Factors Related to Reamputation in Patients with Diabetes Who Have Undergone Minor Amputation: A Single-Facility Retrospective Cohort Study

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Research

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Abstract

Background: With aging, there has been an increase in the number of patients with lower limb amputations, especially in Japan. Previous studies have reported that minor amputation after limb salvage is associated with a high recurrence, with the ulcer recurring within 10.5 months. Age, wounded area, history of peripheral artery disease, and wound infection have been reported as the risk factors of recurrence. Thus far, there are no studies on the association between rehabilitation and reamputation. This study therefore aimed to examine factors predictive of reamputation in patients with diabetes who have undergone minor amputation for developing a rehabilitation program.

Methods: This study included 129 patients who had undergone physical therapy between January 2015 and February 2018. The patients were assigned to the reamputation and non-reamputation groups. We retrospectively studied the patients' medical records and compared the factors between the groups. Next, we analyzed the differences between the factors using Cox proportional hazards analysis.

Results: During the follow-up period, 42 patients (35.2%) underwent reamputation. The factors associated with reamputation were hemodialysis, ankle dorsiflexion angle, and ambulation Functional Independence Measure score.

Conclusions: We identified hemodialysis, ankle dorsiflexion angle, and FIM ambulation were the factors associated with reamputation in patients with diabetes who had undergone minor amputation. Future developing a rehabilitation program focusing on these factors could reduce reamputations.

Background

In Japan, the most frequent cause of amputation is trauma. However, the percentage of amputations due to peripheral circulatory disorders such as arteriosclerosis obliterans and diabetic gangrene has recently increased [1].

In a large-scale epidemiological investigation of the incidence of lower extremity amputations in diabetic patients, the annual incidence was estimated to be 0.05% [2]. In addition, a survey conducted by The Global Burden of Disease study reported that the number of patients with diabetes-related lower-extremity amputation was estimated to be 50,000 in Japan [3].

As Japan is a developed country with a growing elderly population, an increased number of patients with lower limb amputations may result in a greater burden on social welfare and medical expenses. Progress in multidisciplinary treatment has resulted in limb salvage and reduced rates of major amputation in patients with diabetes and peripheral arterial disease [4]. However, patients who had undergone minor amputation after limb salvage treatment presented with a high recurrence rate, and the ulcer has been reported to develop in 69.5% of such cases within 10.5 months [5]. It was reported that 49.1% of such patients underwent ipsilateral reamputation within 3 years after their first surgery, with 78.9% of these undergoing reamputation in the first 6 months [6].

Previous studies have indicated that the risk factors for recurrence in minor amputation cases are age [7], wounded area [8], history of peripheral artery disease [9], and wound infection [10].

The multidisciplinary approach for diabetic foot treatment includes debridement of the wound, management of any infection, revascularization procedures, and postoperative lower limb rest and offloading [11].

Rehabilitation is increasingly performed after amputation to prevent complications and maintain limb function.

If the association between rehabilitation and reamputation was reported, effective interventions could be applied to decrease reamputation. However, there have been no such reports to date. Therefore, this study aimed to examine the predictive factors related to minor reamputation in patients with diabetes to develop a rehabilitation program that would consider the risk of reamputation.

Methods

Study participants

This retrospective cohort study included 245 patients with diabetic ulcers who had undergone a minor amputation followed by physical therapy between January 2015 and February 2018. All subjects were patients admitted at the Oita Oka Hospital. We excluded patients with (1) infections after minor amputation, (2) major amputations (below and above the knee), (3) death or discharge due to systemic complications, (4) use of a wheelchair for mobility before hospitalization, (5) severe progression of dementia, (6) missing data, (7) and no follow-up survey data. Finally, 129 patients were enrolled in this study (Fig. 1).

Major and minor amputations were defined as those proximal and distal, respectively, to the ankle joints, including the toes. Reamputation was defined as occurring in the ipsilateral limb within 1 year after the first amputation.

Data Collection

Measurement items included participants’ basic and medical information, physical function, and the presence or absence of reamputation. Basic information included age, sex, body mass index (BMI), hospitalization, physical therapy period, average length of daily physical therapy in minutes, foot offloading period, comorbidities (hypertension, hyperlipidemia, and heart disease, cerebrovascular disease, chronic kidney disease, and chronic obstructive pulmonary disease), and presence or absence of hemodialysis. The medical information included laboratory parameters (serum albumin, serum hemoglobin, blood glucose, C-reactive protein, white blood cell counts, and estimated glomerular filtration rate), lower limb blood flow data (skin perfusion pressure and ankle-brachial pressure index), wound ischemia foot infection (WIfI) classification system, amputation region (toe, ray, and transmetatarsal), and foot deformation (Charcot joint, hallux valgus, hammer toe, and claw toe). The physical function included knee extension muscle strength, ankle dorsiflexion angle, ankle plantarflexion angle, plantar sensory disorder, and Functional Independence Measure (FIM) ambulation. BMI was calculated by dividing the body weight (kg) by the square of the height (m) and was reported in kg/m^2. The offloading period started from the minor amputation to the start of loading.

