Mortality and Morbidity After Transmetatarsal Amputation: Retrospective Review of 101 Cases

Jason Pollard, DPM,[1] Graham A. Hamilton, DPM, FACFAS,[2] Shannon M. Rush, DPM, FACFAS,[3] and Lawrence A. Ford, DPM, FACFAS[4]

Medical records were reviewed for 90 patients (101 amputations) (mean age 64.3 years, range 39 to 86 years) who underwent transmetatarsal amputation (TMA). The mean follow-up period, excluding those patients who either died or went on to a more proximal amputation less than 6 months after TMA, was 2.1 years. Patients were examined for any postoperative complications associated with TMA. Complications were defined as hospital mortality occurring less than 30 days postoperatively; stump infarction with or without more proximal amputation; postoperative infection; chronic stump ulceration; stump deformity in any of 3 cardinal planes; wound dehiscence; equinus and calcaneus gait. An uncomplicated outcome was defined as the absence of all these complications and an ability to walk on the residuum with a diabetic shoe and filler after a minimum follow-up of 6 months. The χ^2 tests of association were used to determine whether diabetes, a palpable pedal pulse, coronary artery disease, end-stage renal disease, cerebral vascular accident, or hypertension were predictive of or associated with healing. A documented palpable pedal pulse was a predictor of healing ($P = .0567$) and of not requiring more proximal amputation ($P = .03$). End-stage renal disease predicted nonhealing ($P = .04$). A healed stump was achieved in 58 cases (57.4%). Postsurgical complications developed in 88 cases (87.1%). Two patients died within 30 days postoperatively. These data suggest that TMA is associated with high complication rates in a diabetic and vasculopathic population. (The Journal of Foot & Ankle Surgery 45(2):91–97, 2006)

Key words: amputation, transmetatarsal, diabetic foot, gangrene, end-stage renal disease

Transmetatarsal amputation (TMA) is an effective surgical approach to treating forefoot infection, gangrene, and chronic ulceration in diabetic and dysvascular patients (1–10). The goal of TMA is twofold: to adequately control forefoot infection or ischemia by removing all necrotic, ischemic, or infected tissue to a level that allows healing; and to maximize limb function by salvaging the midfoot and rearfoot, thus leaving a plantigrade platform on which the patient can adequately bear weight and walk. However, complications after this limb salvage procedure are not uncommon. Sage et al (11) reported complications in 42% of patients who had midfoot amputation of neuropathic and dysvascular feet. In a study by Mueller et al (12), subsequent skin breakdown developed in 27% of patients who had TMA, and 28% of patients who had TMA required higher amputation. Healing rates after TMA have ranged from 39% to 93.3% (2, 4, 6–8, 10, 12–15).

Despite its potential complications, TMA is considered preferable to below-the-knee amputation (BKA) or above-the-knee amputation (AKA), because TMA allows a weight-bearing residuum to remain and has a lower mortality rate (16). In a study of hospital mortality occurring within 30 days after BKA and AKA, Feinglass et al (17) recorded a 6.3% mortality rate among 1909 patients after BKA and a 13.3% mortality rate among 2152 patients after AKA. Other studies (8, 9, 12) reported substantially lower

Address correspondence to: Graham A. Hamilton, DPM, FACFAS, Department of Orthopedics and Podiatric Surgery, Kaiser Permanente Medical Center, 280 W MacArthur Blvd, Oakland, CA 94611. E-mail: graham.a.hamilton@kp.org

[1]Department of Orthopedics and Podiatric Surgery, Kaiser Permanente Medical Center, Oakland and Richmond, CA; Second-Year Resident, San Francisco Bay Area Foot and Ankle Residency Program, San Francisco, CA.

[2]Department of Orthopedics and Podiatric Surgery, Kaiser Permanente Medical Center, Oakland and Richmond, CA; Staff Podiatric Surgeon, Attending Staff, San Francisco Bay Area Foot and Ankle Residency Program, San Francisco, CA.

[3]Department of Orthopedics and Podiatric Surgery, Kaiser Permanente Medical Center, Walnut Creek, CA; Staff Podiatric Surgeon, Attending Staff, San Francisco Bay Area Foot and Ankle Residency Program, San Francisco, CA.

[4]Department of Orthopedics and Podiatric Surgery, Kaiser Permanente Medical Center, Oakland and Richmond, CA; Staff Podiatric Surgeon, Attending Staff, San Francisco Bay Area Foot and Ankle Residency Program, San Francisco, CA.

