

Original article

# Investigation of amputees with prosthetic limbs at our hospital

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## Abstract

**Objectives:** This study was performed to elucidate the characteristics of amputees in our hospital. We also evaluated whether the causes and characteristics of the amputations influenced the patients' prosthetic walking ability.

**Materials and Methods:** We retrospectively examined 47 amputees in our hospital from December 1996 to April 2016 with respect to the causes and levels of amputation. Of 28 lower limb amputees from April 2008 to April 2016, 22 received prostheses and were divided into 2 groups according to the cause of the amputation, as follows: the internal cause group (e.g., vascular deficiency and infection) and the external cause group (e.g., trauma, burn injury, and crush syndrome). The characteristics and process of achieving prosthetic ambulation were compared between these groups.

**Results:** Trauma was the most common cause of both upper (70.0%) and lower limb amputations (40.5%). Unilateral amputation was performed in 93.2% of patients (upper limb amputation, 100.0%; lower limb amputation, 91.9%). Patients were older in the internal than in the external cause group ( $P = 0.026$ ). The serum albumin ( $P = 0.003$ ) and total cholesterol concentrations ( $P = 0.046$ ) on admission were significantly lower in the internal than in the external cause group. All patients in the internal cause group had comorbidities. The proportions of patients with diabetes mellitus ( $P = 0.011$ ) and cerebrovascular disease ( $P = 0.036$ ) were significantly higher in the internal than in the external cause group. No significant difference in walking ability was found between the internal and external cause groups at the time of discharge.

**Conclusion:** Most amputees in our hospital underwent unilateral lower limb amputation due to trauma. Although the patients with internal causes of amputation were older, more frequently had malnutrition, and had more comorbidities than those with external causes, they achieved prosthetic walking with statistically insignificant difference at the end of hospitalization, excluding six patients who had no prosthetic prescription.

**Key words:** amputee, prosthesis, walking ability, internal cause, external cause

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## Introduction

The incidences and causes of limb amputation vary widely among different countries<sup>1</sup>. Societal aging and lifestyle westernization in Japan have influenced diseases<sup>2, 3</sup>, resulting in a changing environment for limb amputation. In particular, whereas trauma accounted for 70% of the causes of amputations in the 1960s, conditions characterized by vascular deficiency, such as diabetes and arterial sclerosis, now account for 80% of the causes of amputation and replaced trauma as the main cause in Hyogo prefecture in Japan in the 2000s<sup>4</sup>. Studies performed in both the Osaka and Okayama prefectures revealed these same changes in the causes of lower limb amputation<sup>5, 6</sup>. In addition, the sites at which amputation was performed have changed. Although most patients with vascular deficiency used to undergo transfemoral amputation because it carries lower risks of stump-related complications and additional amputation<sup>7</sup>, medical developments and the acknowledged importance of knee conservation conducted to the increased use of trans-tibial amputation.

Although the environment of limb amputation has changed, few reports have described the demographics of

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limb amputation in Japan. Our hospital plays a central role in rehabilitation and manages postoperative limb amputees referred by other hospitals in Ibaraki prefecture. In the present study, we investigated the characteristics and clinical courses of limb amputees in our hospital.

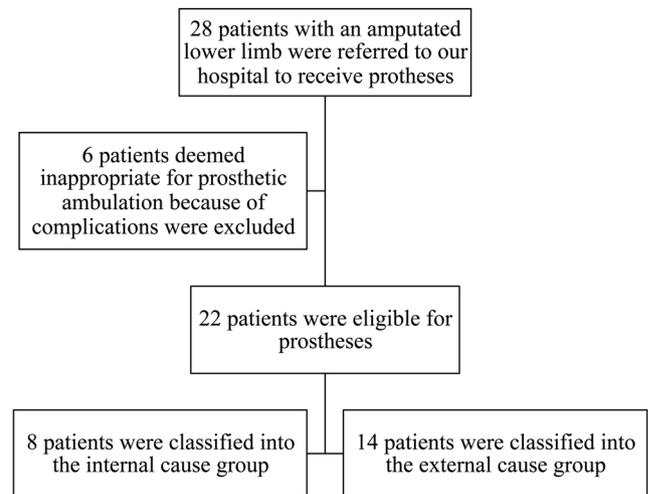
Furthermore, various studies have investigated predictive factors of walking ability following lower limb amputation. Pre-amputation living status, amputation level, age, physical fitness level, and comorbidities were reported to be moderate to strong predictive factors of prosthetic candidacy<sup>1, 8-10</sup>. However, whether the cause of amputation affects the ability to achieve prosthetic ambulation is unclear in previous reports. We therefore evaluated how causal differences in limb amputation influence prosthetic ambulation among lower limb amputees in our institution.

