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Great Toe Necrosis Predicts an Unfavorable Limb Salvage Prognosis

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Summary: The initial location of necrosis may affect the limb salvage rate. This study of 130 patients with chronic toe ulcers or gangrene was performed to assess whether the location of initial necrosis in the toes affected limb salvage prognosis. The patients were divided into 2 groups according to whether the initial necrosis was in the great toe or in other toes. Limb salvage prognosis was determined retrospectively. In the great toe group, the rates of total toe loss and major amputation were 50.0% and 24.4%, respectively. When the initial necrosis was in other toes, these rates were 27.3% and 9.3%, respectively. Great toe necrosis is associated with significantly higher rates of total toe loss (odds ratio = 3.10; $P = 0.003$; 95% confidence interval, 1.43–6.68) and major amputation (odds ratio = 3.66; $P = 0.007$; 95% confidence interval, 1.37–9.79). The great toe is supplied by 3 source arteries, whereas the lesser toes are fed by 1 or 2 arteries. Therefore, necrosis initiating from the great toe may reflect the presence of severe vascular disorders. The great toe is also anatomically connected to much of the foot via the tendons. Infection is more likely to spread along these tendons, which may reduce limb prognosis. Thus, the initial location of necrosis may be predictive of limb prognosis. *(Plast Reconstr Surg Glob Open 2014;2:e216; doi: 10.1097/GOX.0000000000000175; Published online 22 September 2014.)*

The most severe clinical condition that results from peripheral arterial disease (PAD) is critical limb ischemia (CLI); it is also a major cause of difficult chronic limb necrosis[1] and the main cause of lower limb amputation. It often occurs in conjunction with diabetes mellitus (DM), chronic renal insufficiency, and other comorbidities. In particular, diabetes is a determinant of poor outcome after revascularization for CLI.[2] In cases of particularly severe chronic necrosis and ulcers of the lower limbs that are due to DM and PAD, the main goal of therapy is limb salvage.

Of the various parts of the foot, the heel and the great toe are particularly essential for maintaining limb function and structure. However, despite the indispensability of the heel, heel necrosis is associated with a poorer limb salvage prognosis than necroses in other locations.[3] Similarly, our cumulative clinical experience suggests that major amputations may be more likely when the necrosis starts in the great toe than when it starts in the other toes. The great toe is more important than the lesser toes in terms of minimizing deleterious forces at the first metatarsal-phalangeal joint and for kicking in the windlass mechanism, which stiffens the plantar tissues and allows for increased propulsion.[4]

It is possible that the initial location of foot necrosis may influence the limb salvage rate. However,

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this possibility has been poorly studied. Therefore, this retrospective case-control study was performed.

PATIENTS AND METHODS

A case-control trial was designed. The access to patient medical records for retrospective review was approved by the Institutional Review Board of Saitama Medical University Hospital. In total, 130 patients (98 men and 32 women), with chronic toe ulcers or gangrene that was accompanied by DM and/or PAD, were identified. All had been treated at the Wound Healing Center of Saitama Medical University between January 2006 and December 2011. Their ages ranged from 32 to 92 years (median, 65.0 years). Their clinical data are summarized in Table 1. Patients receiving corticosteroids, immunosuppressive agents, radiation therapy, or chemotherapy, or who had malignant tumor tissue at the necrosis location, were excluded. The participants were classified into 2 groups depending on whether the initial necrosis started in the great toe (n = 44) (great toe group) or in other toes (n = 86) (other toes group). Limb prognosis was analyzed retrospectively by calculating the total toe loss and major amputation rates.

Treatment Protocol in Saitama Medical University Hospital

Cases of foot necrosis with PAD or CLI that warranted arterial reconstruction underwent revascularization. These patients received the treatments described below approximately 3 weeks after revascularization because a previous investigation has reported that it takes 3–4 weeks for cutaneous oxygenation to improve and reach the optimal levels for wound healing.[5] Appropriate dressings, as described below, were applied to the wounds after revascularization.

Thus, all areas of necrotic and devitalized tissue were surgically removed until bleeding was macroscopically observed. The dressing was opened on the fourth postoperative day, and the wounds were cleansed at each dressing change and covered again with wound dressings. The dressings were changed as required depending on the characteristics of the wound (a minimum of 3 dressing changes per week). Wound care was standardized throughout the entire study, and several different dressing types were used depending on the type of the wound (eg, dry, wet, and intermediate). The wet and intermediate wounds received daily dressing changes as required by the standard of care. After granulation tissue development, skin graft or flap reconstruction was used to complete wound coverage. Depending on the defect size and location, appropriate reconstructive techniques were chosen. Several small wounds closed spontaneously. Clinical signs of infection were noted, and antibiotic therapy was initiated and swabs were obtained if required. Patients who had limb ulcers with progressive necrosis, uncontrollable infection, and/or intolerable pain underwent major or minor amputation, depending on the severity.

Statistical Analysis

Statistical analysis was performed using Microsoft Excel 97–2003 (Microsoft, Tokyo, Japan). The continuous data were expressed as median and range; the groups were compared by using the Mann-Whitney U test. The groups were compared in terms of categorical data by using the chi-square test. A P value of <0.05 was considered to be significant.