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30-day postoperative mortality after TMA, and a series described by Geroulakos and May (4) had a postoperative mortality rate of 3%.

Although amputation at a higher level often results in more predictable healing (7), BKA or AKA is not done without substantial cost. Waters et al (18) noted that the energy cost of walking with a residual limb is inversely proportional to length of the remaining limb and number of functional joints preserved.

The purpose of the current study is to report our results after TMA in a large diabetic and dysvascular patient population. Associated co-morbidities were examined for statistical significance in either complication or healing rate.

Materials and Methods

Medical charts and electronic databases were retrospectively reviewed for 108 patients seen consecutively for TMA. Surgery was performed by the senior authors at Kaiser Permanente Oakland, Richmond, and Walnut Creek, between April 1993 and January 2004. Outcome assessments were performed by the senior authors at the last documented office visit.

Indications for surgery were chronic forefoot ulceration (Fig 1*A*), forefoot infection, forefoot gangrene (Fig 1*B*), or a combination of these (Table 1). Operative technique and postoperative management were similarly applied for each patient by the attending podiatric surgeons at each institution. Percutaneous tendo-Achilles lengthening (TAL) procedures were routinely performed in all patients who were predicted to be ambulatory after TMA. In cases of extensive infection, the skin incision was not primarily closed at the initial surgery, and only closed when all signs of active infection were eliminated.

Only patients who had a minimum 6 months of postoperative follow-up or had died by follow-up were included in this study. Ninety patients (101 consecutive amputations) satisfied the inclusion criteria. The Kaiser Permanente Northern California Region Institutional Review Board approved the study.

Data collection included age, gender, diabetic versus nondiabetic status, history of coronary artery disease (CAD), cerebral vascular accident (CVA), hypertension, or end-stage renal disease (ESRD). These co-morbid conditions were compared with final outcome (12, 15, 19). Vascular status for all patients was assessed before surgery. Presence or absence of palpable pedal pulses was routinely noted. Presence of an audible Doppler signal, ankle brachial index (ABI) score, angiography results, or toe pressure was recorded for patients who did not have a palpable pulse.

Data were collected retrospectively to assess presence or absence of complications occurring after TMA. Complications were defined alternatively as mortality occurring less than 30 days postoperatively, stump infarction with or without more proximal amputation, postoperative infection, equinus or calcaneus gait, stump deformity in any of the three cardinal planes, wound dehiscence, and chronic stump ulceration. Chronic ulceration was defined as dehiscence lasting more than 90 days or a healed stump that reulcerated. Uncomplicated outcome was defined as absence of all these complications and an ability to walk on the stump with a diabetic shoe and filler after a minimum follow-up of 6 months. Data were compared using χ^2 and Fisher exact tests.

Operative Technique

The TMA procedure was done with the patient supine. The ulcerated or gangrenous forefoot was covered with an elastic bandage or a surgical glove before any incisions were made. Percutaneous TAL (20, 21) was done first and, in some cases, was staged if infection was extensive.

The second part of the operation was amputation of the forefoot. The viable soft-tissue envelope determined the incisional approach. A fishmouth incision proximal to the compromised forefoot tissue and bone was used most commonly. The apexes of the incision were placed medially at about the midshaft level of the first metatarsal and laterally at the midshaft level of the fifth metatarsal (Fig 2*A*). Alternatively, a more transverse dorsal incision was made with a longer plantar flap. The dorsal incision is made first and carried to bone. Bleeding vessels were tied or cauterized. The metatarsal shafts were identified and exposed with a periosteal elevator. The shafts were resected using an oscillating or sagittal saw so that the distal ends of the shortened metatarsals defined a smooth arc. The plantar incision was made next so that a plantar flap was created. The forefoot was removed, and all remaining tendon stumps were excised under tension (Fig 2*B, C*). After irrigation with pulsed lavage, the wound was closed. Strategically placed nonabsorbable deep sutures were used to reapproximate the flaps. The skin was then closed using nonabsorbable suture. The flaps were approximated without any tension (Fig 2*D*).

