

Internal Pedal Amputation in Diabetic Forefoot Ulcers

Diyabetik Ön Ayak Yaralarında İnternal Parmak Ampütasyonu

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Abstract

Objective: Approximately 80% of diabetic foot wounds occur in the front foot. Most of these wounds are associated with bone and joint involvement. Toe amputations and ray amputations are the most frequently performed surgical interventions for lesions limited to the front foot. Many diabetic patients refuse surgery despite having advanced deformities that may cause serious injuries. In regard of such patients, we devised a new alternative surgical procedure that maintains the appearance of the toe and is not perceived by patients as amputation.

Material and Methods: Seventy-six toe lesions of 66 diabetic patients were treated with the new surgical approach between 01-0-2004 and 08-11-2012. Of these patients 50 were male and 16 were female. Their mean age was 60.4 years, and mean duration of diabetes was 16.6 years.

Results: The mean follow-up period was 26.4 (range, 12.0–71.4) months. In 47 patients, the surgical closure healed by primary intention (81%). Dehiscence occurred in 11 patients (19%). Infection of the surgical wound developed in four patients (6.9%). Ulcer relapse occurred in three patients (5.1%). In six patients (10.3%), an ulcer developed in the contralateral foot. In the long-term follow-up, 66 toes of 58 patients were seen to recover in the same or almost same length and width as the other non-deformed toes.

Conclusion: Removal of the involved bone and other involved tissues while preserving the skin and other healthy tissues to reconstruct an acceptable new toe is possible using this new technique.

Keywords: Diabetic forefoot ulcer, internal toe amputation, toe amputation

Öz

Amaç: Diyabetik ayakların yaklaşık %80 ön ayaktan başlar. Çoğu yaralar kemik ve eklem ile ilişkilidir. Parmak ve ray ampütasyonları diyabetik ayağın ön kısmında sıklıkla uygulanan cerrahi işlemlerdir. Çoğu diyabetik hasta, yaraların çok tehlikeli sonuçlar doğurabileceğini bilmesine rağmen ameliyat olmayı kabul etmez. Hastaların bu durumunu göz önünde bulundurarak, ayak parmağının görünüşünde değişikliğe neden olmayan ve hastalar tarafından parmak ampütasyonu gibi algılanmayan yeni alternatif bir cerrahi tekniği tanımladık.

Gereç ve Yöntemler: 01-04-2004 ile 08-11-2012 tarihleri arasında 66 diyabetik hastanın 76 parmak yarası bu yeni cerrahi teknik ile tedavi edildi. Toplam 66 hastanın, 50'si erkek, 16'sı kadın idi. Ortalama yaşı 60,4 ve ortalama diyabet süresi 16,6 yıl idi. Ortalama takip süresi ise 26,4 ay (12 ay ile 71,4 ay arası) idi.

Bulgular: 47 hastada yaralar cerrahi sonrası primer iyileşti (81%). Minör yara iyileşme problemi 11 hastada görüldü (19%). Cerrahi sonrası enfeksiyon dört hastada görüldü (6,9%). Hastaların üçünde aynı ayakta ama farklı alanda (5,1%), altısında ise diğer ayakta ülser oluştu (10,3%). Uzun dönem takip yapabildiğimiz 58 hastanın 66 ayak parmağının neredeyse sağlam bir parmak ile aynı uzunluk ve genişlikte ve herhangi bir deformite olmaksızın iyileştiğini klinik gözlem olarak gördük.

Sonuç: Cildin ve diğer sağlıklı dokuların korunarak enfekte kemik ve diğer dokuların tamamen çıkarıldığı bu yeni cerrahi yöntem ile hastaların kabul edilebilir yeni bir ayak parmağına kavuşabileceğini düşünüyoruz.