The average length of daily physical therapy was calculated by dividing total hours of physical therapy by the number of days in the hospital. The estimated glomerular filtration rate (eGFR) was calculated based on the new Japanese coefficient Modification of Diet in Renal Disease study equation: eGFR ($mL/min/1.73\ m^2$) = 194 × (serum creatinine) − 1.094 × (age) − 0.287 (× 0.739 for females) [12].

Participants were categorized into the following four groups according to the estimated eGFR (1) ≥ 60 $mL/min/1.73\ m^2$, (2) 45–59.9 $mL/min/1.73\ m^2$, (3) 30–44.9 $mL/min/1.73\ m^2$, and (4) < 30 $mL/min/1.73\ m^2$ [13].

We considered angina pectoris, myocardial infarction, percutaneous coronary intervention, or coronary artery bypass grafting as cardiovascular condition-related history and transient ischemic attack, cerebral infarction, or cerebral hemorrhage as cerebrovascular condition-related history. Lower limb blood flow data with skin perfusion pressure as a measure of blood flow were evaluated using a Laser Doppler (SensiLase PAD4000, KanekaMedix, Osaka, Japan). The ankle-brachial index was measured with an automated oscillometric device provided by Omron Colin Co., Ltd. (Tokyo, Japan). We evaluated the wound data using the WIfI and the ischemia and foot infection data using three factors. Severity was classified by the depth, location, and presence or absence of necrotic tissue [14]. Amputation region and foot deformation were evaluated using simple radiography and computed tomography images before and after surgery.

For physical function evaluation, we examined the maximum voluntary isometric knee extension muscle strength using a hand-held dynamometer (μ-tasF-1, Anima, Tokyo, Japan). For knee extensor strength measurements, participants were asked to sit on a chair with the knee flexed at 90 degrees and push at maximum strength against the dynamometer pad for 5 s. Isometric knee extensor strength was measured twice per side, and the highest value for the right and left legs was used to represent the knee extensor muscle strength.

The range of motion in the ankle joint was evaluated by measuring dorsiflexion and plantarflexion on the wound side with a goniometer and the angle that allowed maximum pain-free movement. The presence or absence of plantar sensory impairment was considered as neuropathy when the evaluator size of the Semmes-Weinstein-monofilament was 5.07.

Based on previous studies, we performed three-site tests involving the plantar aspects of the great toe, third metatarsal, and fifth metatarsal [15]. The ambulation status was evaluated using the movement parameter of the FIM score [16].

Intervention

In this study, the goal of rehabilitation intervention was to improve deconditioning and walking ability and expand the activities of daily living during hospitalization. The 1st postoperative day started with strength training and range-of-motion exercises of the hip and knee joints, which were performed according to the pain indication. Additionally, a walking practice started after wound healing.

Statistical analysis

Characteristic data were compared using the Mann–Whitney U test, *t*-test, and χ^2 test, as appropriate. A univariate Cox proportional hazards analysis was used to calculate the reamputation hazard ratio (HR) and its 95% confidence interval. A multivariate Cox regression analysis was used to determine the factors associated with reamputation. We selected the following factors for univariate analysis: age, sex, serum albumin, knee extension muscle strength, hemodialysis, ankle dorsiflexion angle, and FIM ambulation. Subsequently, a multivariate Cox regression analysis with stepwise selection was carried out to identify significant independent factors.

The incidence of reamputation presence and absence was calculated using the Kaplan–Meier curves for the extracted factors. The intergroup differences were estimated using the log-rank test. All analyses were performed with R version 3.2.5 (R Foundation for Statistical Computing, Vienna, Austria). The level of significance was set at $P < 0.05$.

Results

The demographic and medical information of the patients is shown in Table 1. There were 42 patients in the reamputation group within 1 year of discharge and 87 in the non-reamputation group. The reamputation group exhibited significantly higher rates of hemodialysis and FIM ambulation and lower rates of lower ankle dorsiflexion angle than the non-reamputation group (Table 1). Univariate Cox regression analysis showed that knee extension muscle strength, hemodialysis, ankle dorsiflexion angle, and the FIM ambulation administered were potential risk factors for reamputation. Subsequent multivariate Cox regression analysis with stepwise selection identified hemodialysis (HR 2.20, 95% CI 1.12–4.34), ankle dorsiflexion angle (HR 5.82, 95% CI 2.93–11.58), and FIM ambulation (HR 3.85, 95% CI 2.00–7.39) as significant risk factors for reamputation (Table 2). Figure 2, 3, and 4 shows the Kaplan–Meier curves indicating the cumulative incidence of reamputation after minor amputation. In the survival analyses using the Kaplan–Meier log-rank test, presence or absence of hemodialysis (Fig. 2), ankle dorsiflexion angle (Fig. 3), and FIM ambulation (Fig. 4) were significant ($P < 0.05$).

Discussion

The present study examined factors that influence reamputation within 1 year of discharge in patients who had undergone minor amputation. We revealed that the presence or absence of hemodialysis, ankle dorsiflexion angle, and FIM ambulation were associated with reamputation in this patient population. The recurrence rate was 34.5% within 1 year of discharge, similar to previous findings [17].

