

ORIGINAL ARTICLE

Postoperative healing in the diabetic foot is impacted by discharge destination

Rebecca A. Burmeister  | Christine Jarocki | Crystal M. Holmes | Gary M. Rothenberg | Michael E. Munson | Brian M. Schmidt 

Michigan Medicine, Department of Internal Medicine, Division of Metabolism, Endocrinology, and Diabetes, University of Michigan Medical School, Ann Arbor, Michigan

Correspondence

Rebecca A. Burmeister, DPM, MPH, Fellow, University of Michigan, Department of Internal Medicine, Metabolism, Endocrinology and Diabetes, Domino's Farms, 24 Frank Lloyd Wright Drive, Lobby G, Suite 1500, Ann Arbor, MI 48106.
Email: burmeire@med.umich.edu

Abstract

The aim of this study was to evaluate the impact of discharge destination on diabetes-related limb salvage surgery outcomes post-hospitalisation. This was a single-centre, observational, descriptive study of 175 subjects with diabetes who underwent limb salvage surgery of a minor foot amputation or wide incision and debridement for an acutely infected diabetic foot ulcer (DFU). Comparisons were made between subjects discharged home vs a skilled nursing facility (SNF) for 12 months postoperatively. Univariate, multivariate, and time-to-event analyses were performed. The SNF discharge group ($n = 40$) had worse outcomes with longer healing time ($P = .022$), more rehospitalisations requiring a podiatry consult ($P = .009$), increase of subsequent ipsilateral major lower-extremity amputation ($P = .028$), and a higher mortality rate ($P = .012$) within the 12-month postoperative period. There was no significant difference between the cohorts in surgically cleared osteomyelitis ($P = .8434$). The Charlson Comorbidity Index values for those discharged home and those in a short-term nursing facility were similar ($P = .3819$; home $\bar{x} = 5.33 \pm 2.84$ vs SNF $\bar{x} = 5.75 \pm 2.06$). The planned discharge destination after limb salvage surgery among people with an acutely infected DFU should be an added risk factor for healing outcomes. Patients discharged to SNFs experience additional morbidity and mortality compared with patients discharged home post-hospitalisation.

KEYWORDS

diabetic foot, discharge planning, infection, limb salvage, minor foot amputation, ulcer

1 | INTRODUCTION

Approximately 25% of patients with diabetes mellitus (DM) experience a diabetic foot ulcer (DFU) in their lifetime.^{1,2} Healing is often complicated by re-ulceration, with reports suggesting a re-ulceration rate greater than 50% within 3 years.³⁻⁵ Consequently, DFUs increase the risk of a major lower-extremity amputation (LEA). A literature study

estimates that 85% of all major LEAs are preceded by a DFU.⁶ The mortality rate of patients with DM who require a major LEA is greater than 70% within 5 years, and median survival is ~ 2 years.⁷⁻⁹ Because of the high prevalence,^{1,2} reoccurrence,^{5,9} patient psychosocial burden,^{10,11} and financial expenditure associated with DFUs,⁹ many efforts have been taken to better understand and improve outcomes for this multifaceted health problem.

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Any procedure that spares part of the foot, including toe, ray, or midfoot, is considered a minor LEA. Surgeons use minor LEAs when medical management will not successfully clear an infection. Minor LEAs may reduce the rates of major LEAs in patients with infected DFUs.¹² Patients who required a minor LEA demonstrate increased mobility and ability to return to their baseline activity needs compared with patients who required a major LEA.^{13,14}

A review of the literature yields conflicting conclusions regarding outcomes based on hospital discharge destination. In a study evaluating the discharge destinations of over 17 million hospital admissions of Medicare beneficiaries, patients who were discharged home had a 5.6% higher readmission rate compared with patients discharged to a skilled nursing facility (SNF), and there were no mortality differences between the discharge destinations.¹⁵ Other studies that examined discharge destination after vascular surgery, total knee arthroplasty, transcatheter aortic valve replacement, or emergent general surgery found that patients discharged to an SNF, as opposed to their home, experienced worse outcomes, including higher readmission rates, morbidity, or mortality.¹⁶⁻¹⁹

To our knowledge, no publications have evaluated the differences in outcomes of patients discharged home vs an SNF after a minor LEA for a complicated DFU. The primary aim of this study was to examine if the discharge destination could be a risk factor for prolonged healing times after a minor LEA for a complicated DFU. The secondary aim of this study was to examine the influence of patient variables on post-hospitalisation discharge destination.