Anahtar Sözcükler: Diyabetik ön ayak yaraları, internal ayak parmak ampütasyonu, ayak parmak ampütasyonu

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INTRODUCTION

A high proportion of diabetic foot ulcers affect the toes.¹ Amputation is inevitable if the ulcer and/or infection involves the bone and the joint tissues. The level of amputation is closely related to the extent of infection and necrosis of the phalanges.² In distal and middle phalangeal lesions, the conventional procedure is transverse amputation, including the head of the proximal neighboring joint of the diseased phalanx, and closing the defect with dorsal and ventral flaps. Ray amputation is necessary if the metatarsophalangeal joint is involved.³

Most patients and their relatives perceive toe loss as a life-altering event. They cannot overcome their fear and concern regarding the possibility of a life-threatening “pruning” process arising from the toe or their fear of repetitive amputations. For these reasons, many diabetic patients refuse to consider aggravation risks and refuse to undergo toe amputations. Although they may have advanced deformities that may cause serious injuries, these patients disregard surgical therapy recommendations. In regard of these patients who fear conventional amputations, we devised an alternative surgical procedure that maintains the external appearance of the toe.

MATERIAL AND METHODS

This retrospective study was conducted in accordance with the Helsinki Declaration. Between 01-04-2004 and 08-11-2012, 76 toe lesions in 66 diabetic patients were treated using a new surgical approach. All patients had one or more bone and/or joint involvement in addition to soft tissue lesions. Fifty patients were male and 16 were female. Their mean age was 60.4 (range, 54–78) years, and mean duration of diabetes was 16.6 (range, 8–30) years (Table I). Forty toe lesions were observed in the right foot, and 36 toe lesions were observed in the left foot. Diabetic foot ulcer was found in only one toe in 59 patients; in five patients, two toes were affected; in one patient, three toes were affected; and in one patient, four toes were affected. The distribution of initial wound localizations by toes is summarized in Table II. Foot osteomyelitis was diagnosed when the probe-to-bone test result was positive.⁴ Further, soft tissue or bone infection was clinically evaluated based on the criteria described by the International Working Group on the Diabetic Foot.⁵ This includes the presence of purulence, advancing cellulitis, or two or more other local signs of inflammation. At the time of referral, 31 lesions showed acute infection and 45 lesions showed chronic infection. Patients with acute infection (presence of purulence and advancing cellulitis with or without systemic signs of infection) were hospitalized; incision, drainage, and serial debridements were performed. Wet absorbing wound dressings were applied to the wounds twice a day. Antibiotherapy was performed depending on tissue culture antibiograms. Internal toe or ray amputations were performed during debridement, and the wounds were left open. The wounds were closed after wound preparation was complete. Chronic patients were provided with antibiotic therapy and local dressing, and were followed up in the clinic once a week. After 4 to 6 weeks of therapy and local wound care the patients were hospitalized and operated on.

Table I. Descriptive characteristics of the patients

	n
Age	60.4
Gender (male %)	75.7
Duration of DM (years)	16.6
Sensorimotor neuropathy	63
Hospitalization	
Acute	3.4
Chronic	17.2
Vascular status	
Both palpable	37
Only one palpable	12
Both non-palpable	17
Time to heal, mean (days)	26.8
Mean follow-up (months)	26.4

DM: diabetes mellitus

Table II. Characteristics of wounds, surgeries, and outcomes

	n
Level of internal amputation	
Distal phalanx	6
Distal and middle phalanx	42
Ray	28
Initial wound status	
Acute	31
Chronic	46
Initial wound localization	
Distal toe tip	18
Interphalangeal joint area	6
Proximal interphalangeal joint area	25
MP joint area	27
Distribution of lesions	
First toe	14
Second toe	12
Third toe	12
Fourth toe	13
Fifth toe	25
Complications and outcomes	
Wound dehiscence	11
Infection of surgical wound	4
Ulcer relapse	3
Ulcer occurrence in contralateral foot	6

All patients were assessed for sensorimotor neuropathy using vibration testing by the on-off method with 128-Hz tuning fork, the absence of sensitivity in more than five of nine foot



Figure 1. a-f. Extension of the ulcer on the second, third, fourth, and fifth metatarsophalangeal areas through the web space is observed before operation (a-c). The appearance of the foot and the strength of the toes 10 months postoperatively (d-f)

points with a Semmes–Weinstein 10 g filament, and the absence of the Achilles tendon reflex. A total of 63 patients had sensorimotor neuropathy in our study.