Comparing the amputation region, toe amputation showed a high reamputation rate. Regarding the relationship between amputation region and reamputation, a previous study reported that a second amputation was required in 60% of great toe amputation cases after 10 months [18]. Moreover, adjacent toe deformation has been reported as a factor influencing reamputation after toe amputation [19]. In this study, all patients underwent physical therapy, and, therefore, the reamputation rate could be suppressed by preventing deformation. Additionally, high reamputation rates have been reported after transmetatarsal amputation in contrast to our results [20].

In recent years, the wound healing rate after transmetatarsal amputation has improved due to the use of advanced treatment techniques, and even if an increase in the number of surgeries is expected, walking ability can be maintained compared to major amputation [21]. Several previous studies have reported that limited ankle joint mobility may increase plantar mechanical stress [22, 23], especially limited ankle-dorsiflexion. The range of motion has been reported to increase the maximum plantar pressure during walking and cause pressure concentration on the forefoot [24, 25]. In this study, the limited ankle joint mobility caused pressure concentration on the foot during walking, which could have resulted in wound worsening after discharge.

Regarding the relationship between hemodialysis and reamputation, it has been reported that hemodialysis caused periodic fluid fluctuations and worsened microcirculation, thereby promoting blood circulation disorders [26]. Miyajima et al. reported that hemodialysis was also an independent risk factor of major limb amputation [27]. Okamoto et al. reported that approximately 40% of 140 patients who had undergone hemodialysis had a peripheral arterial disease [28].

These findings were similar to ours'. We, therefore, determined that patients who had undergone hemodialysis may have had been wounded and may have undergone reamputation due to peripheral arterial disease. Previous studies have reported the effects of different walking styles and speeds on plantar mechanical stress [29]. In addition, a study reported that an increase in cumulative plantar tissue stress associated with the extension of walking distance resulted in a wound [30].

In this study, the ambulation status was evaluated using the FIM score. However, it was difficult to compare our results with those of previous studies using the index of walking speed and style. Patients with FIM score < 5 were able to walk 50 m independently and were expected to engage in intensive walking after discharge. We also found that hemodialysis, ankle dorsiflexion angle, and FIM ambulation at the time of discharge were related to reamputation rates within 1 year.

Finally, we highlight that the prevention of recurrence has become an important outcome with the progress of limb salvage treatment. This finding suggests that early follow-up is necessary for foot care and rehabilitation in patients who undergo minor amputation and engage in intensive walking.

However, this study has several limitations. First, our results were obtained from a single facility. Similar findings derived from other facilities are needed to validate ours for generalizability. Second, the definition of reamputation was restricted to only the original hospital. Further, patients who had not received physical therapy were excluded. Besides, we did not investigate the living conditions and self-management status of patients after discharge from the hospital.

Moreover, the results may not be generalizable to all hospitalized patients with minor amputation; thus, further longitudinal studies with larger samples in a multiple hospital setting are required to investigate the reamputation rates in hospitalized patients with minor amputation.

Conclusions

To conclude, hemodialysis, ankle dorsiflexion angle, and FIM ambulation were the factors associated with reamputation in patients with diabetes who had undergone minor amputation. The data obtained from this study will be valuable in aiding future rehabilitation program of preventing reamputation. Further studies with larger samples are needed to confirm our results.

Abbreviations

BMI: body mass index

eGFR: estimated glomerular filtration rate

FIM: Functional Independence Measure

HR: hazard ratio

WIfI: wound ischemia foot infection

Declarations

Availability of data and materials

Not applicable.

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None

Authors' contributions

SI and TH were involved in study conception and design, data collection, data analysis and interpretation, and drafting the manuscript. KS, MF, and MO were involved in data interpretation and contributed to drafting the manuscript. All authors have read and approved the final manuscript.

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki (as revised in Brazil in 2013), and approval was obtained from the Ethical Committee of the Oita Oka Hospital (approval number: B0018). In place of informed consent from every participant, consent was sought by publishing details of the study on the homepage of the research institute website, as well as on-site posting in the facility

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

References

1. Ohmine S, Kimura Y, Saeki S, Hachisuka K. Community-based survey of amputation derived from the physically disabled person's certification in Kitakyushu City, Japan. Prosthet Orthot Int. 2012;36:196-202.
2. Iwase M, Fujii H, Nakamura U, Ohkuma T, Ide H. Incidence of diabetic foot ulcer in Japanese patients with type 2 diabetes mellitus: The Fukuoka Diabetes Registry. Diabetes Res Clin Pract. 2018;137:183-9.
3. Zhang Y, Lazzarini PA, McPhail SM, van Netten JJ, Armstrong DG. Global disability burdens of diabetes-related lower-extremity complications in 1990 and 2016. Diabetes Care. 2020; doi: 10.2337/dc19–1614.
4. Holstein P, Ellitsgaard N, Olsen BB, Ellitsgaard V. Decreasing incidence of major amputations in people with diabetes. Diabetologia. 2000;43:844-7.
5. Borkosky SL, Roukis T. Incidence of repeat amputation after partial first ray amputation associated with diabetes mellitus and peripheral neuropathy: An 11-year review. J Foot Ankle Surg. 2013;52:335-8.
6. Kono Y, Muder RR. Identifying the incidence of and risk factors for reamputation among patients who underwent foot amputation. Ann Vasc Surg. 2012;26:112026.
7. Ohsawa S, Inamori Y, Fukuda K, Hirotuji M. Lower limb amputation for diabetic foot. Arch Orthop Trauma Surg. 2001;121:186-90.
8. Skoutas D, Papanas N, Georgiadis GS, Zervas V, Manes C, Maltezos E, et al. Risk factors for ipsilateral reamputation in patients with diabetic foot lesions. Int J Low Extrem Wounds. 2009;8:69-74.