Patients were placed into a posterior splint and were admitted to the hospital for culture-specific intravenous antibiotics and observation. The splint was removed after 2 days, at which time a new dressing was applied. Each subsequent day, the flaps were assessed for signs of infarction or reinfection. When discharged from the hospital, patients were placed in a total-contact cast, which was then removed on a weekly basis. The stump was rechecked on an outpatient basis. Use of an assistive device (eg, walker, crutches, wheelchair) was advised for strict nonweightbearing. Sutures were removed at about 21 days postoperatively. Patients were kept in the contact cast until diabetic shoes with a TMA filler were fabricated and fitted. If any wound

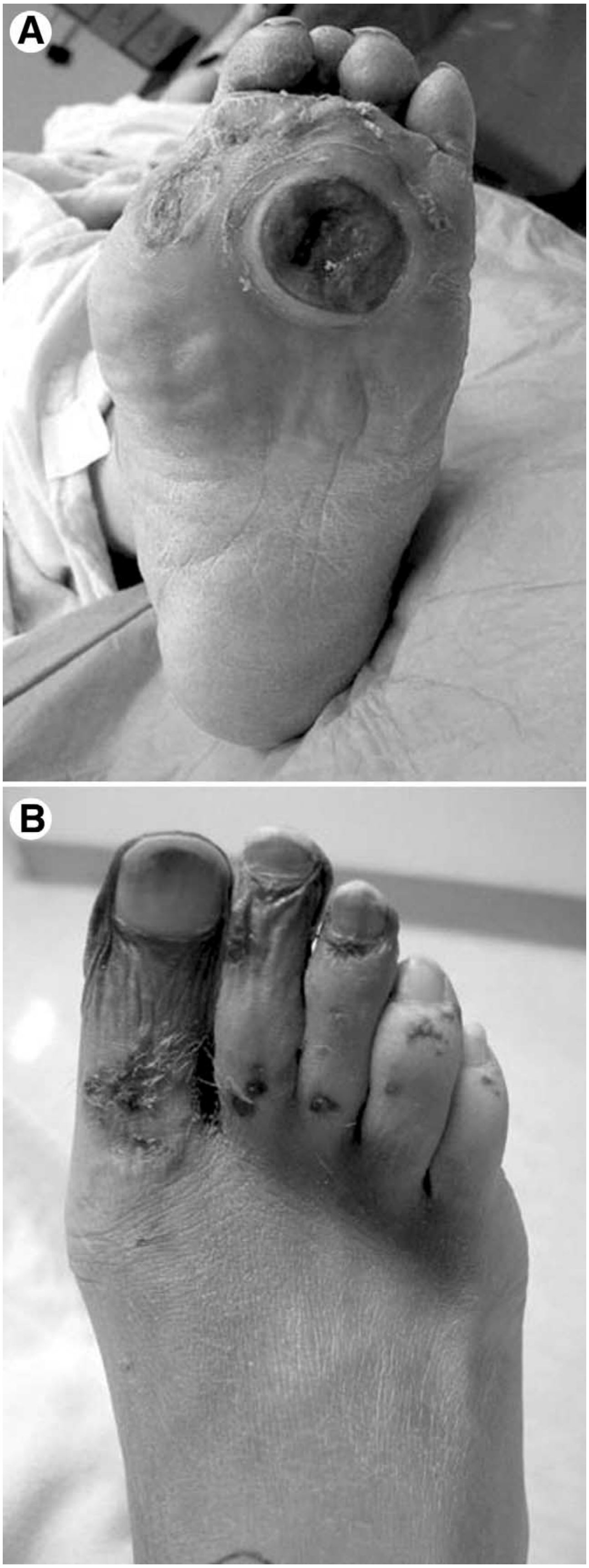

TABLE 1 Indications for transmetatarsal amputation

Indication	Number (%)
Chronic ulceration	8 (7.9)
Gangrene	19 (18.8)
Infection	10 (9.9)
Gangrene and infection	24 (23.8)
Gangrene and ulceration	6 (5.9)
Infection and ulceration	24 (23.8)
Gangrene, infection, and ulceration	10 (9.9)
Total	101 (100)

healing complications were observed, the cast was discontinued or was windowed to allow local wound care.

Results

Demographic characteristics and risk factors for the TMA surgery cohort are shown in Table 2. Mean postoperative follow-up, excluding patients who died or went on to a more proximal amputation less than 6 months after TMA, was 2.1 years. The TMA was done in 101 feet for 91 patients (78 men, 23 women with mean age of 64.3 years [range 39 to 86 years]).

Palpable pedal pulses were noted in 34 patients. Of patients without a palpable pulse, 36 had an audible Doppler signal. Mean ABI was 0.73 (range 0.51 to 0.92), and mean toe pressure was 40.5 mm Hg. Immediate distal revascularization bypass surgery was done for 26 patients before or in conjunction with TMA.