The vascular status was evaluated by pedal pulse palpation. Ischemia was diagnosed by the absence of more than one foot pulse, a non-audible signal upon Doppler ultrasonography of the dorsalis pedis artery, or posterior tibial pulses in the affected extremity. Patients diagnosed with ischemia were referred to undergo vascular surgery (n=17), and an endovascular intervention was performed in eight patients.

This retrospective study was conducted in accordance with the Helsinki Declaration, and informed consent was obtained from all patients.

Surgical Technique

A “Lazy S” incision was made on the appropriate surface of the involved toe. Affected tendons, phalanges, and joint capsules were excised, while the skin and subcutaneous tissue were preserved. The head of the metatarsal bone was included in the excision material if the metatarsophalangeal joint was involved. If the entire distal phalanx was involved, the nail and nail bed were also removed. The same procedure was repeated for each affected toe if necessary. When excising a distal phalanx, a small part of the bone underlying

ing the nail bed may be preserved to keep the nail intact if arterial blood flow is sufficient. After complete excision, all avascular or hypovascular tissues that could complicate healing were removed. If wound hygiene and viability were sufficient, primary skin closure was performed. In patients with acute infection, wound dressings were applied after excision. The wounds were closed after wound preparation was complete. The patients were hospitalized during the early postoperative period. The foot was supported with a short-leg cast splint. The patients were allowed to walk gradually with a splint (3M one-step splint) in the first postoperative week, and full weight-bearing was allowed in the third postoperative week.

RESULTS

All the operations, postoperative follow-up, and examinations were performed by the same author. The mean follow-up duration was 26.4 months (range, 12.0-71.4).

In 55 patients, the surgical closure healed by primary intention (83.3%). Dehiscence occurred in 11 patients (16.6%). Impaired distal toe circulation was the cause of dehiscence in six patients. Four of these patients had non-palpable pedal pulses, one patient had both palpable pedal pulses, and one patient had one palpable pedal pulse. Infection of the surgi-



Figure 2. a-e. Acute progressive diabetic wound infection is observed in the fifth metatarsophalangeal plantar area (a, b). Acceptable length and strength of the fifth toe is observed after magic internal toe amputation (c-e)

cal wound developed in four patients (6%). All these patients healed after a second surgical closure without additional amputation. Ulcer relapse occurred in three patients (4.5%). Recurrence occurred on the adjacent lesser toe in two patients, and in one patient on the plantar surface of the fifth toe while the original lesion was on the first toe. In six patients (9%), an ulcer developed in the contralateral foot.

The mean hospitalization period for chronic wounds was 3.4 (range, 1–12) days, whereas a mean period of 17.2 (range, 13–39) days was observed for acute wounds.

Long-term follow-up revealed approximately similar toe lengths and widths without any deformity (clinical observation) in 76 toes (in 66 patients). In 12 patients, in whom the nail beds and sufficient parts of the distal phalanges were preserved, the nail and the shape of the toe remained intact.

Case 1

A diabetic 76-year-old male patient was referred to our clinic with chronic suppurative ulcers with a blood glucose level of 284 mg/dl. Physical examination revealed suppurative ulcers over firm base tissue on the second, third, fourth, and fifth metatarsophalangeal areas, extending toward the web spaces (Figures 1a-c). Partial internal ray amputations of the second, third, fourth, and fifth toes were performed using dorsal and plantar incisions. Primary healing was achieved without any complications. The lengths and strengths of the toes were good, without any recurrence at 10 months postoperatively (Figure 1d-f).

