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Original Article

Outcome of trans-metatarsal amputations in patients with diabetes mellitus

Joel A. Humphrey[a,*], Senthooran Kanthasamy[a], Patrick Coughlin[b], Anthony P. Coll[c], Andrew A.H. Robinson[a]

[a] Department of Trauma and Orthopaedics, Cambridge University Hospitals NHS Foundation Trust, Cambridge, UK
[b] Department of Vascular Surgery, Cambridge University Hospitals NHS Foundation Trust, Cambridge, UK
[c] Wolfson Diabetes and Endocrine Clinic, Wellcome Trust-MRC Institute of Metabolic Science, Cambridge University Hospitals NHS Foundation Trust, Cambridge, UK

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ABSTRACT

Background: This retrospective case series reports the reoperation rate, survival rate and mobility status in patients with diabetes mellitus who had undergone a trans-metatarsal amputation (TMA) managed within a diabetic foot care service.

Methods: Forty-one consecutive patients (37 men, 4 women) underwent a TMA with primary wound closure between January 2008 and December 2017. Eighty-eight per cent (36/41) of the patients were followed-up for a mean of 2.3 years. The outcomes were retrospectively reviewed.

Results: Four (11%) of the 36 patients required reoperation, including three (8%) major amputations. All of the patients requiring a reoperation had peripheral vascular disease. Eleven patients died giving a four-year survival rate of 69% (25/36). Of the surviving patients who had not required revision to a major amputation 96% (21/22) were fully mobile in bespoke orthoses. A third used a walking cane.

Conclusion: This study shows that a TMA with primary wound closure in patients with diabetes mellitus, is effective for limb salvage with low reoperation and major amputation rates. A well healed TMA stump provides independent mobility in the majority of patients. The failures occurred in patients with peripheral vascular disease who, even after percutaneous trans-luminal angioplasty, had a 19% major amputation rate.

Level of Evidence: Level IV, retrospective case series.

1. Introduction

There are an estimated 4.5 million people living with diabetes mellitus in the United Kingdom. The prevalence is increasing. This includes the one million individuals who are unaware that they are living with Type 2 diabetes [1]. People with diabetes mellitus are at risk of developing foot ulcers as a result of a combination of deformity, peripheral vascular disease, peripheral neuropathy and repetitive microtrauma. The lifetime incidence of foot ulcers is between 19% and 34%, with a recurrence rate of 40% at one year and 60% at three years [2]. Approximately 20% of moderate or severe diabetic foot infections lead to amputation, at some level [3]. Diabetic foot ulcers precede more than 80% of all diabetic amputations, and patients with diabetes mellitus have an eight times higher risk of amputation at the tarsometatarsal joint or higher than the normal population [4,5].

In 1949 McKittrick reported 67% satisfactory outcomes following trans-metatarsal amputation (TMA) in patients with diabetes mellitus [6]. However, the role of TMA in management of diabetic foot disease has been questioned, with reamputation rates of 26–30% being reported [7,8]. Nevertheless, TMAs remain a well recognised limb salvage procedure in the treatment of the diabetic foot. In total 1653 TMAs were performed during 2016/17 in English NHS Hospitals [9]. The outcome of TMA in the modern, multidisciplinary health care environment is still poorly reported.

The purpose of this retrospective case series is to report the reoperation rate, survival rate, and mobility status in patients with diabetes mellitus who had undergone a TMA within our diabetic foot care service.

2. Materials and methods

The hospital records of consecutive patients with diabetes mellitus who had undergone a TMA in our institution over a 10-year period, between January 2008 and December 2017, were retrospectively identified. The occurrence of a TMA was identified using operative log books cross referenced to electronic theatre records.

Each patient was assessed by the multi-disciplinary diabetic foot care team which consisted of diabetologists, vascular surgeons, an

* Corresponding author. Present address: Department of Trauma and Orthopaedics, Milton Keynes University Hospital, Milton Keynes, UK.
E-mail address: drjoelhumphrey@aol.com (J.A. Humphrey).

