



## Reamputation in a cohort of critical limb ischemia patients surviving 2 years after minor amputation

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The prognosis of critical limb ischemia (CLI) patients is generally poor, and the 5-year mortality rate is higher than that of colorectal cancer [1]. In the perioperative period of amputation for gangrene of the foot, there are cases of death and cases where patients cannot undergo surgery due to poor general condition. The diagnostic criteria of CLI are varied and include mild cases where there is no wound on the lower limb but pain at rest. Because of this, it is difficult for wound care workers to prognosticate about CLI patients they are in charge of. Therefore, we examined the outcomes 2 years after surgery for patients with diabetic nephropathy on hemodialysis with wounds healed after treatment with percutaneous transluminal angioplasty (PTA) and minor amputations for cases where patients were able to walk using therapeutic footwear. Since roughly 2 out of every 5 such patients die, it is considered necessary to provide an economically efficient solution for improving the wellbeing of these patients [2]. At the same time, reamputation is a serious problem for survivors after conservative amputation surgery, as wellbeing is affected. Therefore, we looked at reamputation rates within 2 years from surgery along with 2-year survival.

From January 2007 to December 2016, in cases of diabetic nephropathy requiring hemodialysis, foot wounds were evaluated following PTA for increasing blood flow to the lower limb and minor amputation either at the toe or midfoot. Every patient in this study was referred to a cardiologist who specialized in PTA. The cardiologist first performed detailed investigations of the vascular lesion site, such as measuring the ankle-brachial index, ultrasonography, and magnetic reso-

nance angiography, then performed PTA. The angiograph that was obtained when PTA was performed was useful for determining the height of amputation after we confirmed the area supplied by the vessel.

We examined this group in accordance with the following criteria:

1. no history of lower limb surgery before the initial surgery
2. performance of a minor amputation on one side, with healing of the wound
3. production of therapeutic footwear for walking after the wound healed
4. 2-year survival after surgery

We used McNemar's test for statistical analysis. All statistical analyses were conducted using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA), with  $\alpha < 0.05$  considered statistically significant.

Among 39 cases of toe amputation (33 men, 6 women, mean age 67.3 years), there were 9 cases of reamputation (ipsilateral reamputation in 6 cases—66.7%, and contralateral reamputation in 3 cases—33.3%)—a total of 23.1% (Table 1). Among 6 cases of midfoot amputation (5 men, 1 woman, average age 65.0 years), in 1 case, reamputation was required in the contralateral foot due to a burn injury—a total of 16.7% (Table 2, Fig. 1). The total proportion of reamputation when toe amputations and midfoot amputations are combined is 22.2%. There was no significant difference in reamputation rates between the group with initial toe amputation and the group with initial midfoot amputation ( $p = 0.1025$ ). When the case of burn injury is excluded, the reamputation rate was significantly lower in the 5 cases of initial midfoot amputation ( $p = 0.0253$ ). Indeed, there were no instances of ipsilateral reamputation following midfoot amputation, and the ipsilateral reamputation rate after midfoot amputation was significantly lower than the ipsilateral reamputation rate following toe amputation ( $p = 0.0143$ ).

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**Table 1** Baseline characteristics and demographics of patients who underwent toe amputations after PTA. Among the 39 patients who underwent toe amputation, ipsilateral reamputation was performed on six patients and contralateral reamputation was performed on three patients

Patient	Age (years)	Gender	Amputated toes	Reamputated toes
1	60	M	L1	None
2	60	M	L1, 2	None
3	52	M	L5	L3, 4
4	60	F	R1	None
5	71	M	L5	L1
6	68	F	R2	R3
7	59	M	R5	None
8	85	F	L1	L2
9	61	M	R4, 5	None
10	65	M	L5	None
11	77	M	L4	R5
12	75	M	L1	None
13	67	M	L2	R1
14	61	M	R1	None
15	47	M	R3	None
16	44	M	R2, 3, 4, 5	None
17	56	M	L1	None
18	82	M	R1, 2, 3, 4, 5	None
19	88	F	L1	None
20	88	M	L3	None
21	63	M	L4, 5	None
22	68	F	L1	None
23	82	M	R1, 2	None
24	61	M	L1	None
25	85	M	R5	None
26	64	M	L1	R1
27	51	M	R1, 2, 3	R4, 5
28	50	M	L5	None
29	84	M	R5	None
30	74	M	R3	R5
31	57	F	L1	None
32	80	M	L3	None
33	71	M	L3	None
34	54	M	L4	None
35	78	M	L1	None
36	73	M	L5	None
37	71	M	L1	None
38	75	M	R4	None
39	56	M	R4, 5	None

*M* male, *F* female, *R* right, *L* left, *PTA* percutaneous transluminal angioplasty

The number of diabetic patients is increasing worldwide. Especially in Asia, the number of people with diabetes is increasing markedly as a result of the Westernization of meals,

**Table 2** Baseline characteristics and patient demographics of patients who underwent midfoot amputations after PTA. Among the six patients who underwent midfoot amputation, one underwent contralateral reamputation

Patient	Age (years)	Gender	Amputated midfoot	Reamputation
1	75	F	R	None
2	67	M	L	None
3	46	M	R	None
4	69	M	R	L midfoot
5	80	M	L	None
6	53	M	L	None

*M* male, *F* female, *R* right, *L* left, *PTA* percutaneous transluminal angioplasty

among other reasons. Along with that, the number of cases of diabetic nephropathy leading to chronic renal failure has also increased. Because there are not enough kidneys for transplantation in Japan, many patients with chronic renal failure undergo hemodialysis. Because diabetes and chronic renal failure are risk factors for peripheral arterial disease (PAD), the number of CLI patients with comorbid PAD has also increased rapidly [3]. As the number of patients with these conditions has been increasing, there is a great deal of epidemiologic data now available. Nevertheless, we could not find any research reports covering patient backgrounds in a similar fashion to the present study.

