Outcomes of Transmetatarsal Amputations in Patients with Diabetes Mellitus

The purpose of this study was to report on the long-term outcomes of transmetatarsal amputations secondary to sequelae of diabetes mellitus. We abstracted data from 35 diabetic patients receiving a transmetatarsal amputation over a 6-month period in 1992. Patients were followed for a mean 15.1 ± 10.1 months. The results indicated that the most predictive factor determining higher level amputation (transfemoral or transtibial) appeared to be the actual indication for surgery (90.0% ischemia versus 4.0% infection, $\chi^2 = 21.7$, odds ratio = 220, 95% confidence interval = 12.5–3885.0, $p < 0.05$). Those with a diagnosis of infection without underlying critical ischemia were significantly more likely to heal at the level of the foot. While all patients presenting for care had dramatically impaired nutritional values and elevated glucose, albumin was significantly lower in subjects receiving a transfemoral or transtibial revision. High-level amputees were also significantly less likely to have been prescribed depth-inlay shoe gear prior to their amputation (48.0% vs. 10.0%, $\chi^2 = 4.4$, odds ratio = 8.3, 95% confidence interval = 1.0–75.7, $p < 0.05$). Those with a diagnosis of infection without underlying critical ischemia were significantly more likely to heal at the level of the foot. Though revision rates are high, the success rates are also high if that is defined as retaining the foot and providing a prosthesis-free normal gait.
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Key words: diabetes mellitus, amputation, foot, infection, shoes, peripheral vascular disease

Jonathan Hosch, DPM
Carmina Quiroga, DPM
Jan Bosma
Edgar J. G. Peters, MS
David G. Armstrong, DPM, AACFAS[1]
Lawrence A. Lavery, DPM, FACFAS[2]

Diabetes mellitus is a common, indolent disease that affects at least 14 million people in the United States (1). Foot pathology is perhaps the most common complication of diabetes mellitus. Up to 83% of all nontraumatic lower-extremity amputations are associated with diabetes mellitus in the United States (2). Of all hospitalizations associated with diabetes, one-quarter are due to complications of the foot (3). Furthermore, while only 2.3% of patients requiring an amputation are admitted from a long-term care facility, over 25% will be discharged to one (4). Clearly, attention must be drawn to the complications associated with this disease because, as our population ages, the number of patients with diabetes and commensurate diabetes-related complications is likely to increase as well.

In an attempt to salvage the foot for ambulation, partial amputation of the foot is often performed (5, 6). The transmetatarsal amputation (TMA), described by McKittrick and colleagues, is a foot salvage procedure for diabetics with infection and/or gangrene (5). The literature discussing the survival of this procedure varies widely. Healing rates range from 44% to 92% (5–11). The variability of the success of this amputation may be due to bias in patient selection, healing potential, or variations in how success was defined. The medical literature discusses a variety of risk factors for ulceration and amputation in individuals with diabetes mellitus (12, 13). Risk factors that were responsible for the initial amputation are most likely still active. Foot deformity and biomechanical abnormalities are exacerbated by partial-foot amputation and have increased the risk profile of many patients (14). The wide variability reported in reamputations in TMA patients may be due to variations in patient selection.

Patients with amputations due primarily to peripheral vascular disease may have a greater risk of additional proximal amputations compared with amputations that involve neuropathy and infection alone. However, we have been unable to locate manuscripts specifically addressing this topic. Furthermore, we have, in general, identified a paucity of articles addressing the long-term outcomes of diabetes-related TMAs in the medical literature. Therefore, the purpose of this study was to report on the long-term

From the Department of Orthopaedics, University of Texas Health Science Center, San Antonio and the Diabetic Foot Research Group.
[1] Assistant Professor, Department of Orthopaedics. Address correspondence to: the University of Texas Health Science Center, San Antonio, 7703 Floyd Curl Drive, San Antonio, TX 78284-7776. E-mail: armstrong@usa.net
[2] Associate Professor, Department of Orthopaedics.
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outcomes of TMAs secondary to sequelae of diabetes mellitus.