9. Nerone VS, Springer KD, Woodruff DM, Atway SA. Reamputation after minor foot amputation in diabetic patients: Risk factors leading to limb loss. J Foot Ankle Surg. 2013;52:184-7.
10. Acar E, Kacıra BK. Predictors of lower extremity amputation and reamputation associated with the diabetic foot. J Foot Ankle Surg. 2017;56:1218-22.
11. Schaper NC, Van Netten JJ, Apelqvist J, Lipsky BA, Bakker K. Prevention and management of foot problems in diabetes: A summary guidance for daily practice 2015, based on the IWGDF guidance documents. Diabetes Res Clin Pract. 2017; doi: 10.1016/j.diabres.2016.12.007.
12. Matsuo S, Imai E, Horio M, Yasuda Y, Tomita K, Nitta K, et al. Revised equations for estimated GFR from serum creatinine in Japan. Am J Kidney Dis. 2009;53:982-92.
13. Roshanravan B, Khatri M, Robinson-Cohen C, Levin G, Patel KV, de Boer IH, et al. A prospective study of frailty in nephrology-referred patients with CKD. Am J Kidney Dis. 2012;60:912-21.
14. Mills JL Sr, Conte MS, Armstrong DG, Pomposelli FB, Schanzer A, Sidawyet AN, et al. The society for vascular surgery lower extremity threatened limb classification system: risk stratification based on wound, ischemia, and foot infection (WIfI). J Vasc Surg. 2014;59:220-34.
15. Feng Y, Schlösser FJ, Sumpio BE. The Semmes Weinstein monofilament examination as a screening tool for diabetic peripheral neuropathy. J Vasc Surg. 2009;50:675-82.
16. Granger CV, Hamilton BB, Linacre JM, Heinemann AW, Wright BD. Performance profiles of the functional independence measure. Am J Phys Med Rehabil. 1993;72:84-9.
17. Izumi Y, Satterfield K, Lee S, Harkless LB. Risk of reamputation in diabetic patients stratified by limb and level of amputation: a 10-year observation. Diabetes Care. 2006;29:566-70.
18. Murdoch DP, Armstrong DG, Dacus JB, Laughlin TJ, Morgan CB, Lavery LA. The natural history of great toe amputations. J Foot Ankle Surg. 1997;36:204-8.
19. Quebedeaux TL, Lavery LA, Lavery DC. The development of foot deformities and ulcers after great toe amputation in diabetes. Diabetes Care. 1996;19:165-7.
20. Thorud JC, Jupiter DC, Lorenzana J, Nguyen TT, Shibuya N. Reoperation and reamputation after transmetatarsal amputation: a systematic review and meta-analysis. J Foot Ankle Surg. 2016;55:1007-12.
21. Terashi H, Kitano I, Tsuji Y, Hashikawa K, Tahara S. A modified transmetatarsal amputation. J Foot Ankle Surg 2011;50:441-4.
22. Lavery LA, Lavery DC, Quebedeax-Farnham TL. Increased foot pressures after great toe amputation in diabetes. Diabetes Care. 1995;18:1460-62.
23. Armstrong DG, Lavery LA. Plantar pressures are higher in diabetic patients following partial foot amputation. Ostomy Wound Manage. 1998;44:30-2.
24. Lavery LA, Armstrong DG, Boulton AJ, Diabetex Research Group. Ankle equinus deformity and its relationship to high plantar pressure in a large population with diabetes mellitus. J Am Podiatr Med Assoc. 2002;92:479-82.

25. McPoil TG, Yamada W, Smith W, Cornwall M. The distribution of plantar pressures in American Indians with diabetes mellitus. J Am Podiatr Med Assoc. 2001;91:280-7.
26. Shimazaki M, Matsuki T, Yamauchi K, Iwata M, Takahashi H, Genda S, et al. Assessment of lower limb ischemia with measurement of skin perfusion pressure in patients on hemodialysis. Ther Apher Dial. 2007;11:196-201.
27. Miyajima S, Shirai A, Yamamoto S, Okada N, Matsushita T. Risk factors for major limb amputations in diabetic foot gangrene patients. Diabetes Res Clin Pract. 2006;71:272-9.
28. Okamoto K, Oka M, Maesato K, Ikee R, Mano T, Moriya H, et al. Peripheral arterial occlusive disease is more prevalent in patients with hemodialysis: comparison with the findings of multidetector-row computed tomography. Am J Kidney Dis. 2006;48:269-76.
29. Youdas JW, Kotajarvi BJ, Padgett DJ, Kaufman KR. Partial weight-bearing gait using conventional assistive devices. Arch Phys Med Rehabil. 2005;86:394-8.
30. Maluf KS, Mueller MJ. Comparison of physical activity and cumulative plantar tissue stress among subjects with and without diabetes mellitus and a history of recurrent plantar ulcers. Clin Biomech. 2003;18:567-5.