2 | MATERIAL AND METHODS

2.1 | Study design and population

This was an observational, descriptive study. All 175 subjects were inpatients at a tertiary medical centre who underwent a limb salvage surgery of either a minor LEA or wide forefoot incision or debridement for an infected DFU from October 2015 to May 2019. All subjects were admitted on an urgent basis through the emergency department. Patients were excluded if they were managed in the outpatient setting or if they required a primary major LEA.

Once medically stable, patients were discharged to their home or to an SNF. The discharge destination was strategically selected for the patient based on discussions with the patient, patient's caregiver support system, primary medical team, physical therapy team, case manager, and surgical team. Social and medical factors

Key Messages

- The aim of this study was to evaluate the impact of discharge destination on diabetes-related limb salvage surgery outcomes in patients with acutely infected diabetic foot ulcer requiring hospitalisation.
- Despite similar comorbidities, demographics, and wound presentation prior to limb salvage surgery for a diabetic foot infection, participants not randomly discharged to a short term nursing facility were more likely to have complications in the post-operative period and required more days to heal.
- “Subjects” is considered old language in research, and “participant” is more respectful to the individual(s) to whom you are referring.
- In our cohort, the planned discharge destination after limb salvage surgery was identified a risk factor for poor clinical outcomes.

influenced the discharge destination for each patient. Variables that influenced the discharge destination included patient safety measures with focus on weight-bearing recommendations of the operative foot, administration of postoperative medications such as parenteral antibiotics, and need for skilled wound care. Electronic medical records (EMRs) were reviewed for the first 12 months following surgery.

2.2 | Study outcome

Each subject's EMR was interrogated following surgery for 12 consecutive months postoperatively. Patient demographics, laboratory values, wound characteristics, and imaging were collected upon admission. Time to heal the surgical site (in months), rehospitalisations for diabetic foot infections, additional limb salvage foot surgeries, major LEA, mortality, and follow-up were recorded. The Charlson Comorbidity Index (CCI) was calculated for each subject to assess the individual's burden of disease. The complete healing date was noted in the surgeons' clinical notes. The days between the surgical date and the complete healing date were counted. Intervals were also calculated from the date of surgery and either loss of follow-up, failure to heal by 12 months post-operation, major LEA, or death.

2.3 | Statistical Analysis

Categorical variables were analysed with Fisher's exact test and compared between the home discharge group and the SNF discharge group with a P -value $< .05$, indicating a significant difference between the groups. We compared the continuous variables examined between the two groups using analysis of variance. Finally, a Kaplan-Meier curve assessed the time for complete healing between the two cohorts. Censored data consisted of loss to follow-up, unhealed surgical site after 12 months, major LEA, and death prior to complete healing of ulcer and surgical amputation site and were included in the analysis for generalisability.

3 | RESULTS

3.1 | Demographic and comorbidity comparisons

There were 175 patients who met the inclusion criteria. After limb salvage surgery, 135 (77.1%) patients were discharged home, and 40 (22.9%) patients were discharged to an SNF. Figure 1 depicts the study population and the outcomes. Cohorts were similar in age and comorbid status, as validated using the CCI ($P > .05$). There were more subjects with a Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-V), diagnosis in the SNF cohort ($P < .05$). DSM-V diagnoses are not used in CCI scoring.

Table 1 displays all demographic values. The mean age of all subjects was 57.03 years (± 12.75 years), comprising 76% males, with a median CCI score of 5.42 (IQR

5). More subjects in the SNF group had a DSM-V diagnosis ($P < .05$).

