene; and grade 5, whole foot gangrene. We excluded patients with grade 1 and 2 lower extremity wounds from the present retrospective study, focusing instead on those patients with the deepest wounds. The records of our patients also noted the pathophysiologic status of the diabetic ulcers: neuropathic, neuropathic-ischemic, or ischemic.

We reported wound infections as present if the patient records described open skin, persistent purulent drainage, and a positive culture. When antibiogram results were available in the setting of positive wound culture results, directed antibiotic therapy was generally initiated with consultation with an infectious diseases specialist. The duration of diabetes was considered “longer” when the number of years with the diagnosis was equal to or greater than the mean for the group (10.5 years for the amputation group and 11.5 years for the reamputation group).

In our study, the patients had undergone a variety of different evaluations before surgery, including physical examination, ankle-brachial index (ABI), color Doppler ultrasonography (US), and, in a few cases, magnetic resonance imaging. These were the primary modalities that were readily available at our hospital. We examined the distal pulses at surgery using palpation and Doppler US. The level of reamputation, however, was determined primarily by the surgeon’s clinical impression and judgment, considering the health and quality of the soft tissue, degree of bone vascularity, limb perfusion, and functional consequences. A vascular surgery unit is available at our hospital; however, in general, revascularization was not offered to patients with diabetes in this clinical setting. The surgical amputation levels were designated as digital, ray, transmetatarsal, transtibial (below-the-knee), and transfemoral (above-the-knee).

Statistical Analysis

We divided our patients into an amputation group and a reamputation group. The results are presented as the mean and range, and we compared the data using the Student *t* test. We used univariate and multivariate logistic regression analysis to analyze the comorbidities (age, gender, cigarette smoking, diabetes duration, diabetic nephropathy, diabetic neuropathy, peripheral artery disease, hypertension, hyperlipidemia, malignancy, leukocytosis, and wound infection) for each group. Regression models were used to calculate the odds ratio (OR) for each comorbidity, with the 95% confidence interval (CI). R^2 for our regression model was 0.72, and assumptions of the analysis were met. Statistical significance was defined at the 5% ($p \leq .05$) level. We also noted when the 95% CI overlapped the null value (eg, OR of 1.0). However, we did not use the 95% CI as a proxy for the presence of statistical significance, given that others have argued that it is inappropriate to interpret an OR with a 95% CI that spans the null value as indicating evidence of a lack of association between a comorbidity and an outcome (20).

Statistical analysis was performed using the Number Cruncher Statistical System Statistical Program for Windows (NCSS Statistical Software, Kaysville, UT) and the Performance Analysis of Systems and Software (NCSS Statistical Software). Regression analysis was performed using Minitab, version 17, statistical software (Minitab, Inc., State College, PA).

Results

The mean follow-up period of the patients was 20 (range 14 to 27) months. Of 132 patients, 110 had undergone an initial amputation and 22, a reamputation (Table 1). The mean age of all the patients was 64.3 (range 27 to 89) years. Of the 132 patients, 90 were male and 42 were female. The mean diabetes duration was 10.5 years in the amputation group and 11.5 years in the reamputation group. Of the 132 patients, 20 had culture-positive wound infections (Figs. 1 and 2), and 18 had culture antibiogram results available (Table 2).

We found that compared with the group undergoing amputation, the group undergoing reamputation had a significantly longer mean diabetes duration and a significantly greater frequency of male gender, cigarette smoking, diabetic nephropathy, diabetic neuropathy, peripheral artery disease, hypertension, and wound infection (Table 1). In contrast, the 2 groups did not differ in mean age, amputation side, or the frequency of hyperlipidemia, malignancy, or leukocytosis.

According to the Wagner-Meggitt classification for diabetic wounds, of the 110 patients undergoing amputation, 8 (7%) had grade 3 wounds, 80 (73%) had grade 4, and 22 (20%) had grade 5 wounds. Of the 22 patients undergoing reamputation, 14 (64%) had grade 4 wounds and 8 (36%) had grade 5 wounds. Using the pathophysiologic categorization, of the amputation group, 12 wounds (11%) were neuropathic, 42 (38%) were neuropathic-ischemic, and 56 (51%) were ischemic. In the reamputation group, none of the wounds were neuropathic, 8 (36%) were neuropathic-ischemic, and 14 (64%) were ischemic.

The level of amputation was digital in 40 (36%), ray in 38 (35%), transmetatarsal in 20 (18%), transtibial in 8 (7%), and transfemoral in 4 (4%) (Table 3). The level of reamputation was digital in 2 (9%), ray in 2 (9%), transmetatarsal in 4 (18%), transtibial in 12 (55%), and transfemoral in 2 (9%). Of the 22 patients undergoing reamputation, 4 underwent only contralateral amputation (2 at the digital level and 2 at the ray level), 4 underwent both ipsilateral higher level and contralateral amputations (all at the transmetatarsal level), and 14 underwent only ipsilateral higher level amputations (12 from the ray to transtibial and 2 from transtibial to transfemoral). For those patients undergoing reamputation, the mean interval between amputation and reamputation was 4 (range 1 to 7) months (Table 3).

Using multivariate logistic regression analysis, the OR of requiring an amputation was significantly greater for males than females (OR

Table 1
Demographic and clinical characteristics of 132 patients undergoing amputation or reamputation for diabetic wounds at Konya Necmettin Erbakan University Meram Medical Faculty Hospital, January 2013 to March 2016

Characteristic	Amputation Group	Reamputation Group	*p* Value
All patients	110 (100)	22 (100)	
Mean age (y)	64.6	65.2	.09
Gender			.03
Male	72 (65)	18 (82)	
Female	38 (35)	4 (18)	
Side			.09
Right	82 (75)	17 (77)	
Left	28 (25)	5 (23)	
Mean diabetes duration (y)	10.5	11.5	.05
Cigarette smoking	42 (41)	8 (36)	.04
Diabetic nephropathy	38 (35)	2 (9)	.04
Diabetic neuropathy	24 (22)	2 (9)	.04
Peripheral artery disease	62 (56)	8 (36)	.03
Hypertension	54 (49)	9 (41)	.03
Hyperlipidemia	12 (11)	4 (18)	.06
Malignancy	1 (1)	0 (0)	.07
Leukocytosis	14 (13)	4 (18)	.07
Wound infection	16 (15)	4 (18)	.05

Data presented as n (%), unless noted otherwise.

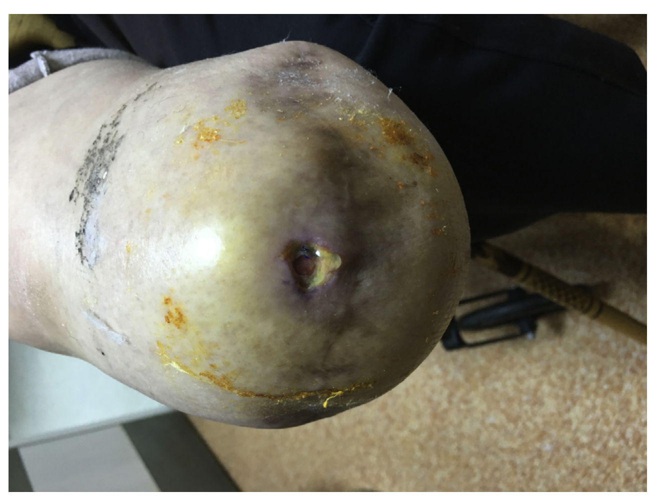

Fig. 1. View from the distal perspective of wound infection involving the right lower extremity after transtibial (below-the-knee) amputation. This patient subsequently underwent transfemoral (above-the-knee) amputation.