Factors affecting healing and survival after finger amputations in patients with digital artery occlusive disease

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Finger; Amputation; Diabetes mellitus; Chronic kidney disease; Connective tissue disease; Scleroderma

Abstract

BACKGROUND: Finger amputations are typically performed as distal as possible to preserve maximum finger length. Failure of primary amputation leads to additional procedures, which could potentially be avoided if a more proximal amputation was initially performed. The effect of single versus multiple procedures on morbidity and mortality is not known. We evaluated factors that predicted primary healing and the effects of secondary procedures on survival.

METHODS: Patients undergoing finger amputations from 1995 to 2011 were evaluated for survival with uni- and multivariate analysis of demographic data and preoperative vascular laboratory studies to assess factors influencing primary healing.

RESULTS: Seventy-six patients underwent 175 finger amputations (range 1 to 6 fingers per patient). Forty-one percent had diabetes, 33% had nonatherosclerotic digital artery disease, and 29% were on dialysis. Sex distribution was equal. Primary healing occurred in 78.9%, with the remainder requiring revisions. By logistic regression analysis, nonatherosclerotic digital artery disease was associated with failure of primary healing (odds ratio = 7.5; 95% confidence interval, 1.03 to 54; \( P = .047 \)). Digital photoplethysmography did not predict primary healing. The overall healing of primary and secondary finger amputations was 96.0%. The mean survival after the initial finger amputation was 34.3 months and did not differ between patients undergoing single (35.6 months) versus multiple procedures (33.6 months). Dialysis dependence was associated with decreased survival (hazard ratio = 2.9; 95% confidence interval, 1.13 to 7.25; \( P = .026 \)).

CONCLUSIONS: Failure of primary healing is associated with the presence of nonatherosclerotic digital artery disease and is not predicted by digital photoplethysmographic studies. Dialysis dependence is associated with decreased survival in patients with finger amputations, but failure of primary healing does not adversely affect survival. A strategy of aggressive preservation of finger length is appropriate for most patients.

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Finger gangrene leading to amputations is rare and has diverse causes and risk factors compared with more frequently encountered lower-extremity atherosclerosis and toe gangrene. Diabetes, vasculitis, renal failure, and connective tissue disorders are among the risk factors and underlying causes of finger gangrene.1,2
Amputations are typically performed as distal as possible to preserve maximum finger length. Failure of primary amputation leads to additional procedures. In patients with multiple comorbidities, as frequently observed in patients requiring finger amputations, the need for additional surgical procedures can theoretically lead to increased morbidity and mortality. This could potentially be avoided if a more proximal amputation is performed first, thereby maximizing wound healing at the expense of function. The effect of single versus multiple procedures on morbidity and mortality is not known. We evaluated factors that predicted primary healing and the effects of secondary procedures on survival.

**Methods**

This study was approved by the Institutional Review Board at Oregon Health & Sciences University (OHSU), Portland, OR. All patients undergoing finger amputations in the Division of Vascular Surgery at OHSU between October 1993 and December 2011 were identified from a prospectively maintained computerized patient registry. Records were reviewed for demographic factors including age; sex; and a history of smoking, hypertension, hyperlipidemia, diabetes, renal failure, chronic obstructive pulmonary disease, cardiac disease, and nonatherosclerotic digital artery diseases (NADs) including connective tissue disorders (eg, systemic lupus erythematosus, scleroderma, polymyositis, dermatomyositis, rheumatoid arthritis, and Sjögren syndrome) and Buerger disease. In the latter part of the series, patients underwent noninvasive testing of digital artery pressures and waveforms with photoplethysmography (PPG) before amputation.

Patients with finger ulcers managed conservatively with debridement and/or pharmacologic therapy were not included in this study. Amputations were performed in patients with either finger gangrene or recalcitrant ulcers not responding to conservative therapy. Amputations were performed as distal in the finger as possible to preserve finger length. Primary closure was performed in cases of dry gangrene or ulceration without infection. In the presence of infection, open amputations with delayed primary closure were performed. The number and location of amputations were recorded. Primary healing was defined as healing without the need for additional procedures after the initial amputation closure. Secondary healing included patients who underwent surgical debridement or revision after the initial procedure. For patients who underwent more than 1 finger amputation at the initial operation, the failure of any finger to achieve primary healing was considered a failure of primary healing, even if some of the fingers healed primarily. Survival was measured based on documented death within the OHSU electronic medical record or through the Social Security Death Index.