Patients and Methods

We abstracted inpatient and outpatient medical records for all amputations that were performed over a six-month period in 1992 by the Podiatry Service of the Department of Orthopaedics in order to identify patients with TMAs. Twenty-three male and 12 female diabetic patients receiving a TMA were identified from records at the University Hospital, San Antonio, TX. Criteria for inclusion required at least a one-year follow-up period. The mean follow-up period was 15.1 ± 10.1 months. All patients were diagnosed with diabetes mellitus utilizing World Health Organization criteria (15). Subjects were classified with diabetes if they were receiving treatment with oral hypoglycemic agents or insulin, if they had a minimum of two fasting glucose measurements greater than 140 mg./dl. or two random glucose tests greater than 200 mg./dl. Patients were excluded if their medical records were incomplete or not available or if the amputation was due to trauma.

The level and causal pathways of each amputation and subsequent proximal reamputation were identified from medical records. Time intervals between the initial amputation and the subsequent dates of healing, ulceration, and reamputation were calculated. The length of hospital stay was determined from the discharge summary. Shoe modifications were also identified before and after each surgery as to whether corrections were made, insoles were provided, or prescription shoes were purchased. Ulceration and reamputation were noted on both the affected and contralateral limbs. The diagnosis of peripheral vascular disease was confirmed in all cases by the Vascular Surgery Service using criteria that has been previously described (16). This included an absolute toe pressure <45 mm. Hg. or an ankle brachial index of < 0.80. A second reviewer verified all information. We defined a successful outcome as one in which the patient retained their foot and were able to rehabilitate to their preamputation activity level.

We used a Chi-squared test with 95% confidence interval (CI) and odds ratio (OR) to compare the risk of high-level (transfemoral or transtibial) amputation for dichotomous variables. A Mann-Whitney *U*-test was used to compare differences in continuous laboratory variables between those who received high-level amputations and those who did not. Values are expressed as mean ± standard deviation. For all analyses, we used an alpha level of 0.05 (17).

Results

Thirty-five patients with an average age of 54.7 ± 8.3 years and a range of 35 to 69 years were evaluated. Sixty-six percent were males and 34% were females. Eighty-three percent of the patients were Mexican-American, 11% were white, and 6% were African-American. All patients were diagnosed with type II diabetes. The duration of diagnosed diabetes mellitus was 14.6 ± 9.9 years with a range of 0 to 33 years. Five patients (14.3%) were diagnosed with diabetes during their amputation hospitalization. Descriptive data are summarized for this population in Table 1.

The most common etiologies of the initial TMA identified from medical records included infection (82.8%), peripheral neuropathy (94.3%), ulceration (51.4%), open previous amputation (42.9%), peripheral vascular disease (34.3%), gangrene (34.3%), wound-healing failure (14.3%), and prophylaxis secondary to difficulty in shoeing (8.6%). However, 82.8% of the cases involved a combination of these etiologies resulting in several different causal pathways. Prior to amputation, 20% of the patients had either a lower extremity by-pass graft or angioplasty.

Twenty-five (71.4%) of the TMAs were left open in the immediate postamputation period and 10 (28.6%) were closed primarily. All 10 amputations that were closed primarily were performed on patients with a primary diagnosis of peripheral vascular disease. The average length of hospital stay was 23.4 ± 20.3 days (see Table 2). Thirty-seven percent of the patients healed following their first surgery without revision or reamputation with a mean of 146.5 ± 47.7 days until return to permanent prescription shoe gear. Sixty-three (n = 22) percent of the patients underwent some type of revision or reamputation of the affected limb. In most cases, this involved revising the TMA to a more proximal transmetatarsal level. Over two-thirds of patients (68.6%) ultimately healed successfully at the transmetatarsal level. Ten required more proximal amputations (28.6%); nine were below-the-knee amputations and one was an above-the-knee amputation. Patients with an etiology including ischemia were far more likely to require a high-level (below knee or above knee) amputation (90.0% *vs.* 4.0%, $\bar{x}^2 = 21.7$, OR = 220, 95% CI = 12.5–3885.0, $p < 0.05$). High-level amputees were also significantly less likely to have been prescribed depth-inlay shoe gear prior to their amputation (48.0% *vs.* 10.0%, $\bar{x}^2 = 4.4$, OR = 8.3, 95% CI = 1.0–75.7, $p < 0.05$). High-level amputees had a significantly lower admission albumin level than patients who healed at the transmetatarsal level (2.3 ± 0.40 *vs.* 2.8 ± 0.65 mg./dl., $p < 0.05$). There was not a significant difference between admission values of white blood cell count, blood glu-