Case 2

A diabetic 56-year-old male patient weighing 162 kilograms was admitted to our clinic with a foot ulcer on the underlying callus plantar to the metatarsophalangeal joint of the fifth toe that had been present for a few months. Due to a recent onset of elevated body temperature, swelling, and redness on the dorsal and plantar surfaces of the foot over one week, the patient was diagnosed with acute progressive diabetic wound infection and was immediately hospitalized (Figures 2a, b). The wounds were drained by incisions. The infection was controlled in one week with the aid of antibiotherapy and wound dressings (Figure 2c). Radical excisions of bone and joint tissues were subsequently performed. Wound hygiene and viability were decided to be sufficient, and the wound was closed primarily with the application of capillary drains. Primary healing was achieved.

Case 3

A male 75-year-old patient with a 30-year history of diabetes presented with an eschar on the left first toe. The patient's foot pulses were non-palpable; however, a consulted cardiovascular surgeon did not recommend vascular intervention. Physical examination revealed necrosis on the medial surface of the first toe with edema and hyperemia around the lesion and at the medial side of the ankle (Figure 3a). Necrosis and infection involving subcutaneous tissue, phalanges, and interphalangeal and metatarsophalangeal joints were observed during wound debridement, and a partial internal ray amputation of the first toe was performed. The necrotic tissues were then removed, and the wound was prepared with serial debridements and wet absorbing dressings (Figure 3b).



Şekil 3. a-d. Acute infection of the first toe is initially observed (a) and after appropriate debridement (including all phalanges and the head of the metatarsal bone except for the distal part of the distal phalange) of the first toe (b). Acceptable appearance of the first toe 18 months postoperatively (c, d)



Figure 4. a-c. A chronic neurotrophic ulcer on the proximal interphalangeal joint (a). The early postoperative condition (b); the postoperative condition after 4 to 5 years (c).

The wound was closed with secondary suturing and was healed completely. The postoperative 18-month result was good, without any recurrence (Figure 3c, d).

Case 4

An obese 60-year-old male patient with a 10-year diabetes history presented with a chronic neurotrophic ulcer on the lateral side of the fifth toe that had been present for three years (Figure 4a). The patient experienced lymphangitis attacks at the ipsilateral cruris accompanied by high fever four to five times a year. The patient had refused suggestions of toe amputation by other surgeons. After a short period of

wound care and preparation, the distal and middle phalanges and the distal portion of the proximal phalanx were excised and the wound was closed. Primary healing was achieved (Figure 4b, c).

DISCUSSION

Deformities arising from underlying neuropathy, natural prominences of the toes, and distal metatarsal heads are the intrinsic causes of foot wounds in diabetic patients.^{6,7} Bone and joint involvement are important pathological signs indicating the necessity for surgical treatment. The level of am-

putation is directly related to the extent of infection of the bone and joint tissues.⁸ Toe and foot amputations are usually performed according to the bone level of amputation. When planning wound management, not only treating the wound but also providing anatomical and functional integrity against possible hazards awaiting the numb foot and removing intrinsic wound origins should be considered.

Internal amputation is not a novel concept. It was used in the late 1800s for the treatment of bone and joint tuberculosis.⁹ As the number of such patients decreased, these procedures declined in popularity until this concept was reconsidered for diabetic foot deformities in the 1990s. The removal of impaired metatarsals and midfoot bones has also been used to treat Charcot foot.¹⁰ However, all these studies focused on procedures targeting deformities at the midfoot or hindfoot. At first, some concerns restrained us from performing internal pedal amputation. One concern was the lack of solid published data on surgical procedures for forefoot internal amputations in diabetic patients. Although favorable results with metatarsal head resection have been reported in a few studies on diabetic foot ulcers,^{6,11-13} internal amputation of forefoot lesions including toe bones and/or metatarsal head resection have only been reported in a recent study by Faglia et al.¹⁴ According to the results of that study, the range of complications after internal pedal amputation was similar to that observed after partial amputation. The limited bone resection (only the proximal phalanx or only metatarsal head resection) and lack of detailed information about the localization of internal amputations in their study represent a major difference from our study. The major difference we present with our technique is the removal of the involved bones of the toe with or without metatarsal head resection (internal ray amputation or internal toe amputation) while preserving healthy soft tissues and the natural appearance of the toe. Another concern was the stability of the toes after bone resection. We observed that our concern that a toe without a bony support may fail to retain its anatomical position and may compromise its own blood circulation or that of other toes by twisting was redundant. We observed that the new toe gained an elastic resistance in a short time and retained its anatomical position. We also observed clinically that the diameter of the new toe was almost the same as that before the operation and did not decrease over time. The toe length also did not decrease over time. The late results showed that the new toes were not different in appearance from other toes; further, the new toes had no deformities that would cause further complications.

