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Results of the modified Pirogoff amputation with cannulated screws for diabetic foot infection

Abdul Aziz Mohd Nather[1], MBBS, FRCSEd, *Jun-Cheong Kong*[1], MBBS, MRCSEd, *Muhammed Yaser Hasan*[1], *Ajay Purushothanam Nambiar*[1], MBBS, MRCSEd

INTRODUCTION Syme amputation has been shown to have value in patients with diabetic foot infections, but it has inherent drawbacks. A potential alternative is the modified Pirogoff amputation. Our objective was to evaluate the outcome of modified Pirogoff amputation using internal fixation with 6.5-mm cannulated screws in the management of diabetic foot.

METHODS This is a prospective study of 13 patients admitted from January 2012 to June 2015. Inclusion criteria were infection limited to the forefoot, presence of a palpable posterior tibial pulse and an ankle-brachial index of more than 0.7. Internal fixation of the calcaneum to the tibial was performed using two 6.5-mm cannulated screws under image intensifier control.

RESULTS In ten cases, the wounds were healed at three weeks. Osseous union was observed in ten cases; the time taken for its occurrence was 2–5 months. Removal of screws was performed in five cases. Five cases developed technical complications of screw tract infection, with two cases having distal screw migration. Good results, defined as cases not requiring a below-knee amputation for two years postoperatively, were obtained in 10 (77%) cases. At the three-year follow-up, three additional cases required proximal amputation, leaving 7 (54%) cases with good outcomes.

CONCLUSION Our prospective study showed that with careful selection of patients, good postoperative results can be obtained. There is a definite role for modified Pirogoff amputation in the management of diabetic foot problems.

Keywords: amputation, cannulated screw, diabetic foot infection, modified Pirogoff amputation

INTRODUCTION

Syme amputation has been shown to have value in patients with diabetic foot infections compared to transtibial amputations,[1] with a variable success rate of 50%–88% in wound healing.[2,3] Furthermore, diabetic patients with a positive posterior arterial circulation can also attain a functional level of ambulation with the Syme amputation.[4] However, the Syme amputation still has disadvantages, including instability of the calcaneal flap, leading to poor adherence to the raw tibial surface; devascularisation from the dissection of the calcaneum from the underlying flap; and significant limb length discrepancy of about 4–5 cm, which can make walking difficult.[3-6]

Pirogoff described an amputation of the foot at the level of the malleolus that included partial preservation of the calcaneum, unlike the Syme amputation. In Pirogoff amputation, the calcaneum is cut at an angle of 90° and fused to the raw tibial surface (Fig. 1a). In our modification, the distal calcaneum is excised in order to avoid using a bigger hindfoot flap and for better centralisation of the heel pad. A 60° oblique osteotomy is performed over the remaining calcaneum, which is then fused to raw tibia surface (Fig. 1b).[6] The benefits of an amputation at the level of the malleolus over the Syme amputation include: reduction in limb length discrepancy, which minimises energy loss when ambulating; a stable tibiocalcaneal stump by achieving osseous union, and allowing a prosthesis to be worn with less friction due to preservation of the medial and lateral malleoli, leading to an earlier return to function.[6-8]

We have previously described the modified Pirogoff amputation using cannulated screws in a cross configuration, with good outcomes after the initial follow-up period of ten months.[6] The objective of this study was to evaluate the long-term outcomes of our modified Pirogoff amputation cohort at one, two and three years.

METHODS

This is a prospective study of 13 cases that underwent a modified Pirogoff amputation from January 2012 to June 2015. Inclusion criteria for the operation included infections limited to the forefoot, presence of a palpable posterior tibial pulse and an ankle-brachial index (ABI) of more than 0.7.[9] Determination of the zone of infection requires clinical experience and a thorough clinical assessment. Signs of infection, such as cellulitis and swelling, should be limited to the metatarsals. Clinical examination is assisted by radiography and magnetic resonance imaging to ensure clear flap margins.

Parameters studied included demographic data (age, gender and ethnicity), duration of diabetes mellitus, glycated haemoglobin level and the presenting diabetic foot problem. Clinical parameters recorded included the presence of a palpable dorsalis pedis and posterior tibial pulse, pulp capillary refill time, ABI and Semmes-Weinstein monofilament test (SWMT) score.

[1]University Orthopaedics, Hand and Reconstructive Microsurgery Cluster, National University Health System, Singapore

Correspondence: A/Prof Abdul Aziz Mohd Nather, Senior Consultant, University Orthopaedics, Hand and Reconstructive Microsurgery Cluster, National University Health System, 1E Kent Ridge Road, NUHS Tower Block Level 11, Singapore 119228. Aziz_nather@nuhs.edu.sg

Table I. Patient demographics of the cannulated screw group (n = 13).