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orthopaedic foot and ankle surgeon, microbiologists, orthotists and podiatrists. The patients were assessed with skeletal imaging and microbiological cultures. Vascular assessment was undertaken in all patients. Further vascular imaging was obtained primarily if at least one distal pulse was not palpable (dorsalis pedis and/or posterior tibial artery) or there were other signs of reduced lower limb arterial circulation.

Complications of diabetes mellitus, including neuropathy, nephropathy and retinopathy were recorded. Previous and subsequent ipsilateral and contralateral limb specific surgery was noted. The American Society of Anaesthesiologists (ASA) physical status classification system was used to determine fitness for surgery [10].

A reoperation was defined as further surgery on the same limb, including wound debridement and revision amputation. A minor amputation was defined as an amputation below the ankle joint. A major amputation was defined as an amputation above the ankle joint. Patients' with peripheral vascular disease were those who had evidence of peripheral arterial disease on an arterial duplex scan (defined as a minimum of a single stenosis of > 50%). Patient follow-up was defined as the period from date of index TMA surgery to the final documented out-patient review, or death. Patient survival was defined as the time from index TMA surgery until study completion or death.

2.1. Statistical analysis

A chi-squared test was used to determine whether there was a significant difference between the patients with and without peripheral vascular disease requiring a reoperation. A paired Student's t-test was used to determine whether there was a statistical difference between the pre-operative creatinine and HbA1c levels in the reoperation group compared to the non-reoperation group. All statistical analysis was performed in Statistical Package for the Social Sciences (SPSS) version 25 for Mac.

2.2. Trans-metatarsal amputation operative procedure

The skin flaps are fashioned according to soft tissue viability, excising necrotic and ulcerated tissues. Full thickness dorsal and plantar flaps are developed, superficial to the long flexor and extensor tendons, retaining as much skin as possible. The proximal metatarsals are divided parallel to the floor with an oscillating saw in non-infected bone. Any sharp edges are smoothed. The second tarsometatarsal joint's integrity is maintained and the Lisfranc ligament is left intact. Thus the first and second metatarsals are cut at the same level. The third to fifth metatarsals are cut in as a cascade to the lateral border of the foot (Fig. 1). The base of the fifth metatarsal is preserved, as it is the attachment of peroneus brevis. The insertion of the tibialis anterior is also preserved. Deep specimens are sent for microbiological culture and sensitivity.

The wound is washed out with three to six litres of normal saline. Following this further post-debridement microbiology swabs are taken. The skin flaps are trimmed, leaving plantar skin in preference to dorsal skin, to allow easy closure (Fig. 2).

Tendo Achillis lengthening (triple hemi-section) is only performed if dorsiflexion of 5° cannot be achieved. All wounds are closed primarily with dermal interrupted 3-0 Monocryl® and vertical mattress 4-0 Nylon for skin.

Postoperative instructions include strict bed rest, plaster protection and antibiotics. The antibiotic regimen is adjusted according to the operative cultures. Antibiotics are continued for one week if the post-debridement cultures are negative and six weeks if they are positive. Plaster protection is continued until the wounds are healed.

When the wounds are soundly healed the patients are supplied with diabetic specification shoes, customised by the orthotist with a total contact insole and forefoot shoe filler.

Fig. 1. Post-operative weight-bearing radiographs following a trans-metatarsal amputation (weight-bearing lateral and antero-posterior views).

3. Results

Forty-one patients (37 men, 4 women) were identified. The mean age at the time of surgery was 63 years (range 39–92). Of the 41 patients 12% (5/41) had type 1 and 88% (36/41) had type 2 diabetes. The mean time from diagnosis of diabetes mellitus to TMA in the type 1 patients was 35 years (range 27 years to 43 years) and 16 years (range 0–44) in the type 2 patients.

Thirty patients (73%, 30/41) had undergone thirty-three operations on the ipsilateral foot prior to their TMA. Seven patients (17%, 7/41) had undergone nine operations on the contralateral lower limb prior to their TMA. Six patients (15%, 6/41) underwent eight operations on the contralateral lower limb after their TMA (Table 1).