Arranged by associated factor, Table 3 shows the percentage of patients who had a healed stump. A healed stump (Fig 2*E*) was achieved in 58 (57.4%) of the 101 amputations, including 49 (55.7%) of the 88 diabetic patients, and 9 (69.2%) of 13 nondiabetic cases. Healing was achieved in 52.6% of patients preoperatively diagnosed with gangrene only, in 60% of patients preoperatively diagnosed with infection, in all patients preoperatively diagnosed with chronic ulceration alone, in 50% of patients with both gangrene and infection, and in 16 (44.4%) of the 36 patients preoperatively diagnosed with ESRD. A palpable pedal pulse was predictive of healing (P = .0567). A healed stump was achieved in 24 (70.6%) of the 34 patients who had a palpable pedal pulse. A healed stump was achieved in 17 (65.4%) of 26 patients who had lower extremity bypass surgery immediately before amputation.

Two patients died within 30 days, yielding a perioperative mortality rate of 1.98%. Both patients who died in the immediate postoperative period had ESRD. End-stage renal

FIGURE 1 Photographs of forefoot before transmetatarsal amputation show (*A*) ulceration and (*B*) gangrene.

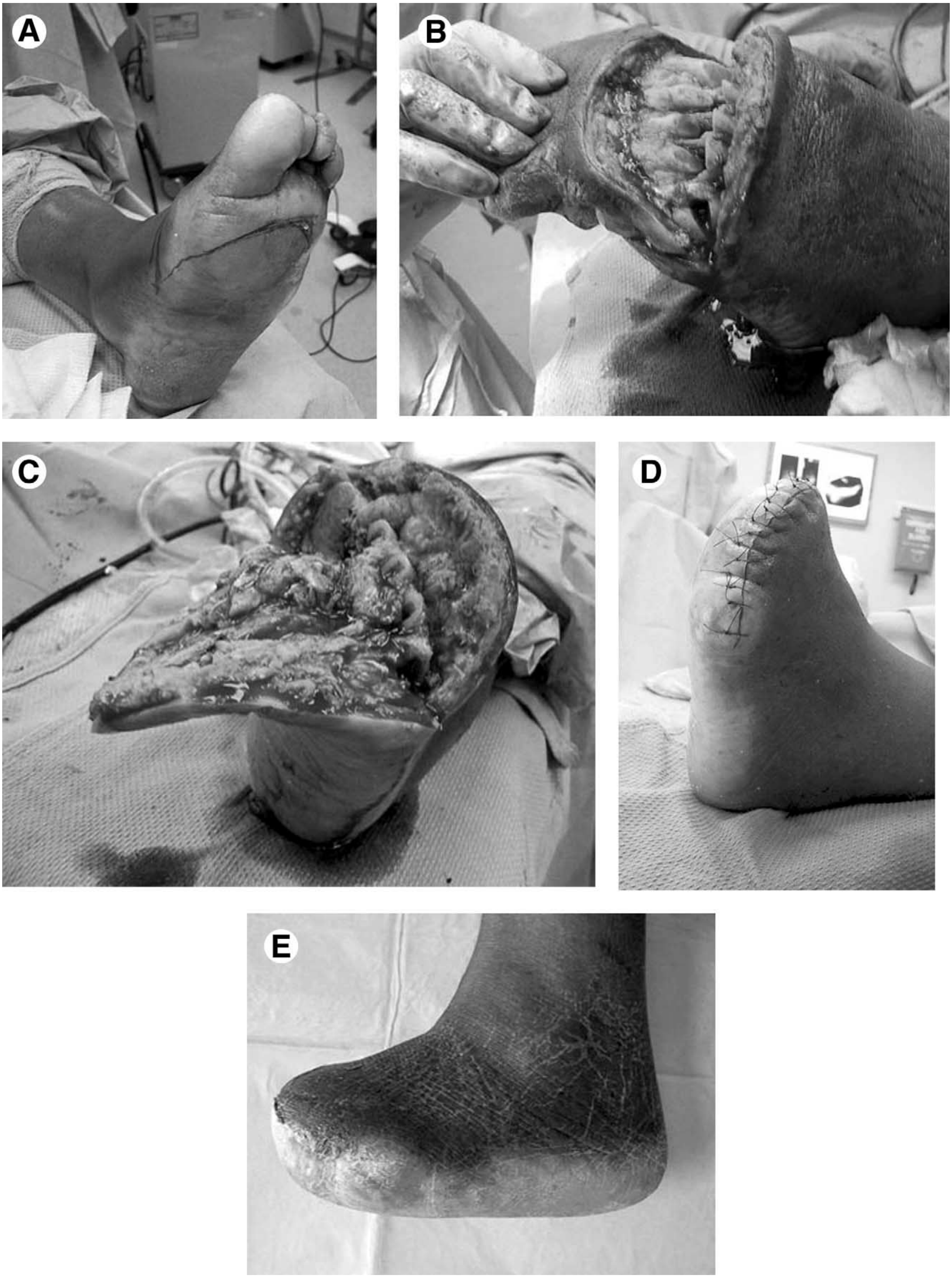

FIGURE 2 Intraoperative photographs show (*A*) fishmouth incision for transmetatarsal amputation; (*B*) forefoot detachment after metatarsal osteotomy; (*C*) flaps before closure; (*D*) simple interrupted closure of flaps; and (*E*) healed plantigrade stump 4 weeks postoperatively.

TABLE 2 Demographic characteristics[a]

Characteristic	No. (%)
Gender	
Male	78 (77.2)
Female	23 (22.8)
Diabetes mellitus	88 (87.1)
Coronary artery disease	46 (45.5)
Hypertension	83 (82.2)
Cerebral vascular accident	21 (20.8)
Palpable pedal pulses	34 (33.7)
End-stage renal disease	36 (35.6)
>1 indication for surgery	64 (63.4)
Healed stump	58 (57.4)
More proximal amputation	31 (32.0)

[a]Mean age 64.3 year (SD = 11.1 year) at the time of amputation.

TABLE 3 Percentage of patients with healed stump, by associative factor

Associative Factor	Percentage Healed (n = 101)		*P*
	With Risk Factor	Without Risk Factor	
Coronary artery disease	52.2	61.8	.33
Hypertension	57.6	61.1	.73
Cerebral vascular accident	52.4	58.8	.60
Palpable pedal pulses	70.6	50.8	.0567
End-stage renal disease	44.4	65.6	.04