No.	Age (yr)	Gender	Ethnicity	Type of DM	Duration of DM (yr)	HbA1c (%)	Type of diabetic foot problem; location
1	52	Female	Malay	2	14	8.2	Abscess; right forefoot
2	49	Male	Malay	2	1	7.1	Severe infection; left forefoot
3	67	Female	Chinese	2	7	8.4	Wet gangrene; right forefoot
4	54	Female	Malay	2	10	9.4	Osteomyelitis; right fourth toe
5	47	Female	Indian	2	17	13.6	Wet gangrene; right first toe
6	50	Female	Indian	2	1	6.6	Wet gangrene; left fourth and fifth toes
7	63	Male	Chinese	2	10	8.4	Wet gangrene; left big toe
8	60	Male	Indian	2	5	10	Wet gangrene; right fifth toe
9	56	Male	Chinese	2	7	6.3	Wet gangrene; right forefoot
10	44	Male	Indian	2	5	14	Infection; first-ray amputation
11	58	Male	Malay	2	11	8.6	Osteomyelitis; left second and third metatarsals
12	46	Female	Chinese	2	15	8.5	Osteomyelitis; right fifth metatarsal
13	64	Male	Indian	2	30	9.2	Osteomyelitis; left forefoot

DM: diabetes mellitus; HbA1c: glycated haemoglobin

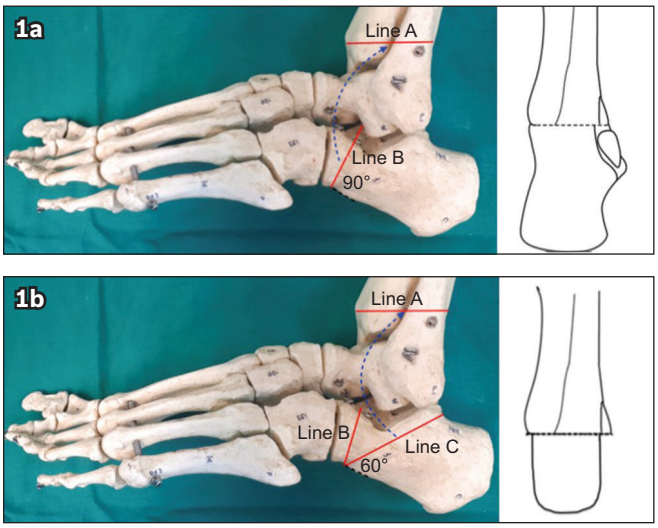

Fig. 1 Photographs show (a) original Pirogoff 90° calcaneal osteotomy (Line B) with fusion to the tibia cut (Line A); and (b) modified Pirogoff osteotomy with distal calcaneal cut (Line B) and a 60° oblique cut (Line C). After removal of the wedge, the oblique osteotomised calcaneal surface (Line B) is fused to the raw tibia (Line A), resulting in a smaller stump compared to the original technique.

Fig. 2 (a) Radiographs and (b) clinical photo show tibio-calcaneal fusion and a healed modified Pirogoff stump.

Haematological parameters evaluated included total white blood cell (WBC) count, C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and haemoglobin (Hb), albumin and creatinine levels. Time of wound healing and time taken for osseous union to occur were studied. Complications of the modified Pirogoff amputation were documented, and subsequent surgery required was described.

All patients were started on intravenous co-amoxiclav after tissue culture was taken during the operation. They were subsequently administered the antibiotic of choice based on the antibiotic sensitivity of the intraoperative cultures taken. All 13 cases were internally fixed with two 6.5-mm cannulated screws inserted from the calcaneum into the talus (Fig. 2). To achieve good fixation, the screw must engage the outer cortex of the tibia to reduce the incidence of screw migration and subsequent cut-out. A patient is defined to have a good outcome if a below-knee amputation (BKA) is not performed. The outcomes were assessed at one year, two years and three years postoperatively.

RESULTS

The age of our cohort ranged from 46 to 67 years (average 54.6 years). Seven patients were male and six were female. There were four Chinese, four Malay and five Indian patients. All cases were admitted due to diabetic foot infections, ranging from abscesses to osteomyelitis, that were confined to the forefoot (Table I).

All cases had palpable posterior tibial pulses and an ABI of more than 0.7. Pulp capillary refill time was less than two seconds in all patients. Nine patients had an SWMT score of < 8 (loss of protective sensation). This is further illustrated in Table II.

The results of the initial investigations on admission are detailed in Table III. All cases had elevated markers of infection (WBC, CRP and ESR). Hb was < 10 g/dL in four patients. Using albumin as a marker for nutritional status, we found that only three patients had adequate nutrition. Elevated creatinine levels were seen in four cases. Two patients (Cases 1 and 12) were already on haemodialysis.