Tables

Table 1 Patients categorized into reamputation and non-reamputation				
Characteristics	Total (n=129)	Reamputation group (n =42)	Non-reamputation group (n =87)	p value
Age (years)	66.2 ± 12.3	66.7 ± 12.6	66.0 ± 12.3	0.75
Gender, Male, n (%)	83 (64.3)	30 (71.4)	53 (60.9)	0.18
BMI (kg/m2)	22.9 ± 2.3	22.7 ± 2.8	23.0 ± 2.5	0.69
Hospitalization days	33.4 ± 15.7	36.2 ± 16.5	34.3 ± 18.1	0.41
Physical therapy period (days)	23.0 ± 9.2	22.6 ± 9.3	23.1 ± 9.2	0.79
Physical therapy time (min)	40.2 ± 14.8	41.5 ± 7.8	39.6 ± 10.3	0.63
Off Loading period (days)	15(11–20)	15 (11–20)	17 (12–20)	0.71
Comorbidities, n (%)				
Hypertension	64 (49.6)	22 (52.3)	42 (48.2)	0.53
Heart disease	40 (31.0)	12 (28.5)	28 (32.1)	0.65
Cerebrovascular disease	6 (0.4)	2 (4.2)	4 (4.5)	0.41
COPD	4 (0.2)	1 (2.1)	3 (3.4)	0.98
Hemodialysis	41 (31.7)	19 (40.4)	22 (25.2)	<0.01
Laboratory parameters				
Serum albumin (g/dL)	2.7 ± 1.1	2.6 ± 1.0	2.8 ± 1.1	0.52
Serum hemoglobin (g/dL)	11.4 ± 2.2	11.1 ± 1.9	11.9 ± 2.3	0.09
Blood glucose	183.6 ± 19.3	179.7 ± 17.4	187.2 ± 21.8	0.19
CRP (mg/dl)	0.4 ± 1.1	0.5 ± 1.4	0.7 ± 0.9	0.35
WBC 103/μL	9435.9 ± 3203.6	9154.7 ± 3069.3	9573.2 ± 3276.0	0.44
eGFR (mL/min/1.73 m2), n (%)				
eGFR ≥ 60	39 (30.2)	12 (28.5)	27 (31.0)	0.91
eGFR 45–59	14 (10.8)	4 (9.5)	10 (11.4)	
eGFR 30–44	17 (13.1)	5 (11.9)	12 (13.7)	
eGFR < 30	59 (45.7)	21 (50.0)	38 (43.6)	
Lower limb blood flow				
SPP (mmHg)	36.7 ± 14.6	35.9 ± 14.2	37.1 ± 14.8	0.58
ABI	0.5 ± 0.2	0.6 ± 0.2	0.5 ± 0.3	0.15
WIfI classification, n (%)				
W0	23 (17.8)	8 (19.0)	19 (21.8)	0.81
W1	35 (27.1)	13 (30.9)	27 (31.0)	
W2	41 (31.7)	11 (26.1)	19 (21.8)	
W3	46 (35.6)	10 (23.8)	22 (25.2)	
Amputation region, n (%)				
Toe amputation	63 (48.8)	22 (52.3)	41 (47.1)	0.06
Ray amputation	42 (32.5)	13 (30.9)	29 (33.3)	0.51
Transmetatarsal amputation	24 (18.6)	7 (16.6)	17 (19.5)	0.34
Foot deformation, n (%)				
Charcot joint	12 (9.3)	4 (8.5)	8 (9.1)	0.97
Hallux valgus	19 (14.7)	7 (14.8)	12 (13.7)	0.68
Hammer toe	17 (13.1)	7 (14.8)	10 (11.4)	0.24
Claw toe	19 (14.7)	8 (17.0)	11 (12.6)	0.35
Physical function				
Knee Extension Muscle Strength(kgf)	20.4 ± 6.1	19.2 ± 5.8	21.0 ± 6.2	0.11
Ankle dorsiflexion angle (°)	6.4 ± 8.5	2.6 ± 9.2	8.3 ± 7.6	<0.01
Ankle plantar flexion angle (°)	17.5 ± 11.5	16.7 ± 11.9	17.8 ± 11.7	0.61
Plantar Sensory disorder, n (%)	94 (72.8)	32 (76.1)	62 (71.2)	0.62
FIM ambulation point	5 (4–6)	5 (4–6)	6 (5–7)	<0.01

Data expressed as mean ± standard deviation, median (interquartile range), n(%). BMI, body mass index; COPD, chronic obstructive pulmonary disease; CRP, c-reactive protein; WBC, white blood cell; SPP, skin perfusion pressure; ABI, ankle brachial pressure index; FIM, Functional Independence Measure.