## Materials and Methods

We retrospectively examined the medical records of amputees in our hospital from December 1996 to April 2016. Forty-seven patients were eligible for our study. We investigated the causes and levels of amputation, as well as the clinical courses of patients with prostheses.

Twenty-two of 28 lower limb amputees were treated with prostheses between April 2008 and April 2016. We divided the 22 patients into two groups according to the cause of amputation, as follows: the internal cause group (e.g., vascular deficiency and infection) and the external cause group (e.g., trauma, burn injury, and crush syndrome; Figure 1). Trauma included traffic accidents and injury by machines such as conveyor belts. Eight of the 22 patients underwent amputations because of internal causes; and 14, because of external causes. The excluded six amputees were determined to be inappropriate for prosthetic ambulation because of complications; all six patients underwent amputation due to internal causes.

We compared the patients' characteristics (age, sex, body mass index, cause of amputation, amputation level, duration to hospital admission, nutritional status, and comorbidities). Onset was defined as the date of the first consultation for the causative disease in the internal cause group and the date of the injury in the external cause group. The duration from amputation to hospital admission was defined as the time from the operation to the admission for rehabilitation to achieve prosthetic walking ability. Each patient's nutritional status was verified on the basis of the serum albumin concentration, total cholesterol concentration, and lymphocyte count on admission. As the Controlling Nutritional Status score is a well-established parameter in nutritional evaluation<sup>11</sup>, we extracted its components, including serum albumin concentration, total cholesterol concentration, and



**Figure 1** Twenty-eight patients who had a unilateral or bilateral lower limb amputation were referred to our hospital to receive prostheses between April 2008 and April 2016. Six patients were excluded because they were considered inappropriate for prosthetic ambulation owing to complications. Twenty-two of the 28 received prostheses and were admitted to our hospital for rehabilitation. We divided the 22 patients into two groups according to the cause of amputation, as follows: the internal and external cause groups.

lymphocyte count. However, we evaluated these factors independently because we lacked data regarding the total cholesterol concentration for 11 patients. We also investigated the existence of injuries at other limbs, including the clavicle and pelvis in the external group. Furthermore, we compared the rehabilitation progress (course to discharge and status of prosthetic ambulation at discharge).

The Shapiro-Wilk test was used to determine whether the data were normally distributed. The Student *t* test was used to compare parametric numeric data with normality, and the Mann-Whitney *U* test was used to compare parametric numeric data without normality and nonparametric numeric data. The chi-square test or Fisher exact test was used to compare categorical data. A *P* value of < 0.05 was considered statistically significant. Statistical analysis was performed with SPSS ver. 23 (IBM Corp., Armonk, NY, USA).

## Results

The causes of amputation and levels of limb amputation in our institution from 1996 to 2016 are summarized in Tables 1 and 2, respectively. In total, 47 patients were evaluated. Trauma was the most common cause of both upper (70.0%) and lower limb amputations (40.5%), and vascular

**Table 1** Causes of amputation in our institution from 1996 to 2016

Upper limb amputation	10
Trauma	7
Burn injury	2
Tumor	1
Lower limb amputation	37
Trauma	15
Vascular deficiency	12
Infection	6
Burn injury	3
Muscular crush syndrome	1

deficiency was the second common cause (32.4%) of lower limb amputations. We prescribed prostheses to 40 amputees, but not to 7 amputees because of heart failure, dementia, poor preoperative activities of daily living, and severe joint contracture. Upper limb amputees were prescribed cosmetic prostheses (90.0%) and functional prostheses (50.0%). Unilateral limb amputation was performed in 44 patients; and bilateral limb amputation, in 3. Among those who underwent unilateral amputation, 10 (100.0%) and 34 (91.9%) had upper and lower limb amputations, respectively. The major methods of amputation were transtibial and transfemoral amputations.

Of the 28 lower limb amputees treated between April 2008 and April 2016, 22 received prostheses. The cause of amputation in 12 (54.5%) of the 22 patients was trauma. Such injury is a major cause of amputation in our hospital. Five (22.7%) of the 22 patients underwent amputations because of vascular deficiency; and three (13.6%), because of infection. The remaining two patients (9.1%) had a burn injury and muscle crush syndrome, respectively.