The indications for performing a TMA were digital gangrene in 7/41 patients (17%) and the remainder had a non-healing ulcer, which was recalcitrant to off-loading. Of these non-healing ulcers osteomyelitis was present in 30/34 (88%) and absent in 4/34 (12%). Osteomyelitis was confirmed on MRI in 29 patients and a single patient had advanced radiological bony destruction.

On the operated foot both distal pulses were palpable in 34% (14/41) of patients, a single distal pulse was palpable in 29% (12/41) of patients and no pulses were palpable in 36% (15/41) of patients. Other pre-existing diabetic complications included lower limb neuropathy

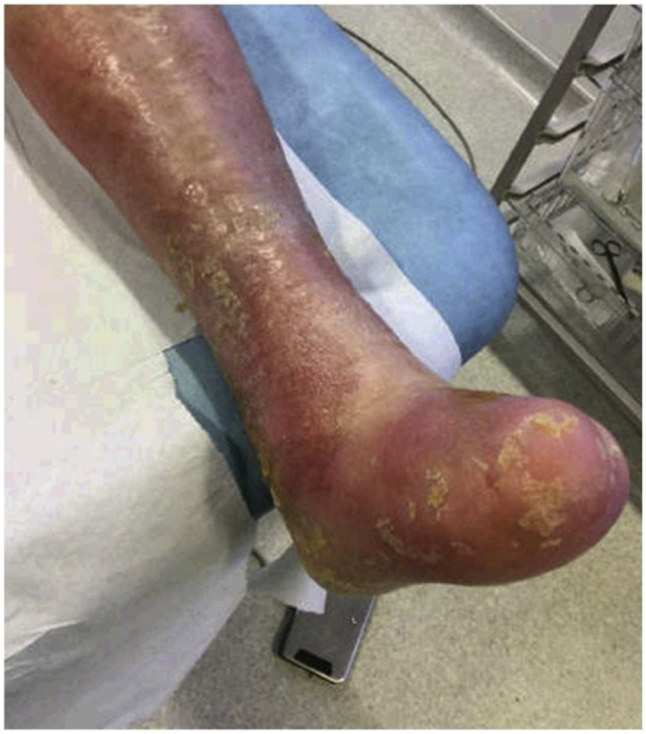

Fig. 2. A clinical photo of a post surgical trans-metatarsal amputation with a well healed plantigrade stump suitable for full weight-bearing in an orthosis.

(95%, 39/41), nephropathy (63%, 26/41) and retinopathy (51%, 21/41).

The mean preoperative American Society of Anaesthesiologists (ASA) physical status classification system was 2.9 (range 2–4).

All forty-one patients grew at least one micro-organism from pre-operative ulcer or wound swabs during their admission. The spectrum of micro-organisms grown is summarised in Table 2. Seventeen patients (41%) grew one micro-organism, thirteen patients (32%) grew two micro-organisms, six patients (15%) grew three micro-organisms, four patients (10%) grew four micro-organisms and one patient (2%) grew five micro-organisms.

The mean perioperative HbA1c was 71 mmol/mol (range 36–117), with a mean of 70 mmol/mol (range 44–87) for the type 1 and 72 mmol/mol (range 36–117) for the type 2. Normal HbA1c is below 42 mmol/mol.

Seventy-one per cent (29/41) of patients required vascular assessment with an arterial duplex scan. Thirty-nine per cent (16/41) of patients had peripheral vascular disease requiring percutaneous trans-luminal angioplasty before amputation, to establish in-line flow to the foot. No patients required open operative vascular revascularisation prior to their TMA.

Tendo Achilles lengthening was required in five (12%) patients.

In total 88% (36/41) of the patients were followed-up by our diabetic foot service for a mean of 2.3 years. Of the patients lost to follow up four patients had early post-operative follow-up in their referring hospital, for geographical reasons. One patient was a repeat outpatient non-attender.

Table 2
The spectrum of pre-operative trans-metatarsal amputation microorganisms grown.