**Statistical analysis**

An analysis of risk factors in patients with primary healing of finger amputations compared with nonprimary healers was performed with the chi-square or Fisher exact test for categoric variables and the Student t test for continuous variables. Multivariate logistic regression analysis was performed to assess factors associated with primary healing. Survival was evaluated with Kaplan-Meier analysis with log-rank testing, and multivariate survival analysis was performed with Cox proportional hazards analysis. Healing was analyzed per finger. Demographic variables were analyzed per patient. In patients with more than 1 amputation, the initial amputation was used for analysis. Significance was set at a P value <.05.

**Results**

During the study period, 76 patients underwent 175 finger amputations. Sixty patients experienced primary healing, whereas 16 did not achieve primary healing. Twenty-five patients underwent more than 1 finger amputation at the initial setting; however, in only 1 case did a finger not heal primarily in the presence of other fingers healing. In all other cases, either all fingers healed primarily or all did not heal. Demographic factors for the 76 patients are included in Table 1. The rate of primary healing was significantly less in patients with NAD compared with those without (56% vs 27%, P = .025). In the NAD group, diagnoses included scleroderma in 10 patients, Buerger disease in 7, mixed connective tissue disease in 6, Sjögren syndrome in 2, and systemic lupus erythematosus in 1 (1 patient had both scleroderma and Sjögren syndrome). There were no other significant demographic differences between the 2 groups. By logistic regression analysis, NAD was associated with the failure of primary healing (odds ratio = 7.5; 95% confidence interval, 1.03 to 54; P = .047).

A single finger was amputated in 31 patients, 2 fingers in 17, 3 fingers in 12, 4 fingers in 7, 5 fingers in 8, and 6 fingers in 1 patient. Eighty-three amputated digits were from the left hand and 92 from the right. Amputated digits included the first finger (n = 11), second finger (n = 58), third finger (n = 50), fourth finger (n = 35), and fifth finger (n = 21). Amputation revision was required in 16 of 76 patients (20.5%) and in 37 of 175 amputations (21.1%). The median time to revision after initial amputation was 1.5 months (range 0 to 154 months). In patients with a history of dialysis, 20 were receiving hemodialysis from arm access, 1 from a central venous catheter, and 1 had received a kidney transplant. In the patients with arm access, the finger amputation occurred on the same side as the access in 11 (55%) and in the contralateral arm in 9 cases (45%). The type of anesthesia at the initial operation was general in 45% and regional in 55%. The type of
anesthetic had no effect on either amputation healing or survival.

Twenty-one of the 76 patients underwent measurement of digital artery pressures before amputation, but this did not predict primary healing (finger systolic pressure 58.8 ± 76.5 mm Hg in nonhealers vs 45.7 ± 6.6 mm Hg in primary healers, \( P = .708 \)). Likewise, the digital:brachial index did not predict healing (digital:brachial index: .40 ± .49 in nonhealers vs .38 ± .39 in nonhealers, \( P = .936 \)).

The overall median survival of the patient cohort was 34.3 months, with no difference in survival between primary healers (35.6 months) and nonhealers (33.6 months). Kaplan-Meier survival for the patient cohort at 1 and 3 years was 81.1% and 67.2%, respectively. There were no survival differences at these time points between primary healers and nonhealers (primary healers 84.6% and 67.5%; nonhealers 68.8% at both time points, \( P = .38 \)). The group of patients with dialysis-dependent renal failure had the worst survival, which is not surprising given their overall debility. As noted, however, the number of surgical procedures for finger gangrene did not influence survival. Although it is prudent to minimize operations as much as possible, it is reasonable to limit tissue resection in an attempt to preserve finger length. Although autoamputation is occasionally pursued in patients with poor life disorders that are particularly prone to affecting digital arteries with preservation of the arterial inflow proximal to the wrist. Primary healing was lowest in the group of patients with NAD. Of the connective tissue disorders in this patient population, the most frequent was systemic sclerosis (scleroderma). These patients are prone to soft-tissue fibrosis in addition to digital arterial occlusion. This combination of factors may be responsible for the lower primary healing in this group compared with the diabetic and renal failure groups.