3.2 | Laboratory and imaging comparisons

All laboratory values were collected at the time of admission. Laboratory values that reached statistical significance are displayed in Table 1. Subjects discharged to an SNF had higher erythrocyte sedimentation rates (ESRs) ($F < 0.05$), mean corpuscular haemoglobin concentration ($F < 0.001$), red blood cell distribution width (RDW) ($F < 0.0001$), lymphocyte percentage ($F < 0.05$), absolute lymphocytes ($F < 0.05$), and calcium ($F < 0.01$).

There were no statistically significant differences between groups in terms of presurgical radiograph, magnetic resonance imaging, and non-invasive peripheral vascular study results.

3.3 | Comparisons of initial DFU characteristics and surgical findings

According to infection staging by the Infectious Disease Society of America (IDSA),²⁰ the SNF discharge cohort had more severe infected DFUs compared with those discharged home (2.65 vs 2.38; $P < .05$). No DFU clinical characteristic (ie, associated erythema, purulent drainage, positive probe to bone) reached statistical significance ($P > .05$).

No difference was noted in terms of achievement of surgically clear microbiology margins, with 71.9% ($n = 97$) in the group that was discharged home and 70.0% ($n = 28$) in the group that as discharged to an SNF ($P > .05$).

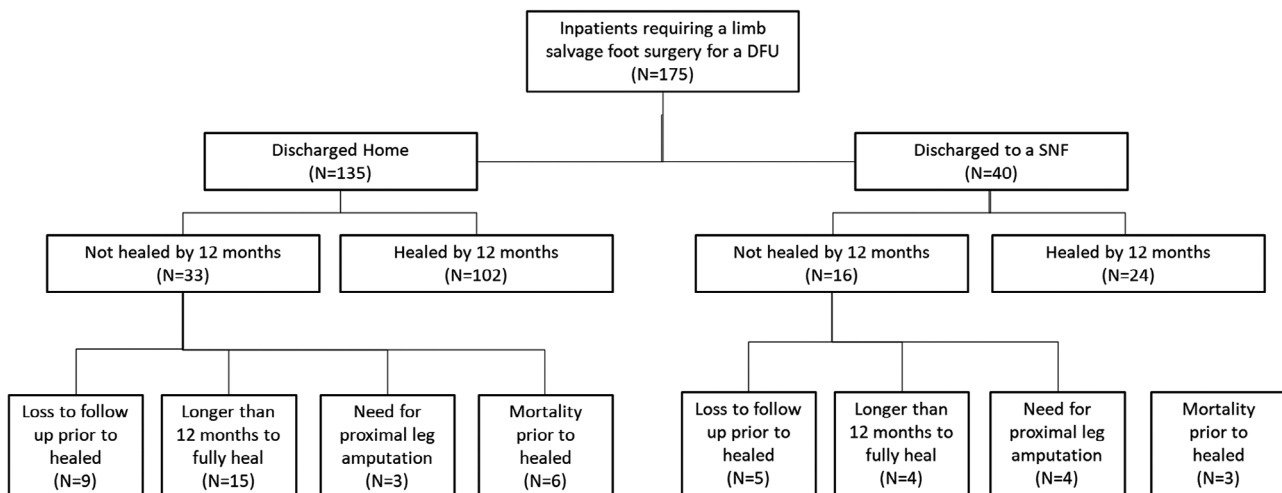


FIGURE 1 Study population and outcomes

TABLE 1 Demographic, comorbidity, and laboratory value comparison between the two discharge destinations