Microorganism	Number of positive wound swabs
Methicillin sensitive *Staphylococcus aureus* (MSSA)	14
Enterococcus faecalis	14
Staphylococcus coagulase negative	12
Pseudomonas	10
Methicillin resistant *Staphylococcus aureus* (MRSA)	6
Group B streptococcus	4
Diphtheroids	4
Proteus	4
Group C/Group G streptococcus	2
Actinobacter	2
Enterobacter cloacae	1
Streptococcus dysgalactiae	1
Streptococcus milleri	1
Streptococcus anginosus	1
Citrobacter freundii	1
Staphylococcus epidermis	1
Corynebacterium	1
Staphylococcus lugdunensis	1
Eggerthella lenta	1
Citrobacter koseri	1

In the 36 reviewed patients the wound healed acutely (< 28 days) in 95% (35/36). One wound dehisced on day six postoperatively and required revision of the trans-metatarsal stump and re-closure. Following re-closure this wound healed uneventfully.

Four of the 36 patients (11%) underwent a total of five reoperations, at a mean 1.9 years from the index surgery (6 days–4.4 years) (Table 3). One patient required two further operations, with debridement of an infected, necrotic TMA stump, which was then revised to a below knee amputation. A total of three TMAs were revised to a below knee amputation, an overall 8% major amputation rate, at a mean of 2.5 years from the index surgery (2.1 months–4.4 years).

All four patients who underwent reoperation had undergone peripheral vascular reconstruction with percutaneous transluminal angioplasty. Patients requiring vascular reconstruction were significantly ($p < 0.05$) more likely to require further surgery than those who did not. The patients undergoing vascular reconstruction had a reoperation rate of 25% (4/16) and major amputation rate of 19% (3/16).

The four re-operated patients were all complex, with diabetic neuropathy, nephropathy and retinopathy as well as their vascular disease. There was no statistical difference ($p = 0.36$) between the pre-operative creatinine levels in the reoperation group (mean 229 μmol/L, range 137–386) compared to the non-reoperation group (170 umol/L, range 49–614). There was no statistical difference ($p = 0.11$) between the pre-operative HbA1c levels in the reoperation group (mean 83 mmol/

Table 1
Foot surgery required prior to a trans-metatarsal amputation.

Operation	Ipsilateral forefoot (preoperatively)	Contralateral lower limb (preoperatively)	Contralateral lower limb (postoperatively)
First ray amputation	7	0	0
Other ray amputations	6	0	1
Toe amputations	15	3	3
Drainage of abscess	2	0	2
Ulcer debridement	3	1	1
Transmetatarsal amputation	–	4	0
Below knee amputation	–	1	1

Table 3
The indications and timing of the reoperations required post trans-metatarsal amputation.

Indication	Reoperation	Time from Index Surgery	Pre-operative arterial revascularisation	Further reoperation
Infected and necrotic stump	Wound debridement & tendo Achilles lengthening	2.3 years	Yes	Below knee amputation (2.8 years from TMA)
Infected and necrotic stump	Below knee amputation	4.4 years	Yes	No
Dehisced and necrotic stump	Revision closure TMA	6 days	Yes	No
Dehisced and necrotic stump	Below knee amputation	2.1 months	Yes	No

mol, range 71–102) compared to the non-reoperation group (mean 71 mmol/mol, range 44–107).

There were no early perioperative (< 30 days) deaths. Two patients died during their inpatient admission, at 73 and 78 days post-operatively. The cause of the deaths was multi-organ failure in one and an acute gastrointestinal bleed in the other. The mean length of stay for the 39 discharged patients was 38 days (range 8–102).

A further nine patients died in the community (mean 3.7 years, range 1.2–8.3). None of the re-operated patients died. Therefore, in total eleven patients died during the study period, with a four-year survival rate following a TMA is 69% (25/36).

There were 22 patients surviving, with a healed TMA stump, 11 having died and three with major amputations. Of these twenty-two 64% (14/22) walked without a gait aid and were fully mobile; 32% (7/22) were fully mobile with a walking cane and 4% (1/22) mobilised in a wheelchair.