TABLE 1 Descriptive characteristics

Group	n	Age (Years)	Race (% Mexican-American/White/African-American)	% Male	Duration of Diabetes (Years)	Albumin (mg./dl.)	Total Lymphocyte Count	WBC ($\times$1000 cells/mm.^{3})	Hgb (mg./dl.)	Glucose (mg./dl.)	Ankle Brachial Index
Total	35	54.7 ± 8.3	83/11/6	65.7	14.6 ± 9.9	2.7 ± 0.61	1907.7 ± 891.4	12.1 ± 5.2	11.4 ± 1.9	271.7 ± 142.2	1.00 ± 0.29
TMA as final level	25	54.1 ± 9.0	84/12/4	68.0	13.3 ± 10.9	2.8 ± 0.65	1914.2 ± 948.4	11.5 ± 5.4	11.8 ± 1.8	266.6 ± 158.9	1.03 ± 0.29
Leg amputation	10	56.1 ± 6.5	80/10/10	60.0	16.8 ± 7.2	2.3 ± 0.40*	1891.5 ± 776.4	13.6 ± 4.6	10.6 ± 2.0	287.4 ± 74.2	0.90 ± 0.31

* $p < 0.05$.

TABLE 2 Mean time intervals

Length of Stay per Hospitalization (days)	Time from TMA to Revision (days)	Time from TMA to Healing (days)	Follow-Up Period Following First Hospital Discharge (months)
23.4 ± 20.3	46.3 ± 93.3	145.6 ± 87.1	15.1 ± 10.1

cose, hemoglobin, or total lymphocyte count between the high-level amputees and patients who healed at the level of the foot.

We also evaluated ipsilateral and contralateral reulceration among patients with TMAs during the follow-up period. Six (24.0%) transmetatarsal stumps ulcerated during the follow-up period. However, ulceration of the contralateral limb occurred in eight patients (33.3%). Four of those (50%) contralateral ulcerations subsequently went on to amputation.

Discussion

The TMA is a commonly performed procedure for both limb-threatening infection and ischemia in diabetic patients. Some physicians may still consider this a risky procedure due to the low healing rates and high rates for revision that are recorded in the literature. TMAs may provide a better functional result when compared with more proximal amputations. Friedmann stated that by salvaging the foot at this level "gait is improved by maintaining a foot lever arm" (18). Friedmann went on to state that the TMA "preserves all but part of heel-off and toe-off and lowers energy expenditure by smoothing the path of the center of gravity during walking," when compared with a more proximal amputation that must function with a prosthesis.

The literature that discusses the survival rate of the transmetatarsal amputee varies widely. Healing rates range from 44% to 92% (18). Variations in how success was defined may be the answer to why there is such a large degree of variability in the reported rates of TMAs. Some authors simply define "success" as closure of the wound, re-epithelialization of the wound, or by determining when the stump may be weightbearing. Many of these definitions do not report long-term results. We defined success as a process in which the patient retains his or her foot with complete re-epithelialization of the wound and can ambulate without the use of a prosthesis. Although 63% of our patients underwent some type of revision or reamputation, three-quarters of patients retained their foot for ambulation without the use of a prosthetic. This is comparable to other reports in the medical literature (5, 19).

Patient selection may also be important when reviewing the literature to identify the success of TMAs. While our cohort consisted exclusively of patients with type II diabetes mellitus, much of the literature combines diabetics with nondiabetics or type II diabetics with type I diabetics. Therefore, it would be expected that our healing rates would be lower compared with studies that combined both records of those with and without diabetes mellitus.

While an amputation at a higher level often results in more predictable healing, it is not without significant cost. There is an increase in the energy expenditure required for normal walking after a below-knee amputation. Energy demands are increased even more dramatically after above-knee amputation, which can aggravate the often already compromised cardiac and pulmonary function present in many people with diabetes (20, 21). Pinzur *et al.* and Walker and coworkers also found that the metabolic demand after amputation is increased with more proximal amputations. Walking speed, on the other hand, decreases with more proximal amputations (20, 22). Consequently, Walker suggested that an amputation should be performed at the lowest possible level. Additionally, following a high-level amputation, contralateral amputation and mortality seem to increase dramatically. Goldner (23) emphasized that the contralateral leg of the diabetic amputee "shares the fate of the first rather often and relatively soon." He indicated that over two-thirds of contralateral limbs would be ultimately amputated. Whitehouse and coworkers (24) acknowledged this fact, but also emphasized the greater likelihood of a diabetic amputee losing his life before losing his contralateral leg.