Regarding reamputation performed after treatment of diabetic foot lesions with minor amputations, Borkosky et al. [4] did not include CLI in their analysis of reoperation performed after initial treatment. They report that the reoperation rate in a cohort with diabetic foot lesions with peripheral sensory neuropathy treated with first ray amputation with a weighted mean follow-up period of 26 months was 19.8%. Chu et al. [5] reported that the reamputation rate after toe amputation where wound healing was completed was 17.5% at 1 year and 22.3% at 3 years. The reamputation rate of our sample was 23.1% after 2 years. The fact that all our cases had CLI seems to have resulted in a reamputation rate slightly higher than that reported by Chu et al. Also, Chu et al. reported that reamputation was ipsilateral 68.9% of the time and contralateral 31.1% of the time. In our case, reamputation was ipsilateral 66.7% of the time and contralateral 33.3% of the time. From these data, it seems that the risk of reamputation after initial toe amputation was double on the ipsilateral side compared to the contralateral side.

In this study, the rate of reamputation after initial midfoot amputation was remarkably lower than the rate of reamputation after toe amputation. The following three items can be seen as factors:

- (1) Toes are vulnerable to injury due to mechanical stimulation while walking. In the case of midfoot amputation,

**Fig. 1** Midfoot amputation was performed for right foot gangrene in a 69-year-old man with a 12-year history of type II diabetes and a 5-year history of hemodialysis required by diabetic nephropathy. Right midfoot amputation 3 months after surgery; the left foot sustained a burn injury (a). The range of gangrene is demarcated (b). Left midfoot amputation following percutaneous transluminal angioplasty (c). One and a half years after surgery (d)



- there are no remaining toes to injure. Therefore, it is expected that these patients would require fewer reamputations.
- (2) Loss of ambulatory function after amputation is considerably larger following midfoot amputation than it is following toe amputation. As a result, therapeutic footwear to compensate for the loss of function complicates disposition: it takes time and effort to attach and detach therapeutic footwear, so patients tend to refrain from going outside the home. As a result, ironically, there is less burden on the foot and less chance of causing a new wound.
  - (3) In Japan, there is no custom to wear shoes indoors [3]. As a result, patients with initial toe amputation do not wear therapeutic footwear indoors, and walking on bare feet results in development of wounds on the remaining toes.

In this study, we did not examine any parameters related to walking (i.e., distance, time, frequency, location) following small amputations, nor did we determine compliance with therapeutic footwear. Therefore, whether (2) and (3) above are factors that result in lower rates of reoperation after

midfoot amputation is a subject that should be more thoroughly investigated in the future. Going forward, during postoperative follow-up, a questionnaire will be used to inquire about gait when the patient is leaving to go shopping or attend a hospital appointment, or when the patient is using interior spaces, such as the toilet or bedroom. We believe this questionnaire will allow us to investigate the relationship between these factors and the recurrence rate, which will contribute to novel epidemiology data regarding this point. Since we already know that patients' adherence to treatment recommendations is related to the recurrence of foot wounds [6], it will be desirable to perform future epidemiology surveys that consider compliance with therapeutic footwear by individual patients. In this study, because 1 in 5 patients surviving 2 years after initial small amputation required reoperation, efforts to improve the wellbeing of CLI patients, including prevention of wound recurrence, are urgent.

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## Compliance with ethical standards

**Conflict of interest** Kyoichi Matsuzaki, Masahiro Toriumi, and Reina Kitabata declare that they have no conflict of interest.

**Ethical approval** For this retrospective study, formal consent from a local ethics committee is not required.

**Informed consent** Patients provided written consent before their inclusion in the study. Additional consent was obtained for the use of their images.

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## References

1. Armstrong DG, Wrobel J, Robbins JM (2007) Guest editorial: are diabetes-related wounds and amputations worse than cancer? *Int Wound J* 4(4):286–287
2. Matsuzaki K, Hayashi R, Okabe K, Aramaki-Hattori N, Kishi K (2015) Prognosis of critical limb ischemia: major vs. minor amputation comparison. *Wound Repair Regen* 23(5):759–764
3. Matsuzaki K (2009) The development of wound care as a clinical specialty in Japan. *Int Wound J* 6(5):313–315
4. Borkosky SL, Roukis TS (2012) Incidence of re-amputation following partial first ray amputation associated with diabetes mellitus and peripheral sensory neuropathy: a systematic review. *Diabet Foot Ankle*. <https://doi.org/10.3402/dfa.v3i0.12169>
5. Chu YJ, Li XW, Wang PH, Xu J, Sun HJ, Ding M, Jiao J, Ji XY, Feng SH (2016) Clinical outcomes of toe amputation in patients with type 2 diabetes in Tianjin, China. *Int Wound J* 13(2):175–181
6. Armstrong DG, Boulton AJM, Bus SA (2017) Diabetic foot ulcers and their recurrence. *N Engl J Med* 376(24):2367–2375