Arthrodesis operations may be considered as an alternative to our approach.¹⁵ For isolated lesions of metatarsophalangeal or interphalangeal joints of the first toe, limited bone and joint resection may be sufficient. Successful recovery may be achieved with arthrodesis in these cases. However, the other toes are composed of short phalangeal bones, and diabetic lesions are usually not limited to only one joint or phalanx. Arthrodesis operations are inapplicable in cases that necessitate the resection of more than one phalanx or joint. Therefore, conventional toe amputations or internal forefoot am-

putations appear to be appropriate treatment modalities for these patients.

This new technique is appropriate for both acute infectious and chronic lesions. If clinical signs of acute infection are observed after the resection of bone and bradytrophic tissues, wound preparation with serial wet-to-dry dressings and secondary closure can be applied.

Internal amputation is also a good option for both treatment and prophylaxis of neurotrophic ulcers due to claw foot deformity. This deformity usually involves the distal and middle phalanges of the shorter second, third, fourth, and fifth toes. If a partial phalangeal resection is applied, preserved bone fragments may compromise blood flow. Furthermore, excising only the distal phalanx is usually not sufficient to correct the claw appearance of the toe; therefore, the middle phalanx should almost always be included.

Nail problems may also arise. The nail bed and the nail should be included in the excision material if the distal phalanx is involved. If the bone tissue underlying the nail bed is healthy and there is sufficient blood flow, the nail may be kept intact. We kept the nail intact in 12 suitable patients.

There are some limitations when performing this surgical operation. This method is only suitable if adequate soft tissue on the toe is available to achieve primary closure of the wound. Moreover, blood circulation in the foot is an important determinant of this technique. Blood flow is deemed as sufficient if the dorsalis pedis artery and/or posterior tibial artery pulses are palpable. If both foot artery pulses are non-palpable, conventional toe or ray amputation should be performed. Although internal amputation was successfully achieved in our patients whose foot pulses were non-palpable, distal tip or total toe necrosis may develop after internal toe or ray amputations. Additionally, with this operation, the toes can no longer articulate, which will limit the patient's activity. A greater functional deficit must be accepted by patients, especially those who undergo internal first ray amputation. Ray amputations were performed in 10 of 14 first toe internal amputations; this limited the patients' activities due to decreased push-off strength in the foot. The same functional limitations are present in both internal amputation and conventional ray or toe amputations. Furthermore, most of our patients were limited household ambulators. Moreover, they often walked slowly and gently, therefore, required only minimal or moderate protection against plantar forces on the residual foot tissues. In the absence of any complications, comfortable regular footwear is recommended to our patients, especially those who had undergone lesser toe internal amputations, particularly for 8 to 16 weeks postoperatively. However, a therapeutic shoe with a rigid sole suitable for the foot was provided to the patients, especially those who had undergone internal ray amputations. A functional orthosis capable of accepting repeated weight-bearing stimuli is required to maintain intact skin. The adoption of an optimal orthosis is vital for both partial (classic) and internal amputation patients.

CONCLUSION

We hope that our study provides a new perspective on conventional toe operations. Removal of the involved bone and other involved tissues while preserving the skin and other healthy tissues to reconstruct an acceptable new toe is possible with this new technique.

Ethics Committee Approval: Authors declared that the research was conducted according to the principles of the World Medical Association Declaration of Helsinki "Ethical Principles for Medical Research Involving Human Subjects", (amended in October 2013).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

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