Objective measures of digital artery perfusion (ie, the measurement of digital artery pressures and digital:brachial indices) were not helpful in determining the likelihood of primary healing. Intuitively, one would predict that improved perfusion would be associated with improved healing. We have previously shown that PPG correlates to the severity of hand ischemia. Its role in predicting amputation healing is not known. These tests were performed only recently in this patient series, so only one quarter of patients underwent such testing, which increases the possibility of a type II error. Additionally, with the switch to an electronic medical record at our institution, it is possible that some of the vascular laboratory studies, which were initially recorded on paper, were not completely transferred. Thus, one cannot definitively state that the noninvasive assessment of digital perfusion is not useful; however, its role is not yet defined.

Survival is poor in all patients with digital gangrene, with median survival of the entire patient cohort of 34.3 months. The group of patients with dialysis-dependent renal failure had the worst survival, which is not surprising given their overall debility. As noted, however, the number of surgical procedures for finger gangrene did not influence survival. Although it is prudent to minimize operations as much as possible, it is reasonable to limit tissue resection in an attempt to preserve finger length. Although autoamputation is occasionally pursued in patients with poor life

### Comments

In our series, primary finger amputation healing was successful in 78.9% of amputations. In the remaining 21.1%, an initial failure of wound healing necessitated additional revision procedures. Although additional procedures lead to the potential for perioperative morbidity and mortality, we saw no increase in these complications in patients who required multiple procedures. Given these findings, we support a philosophy of preservation of maximal finger length when performing digital amputations.

The 3 main risk factors for digital gangrene in this series were renal failure, diabetes, and NAD. All 3 are systemic

### Table 1 Demographics of 76 patients undergoing finger amputations

<table>
<thead>
<tr>
<th>Factor</th>
<th>All (N = 76)</th>
<th>Primary healers (n = 60)</th>
<th>Nonhealers (n = 16)</th>
<th>( P ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (% male)</td>
<td>38 (50)</td>
<td>33 (55)</td>
<td>5 (31)</td>
<td>NS</td>
</tr>
<tr>
<td>Age (y)</td>
<td>51.9 ± 11.3</td>
<td>52.5 ± 11.6</td>
<td>49.3 ± 10.2</td>
<td>NS</td>
</tr>
<tr>
<td>Diabetes (%)</td>
<td>31 (41)</td>
<td>25 (41)</td>
<td>6 (38)</td>
<td>NS</td>
</tr>
<tr>
<td>Hypertension (%)</td>
<td>40 (53)</td>
<td>33 (55)</td>
<td>7 (44)</td>
<td>NS</td>
</tr>
<tr>
<td>CAD/CHF (%)</td>
<td>30 (40)</td>
<td>22 (37)</td>
<td>8 (50)</td>
<td>NS</td>
</tr>
<tr>
<td>Hyperlipidemia (%)</td>
<td>16 (21)</td>
<td>14 (23)</td>
<td>2 (13)</td>
<td>NS</td>
</tr>
<tr>
<td>COPD (%)</td>
<td>8 (11)</td>
<td>8 (13)</td>
<td>0 (0)</td>
<td>NS</td>
</tr>
<tr>
<td>Dialysis (%)</td>
<td>22 (29)</td>
<td>17 (28)</td>
<td>5 (31)</td>
<td>NS</td>
</tr>
<tr>
<td>Cancer (%)</td>
<td>6 (8)</td>
<td>6 (10)</td>
<td>0 (0)</td>
<td>NS</td>
</tr>
<tr>
<td>Current smoker (%)</td>
<td>31 (41)</td>
<td>25 (44)</td>
<td>6 (46)</td>
<td>NS</td>
</tr>
<tr>
<td>Ever smoker (%)</td>
<td>52 (68)</td>
<td>42 (74)</td>
<td>10 (77)</td>
<td>NS</td>
</tr>
<tr>
<td>CTD/Buergers (%)</td>
<td>25 (33)</td>
<td>16 (27)</td>
<td>9 (56)</td>
<td>.025</td>
</tr>
<tr>
<td>Serum albumin</td>
<td>2.61 ± 0.67</td>
<td>2.73 ± 0.70</td>
<td>2.17 ± 0.38</td>
<td>NS</td>
</tr>
<tr>
<td>BMI</td>
<td>25.1 ± 7.2</td>
<td>25.5 ± 7.4</td>
<td>22.4 ± 5.9</td>
<td>NS</td>
</tr>
</tbody>
</table>