Wounds were healed at three weeks in ten patients (Table IV). There was delayed healing in two cases. One case

Table II. Clinical vascular examination.

No.	Dorsalis pedis pulse	Posterior tibial pulse	Capillary refill time (s)	ABI	SWMT (out of 10)
1	Present	Present	< 2	1.20	7
2	Absent	Present	< 2	1.03	6
3	Present	Present	< 2	0.80	7
4	Present	Present	< 2	1.26	7
5	Present	Present	< 2	1.20	6
6	Present	Present	< 2	1.23	5
7	Absent	Present	< 2	2.01	8
8	Present	Present	< 2	1.15	2
9	Present	Present	< 2	1.40	0
10	Present	Present	< 2	1.22	1
11	Present	Present	< 2	1.20	8
12	Absent	Present	< 2	0.80	8
13	Present	Present	< 2	1.20	10

ABI: ankle-brachial index; SWMT: Semme-Weinstein monofilament test

Table III. Initial investigations on admission.

No.	WBC ($\times 10^9$/L)	CRP (mg/L)	ESR (mm/hr)	Hb (g/dL)	Albumin (g/L)	Cr (µmol/L)
1	28.97	266	81	11.8	33	810
2	17.48	296	69	12.0	31	73
3	9.55	25	27	11.8	38	45
4	25.01	260	90	11.1	32	50
5	24.31	391	106	11.8	30	46
6	10.00	75	70	9.7	33	84
7	18.30	253	79	11.7	31	134
8	21.00	169	70	13.6	30	95
9	9.70	153	68	9.5	40	133
10	16.70	370	117	9.6	38	83
11	11.90	52	49	9.0	31	71
12	30.00	403	70	10.2	28	644
13	8.06	22	37	13.1	35	79

Cr: creatinine; CRP: C-reactive protein; ESR: erythrocyte sedimentation rate; Hb: haemoglobin; WBC: white blood cell

Table IV. Outcome and long-term follow-up.

No.	Wound healing at 3 wk	Wound healing at 6 wk	Duration to osseous union	Postoperative complication	Surgery required	Outcome at			Ambulation status
						1 yr	2 yr	3 yr	
1	Healed	–	4 mth	Infection of stump at 32 mth	BKA	Good	Good	Fail	–
2	Healed	–	4 mth	Infection of stump at 26 mth	BKA	Good	Good	Fail	–
3	Healed	–	5 mth	Screw tract infection and migration at 2.5 mth	Removal of screws	Good	Good	Good	Ambulate on prosthesis
4	Healed	–	4 mth	Screw tract infection at 19 mth	Removal of screws	Good	Good	Good	Ambulate on prosthesis
5	Healed	–	2 mth	Screw tract infection at 32 mth	BKA	Good	Good	Fail	–
6	Healed	–	4 mth	Screw tract infection and migration at 29 mth	Removal of screws	Good	Good	Good	Ambulate on prosthesis
7	NA	NA	NA	Infected stump at 5 days	BKA	Fail	Fail	Fail	–
8	Delayed healing	Infected	NA	Infected stump at 6 wk	BKA	Fail	Fail	Fail	–
9	Healed	–	4 mth	None	None	Good	Good	Good	Ambulate on prosthesis
10	Healed	–	4 mth	None	None	Good	Good	Good	Ambulate on prosthesis
11	Healed	–	2 mth	Ulceration from screw heads, screw tract infection at 4 mth	Removal of screws	Good	Good	Good	Ambulate on prosthesis
12	Healed	–	2 mth	Stump infection at 3 mth	BKA	Fail	Fail	Fail	–
13	Delayed healing	Healed	NA	Screw tract infection at 1 mth	Curettage of tracts, removal of screws and staples fixation	Good	Good	Good	Ambulate on prosthesis

BKA: below-knee amputation; NA: not applicable

developed a deep wound infection on the fifth postoperative day and required a BKA. Osseous union between the distal tibial surface and calcaneum stump occurred in ten cases. Union occurred at two months for three cases, five months for one case and four months for six cases. Six cases developed technical complications of screw tract infection, with two cases having distal screw migration in addition to the infection. The screws were removed, the tracts curetted and the bony surfaces re-osteotomised. One patient (Case 13) had fixation of the distal tibia and calcaneum stump with surgical staples (size 18, Smith and Nephew, Memphis, TN, USA) for fixation, as osseous union had not yet occurred at six months postoperatively; in the other four cases, there was osseous union.

