CHAPTER **45**

DIGITAL AMPUTATION PLANNING IN THE DIABETIC PATIENT: The Too Few Toes Principle

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INTRODUCTION

The US spends one in five health care dollars on the care of diabetic patients, with the total cost of diagnosed diabetes estimated at over $245 billion in 2012 (1). For the diabetic patient with at least one form of foot disease, (defined as the presence of neuropathy, peripheral arterial disease, foot deformity, active infection, ulceration or gangrene in at least one lower extremity) the odds of inpatient mortality and length of hospital stay are respectively 31% and 101% greater when compared to similar patients without any foot disease (2). Likewise, the correlation between diabetes related foot ulcers and a progressive decline in patient quality of life is already well described in the literature (3-7).

In 2008 alone, surgeons performed 67,000 foot amputations in patients with diabetes within the US, many of which were attempts at limb salvage. Diabetic foot amputations often require revisional procedures and are associated with increased morbidity, costs to the patient and healthcare system, and serial loss of function. Although much has been written about hallux and partial forefoot amputations, little attention is directed towards preoperative planning of digital amputations in the diabetic patient. While a global mindset of limb salvage and gratuitous tissue loss prevention may be ideal, there may be circumstances in which saving residual toes may greatly increase the patient's risk for ulceration and additional surgery. Therefore, due diligence on behalf of the surgeon in the initial selection of amputation level may greatly benefit the patient's postoperative function and long-term outcomes. In this article, the authors suggest an algorithm for preoperative digital amputation selection, which we have found to best optimize post-amputation ambulation and reduce high reulceration risk scenarios in the diabetic patient requiring digital amputation.

PROPOSED PRINCIPLE

The authors relate a simple point system to determine whether isolated digital resections or a more proximal amputation may benefit the patient. Limb salvage procedures that leave an extremity scoring 3 points or less should be considered for a transmetatarsal amputation (TMA) based on the patient's metabolic and functional status, with scoring determined by summating the point values of each extremities remaining digits following the procedure. Due to their respective importance during gait, the hallux is given 2 points, while the fifth toe is not scored. The second, third, fourth toes are each given 1 point. Figures 1-6 best demonstrate this principle, and reinforce the concept of biomechanical instability and increased risk for reulceration that are present in extremities scoring 3 points or less.

HALLUX CONSIDERATIONS

The hallux and medial column have an outsized influence on gait and function (8). Amputations of the first ray affect the natural biomechanics of the foot and have been shown to produce a lateral redistribution of the patient's ambulatory load postoperatively (9). This redistribution of stress during ambulation places the remaining foot at an increased risk for developing new ulcerations and infections, which may ultimately lead to additional amputations (10, 11). Nearly 50% of patients who underwent partial first ray resections require a subsequent more proximal amputation (12, 13). When modification of the hallux alone causes this predictable complication rate, it is reasonable to anticipate that additional toe resections would create an even greater imbalance of pressure on the remaining extremity. This imbalance undoubtedly further escalates the patients' risk of future complications.

LESSER DIGIT CONSIDERATIONS

Limited research has examined the biomechanical changes of forefoot pressure following resections of the lesser toes (14). Despite this paucity of peer-reviewed literature, many practitioners anecdotally relate elusive results in patient satisfaction following multiple lesser toe amputations (15). Isolated and/or combined lesser digital resections place the remaining foot under increased load, exacerbating the risk for complications secondary to peak pressures and shear forces (11).

TRANSMETATARSAL AMPUTATION

Pinzur and Marco et al described the appropriate selection of amputation level in terms of “biological amputation level” with regards to vascularity, nutrition, immune and infection status of present wounds, and past histories of any comorbidities such as hypertension, diabetic neuropathy, renal or peripheral vascular disease, and patient smoking history (16). However, fully inclusive criteria should also include factors such as the potential survivorship of the patient with the risk of multiple surgeries, the potential cost to the patient due to lost work time, insurance co-pay or out of pocket expenses, and the biomechanical changes in ambulation and subsequent mobilization (17). Based on the latter considerations, it would seem prudent to assess whether the remaining extremity will meet the functional expectations of each patient without severely increasing their risk for reamputation. Figures 1-6 show unstable, difficult shoe fitting feet, which are evidenced by ulcerations.

While multiple toe resections may leave the patient in an unstable or “‘at risk” predicament, a TMA may arguably provide the patient a better platform for ambulation and recovery. TMA in an appropriate patient preserves a large amount of the distal weightbearing length and propulsive power of the foot while maintaining a relatively energy-efficient gait (18-20). Smaller studies have found 24% of patients who received partial first ray resections eventually required a TMA as a secondary surgical intervention (12, 13). In addition, prescriptive shoes and insoles may be easier to be developed for a foot with healed TMA when compared to foot with residual toes. Ultimately, TMAs are effective in maintaining limb length and produce a similar gait pattern and exertive demand without limitation of ambulatory status.

However, TMA are not without risks. It is reported that about 28% require a more proximal re-amputation following TMA due to nonhealing wounds (2-4). Factors affecting TMA healing rates have a strong positive correlation with palpable pedal pulses and a negative correlation with the presence of end stage renal disease and other comorbidities (18). It has been observed that 89% of patients who received a revision of a TMA had significant comorbidities, further outlining the need for throughout presurgical planning and screening (21). Success of the TMA may also be improved by minimizing soft-tissue stripping in the area of the collateral ligaments during distal metatarsal osteotomies (19), and by performing a rear foot extrinsic tendon balancing procedure to address musculoskeletal changes (20).

