



## Factors Predicting Length of Hospital Stay and Extended Care Facility Admission After Hindfoot Arthrodesis Procedures



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### ARTICLE INFO

Level of Clinical Evidence: 3

#### Keywords:

discharge disposition  
hindfoot arthrodesis  
health insurance  
length of hospital stay  
predictive modeling  
skilled nursing facility

### ABSTRACT

Delayed identification of patients requiring admission to extended care facilities (ECFs) can lead to greater healthcare costs through an increased length of hospital stay (LOHS). Previous studies of hip and knee arthroplasty identified factors associated with a likely discharge to an ECF. These issues have not been extensively studied for major hindfoot procedures. We conducted a retrospective review of 198 cases treated during a 3-year period to identify the risk factors for an extended LOHS and ECF admission after ankle arthrodesis, triple arthrodesis, pantalar arthrodesis, and subtalar arthrodesis. The primary outcomes were LOHS and ECF admission. The independent predictors included age, sex, body mass index, housing status, American Society of Anesthesiologists class, diabetes and/or diabetic neuropathy, health insurance, fixation type, and perioperative infection. Stepwise multiple regression analysis was used to determine which variables were related to a longer LOHS. Nonparametric discriminant function analysis was used to identify the preoperative factors that best predicted ECF admission. A longer LOHS was significantly related to postoperative ECF admission, Centers for Medicare and Medicaid Services (CMS) insurance, diabetic neuropathy, external fixation, and infection. ECF admission was required for 34 of 198 patients (17.2%). Discriminant analysis found that older age, living alone, external fixation, and CMS insurance predicted a greater probability of ECF admission. The function accurately classified 94% of ECF admissions and 80% of non-ECF admission patients. ECF admission and CMS insurance extended the LOHS, likely owing to the administrative process of arranging an ECF discharge. If externally validated, the function we have derived could provide preoperative identification of likely ECF discharge candidates and reduce costs by shortening the LOHS.

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Between 13% and 54% of all patients undergoing total joint arthroplasty of the hip, knee, or ankle are discharged to an extended care facility (ECF) (1–8). Much less is known about discharge disposition rates after hindfoot arthrodesis procedures, which have become significantly more frequent since the mid-1990s (9). A recent study suggested, however, that the rate of postoperative discharge to an ECF after hindfoot arthrodesis procedures is 17% to 21% of patients, within the reported range for arthroplasty (10).

Certification for ECF discharge often requires a few days to complete and requires a physical therapy evaluation. Thus, a patient who might have been discharged on postoperative day 3 might find their length of hospital stay (LOHS) increased simply because of waiting for completion of the requisite administrative functions for an ECF discharge. Multiple studies have shown an association between discharge to an ECF and an increased LOHS of  $\geq 1$  days (4,11). Pressure to reduce LOHS as a cost-saving measure continues to increase, and earlier discharge has not been correlated with any increase in readmission rates, at least in the case of total knee arthroplasty (12). The ability to begin administrative procedures for discharge to ECF earlier than is currently typical would therefore be 1 method to reduce LOHS-related costs without placing patients at increased risk of readmission.

In many cases, the factors predicting the need for ECF admission after hindfoot arthrodesis procedures can likely be observed preoperatively and are independent of the particular surgery

**Financial Disclosure:** None reported.

**Conflict of Interest:** None reported.

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performed. A central factor is that most patients undergoing these procedures will very often not be allowed to bear weight on the operative extremity. That factor and the patient's age, home living situation, body composition, and other health concerns can all predict the LOHS and the need for ECF admission (1–4,11,13–17). In cases in which patients have private insurance, these predictive factors can be used to arrange ECF admission preoperatively, because patients undergoing these procedures are often medically ready for discharge on the first postoperative day. This also holds true for patients in the Medicare and Medicaid populations; however, the current Centers for Medicare and Medicaid Services (CMS) guidelines require a 3-day minimum inpatient stay for coverage to extend to ECF placement after discharge. Significant healthcare savings could be realized if patients requiring ECF admission could be identified preoperatively and then discharged on the first postoperative day when most are medically ready.

Several previous studies have identified the patient characteristics predicting postoperative discharge to an ECF after hip and knee arthroplasty (1–3,11,14,18). In the present study, we performed a similar consecutive review of patients who underwent various hindfoot arthrodesis procedures. Our purpose was to first determine which factors, including discharge to an ECF, were most influential in extending the LOHS in this cohort of patients. Next, we used discriminant function analysis to identify characteristics other than the LOHS that would accurately predict their need to be discharged to an ECF postoperatively. The resulting function, once validated in an independent sample, could be used to initiate discharge planning to an ECF on, or even before, admission for hindfoot arthrodesis. Clinically, such a method would reduce the number of patients with an increased LOHS resulting from discharge planning delays.

## Patients and Methods

The operative records of 2 orthopedic foot and ankle surgeons from 2011 to 2013 were searched retrospectively for the following procedures: ankle arthrodesis, triple arthrodesis, pantalar arthrodesis, or subtalar arthrodesis. The search resulted in a sample of 198 unique individuals who had undergone these procedures. For each patient, we collected the following information: age, sex (1, male; 2, female); body mass index (BMI), housing status (1, lives with others; 2, lives alone); American Society of Anesthesiologists class (classes 1 through 4), diabetic status and related neuropathy (0, no diabetes; 1, diabetes without neuropathy; 2, diabetes with neuropathy), health insurance covering the surgery (private insurance or workers' compensation, 1; CMS [Medicare or Medicaid], 2), fixation type (external weightbearing, 1; internal non-weightbearing, 2); perioperative infection status (no, 1; yes, 2); LOHS, and ECF admission (yes, 1; no, 2).