Table 2 Factors associated with reamputation

Parameter	Univariate analysis			Multivariate analysis		
	HR	95%CI	p value	HR	95%CI	p value
Age	0.91	0.49-1.69	0.773			
Sex, male	1.005	0.98 -1.03	0.672			
Serum albumin	0.922	0.70 -1.20	0.549			
Knee Extension Muscle Strength	0.949	0.90-0.99	0.031	0.95	0.91-1.00	0.06
Hemodialysis	2.974	1.54-5.73	<0.001	2.2	1.12-4.345	0.02
Ankle dorsiflexion angle	5.572	2.88-10.77	<0.001	5.82	2.93-11.58	<0.001
FIM ambulation	3.168	1.68 -5.96	<0.001	3.85	2.00-7.39	<0.001

FIM: Functional Independence Measure HR: Hazard Ratio, CI: Confidence Interval
Influential factors to reamputation (in the first 1 year) the results of Cox proportional hazard analysis

Figures

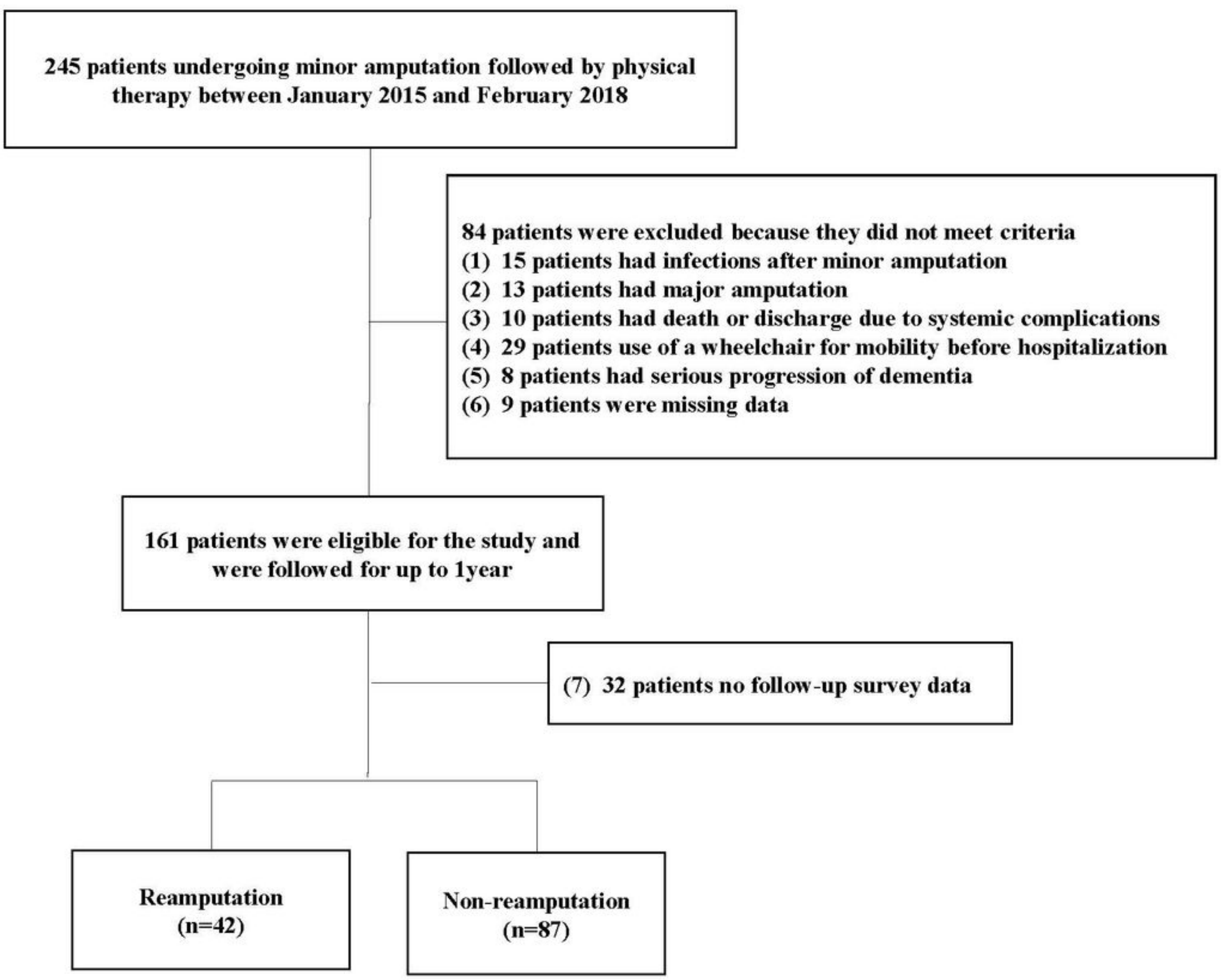

Figure 1

Flowchart of patient selection

Fig. 2

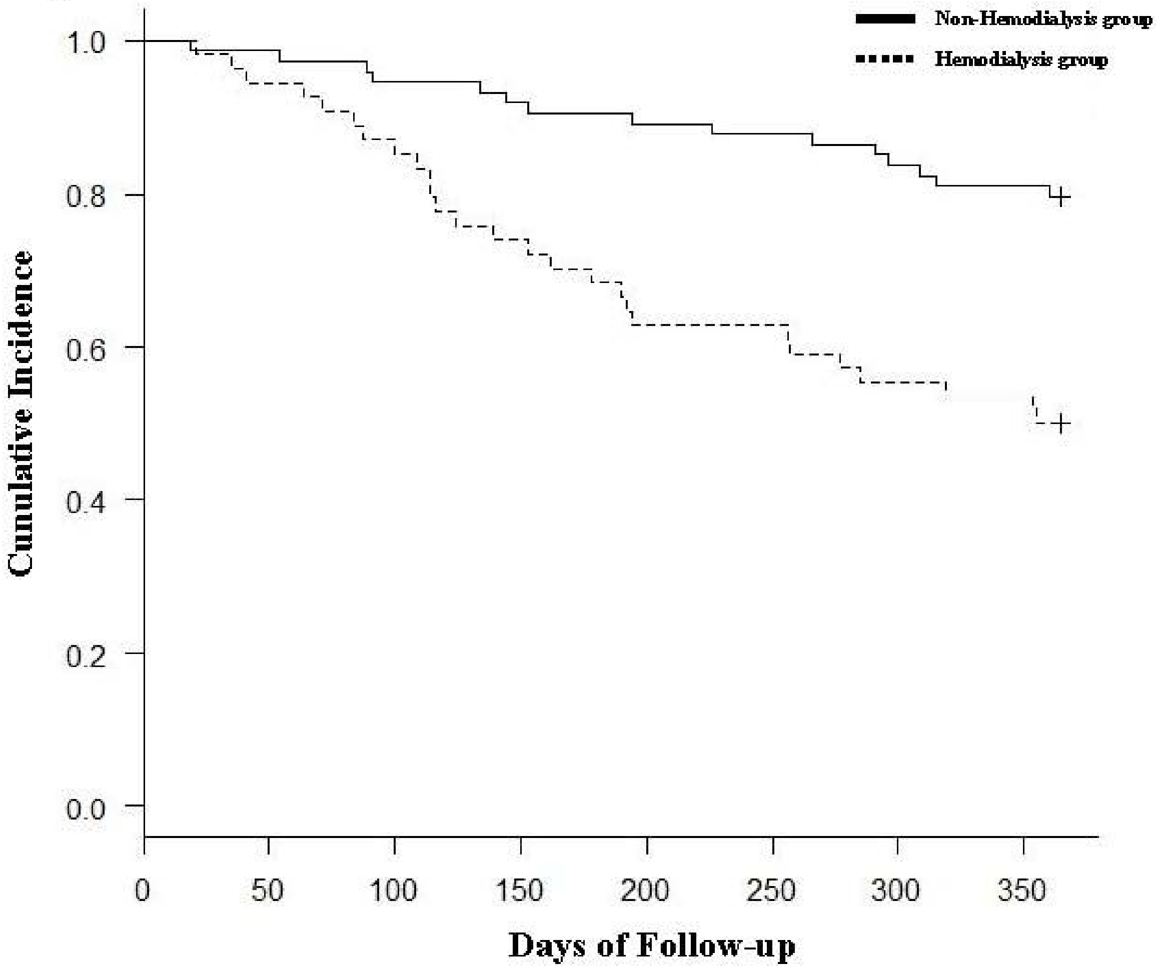

Figure 2

Kaplan−Meier curves of survival versus reamputation: presence or absence of hemodialysis.