Diabetes mellitus	55.7	69.2	.36

TABLE 4 Percentage of patients who progressed to more proximal amputation, by associative factor

Associative Factor	Percentage With More Proximal Amputation (n = 97)		*P*
	With Risk Factor	Without Risk Factor	
Coronary artery disease	37.2	27.8	.32
Hypertension	33.8	23.5	.41
Cerebral vascular accident	25.0	33.8	.45
Palpable pedal pulses	17.7	39.7	.03
End-stage renal disease	39.4	27.0	.21
Diabetes mellitus	31.0	38.5	.59

disease was a statistically significant predictor of nonhealing (P = .04). Arranged by associative factor, Table 4 shows the percentage of patients for whom more proximal amputation was required. A documented palpable pedal pulse was a statistically significant predictor for not requiring more proximal amputation (P = .03). For 31 patients, stump infarction (Fig 3) required more proximal amputation. Wound dehiscence was observed in 52 (51.5%) of the 101 amputations; for 29 (55.8%) of the 52 patients with

FIGURE 3 Photograph shows infarction of plantar medial flap. Failed healing in this stump resulted in below-the-knee amputation.

wound dehiscence, a healed stump was achieved. The stump was surgically revised in 21 (20.8%) of the 101 amputations. Thirty-one had chronic stump breakdown. Of 10 (9.9%) stump deformities, 5 had muscle imbalance that was successfully treated with tendon-balancing procedures, 2 were successfully managed with ankle-bracing foot orthoses, 2 required a more proximal amputation, and 1 died during the follow-up period. Thirty (53.6%) of 56 patients with a healed stump were independently mobile, and 26 (46.4%) of 56 patients with a healed stump required an assistive device.

Postsurgical complications developed in 88 of the 101 patients, of whom 46 had a diagnosis of CAD, 83 had a diagnosis of hypertension, 21 had a history of CVA, and 36 had ESRD. Of the 31 patients for whom more proximal amputation was required, 1 had a Lisfranc procedure, and 2 had a Chopart procedure; 21 of the 31 patients had BKA, and 7 of the 31 patients had AKA.

Postoperative wound infection developed in 19 of the 101 patients and was successfully treated with oral antibiotic agents and local wound care. No calcaneus or equinus gait had developed in any patient with a healed stump when last seen.