Diabetic neuropathy was assessed from medical record review and was confirmed radiographically. Patients classified as "yes" for perioperative infection status were those who presented with Charcot arthropathy or a chronically infected ankle fracture at surgery. They underwent debridement and hardware removal and were placed in a ring external fixator for definitive treatment. These patients required intravenous antibiotics, but none required a return to the operating room and none required additional postoperative wound care. Every patient discharged to an ECF was admitted specifically to a skilled nursing facility. The local institutional review board approved all the study procedures.

## Statistical Analysis

Stepwise multiple linear regression analysis was used to determine the factors that significantly influenced LOHS. Standardized regression coefficients were then used to compare the relative influence of each variable on LOHS. Discriminant function analysis was used to determine the optimal set of independent variables that most accurately sorted the sample into the 2 groups corresponding to ECF admission or non-ECF admission. The primary outcome measure (dependent variable) was whether each patient was admitted to an ECF. The independent predictor variables were only included in the discriminant analysis if they differed significantly between the 2 groups, which we determined using Wilcoxon-Mann-Whitney tests.

Because several of these independent predictor variables were ordinal, we used the nonparametric *k*-nearest-neighbors discriminant analysis technique to classify cases and evaluate the accuracy of the function (19). Two subanalyses were run, differing with regard to whether the prior probabilities were set to be equal or proportional. Prior probabilities are central to the manner in which the discriminant function sets the boundary

between groups in multivariate space. With 2 possible groups (as in the present study), if the likelihood of discharge disposition for any new patient before surgery were completely unknown, without any additional information, we would have to assume that they would have equal probabilities of being discharged to an ECF or not (0.500 versus 0.500). The actual proportions of patients discharged to an ECF vary widely, however, ranging from 13% to 54% in total knee and hip arthroplasty (1–3,5–7) and closer to 20% in a previous study of hindfoot procedures (10). In the present sample, only 17.2% of patients undergoing hindfoot procedures required discharge to an ECF. Given these data, the proportional prior probability for our sample would be 0.172 for discharge to an ECF versus 0.828 for a non-ECF discharge.

Compromises are associated with which set of prior probabilities are used. Equal prior probabilities will overestimate the actual rate of ECF admission in the sample, indicating that the function will be biased toward classifying individual cases as requiring ECF admission and thus prone to false-positive results. In contrast, if the prior probabilities are set to be proportional to the observed rate of ECF admission, the criteria for assignment to the ECF admission group will be narrower. This scenario could result in an elevated rate of false-negative results, leading to individuals on the group boundary who actually should be discharged to an ECF not being classified as requiring an ECF discharge.

In the broader clinical context, we suggest that the real-world costs in terms of time and financial resources are greater for the false-negative cases than for the false-positive cases. The failure to pre-identify patients as requiring ECF admission would lead to the same unnecessary extension of the LOHS owing to administrative delays that form the central problem the present analysis seeks to address. The reverse situation, a false-positive assignment resulting in ECF arrangements made in advance unnecessarily and then cancelled, seems to us to be less costly. The costliness of each scenario is, however, debatable and might vary depending on the healthcare system and conditions; thus, we present the results of these 2 subanalyses for comparison.

Within each subanalysis, an iterative process was used to find the most accurate value of *k*-nearest-neighbors for classifying individual cases. Analyses were run with the value of *k* set to every integer from 1 to 14 ( $\sqrt{N}$ ), inclusive. The specific value of *k* is essentially unimportant, outside of any effect it might have on the classification accuracy of the function (19). The results were therefore compared to determine the value of *k* that produced the most accurate classification rate. The accuracy of each *k*-value was judged on the rates of correct classification within each ECF admission group, the cumulative correct classification rate among all patients, and the mean of the 2 groups' correct classification rates. The *k*-value producing the greatest level of accuracy in the largest number of these categories was chosen for the final discriminant function classification results.

Wilcoxon-Mann-Whitney tests were then used to compare the values of the study variables between any misclassified cases and any correctly classified cases within the ECF admission and non-ECF admission groups. The post hoc analysis was used to further clarify why certain cases were incorrectly classified and to identify the sources of any bias resulting from the independent variables in erroneous classifications. With regard to statistical power, no method is available for calculating power, per se, for a discriminant function analysis. Instead, the general guideline is that the sample should include  $\geq 5$  observations for every independent predictor variable included in the analysis, and the number of the smallest group should exceed the number of independent variables. The present study was designed to analyze  $\leq 9$  independent variables in a sample of 198, for an a priori observation-to-variable ratio of  $\geq 22$ . The smaller of the 2 groups was the ECF admission group, 34 patients. Both samples were therefore well above the minimum thresholds. All statistical analyses were performed in SAS, version 9.3, statistical software (SAS Institute, Cary, NC), and  $\alpha$  was set to 0.05.

## Results

Of the 198 patients in the present study, 34 were admitted to an ECF postoperatively and had a significantly longer LOHS ( $p < .01$ ) than the remaining 164 patients who were not admitted to an ECF. The patient data stratified by type of procedure are listed in Table 1. The pre- and perioperative characteristics of each subgroup (ECF admission versus non-ECF admission) are presented in Table 2. The 2 groups

**Table 1**  
Frequency of patients stratified by procedure

Procedure	Patients (%)		
	ECF Admission (n = 34)	Non-ECF Admission (n = 164)	Total (n = 198)
Triple arthrodesis	38	45	44
Pantalar arthrodesis	12	2	4
Subtalar arthrodesis	6	23	20
Ankle fusion	15	17	16
Subtalar arthrodesis and ankle fusion	29	13	16

Abbreviation: ECF, extended care facility.

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