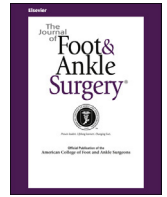




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## Original Research

## Three-Year Morbidity and Mortality Rates After Nontraumatic Transmetatarsal Amputation

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## ABSTRACT

Patients requiring a nontraumatic transmetatarsal amputation (TMA) typically have multiple comorbidities that place them at high risk of postoperative complications and additional surgery. The present study identified the demographic, clinical, and surgical risk factors that predict complications after a nontraumatic TMA, including the incidence of 3-year mortality, proximal limb amputation, and lack of healing. The electronic medical records of patients who had undergone TMA within a Kaiser Permanente Northern California facility from March 2007 to January 2012 ( $n = 375$ ) were reviewed. We used bivariate and multivariate analyses to examine the variations in the rates of TMA complications according to sex, age, race, and comorbid conditions, including nonpalpable pedal pulses, end-stage renal disease, coronary artery disease, hypertension, smoking status, and preoperative albumin  $<3.5$  mg/dL. After a nontraumatic TMA, 136 (36.3%) patients had died within 3 years, 138 (36.8%) had required a more proximal limb amputation, and 83 (22.1%) had healed without complications. The patients with nonpalpable pedal pulses had 3 times the odds of requiring a proximal limb amputation (adjusted odds ratio [aOR] 3.07; 95% confidence interval [CI] 1.84 to 5.11), almost twice the odds of dying within 3 years (aOR 1.70; 95% CI 0.98 to 2.93), and  $>2$  times the odds of not healing after the TMA (aOR 2.45; 95% CI 1.40 to 4.31). The patients with end-stage renal disease had 3 times the odds of dying within 3 years (aOR 3.10; 95% CI 1.69 to 5.70). The present findings can help us identify patients with an increased risk of postoperative complications after nontraumatic TMA, including patients with nonpalpable pedal pulses or end-stage renal disease, and suggest the vulnerability of this patient population.

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The rates of lower extremity amputations and diabetic-related complications have been increasing, owing to the ~30 million Americans with type 2 diabetes mellitus (DM) and another 1.4 million with a new diagnosis of DM annually (1). From 2006 to 2010, the increase in nontraumatic lower extremity amputations performed on patients with DM in the United States was  $>10\%$  (65,700 versus 73,000, respectively) (2).

Amputations are used to treat chronic ulceration of the diabetic or ischemic limb and severe infection and gangrene (3,4). Significant morbidity and mortality are associated with lower extremity

amputations, including above-the-knee (AKA) and below-the-knee (BKA) amputations, both referred to as proximal limb amputations. A 2012 study from the American College of Surgeons National Surgical Quality Improvement Program found a 30-day postoperative mortality of 12.8% for AKA and 6.5% for BKA (5). Previous studies have shown that the 3-year mortality after AKA was 61%, and the 3-year mortality after BKA was 43% (6). Thorud et al (7) reported a 5-year mortality rate after BKA and AKA of 40% to 82% and 40% to 90%, respectively, in a systematic review. A recent meta-analysis examining long-term mortality after lower extremity amputation found an overall mortality rate of 71% and 62% at the 3- and 5-year follow-up points, respectively (8).

In an attempt at limb salvage, transmetatarsal amputations (TMAs) are performed as an alternative to proximal limb amputations (4,9). If successful, a TMA can maintain limb function and the ability to ambulate independently of a prosthesis. Although TMA is a lower risk surgery compared with a major lower limb amputation, such as an

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AKA or a BKA, the 30-day mortality after a TMA has been 1.9% to 5.6% (3,10,11). Also, TMAs have been associated with an increased incidence of postoperative complications. Some of the known risk factors for mortality include end-stage renal disease (ESRD) requiring hemodialysis, chronic obstructive pulmonary disease, hypertension, gangrene, stroke, and hypoalbuminemia (3,5,6). However, few previous studies have assessed the intermediate- and long-term mortality after TMA.

The primary aim of the present study was to determine the 3-year rate of mortality, proximal limb amputation, and failure to heal after a nontraumatic TMA. The secondary aim was to identify the demographic, clinical, and surgical risk factors predictive of these complications. We reviewed the incidence of complications after nontraumatic TMAs in a contemporary, racially diverse, community-based patient population.

## Patients and Methods

The electronic medical records were reviewed for patients who had undergone TMA at a Kaiser Permanente Northern California facility from March 2007 to January 2012. Only patients with a minimum 3-year postoperative follow-up period or those who had died within 3 years of the index procedure were included in the present study. We found a total of 375 TMAs performed by 82 different surgeons.

Information was obtained from the preoperative history and physical examination records. The indications for surgery were infection, gangrene, ulceration of the forefoot, or a combination of these. The surgical technique (whether percutaneous Achilles tendon lengthening [TAL] was performed) and postoperative management (casting, suture removal, and weightbearing status) were determined by the operative surgeon.

The patient demographic and clinical data were collected by a review of the medical records. The demographic variables included age (in years), sex, and race (white versus nonwhite). The comorbidities included DM, coronary artery disease (CAD), hypertension, peripheral vascular disease (PVD), ESRD, and current smoking status. The diagnoses were identified using the International Classification of Diseases, 9th and 10th revision, codes. We also assessed albumin if results were available within 90 days before the procedure. The albumin was recorded as  $>3.5$  or  $<3.5$  mg/dL to indicate the patient's nutritional status (an albumin level  $<3.5$  mg/dL suggests chronic malnutrition). The preoperative progress notes were reviewed to determine the patient's vascular status, which was recorded as palpable versus nonpalpable pedal pulses.