The mean ages of the patients in the internal and external cause groups were 56.1 and 38.4 years, respectively ( $P = 0.026$ ; Table 3). Although no significant difference was observed in the level of amputation, most amputations in the internal and external cause groups were unilateral transfemoral amputations (62.5%) and unilateral transtibial amputations (50.0%), respectively. With respect to the patients' nutritional status, serum albumin ( $P = 0.003$ ) and total cholesterol concentrations ( $P = 0.046$ ) were significantly lower in the internal than in the external cause group. All the patients in the internal cause group had comorbidities. The proportions of patients with diabetes mellitus ( $P = 0.011$ ) and cerebrovascular disease ( $P = 0.036$ ) were significantly higher in the internal than in the external cause group. Eight of the 14 amputees in the external group had injuries at other limbs, including the clavicle and pelvis.

All 22 patients with lower limb amputation achieved

**Table 2** Levels of limb amputation in our institution from 1996 to 2016

Level of limb amputation	n
Unilateral limb amputation	44
Upper limb	10
Finger amputation	3
Wrist disarticulation amputation	1
TRA	2
THA	4
Lower limb	34
Below-ankle disarticulation	1
TTA	16
TFA	16
HDA	1
Bilateral limb amputation	3
Lower limbs	3
Bilateral TTA	1
Unilateral TTA + unilateral TFA	1
Bilateral TFA	1

TRA: transradial amputation, THA: transhumeral amputation, TTA: transtibial amputation, TFA: transfemoral amputation, HDA: hip disarticulation amputation.

prosthetic ambulation. However, 50% of the patients in the external cause group accomplished independent walking, and 75% of the patients in the internal cause group walked with a cane or walker (Table 4). The time from amputation to discharge tended to be shorter in the internal than in the external cause group (186.5 vs. 267.5 days, respectively;  $P = 0.082$ ).

## Discussion

The present study shows that most of the patients who underwent amputation in our hospital experienced trauma to a unilateral lower limb. The number of amputees aged > 65 years has been increasing with the aging of the society in Japan<sup>5, 12</sup>. A study performed in Kitakyushu City revealed that 55.4% of all amputees between 2001 and 2005 were > 65 years old<sup>13</sup>. However, in our institution, only 3 (13.6%) of the 22 patients treated between April 2008 and April 2016 were older. The lower proportion in our study was likely because the study population was derived from limited departments with no dialysis facilities. Comorbidities associated with lifestyle-related diseases typically increase with age. For example, diabetes mellitus and arterial sclerosis, which can lead to amputation, are strongly associated with chronic kidney disease. Webster *et al.*<sup>14</sup> described the relationship between treatment with prostheses following lower limb amputation and dialysis. However, we had no dialysis facili-

**Table 3** Characteristics of the patients in the internal and external cause groups

	Internal cause (n = 8)	External cause (n = 14)	<i>P</i>
Age, years	56.1 ± 11.4	38.4 ± 17.9	0.026
Male sex	7 (87.5)	11 (78.6)	0.535
Body mass index, kg/m <sup>2</sup>	20.81 (18.34–22.36)	20.45 (19.67–22.17)	0.728
Cause of amputation			
Trauma	0	12	
Vascular deficiency	5	0	
Infection	3	0	
Others	0	2	
Amputation level			
Unilateral TTA	2 (25.0)	7 (50.0)	0.246
Unilateral TFA	5 (62.5)	5 (35.7)	0.221
Unilateral HDA	1 (12.5)	0 (0.0)	0.364
Bilateral lower limb amputation	0 (0.0)	2 (14.3)	0.394
Duration to hospital admission, days			
From onset to amputation	10.5 (1.8–30.3)	2.5 (0.0–18.0)	0.188
From amputation to admission	38.0 (34.5–47.3)	81.5 (39.0–358.0)	0.127
Nutritional status			
Albumin, g/dL	3.6 (3.3–3.6)	4.1 (3.9–4.3)	0.003
Total cholesterol, mg/dL	152 (140–167)	186 (162–192)	0.046
Lymphocytes, cells/μL	1993 (1810–2180)	1865 (1518–2554)	0.714
Comorbidities			
Diabetes mellitus	5 (62.5)	1 (7.1)	0.011
Hypertension	3 (37.5)	1 (7.1)	0.117
Cerebrovascular disease	3 (37.5)	0 (0.0)	0.036
Cardiovascular disease	2 (25.0)	1 (7.1)	0.291
Arthritis	2 (25.0)	0 (0.0)	0.121
Hyperuricemia	1 (12.5)	1 (7.1)	0.606
Psychiatric disorder	1 (12.5)	1 (7.1)	0.606

Data are presented as mean ± standard deviation, n (%), median (range), or n. TRA: transradial amputation, THA: transhumeral amputation, TTA: transtibial amputation, TFA: transfemoral amputation, HDA: hip disarticulation amputation.