BMI = body mass index; CAD = coronary artery disease; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; CTD = connective tissue disease.
expectancy, the patients in this series were living independently at the time of amputation, and their life expectancy was not believed to be so poor as to preclude surgery.

Surprisingly little data exist on finger amputation outcomes in patients with digital ischemia. The majority of published reports address finger ischemia in the connective tissue disease (CTD) group, most frequently in systemic sclerosis. Over half of the patients with systemic sclerosis develop digital ulcerations during the course of their disease, with approximately 10% requiring digital amputations at a rate of 1% to 2% per year of disease.4–7

Hand ischemia related to chronic kidney disease is a well-known phenomenon. We have previously shown that the ischemic process occurs irrespective of the laterality of dialysis access.8 This was further confirmed in this study in which the laterality of finger amputation was nearly equally distributed between the access and nonaccess arms. The mechanism of finger gangrene in patients with chronic kidney disease appears to be accelerated atherosclerosis, with an increased risk of cardiovascular events and death.9

Limitations of this study include its retrospective nature. All patients were treated with the same philosophy of maximal finger preservation. However, as noted, preoperative noninvasive vascular workup was not standardized. Although this represents one of the largest series of finger amputations secondary to digital ischemia in the literature, it is a heterogeneous group, making overall generalizations difficult.

Although patients with digital artery ischemia have a poor overall survival rate, attempts to preserve maximal finger length are warranted. The vast majority of patients heal amputations primarily, and those who require additional procedures for revision do not have adverse outcomes compared with primary healers.

References


Discussion

James Peck, M.D. (Portland, OR): Symptomatic hand ischemia occurs infrequently. It accounts for less than 5% of patients with extremity ischemia. Most patients with hand ischemia have no fixed arterial obstruction and experience cold or stress-induced vasospastic symptoms. The common vasospastic Raynaud syndrome is a nuisance condition. In contrast, the patients in this study had permanent small artery obstruction of the palmar and digital arteries. They have persistent symptoms of hand ischemia. This includes rest pain and ulceration in addition to a marked sensitivity to cold and stress. These patients had obstructive Raynaud syndrome called Raynaud phenomenon or secondary Raynaud. Symptoms in these patients represent more than a nuisance condition and can lead to significant tissue loss. Vascular laboratory classification as obstructive Raynaud syndrome strongly predicts digital ulceration in 50% of patients and 10% to 20% require amputations. The 3 main risk factors for digital gangrene in these 76 patients were artherosclerotic: diabetes (41%), renal failure (29%), and nonatherosclerotic disease (33%). The nonatherosclerosis disease group was patients with scleroderma, Buerger syndrome, and mixed connective tissue disorders. As expected, finger amputation failed to heal more frequently in the nonatherosclerosis group because of concomitant soft-tissue fibrosis. In 1995, McLafferty from OHSU reported that finger PPG is as accurate as

![Figure 1](image-url) Survival after finger amputations in patients achieving primary healing versus nonprimary healing.
arteriography for determining the severity of hand ischemia. Unfortunately, only 27.6% of patients in this present report by McClary and Landry had finger PPG. The failure of primary healing and the number of amputations did not adversely affect survival. However, survival was poor at 34 months. This article concluded that a strategy of aggressive preservation of finger length is appropriate for most patients with obstructive secondary Raynaud hand ischemia. Unfortunately, the role of digital PPG in predicting amputation healing could not be determined.