RESULTS

The 2 groups did not differ significantly in terms of any of the systemic parameters, risk factors, and

Table 1. Summary of the Clinical Data of the Patients

	Overall	Hallux Group	Other Toes Group	*P*
Systemic parameters				
Age (yr), median (range)	65.0 (32–92)	65.5 (40–82)	65.0 (32–92)	0.62
Male sex (%) (*n*)	75.4 (98/130)	77.3 (34/44)	74.4 (64/86)	0.72
Body mass index (kg/m^2), median (range)	22.2 (50.6–12.2)	21.8 (12.9–36.4)	22.4 (12.2–50.6)	0.86
Risk factors (%) (*n*)				
Diabetes mellitus	86.9 (113/130)	90.9 (40/44)	84.9 (73/86)	0.33
Chronic renal failure	50.8 (66/130)	50.0 (22/44)	51.1 (44/86)	0.90
Peripheral artery disease	60.0 (78/130)	63.6 (28/44)	58.1 (50/86)	0.54
Preoperative laboratory results, median (range)				
Hemoglobin (mg/dl)	9.8 (6.3–13.9)	9.7 (6.7–13.2)	9.9 (6.3–13.9)	1.00
Albumin (g/dl)	3.1 (1.6–4.4)	3.1 (2.0–3.9)	3.1 (1.6–4.4)	0.28
C-reactive protein (mg/dl)	2.12 (0.1–34.8)	2.8 (0.1–34.8)	1.7 (0.1–18.4)	0.07
Limb prognosis (%) (*n*)				
Total digit loss	33.1 (43/130)	50.0 (22/44)	24.4 (21/86)	0.003*
Major amputation	15.4 (20/130)	27.3 (12/44)	9.3 (8/86)	0.007*

The P values reflect comparisons between the great toe group and the other toe group.
*$P < 0.05$.

preoperative laboratory results. For the great toe group, the rates of total toe loss and major amputation were 50.0% (22/44) and 24.4% (12/44), respectively. For the other toes group, these rates were 27.3% (12/86) and 9.3% (8/86), respectively. Chi-square test showed that compared with the other toes group, the great toe group had significantly higher rates of total toe loss (adjusted odds ratios = 3.10; P = 0.003; 95% confidence interval, 1.43–6.68) and major amputation (adjusted odds ratio = 3.66; P = 0.007; 95% confidence interval, 1.37–9.79).

DISCUSSION

Many factors, including sex,[6,7] age,[6,7] physiological[8] and biochemical[9,10] variables, nutritional status,[9] and complications,[11–13] have been reported to be predictors of wound prognosis in chronic ulcers. Another key predictor of limb prognosis may be the initial location of necrosis. The present study investigated the influence of initial toe necrosis location on limb prognosis in patients with DM and PAD. Great toe origin necrosis was associated with significantly higher rates of major amputation and total toe loss than a necrosis origin in other toes. Judging from the odds ratios, the risks of major amputation and total toe loss are increased by 3.66- and 3.1-fold in great toe necrosis compared with necrosis in other toes. It has been reported that patients with diabetes and peripheral neuropathy who undergo a partial first ray amputation show a high rate of progression to a more proximal repeat amputation, despite initial healing.[14,15] Our results are consistent with these reports. Two possible mechanisms, one based on the angiosome and the other based on anatomy, may explain these results.

More than 60% of diabetic necrosis cases have insufficient blood flow due to peripheral vascular disease.[16] The atherosclerotic disease usually manifests below the popliteal artery and involves one or more of the 3 lower leg arteries, namely the anterior tibial artery, the posterior tibial artery, and/or the peroneal artery.[17] The "angiosome" concept divides the whole body into vascular territories that are supplied by specific source arteries.[18] Heel ulcers are associated with a worse limb prognosis than ulcers in other locations,[17] even though the heel has 2 overlapping source arteries (the medial and lateral calcaneal arteries).[19] Thus, the presence of heel ulcers may reflect the presence of more severe vascular diseases. Similarly, the territory of the great toe is supplied by 3 source arteries (the medial plantar artery, lateral plantar artery, and dorsal metatarsal artery), whereas the lesser toes are mainly fed by 1 or 2 sources (the lateral plantar artery and/or dorsal metatarsal artery). Thus, the great toe area has more overlapping source arteries, probably because this site contributes to the pedal functions more significantly and contains a much larger amount of tissue than the lesser toes. Thus, insufficiency of blood flow in the great toe may be less likely to occur than the other toes, which suggests that patients whose necrosis starts in the great toe may have severe vascular disorders that promote poor limb prognosis.

One of the major risk factors for massive tissue loss is uncontrollable infection. Infection is known to spread through the foot along the tendons and their sheaths[20] due to the to-and-fro motion of the tendon, which serves to pull the bacteria through the foot. Moreover, great toe function involves a more diverse and complex operation than the functions of the other toes. Anatomical features that help the great toe to achieve this behavior include specific tendons, such as the adductor hallucis muscle tendon, which has transverse and oblique heads, and the abductor hallucis muscle tendon. The great toe is anatomically connected to a wide area of the foot via these tendons. Therefore, infections and colonization of the great toes are more likely to compromise the entire foot structure than infections in the other toes. This may explain, at least in part, the poor limb prognosis associated with necrosis that starts in the great toe.

CONCLUSIONS

To the best of our knowledge, this is the first detailed description of the effect of the initial location of necrosis on limb prognosis. This study indicates that the initial location of necrosis can serve as a major predictor of lower limb prognosis.

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