In conclusion, forefoot operations in the diabetic patient that leave the patient with an unstable configuration of residual toes violate basic rheologic principles and place the patient at a heightened long-term risk for ulceration and further surgical interventions . In the event multiple-toe amputations are required, the authors have found that patients who undergo limb salvage surgery that would leave the foot with a score of 3 or less per scoring system as proposed above would benefit from a more definitive surgical intervention such as TMA. Such an approach provides a functional limb sparing alternative without the long-term morbidity associated with repeat ulceration, rehospitalization, and surgical revision.

Figure 1. Patient with scoring of 1 (1 residual lesser toe). Consider the difficulty this patient has with shoe fitting and maintaining balance.

Figure 1B. Due to biomechanical instability, this patient developed a plantar transfer lesion, which is a predictable result of this high risk foot type. It is likely a TMA would have provided a more durable, balanced, and predictable ambulatory base.

Figure 2A. Patient with scoring of 2 (residual third and fourth digits).

Figure 2B. Due to difficulty with shoe fitting, the patient developed plantar ulcerations

Figure 2C. Ulcerations also developed on the distal stump of second metatarsal.

Figure 3. Patient with scoring of 2 (residual hallux and fifth toe) who presented with an infected pressure ulcer on the distal residual hallux.

Figure 4. Patient with scoring of 2 (residual third-fifth toes) with nonhealing wound on the amputation stump of the hallux and second toe.

REFERENCES

1. American Diabetes A. Economic costs of diabetes in the US in 2012. Diabetes Care 2013;36:1033-46.
2. Nirantharakumar K, Saeed M, Wilson I, Marshall T, Coleman JJ. In-hospital mortality and length of stay in patients with diabetes having foot disease. J Diabetes Complications 2013;27:454-8.
3. Boulton AJ, Vileikyte L, Ragnarson-Tennvall G, Apelqvist J. The global burden of diabetic foot disease. Lancet 2005;366:1719-24.
4. Brownrigg JRW, Davey J, Holt PJ, et al. The association of ulceration of the foot with cardiovascular and all-cause mortality in patients with diabetes: a meta-analysis. Diabetologia 2012;55:2906-12.
5. Ghanassia E, Villon L, Thuan dit Dieudonné J-F, Boegner C, Avignon A, Sultan A. Long-term outcome and disability of diabetic patients hospitalized for diabetic foot ulcers: a 6.5-year follow-up study. Diabetes Care 2008;31:1288-92.
6. Morbach S, Furchert H, Groblinghoff U, et al. Long-term prognosis of diabetic foot patients and their limbs: amputation and death over the course of a decade. Diabetes Care 2012;35:2021-7.

Figure 5A. Patient with scoring of 3 (residual hallux and fourth toe).

Figure 5B. Difficult to heal plantar wound due to tension.

Figure 6. Patient with scoring of 3 (residual second-fourth toes) with chronic ulceration on the plantar fourth metatarsal head.

7. Moulik PK, Mtonga R, Gill GV. Amputation and mortality in new-onset diabetic foot ulcers stratified by etiology. Diabetes Care 2003;26:491-4.
8. Murdoch DP, Armstrong DG, Dacus JB, Laughlin TJ, Morgan CB, Lavery LA. The natural history of great toe amputations. J Foot Ankle Surg 1997;36:204-8.
9. Lavery LA, Lavery DC, Quebedeax-Farnham TL. Increased foot pressures after great toe amputation in diabetes. Diabetes Care 1995;18:1460-2.
10. Quebedeaux TL, Lavery LA, Lavery DC. The development of foot deformities and ulcers after great toe amputation in diabetes. Diabetes Care 1996;19:165-7.
11. Armstrong D, Lavery L. Plantar pressures are higher in diabetic patients following partial foot amputation. Ostomy Wound Manage 1998;44:30-2.
12. Borkosky SL, Roukis TS. Incidence of repeat amputation after partial first ray amputation associated with diabetes mellitus and peripheral neuropathy: an 11-year review. J Foot Ankle Surg 2013;52:335-8.
13. Kadukammakal J, Yau S, Urbas W. Assessment of partial first-ray resections and their tendency to progress to transmetatarsal amputations: a retrospective study. J Am Podiatr Medical Assoc 2012;102:412-6.
14. Solan MC, Davies MS. Revision surgery of the lesser toes. Foot Ankle Clin 2011;16:621-45.
15. Femino JE, Mueller K. Complications of lesser toe surgery. Clin Orthop Relat Res 2001;391:72- 88.
16. Pinzur MS, Gottschalk FA, Pinto MAGdS, Smith DG. Controversies in lower-extremity amputation. J Bone Joint Surg 2007;89:1118-27.
17. Attinger CE, Brown BJ. Amputation and ambulation in diabetic patients: function is the goal. Diabetes Metab Res Rev 2012;28 Suppl 1:93-96.
18. Pollard J, Hamilton GA, Rush SM, Ford LA. Mortality and morbidity after transmetatarsal amputation: retrospective review of 101 cases. J Foot Ankle Surgery 2006;45:91-7.
19. Petersen W, Lankes J, Paulsen F, Hassenpflug J. The arterial supply of the lesser metatarsal heads: a vascular injection study in human cadavers. Foot Ankle Int 2002;23:491- 5.
20. McCallum R, Tagoe M. Transmetatarsal amputation: a case series and review of the literature. J Aging Res 2012:797218.
21. Anthony T, Roberts J, Modrall JG, et al. Transmetatarsal amputation: assessment of current selection criteria. Am J Surg 2006;192:e8-11.