It has often been difficult to determine when a TMA is an appropriate level of amputation and whether or not healing will result for a given case. Identifying risk factors has provided insights into establishing criteria for amputation level selection. Pinzur *et al.* stated that the ankle brachial index (ABI), when lower than a certain minimum value (0.5 in patients with diabetes), should be considered a significant risk factor (7). However, Malone and coworkers rejected the use of the ABI as a predictor for amputation success, citing a lack of statistical reliability (25). This is due largely to the fact that medial arterial calcinosis often renders falsely elevated ankle pressures by making them less compliant to compression. These criteria are not set in stone and must be further investigated. Clearly, however, TMAs performed for the treatment of critical limb ischemia carries with it a much poorer long-term prognosis than does a TMA performed for nonischemic infection ablation.

It was interesting to note that subjects who had been prescribed depth-inlay shoes at some point prior to their amputation were significantly less likely to require a below- or above-knee amputation. While clinical studies by Uccioli and associates (26) and Chantelau *et al* (27) suggest that the development of new ulcerations in high-risk diabetics can be significantly decreased with therapeutic footwear and insoles, we are unaware of any study that has linked prescription shoe wear to a reduction in high-level amputation. This association between shoe gear and high-level amputation also may be due to the fact that patients receiving depth-inlay shoes were more likely to have received regular foot care than those who did not. However, this question is more than compelling enough to warrant further discussion and investigation.

Previous studies have suggested that low albumin, total lymphocyte count, and hemoglobin were good indicators for amputation failure (28, 7). With the exception of albumin levels, none of these factors predicted the need for proximal amputation in this study. In fact, both patients who retained their foot and those who required a transfemoral or transtibial amputation had very low values in all of these indices on hospital admission.

In conclusion, the TMA has, and continues to be, a successful level of amputation for retaining functional activity in diabetic patients. In this population, the most predictive factor determining higher level amputation (transfemoral or transtibial) appeared to be the actual indication for surgery. Those with a diagnosis of infection without underlying critical ischemia were significantly more likely to heal at the level of the foot. While all patients presenting for care had dramatically impaired nutritional values and elevated glucose, albumin was significantly lower in subjects receiving a transfemoral or transtibial revision. It also appears that prescription shoe gear (and the commensurate increased attention provided to the foot) appears to reduce the risk for patients receiving a high-level revision. Although revision rates are high, success rates are also high if success rate is defined as retaining one's foot and providing a prosthesis-free normal gait.

References

1. National Diabetes Advisory Board. *The National Long-range Plan to Combat Diabetes*. National Institutions of Health. Bethesda, 1987.
2. Armstrong, D. G., Lavery, L. A., van Houtum, W. H., Harkless, L. B. Seasonal variations in lower extremity amputation. J. Foot Ankle Surg. 36:146–150, 1997.
3. Levin, M. Pathophysiology of diabetic foot lesions. In: *Clinical Diabetes Mellitus: A Problem-Oriented Approach*, pp. 504–510, edited by J. K. Davidson, Theime Medical, New York, 1991.
4. Lavery, L. A., van Houtum, W. H., Armstrong, D. G. Institutionalization following diabetes-related lower extremity amputation. Am. J. Med. 1997, In Press.
5. McKittrick, L. S., McKittrick, J. B., Risley, T. S. Transmetatarsal amputation for infection or gangrene in patients with diabetes mellitus. Ann. Surg. 130:826–830, 1949.