	Home group, mean (SD) or n (%)	Skilled nursing facility group, mean (SD) or n (%)	<i>P</i> value
Charlson comorbidity index total score	5.33 (2.84)	5.75 (2.06)	.38
<i>History of myocardial infarction</i>	24 (17.8%)	10 (25.0%)	.36
<i>Congestive heart failure</i>	26 (19.3%)	12 (30.0%)	.18
<i>Peripheral vascular disease</i>	46 (34.1%)	20 (50.0%)	.09
<i>History of cerebrovascular accident or transient ischaemic attack</i>	13 (9.6%)	5 (12.5%)	.56
<i>Dementia</i>	0 (0.0%)	0 (0.0%)	1.00
<i>Pulmonary disease</i>	11 (8.1%)	6 (15.0%)	.38
<i>Connective tissue disease</i>	7 (5.2%)	2 (5.0%)	1.00
<i>Peptic ulcer disease</i>	2 (1.5%)	1 (2.5%)	.54
<i>Liver disease</i>	14 (10.4%)	0 (0.0%)	.042
<i>Diabetes mellitus</i>	135(100.0%)	40 (100.0%)	1.00
<i>Hemi/paraplegia</i>	4 (3.0%)	0 (0.0%)	.58
<i>Severe renal disease</i>	15 (11.1%)	7 (17.5%)	.29
<i>Malignant solid tumour</i>	22 (16.3%)	4 (10.0%)	.45
<i>Leukaemia</i>	0 (0.0%)	0 (0.0%)	1.00
<i>Lymphoma</i>	1 (0.7%)	5 (12.5%)	.003
<i>AIDS</i>	0 (0.0%)	0 (0.0%)	1.00
<i>Body mass index (kg/m²)</i>	33.29 (7.12)	32.78 (6.22)	.68
<i>Gender (% male)</i>	106 (78.5%)	27 (67.5%)	.28
<i>Employed at time of surgery</i>	30 (22.2%)	7 (17.5%)	.66
<i>Tobacco use</i>	35 (25.9%)	15 (37.5%)	.17
<i>Ambulating prior to surgery</i>	132 (91.0%)	40 (100.0%)	1.00
<i>Prior established podiatric care</i>	94 (69.6%)	29 (72.5%)	.85
<i>DSM-V diagnosis</i>	17 (12.6%)	11 (27.5%)	.047
<i>Depression</i>	16 (11.9%)	10 (25.0%)	.07
<i>Diabetic peripheral neuropathy</i>	125 (92.6%)	37 (92.5%)	1.00
<i>History of previous pedal amputation</i>	49 (36.3%)	14 (35.0%)	1.00
<i>Erythrocyte sedimentation rate</i>	64.71 (33.62)	81.03 (33.02)	.013
<i>Mean corpuscular haemoglobin concentration</i>	33.10 (1.49)	32.34 (1.09)	<.001
<i>Red blood cell distribution width</i>	13.82 (1.79)	15.66 (4.74)	<.001
<i>Abs. lymphocytes</i>	1.79 (1.14)	1.40 (0.69)	.045
<i>Calcium</i>	9.06 (0.53)	8.85 (0.59)	.039
<i>Infectious Disease Society of America classification</i>	2.38 (0.71)	2.65 (0.79)	.041

Note: Bold value indicates a significant *p*-values. Italic value indicates an ANOVA test for that variable.

3.4 | Longitudinal healing outcome comparisons

Table 2 displays healing outcome variables within the 12-month postoperative period. The SNF discharge group required longer hospitalisation for admitting diagnosis (significant $F < 0.0001$). The SNF group showed higher

rates of readmission with a foot-related issue ($P < .01$). In addition, more patients in the SNF group required a major LEA ($P < .05$) or underwent additional forefoot limb salvage surgery within the first 6 months postoperatively ($P < .05$). Finally, the SNF group had a higher mortality rate compared with the home discharge group ($P < .05$).