**Table 4** Rehabilitation progress in the internal and external cause groups

	Internal cause (n = 8)	External cause (n = 14)	<i>P</i> value
Course to discharge, days			
Hospitalization period	146.5 (131.5–151.8)	139.5 (89.8–171.0)	0.901
From amputation to discharge	186.5 (180.0–196.8)	267.5 (185.3–358.0)	0.082
Prosthetic ambulation at discharge			
Independent gait	2 (25.0)	7 (50.0)	0.246
With cane	4 (50.0)	6 (42.9)	0.546
With walker	2 (25.0)	1 (7.1)	0.291

Data are presented as median (range) or n (%).

ties, and our study therefore included few older patients with severe comorbidities.

Walking ability was not significantly different between the internal and external cause groups. The internal cause group was characterized by advanced age, lower serum albumin and total cholesterol concentrations, and more co-

morbidities when compared with the external cause group. We also observed a higher frequency of transfemoral and hip disarticulation amputations in the internal cause group. By contrast, the external cause group was characterized by a higher ratio of transtibial amputation and included bilateral lower limb amputees. Although the differences between the

two groups were not significant, the period from amputation to hospital admission was twice as long in the external than in the internal cause group. In this study, the patients with internal cause had more poor prognostic factors for achieving prosthetic ambulation than the patients with external causes. We expected that the rehabilitation process would be longer or that failure to achieve prosthetic walking ability would occur more frequently in the internal than in the external cause group. However, an approximately equivalent hospitalization period enabled patients in both groups to achieve prosthetic walking, although the patients in the internal cause group tended to walk with devices such as canes and walkers. One conceivable reason for this is that the characteristics of the patients in our hospital were affected by limited hospital functions as previously explained. Furthermore, we selected appropriate patients to achieve prosthetic ambulation. We decided that prostheses were inappropriate for patients with complications such as severe cardiac failure and dementia. All six amputees who did not receive prostheses were in the internal cause group. This selection method may explain why the patients in the present study were younger than those in previous reports<sup>8)</sup> and why even patients in the internal cause group could obtain walking ability. Prescription of prostheses depending on the patient's status resulted in an improved rate of achieving prosthetic ambulation. We also consider injuries to other limbs in the external cause group an important factor for rehabilitation. Injuries to other limbs might require longer acute-phase treatment and delay admission to our hospital. After admission, it might influence the hospitalization period because un-amputated limbs do not function well in support of rehabilitation. Moreover, one amputee with a burn injury in the external cause group developed frequent stump-related complications and required a long time before being able to walk with a prosthesis. Medical care was provided to all the amputees by using a multidisciplinary team approach that involved a physical therapist, an occupational therapist, a prosthetist, a clinical psychotherapist, a medical social worker, a nurse, and a physiatrist in our hospital. These reasons possibly caused no significant difference in walking ability between the internal and external cause groups. The significant difference in serum albumin and total cholesterol concentrations between the two groups had no implication to walking ability. A supposable reason was that even the serum albumin and total cholesterol concentrations in the internal cause group were inapplicable to poor nutritional condition despite the significantly worse data than those in the external cause group. Thus, the outcome possibly did not significantly differ between the two groups.

Our study had several limitations. First, some patient bias was present because of the characteristics of our insti-

tution. Few patients in our study had severe comorbidities and complications because our institution has limited departments and facilities such as dialysis equipment. These features resulted in a younger population than those in other institutions and thus a higher ratio of external causes of amputation. Second, this was a retrospective study of a small number of patients. The evaluation of the patients' pre- and post-rehabilitation states was not consolidated. In the future, a unified evaluation and prospectively collected data might reveal significant differences among amputees with prostheses.

## Conclusion

This study showed that most amputees in our hospital had sustained trauma to a unilateral lower limb. Although the patients with internal causes of amputation were older, more frequently had malnutrition, and had more comorbidities than those with external causes, they achieved prosthetic walking with no statistically significant difference at the end of hospitalization, excluding the six cases who did not receive prostheses.

**Conflict of interests:** None of the authors have financial relationships or competing interests relevant to this manuscript to disclose.

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