6. Sanders, L. J., Dunlap, G. Transmetatarsal amputations: A successful approach to limb salvage. J. Amer. Podiatr. Med. Assn. 82:129–135, 1992.
7. Pinzur, M., Kaminsky, M., Sage, R., Cronin, R. Osterman, H. Amputations at the middle level of the foot. J. Bone Joint Surg. 68A:1061–1064, 1986.
8. Durham, J. R., McCoy, D. M., Sawchud, A. P., Meyer, J. P., Schwarcz, T. H., Eldrup-Jorgensen, J., Flanigan, D. P., Schuler, J. J. Open transmetatarsal amputation in the treatment of severe foot infections. Am. J. Surg. 158:127–130, 1989.
9. Larson, U. L. F., Anderson, G. B. J. Partial amputation of the foot for diabetic or arteriosclerotic gangrene. J. Bone Joint Surg. 60B:126–130, 1978.
10. Effrey, D. J., Lim, R. C., Schecter, W. P. Transmetatarsal amputation. Arch. Surg. 112:1366–1370, 1977.
11. Hodge, M. J., Peters, T. G., Efird, W. G. Amputation of the distal portion of the foot. South. Med. J. 82:1138–1142, 1989.
12. Lavery, L. A., Armstrong, D. G., Vela, S. A., Quebedeaux, T. L., Fleischli, J. G. Identifying high risk patients for diabetic foot ulceration: Practical criteria for screening. Arch. Intern. Med. 1997, In Press.
13. Reiber, G. E., Pecoraro, R. E., Koepsell, T. D. Risk factors for amputation in patients with diabetes mellitus: A case control study. Ann. Intern. Med. 117:97–105, 1992.
14. Lavery, L. A., Lavery, D. C., Quebedeaux, T. L. Increased foot pressures after great toe amputation in diabetes. Diabetes Care 18:1460–1462, 1995.
15. World Health Organization. *Second Report on Diabetes Mellitus*. Geneva, 1980.
16. Armstrong, D. G., Lavery, L. A., Harkless, L. B. Treatment-based classification system for assessment and care of diabetic feet. J. Am. Podiatr. Med. Assn. 86:311–316, 1996.
17. Kirkwood, B. R., Essentials of Medical Statistics. Blackwell, Oxford, 1988.
18. Friedmann, L. W., Padula, P. A., Weiss, J. M., Root, B., Polchaninoff, M., Shapiro, D. Studies on the survival of transmetatarsal amputation stumps. Vascular Surgery Proceedings of 34th Annual Meeting of the American College of Angiology, Paradise Island, Bahamas, October 1987.
19. Mueller, M. J., Allen, B. T., Sinacore, D. R. Incidence of skin breakdown and higher amputation after transmetatarsal amputation: Implications for rehabilitation. Arch. Phys. Med. Rehabil. 76:50–54, 1995.
20. Pinzur, M. S., Gold, J., Schwartz, D., Gross, N. Energy demands for walking in dysvascular amputees as related to the level of amputation. Orthopaedics 15:1033–1073, 1993.
21. Harris, K. A., van Schie, L., Carroll, S. E., Death, A., Maryniak, O., Meads, G. E., Sweeney, J. P. Rehabilitation potential of elderly patients with major amputations. J. Cardiovasc. Surg. 32:463–467, 1991.
22. Walker, R. L., Perry, J., Antonelli, E. E., Hislop, H. Energy cost of walking of amputees: The influence of level of amputation. J. Bone Joint Surg. 58A:42–46, 1976.
23. Goldner, M. G. The fate of the second leg in the diabetic amputee. Diabetes 9:100–103, 1960.
24. Whitehouse, F. W., Jurgenson, C., Black, M. A. The later life of the diabetic amputee. Diabetes 17:520–521, 1968.
25. Malone, J. M., Anderson, G. G., Lalka, S. G., Hagaman, R. M., Henry, R., McIntyre, K. E., Bernhard, V. M. Prospective comparison of noninvasive techniques for amputation level selection. Am. J. Surg. 154:179–184, 1987.
26. Uccioli, L., Faglia, E., Monticone, G., Favales, F., Durola, L., Aldeghi, A., Quarantiello, A., Calia, P., Menzinger, G. Manufactured shoes in the prevention of diabetic foot ulcers. Diabetes Care 18:1376–1378, 1995.
27. Chantelau, E., Kushner, T., Spraul, M. How effective is cushioned therapeutic footwear in protecting diabetic feet? A clinical study. Diabetic Medicine 7:335–339, 1990.
28. Dickhaut, S. C., DeLee, J. C., Page, C. P. Nutritional status: Importance in predicting wound-healing after amputation. J. Bone Joint Surg. 66A:71–75, 1984.