TABLE 2 Comparison of 12-month outcomes between the home discharge group and the skilled nursing facility (SNF) discharge group

Event within 12-month follow-up period	Home group, mean (SD) or n (%)	SNF group, mean (SD) or n (%)	Significance F or P value
Length of hospitalisation at time of surgery	6.46 days (3.60)	10.78 days (10.16)	<.001
Rehospitalised with a pedal issue	42 (31.1%)	22 (55.0%)	.009
Ipsilateral below or above knee amputation	2 (1.5%)	4 (10%)	.028
Mortality	6 /110 (5.5%)	7 /34 (20.6%)	.012
New diabetic foot ulcer (DFU) at 3-month follow-up	43/130 (33.1%)	12/37 (32.4%)	1.00
New DFU at 6-month follow-up	43/107 (40.2%)	14/29 (48.3%)	.53
New DFU at 12-month follow-up	47/104 (45.2%)	16/26 (61.5%)	.19
Any additional limb salvage surgery needed by 6-month follow-up	24/107 (22.4%)	11/29 (37.9%)	.045
Any additional limb salvage surgery needed over the 12-month follow-up	36/135 (26.7%)	16/40 (40%)	.12

Note: Italic value indicates an ANOVA test for that variable.

A Kaplan-Meier curve with censored data (Figure 2) was used to compare time to heal between the home discharge and the SNF discharge groups. The cohort discharged to an SNF experienced less complete healing than the home discharge cohort ($P < .05$). The average days to heal for patients discharged home vs SNF patients was 81.9 days and 140.4 days, respectively. Approximately 50% of the patients discharged home healed within 1 month postoperatively, while the SNF group experienced that threshold at ~3 months postoperatively.

4 | DISCUSSION

Subjects who were discharged to an SNF following limb salvage surgery of a minor LEA or wide incision and debridement were more likely to experience postoperative complications. These complications, including a longer initial hospitalisation, increased the need for rehospitalisation along with the need for an additional podiatry evaluation, conversion to an ipsilateral major LEA, increased time to heal the limb salvage operative site, and an increased mortality rate.

Patients discharged to an SNF had a significantly longer hospitalisation for the limb salvage surgery ($P < .001$). This longer hospitalisation may be related to the planning of services required for SNF discharge. A previous study examined the concepts of medically fit for discharge (MFFD) vs therapy fit for discharge (TFFD).²¹ The average postoperative stay was 18 days, despite patients, on average, being MFFD and TFFD on days 8 and 11 after amputation, respectively.²¹ This study also found that patients electively admitted for major LEA, compared with an emergent admission resulting in a

major LEA, had shorter hospitalisations. The study theoretically explained this difference in length of stay using the ability to plan and coordinate services for the elective admission group prior to the admission and general health differences of the elective vs emergent admission groups.²¹ However, this study did not include patients with a minor LEA, and unfortunately, our subjects required emergent admissions for their DFU infections.

The CCI is a method to compare subjects as a whole patient as opposed to any one comorbidity. Patient age and 16 differently weighted comorbidities are used to calculate the estimated 10-year survival.^{22,23} The CCI focusses on comorbidities that have previously been shown to effect and predict mortality risk in patients. The CCI has gained popularity and validity and comprises part of the LACE index (length of stay, acuity of admission, CCI, and emergency department use), which is a validated, predictive scoring model that identifies patients at high risk of costly rehospitalisation.²⁴ The fact that there was no significant difference in CCI scores between the cohorts in our study, yet subjects discharged to an SNF did significantly worse in postoperative outcomes, highlights the complexity of treating diabetic foot infections and osteomyelitis.

Our current data analysis showed that patients were more likely to be discharged to an SNF if they had a DSM-V diagnosis ($P < .05$). Mental health comorbidities are not used to calculate CCI scores and may explain some of the differences in our outcomes. Mental health comorbidities have a negative impact on overall diabetes outcomes. A previous study found that patients with DM and depression were at a 33% higher risk of a major LEA, but there was no significant difference in the risk of a minor foot amputation.¹¹ We did not find a difference in