Fig. 3

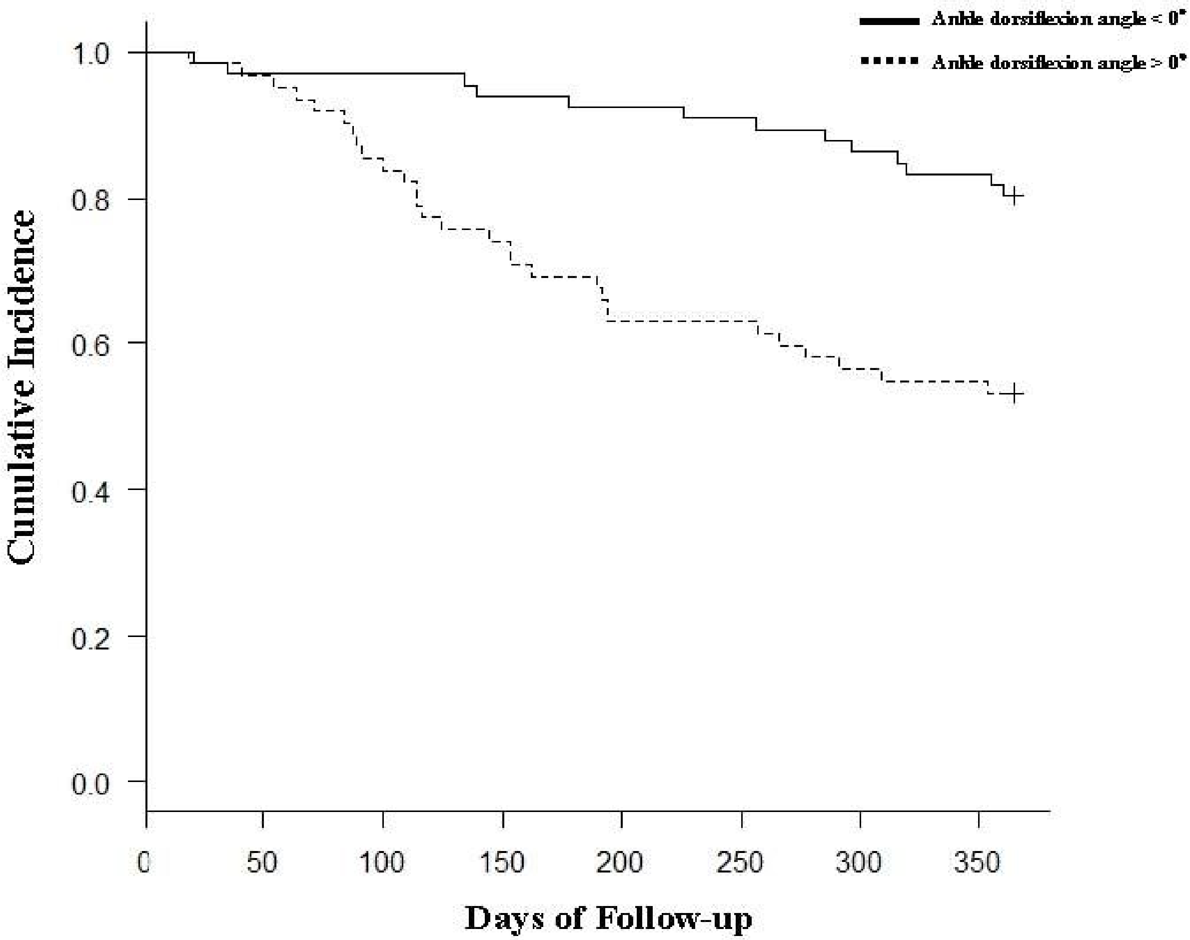

Figure 3

Kaplan–Meier curves of survival versus reamputation: presence or absence of ankle dorsiflexion limitation.

Fig. 4

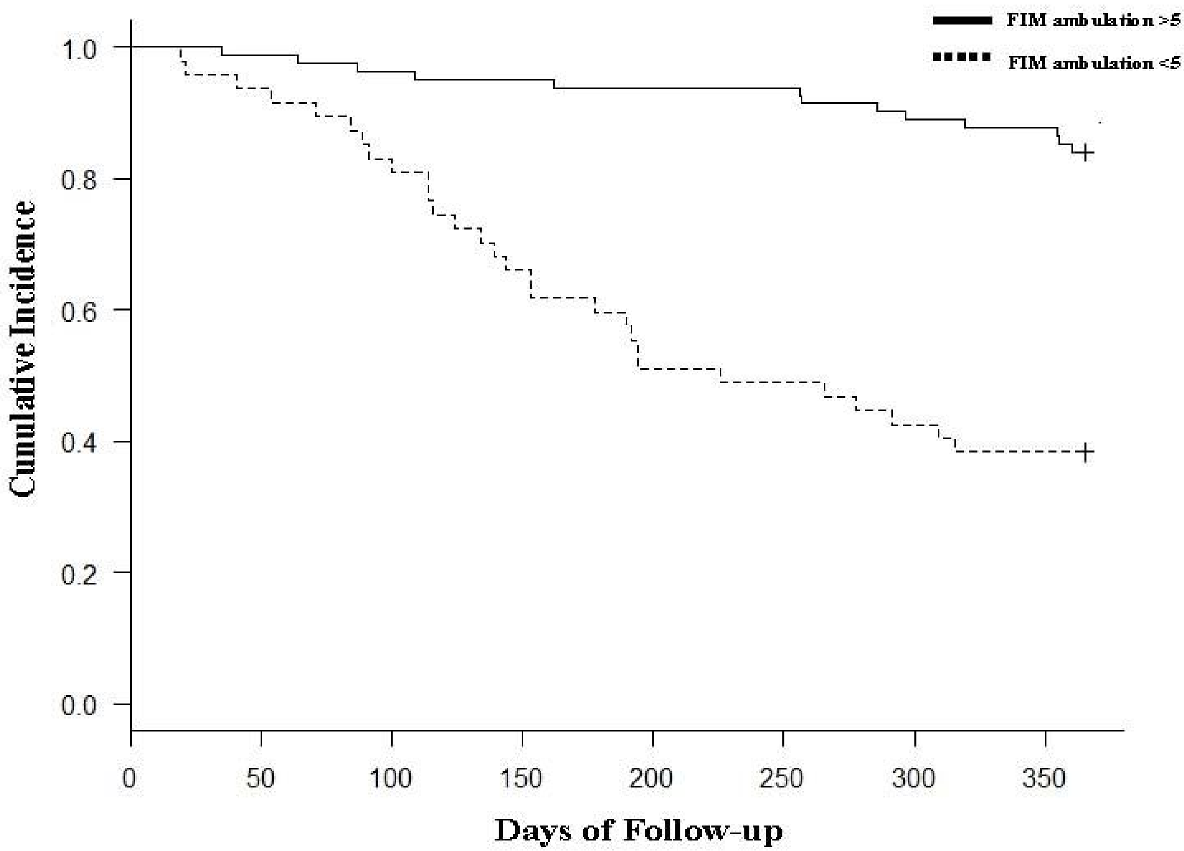

Figure 4

Kaplan–Meier curves of survival versus reamputation: ambulation group and non-ambulation group.