4. Discussion

This study documents TMA in patients with diabetes mellitus. We consider that TMA is effective for limb salvage, with low reoperation and major amputation rates.

Patients with a diabetic foot disease are best managed with a team approach [11]. Our diabetic foot care service complies with the Diabetic Foot NICE guidelines (NG19) [4,12]. This model aims to improve patient care by providing timely lower limb revascularization, physiological optimization, management of co-morbidities, biomechanical offloading, nutritional assessment, and treatment of infection.

The amputation level on whether a well healed long-term amputation stump could be achieved was determined. This depended on a number of factors, including the ulcer's location, the condition of the soft tissues, the vascular supply and the extent of the soft tissue and bony infection. To achieve primary closure in the presence of previous surgery, it is often necessary to maintain as much skin as possible, and then fashion the flaps according to that skin which is available. Such an approach allows preservation of the foot and an amputation covered with plantar skin. This is important, as patients who undergo a minor amputation are more likely to return to living independently (93% v 61%) and walking (70% v 19%) when compared to patients undergoing a major amputation [13]. The metabolic cost of walking also increases the more proximal the amputation [14].

In this series there was an 11% reoperation rate, with an 8% major amputation rate. In other series of TMAs in patients with diabetes mellitus the reoperation rate varies from 9.5% to 63%, and major amputation rates also vary with reported figures as high as 21.6% and 35.3% [15–18]. A recent systematic review of the literature documented a 33.2% major amputation rate following TMA [7]. Similarly a review of the American College of Surgeons' database showed a reoperation rate of 26.4% in twelve-hundred TMAs [8]. These last two studies included patients without diabetes mellitus and with varying degrees of peripheral vascular disease.

Whilst the patients without peripheral vascular disease all achieved a long-term healed TMA, the patients with peripheral vascular disease requiring vascular reconstruction fared less well, with a 25% reoperation and a 19% major amputation rate. Previous studies have shown that peripheral vascular disease is a risk factor for failure following minor foot amputation [19]. This study confirms these findings for TMA, even when revascularization has been performed preoperatively.

The reported 30-day perioperative mortality rate for diabetic foot surgery ranges from 3 to 17%, none of our patients died in this period. Diabetic major amputations have a poor prognosis with a five-year survival rate of 29%, which is comparable to patients with malignant disease [20–22]. Mortality is lower after diabetic minor amputation than major amputation, with a five-year survival rate of 44 to 46% [13,15,22,23]. Risk factors for death identified are increased age, male gender, peripheral vascular disease and renal disease [24]. Our four-year survival rate is better, at 69%.

The soft tissues are important in this type of surgery. This impacts in two ways. Firstly, balancing the foot position. A tendo-Achilles release to reduce peak plantar 'forefoot' pressures was performed in 12% of patients [25]. The wounds were also primarily closed without drainage as this hastens and improves healing rates [26].

In the literature good results have been reported regarding mobility of patients following a TMA with 73% to 77% of cases ambulating independently [27,28]. In our surviving patients, who had not undergone a major amputation, 64% (14/22) walked without a gait aid and were fully mobile and 32% (7/22) were fully mobile with a stick. The patients wore a diabetic specification shoes with a customised total contact insole and toe filler, to reduce plantar pressures [29].

This study has several limitations, mainly the relatively small numbers and its retrospective design. Thirteen percent of the patients were not followed-up in our tertiary referral diabetic foot service, as long-term surveillance was more practical for the patients in their local hospital. No Patient Reported Outcome Measures were obtained.

5. Conclusion

This study documents the outcome for TMAs in patients with diabetes mellitus, and shows that it is an effective limb salvage option, with a low reoperation and major amputation rates. The outcome is less favourable in patients with peripheral vascular disease requiring preoperative peripheral vascular reconstruction. Although the major amputation rate in this group was significantly higher than those patients without peripheral vascular disease ($P < 0.05$), it was still only 19%. Good four year survival rates were achieved. A well healed TMA stump gives a durable, functional result, allowing independent walking in the majority of patients.

Conflict of interest

The authors have nothing to disclose.

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