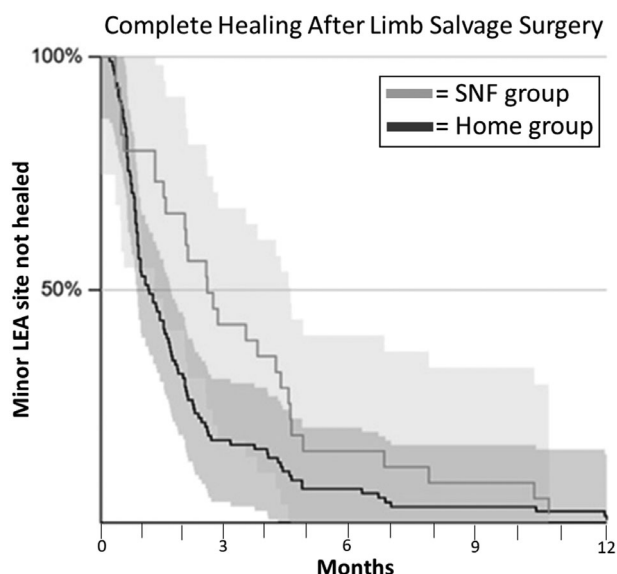


FIGURE 2 Kaplan-Meier curve compared time with complete healing after limb salvage surgery between subjects discharged home vs those discharged to a skilled nursing facility

the need for conversion to major LEA occurrence in patients with a DSM-V condition compared with those without ($P > .05$).

There was a significant difference of ESR values between our cohorts ($P < .05$; home $\bar{x} = 64.71$ mm/h vs SNF $\bar{x} = 81.03$ mm/h). However, both cohorts had an average ESR greater than 60 mm/h, which has been the benchmark when combined with a c-reactive protein (CRP) level greater than 7.9 mg/dL as predictors of underlying osteomyelitis.²⁵ The statistically significant difference of ESR averages may not be clinically significant because, at this time, no literature supports the presumption that the elevation of the ESR is proportional to severity of diabetic foot osteomyelitis.²⁵

It would be expected that the SNF cohort would have more assistance in care compared with patients discharged to their home, and the result of additional support would allow patients to reduce complications and be a protective factor. Our data demonstrate that this was not the case, and home discharge resulted in improved outcomes for our patient population. Specifically, during the 12-month postoperative period, the SNF group had higher readmission rates ($P < .01$), slower time to heal, and lower rates of complete healing ($P < .05$); was more likely to convert to major LEA ($P < .05$); and had a higher mortality rate ($P < .05$). Our findings were parallel to those of previous works demonstrating that patients discharged to an SNF following vascular surgery had higher readmission and mortality rates.¹⁹ Thus, discharge destination planning is complicated and multifactorial, has improvement potential,

and significantly impacts postoperative diabetic limb salvage surgery outcomes.

Our efforts are not without limitations. First, this was an observational study, and the objective decision-making process surrounding discharge disposition, including the specific reasons for determination of discharge disposition, were not fully captured. Second, the data evaluated are based on relatively non-modifiable variables, such as patient age and certain comorbidities. Third, because of the nature of the large tertiary care facility where we recruited our subjects, 11.4% of our patients were lost to follow-up. However, the 11.4% loss to follow-up rate should have a minimal effect on our measured variables between the two groups and could be explained by our hospital acting as a regional medical centre for the entire state.

5 | CONCLUSIONS

Discharge to an SNF after limb salvage surgery for an infected DFU had worse outcomes in terms of healing, rehospitalisation, need for a major LEA, and mortality, compared with patients who were discharged home, despite similar proximal bone surgical clear microbiological margin rates. This was previously unrecognised as a stand-alone risk factor that could partially predict outcomes in this patient cohort. It is also important that future research endeavours should examine modifiable factors that contribute to postoperative outcomes for an infected DFU. Modifiable risk factors that may improve outcomes include direct communication between the surgical team and SNF providers, ensuring SNF providers are trained for limb salvage postoperative patients with diabetes, tracking SNF staff to patient ratios, and surgical team awareness that a discharge to an SNF can indicate that the postoperative course is likely to be more complicated compared with a patient who is deemed safe to discharge home.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ORCID

Rebecca A. Burmeister  <https://orcid.org/0000-0002-6724-3117>

Brian M. Schmidt  <https://orcid.org/0000-0002-2561-9243>

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