Discussion

Bernard and Heute first described TMA in 1855 for treatment of trenchfoot. However, the TMA limb salvage procedure was not popularized until 1949, when McKittrick and colleagues (8) first reported a series of 215 TMA procedures done to treat infection or gangrene in patients with diabetes mellitus. These investigators reported a healing rate of 72%, a 12.5% rate of amputation higher on the limb, postoperative hospital stay of 30 days, and a 0.9% rate of hospital mortality within 30 days after amputation. If the criteria for postoperative complications described in our study were applied to the study by McKittick et al (8), the overall healing rate in their study would recalculate to 59%.

Tracy et al (22) reported a 70% healing rate after TMA and a 4.8% hospital mortality rate. In a study of 41 TMA procedures, Thomas and colleagues (15) reported a healed stump in 46% of patients, a more proximal amputation rate of 36%, and a hospital mortality rate of 17%. Quigley et al (10) reported 33 consecutive TMA cases, of which 76% required a further procedure, either debridement (in 12 patients) or major amputation (in 18 patients). For the patients described in the present study, a healed stump was achieved in 57.4% of cases, with a more proximal amputation rate of 32% and hospital mortality of 1.98%. These findings were comparable with other series in healing, although mortality rate was generally lower in the current study (10, 15, 22).

We found no statistically significant difference in healing rates among diabetic versus nondiabetic patients. This finding was consistent with other reports, in which any effect of diabetes failed to reach statistical significance (4, 6, 10), but the finding contrasts with some other reports in which nondiabetic patients had substantially better healing than did diabetic patients (13, 17).

End-stage renal disease had a statistically significant effect on healing but not on mortality. Of the 36 patients with a diagnosis of ESRD at the time of amputation, a healed stump was achieved in only 44.4%. Both patients who died in the immediate postoperative period had ESRD. Eggers et al (23) studied nontraumatic lower extremity amputation in patients with ESRD and found that the rate among diabetic persons with ESRD was 10 times higher among the general diabetic population and that two-thirds died within 2 years after the first amputation.

The 65.4% rate of healing reported in the current study for patients who had bypass revascularization accompanying TMA agreed with results of other series. Miller et al (9) reported a 62% healing rate with adjunct revascularization and added that this rate reached 83% when the bypass remained patent for at least 3 months after amputation. La Fontaine and colleagues (24) reported that in 80% of patients with revascularization, the healed stump was preserved when examined at mean follow-up of 36.4 months.

Multiple invasive and noninvasive studies have assessed peripheral vascular status and attempted to predict the potential for wound healing. Wagner (25) predicted healing at a level where flow was pulsatile and the ABI was 0.45. In a prospective study, Pinzur et al (26) reported a 92.2% healing rate after TMA with a minimum ABI value of 0.45 in nondiabetic and 0.5 in diabetic patients, blood total lymphocyte count of $>1.5 \times 10^3/\mu L$ ($>1.5 \times 10^9/L$), and serum albumin levels of ≥ 3.0 g/dL (≥ 30 g/L). However, Malone et al (27) reported that the ABI was not statistically reliable as a predictor of amputation healing. Several reports support this finding, stating that cuff occlusion tests are often inaccurate in diabetic patients because of medial calcification of peripheral vessels. Transcutaneous oxygen pressure ($TcPO_2$) is another noninvasive test used to determine amputation healing. Bunt and Holloway (28) reported that a $TcPO_2$ value >30 mm Hg accurately predicted the success of major amputation in 88% of patients and success of minor amputation in 85% of patients. However, no single noninvasive test has been universally accepted for predicting healing after amputation.

In the current study, a palpable pedal pulse was a clinically significant predictor of healing. However, in our patients without palpable pedal pulse, methods of noninvasive diagnostic evaluation varied. This varied assessment of pedal perfusion made it difficult to find correlations with healing potential after amputation. Of the demographics and types of co-morbidity studied, hypertension, CVA, and a history of CAD failed to reach statistical significance as predictors of healing and immediate postoperative mortality after TMA.

Our results for patients with wound dehiscence (the most common complication occurring after TMA) and for patients with chronic stump breakdown (the next most common complication) can be compared with the study of Mueller et al (12). They reported that 27% of patients had skin breakdown after TMA and that in 48% of these patients, skin breakdown occurred in the first 3 months after TMA.

Conclusion

The current study describes morbidity and mortality after TMA in a large population of diabetic and vasculopathic patients. The diagnosis of ESRD was found to be a statistically significant predictor for failure to heal. Patients with a palpable pedal pulse had statistically significant predictable healing as well as not requiring a more proximal amputation. Therefore, we believe that these factors should be considered when counseling patients about potential risks and benefits of TMA.

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