The primary outcome variables were 3-year mortality (i.e., dying within 3 years after the nontraumatic TMA), proximal amputation (defined as additional amputation of the leg within 3 years after the initial TMA procedure), and healing (defined as the absence of postoperative complications during the 3-year follow-up period). The complications considered indicative of nonhealing included: (1) revision of the amputation, defined as a return to the operating room for any reason; (2) postoperative infection, defined as any superficial or deep infection requiring oral antibiotics, admission to the hospital for intravenous antibiotics, and/or an unplanned return to the operating room; (3) chronic stump ulceration, defined as a nonhealing wound at the surgical site requiring  $>4$  weeks of wound care; (4) calcaneal gait, defined as any increased pressure at the plantar heel resulting in a pressure sore; (5) stump deformity, defined as a nonplantigrade foot; and (6) stump infarction, defined as ischemia or necrosis of the incision site.

Comparisons involving categorical variables were performed using a  $\chi^2$  or Fisher's exact test. Normally distributed continuous variables were compared using Student's *t* test or analysis of variance. All analyses were performed using Statistical Analysis Systems, version 9.3 (SAS Institute, Cary, NC), and a 2-sided  $p < .05$  was considered to indicate statistical significance. Multivariable logistic regression analyses were conducted to examine the adjusted associations between the patient demographic, clinical, and surgical characteristics and postoperative outcomes (death within 3 years, proximal amputation requirement, and failure to heal).

## Results

### Descriptive Characteristics

Of the 375 patients who underwent TMA from 2007 to 2012, the most common indication for TMA was ulceration with infection (30.3%), followed by gangrene of the foot (27.5%). The mean patient age at surgery was  $66.4 \pm 12.8$  (range 26 to 96) years. Of the 375 patients, 266 (70.9%) were male, and 200 (53.3%) were white (Table 1). Regarding the clinical and surgical characteristics, of the 375 patients, 36 (9.8%) were current smokers, 326 (86.9%) had DM, 326 (86.9%) had hypertension, 225 (60.0%) had nonpalpable pulses, and 93 (24.8%) had

ESRD and required hemodialysis (Table 1). Finally, only 126 (33.6%) patients underwent TAL concurrent with the TMA.

### Mortality

Of the 375 patients, 136 (36.3%) died within 3 years of the TMA, with 8 (2.1%) dying within 30 days. The mean age of those who died was slightly older than that of the mean overall study population, and females were more likely to die within 3 years compared with males (45.0% versus 32.7%,  $p = .025$ ; Table 1). We found no variations in mortality when stratified by race. A larger proportion of patients with CAD (43.2% versus 31.7%), ESRD (49.5% versus 31.9%), PVD (46.2% versus 21.3%), and a preoperative albumin  $<3.5$  mg/dL (45.4% versus 31.8%) had died within 3 years compared with their disease-free counterparts ( $p < .05$ ). The 3-year mortality for patients with nonpalpable pedal pulses was 46.2% compared with 21.3% for patients with palpable pulses ( $p = .0001$ ). On multivariable logistic regression analysis, older age, current smoking, nonpalpable pulses, and ESRD conferred an increased odds of mortality within 3 years (Table 2). The c-stat for the model was 0.81, indicating good predictability.

### Proximal Limb Amputation

The presence of nonpalpable pedal pulses was a significant risk factor for proximal limb amputation. Of the patients with nonpalpable pedal pulses, 103 (45.8%) required proximal limb amputations compared with 35 (23.3%) of those with palpable pedal pulses ( $p = .0001$ ). Of the 138 patients who underwent a proximal limb amputation, 44 (31.9%) had ESRD and 94 (68.1%) did not ( $p = .015$ ). On multivariable analysis, the presence of nonpalpable pulses was the only risk factor associated with an elevated odds of proximal limb amputation (adjusted odds ratio [aOR] 3.07; 95% confidence interval [CI] 1.84 to 5.11; Table 2).

### Failure to Heal

Of the 375 patients, only 83 (22.1%) healed from their amputation without complications (Fig.). The common complications included chronic stump ulceration in 224 (59.7%), revision amputation in 127 (33.9%), postoperative infection in 115 (30.7%), and stump infarction in 117 (31.3%). Males were less likely to heal than were females (81.2% versus 69.7%;  $p = .0151$ ). Of the patients with nonpalpable pedal pulses, 188 (83.6%) developed a complication and failure to heal the stump compared with 104 (69.3%) of the patients with palpable pedal pulses ( $p = .0012$ ). The other predictors of a failure to heal without complications were no TAL (81.1% versus 71.4%;  $p = .0327$ ) and hypertension (80.4% versus 61.2%;  $p = .0026$ ; Table 1). On multivariable analysis, male sex, hypertension, nonpalpable pulses, and no TAL continued to be associated with increased odds of not healing (Table 2).

## Discussion

The present study identified multiple risk factors associated with the development of complications after a nontraumatic TMA, a procedure performed for the treatment of limb-threatening infection, gangrene, and ulceration in patients with DM and PVD. Despite the high 3-year mortality and complication rate in the present study, this rate is lower than those reported after BKA or AKA (6) and provides evidence that nontraumatic TMA could be an effective procedure for limb salvage. However, Thorud et al (12), in a recent systematic review and meta-analysis, questioned the utility of performing an amputation at this level compared with other forefoot amputations. They found a reoperation rate of 26.9% (391 of 1453), with a rate of reamputation

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