Good results (i.e. not requiring a below-knee amputation) were seen in 10 (77%) out of the 13 cases at one year. At two years, good results continued to be seen in all ten cases. At three

years, an additional three cases required a BKA, leaving good results in only 7 (54%) cases.

DISCUSSION

In 1854, Russian surgeon Nikolai Ivanovich Pirogoff first described the surgical technique for an amputation that was subsequently named after him.[10] His initial technique involved amputation of the foot at the level of the malleolus, with preservation of the calcaneum and a posterior skin flap. Calcaneal osteotomy perpendicular to the calcaneal axis was then performed, and the flap was folded upward and forward to create a weight-bearing stump. Stabilisation of the bony interface was originally achieved using an external cast. The lack of suitable options for tibiocalcaneal osteosynthesis partially contributed to its relatively limited early use.[10]

Recently, the modified Pirogoff amputation has started to regain popularity with internal fixation techniques for a variety of indications. In 1995, Rijken described successful use of a modified Pirogoff amputation with the calcaneum cut parallel to the posterior talocalcaneal facet (approximately 50°) in six patients with severe traumatic foot injuries, with a good outcome in all cases.[11] In 2003, Taniguchi et al reported a case series of modified Pirogoff amputations for 11 patients (for 12 ankles) for a variety of indications (including osteomyelitis, metastatic tumour and traumatic cases). He obtained good results in patients without peripheral vascular disease, with 73% having a good outcome.[5] Langeveld et al and den Bakker et al reported similarly successful results for infective/ischaemic necrosis and trauma, respectively, in their case reports.[12,13] In a subsequent paper in 2011, Langeveld et al recommended a modified 60° calcaneal cut to improve the weight-bearing axis of the stump.[7] Most recently in 2014, Nather published a case series with six patients describing the surgical technique of the modified Pirogoff amputation with cannulated screws with good results in all patients at ten months of follow-up.[6]

We performed the modified Pirogoff amputation for diabetic foot infections with strict inclusion criteria of infections limited to the forefoot, presence of a palpable posterior tibial pulse and an ABI of more than 0.7. With such carefully selected patients, a good outcome was seen in ten out of 13 cases at the one- and two-year follow-up. This outcome is superior to that of the Syme amputation. Frykberg et al, in a study of 26 cases of the Syme amputation in 2007, reported that good outcomes were seen in 12 (46.2%) cases. However, ten out of the 26 cases subsequently required BKA, at an average of 27.7 weeks postoperatively. They also reported three mortalities in their series.[14] On the other hand, Pinzur et al performed a retrospective study of 97 patients with diabetic foot infections who underwent Syme amputation, with a minimum of two years' follow-up. They observed good outcomes in 80 (82.5%) patients, but there was a mortality of 30 (30.9%) out of 97 patients at an average of 57.1 months following surgery.[2] In our cohort, at the three-year follow-up, there were no mortalities and good results were still obtained in seven out of 13 cases.

However, we did noted a high incidence of technical complications with a two-screw technique. Five cases developed screw tract infection, with two cases having distal screw migration in addition to the infection. The senior author proposes that in the future, cannulated screws be used in conjunction with surgical staples (size 18, Smith and Nephew, Memphis, TN, USA) for internal fixation. He further recommends that the cannulated screws be removed at six months, following successful osseous union, to reduce the problem of pin tract infections and distal screw migration.

The limitations of our study are its small sample size and a relatively short follow-up. Furthermore, this was a single series study that did not have a control arm.

In conclusion, our prospective study showed that with careful patient selection, good results can be obtained with the modified Pirogoff amputation for diabetic foot infections. At the one- and two-year follow-up, we had ten cases with good outcomes; at the three-year follow-up, we had seven cases with good outcomes. There is a role for the modified Pirogoff amputation in the management of diabetic foot problems. Our modified Pirogoff amputation had a 54% overall success rate at three years.

REFERENCES

1. Finkler ES, Marchwiany DA, Schiff AP, Pinzur MS. Long-term outcomes following Syme's amputation. Foot Ankle Int 2017; 38:732-5.
2. Pinzur MS, Stuck RM, Sage R, Hunt N, Rabinovich Z. Syme ankle disarticulation in patients with diabetes. J Bone Joint Surg Am 2003; 85-A:1667-72.
3. Jany RS, Burkus JK. Long-term follow up of Syme amputations for peripheral vascular disease associated with diabetes mellitus. Foot Ankle 1988; 9:107-10.
4. Laughlin RT, Chambers RB. Syme amputation in patients with severe diabetes mellitus. Foot Ankle 1993; 14:65-70.
5. Taniguchi A, Tanaka Y, Kadono K, Inada Y, Takakura Y. Pirogoff ankle disarticulation as an option for ankle disarticulation. Clin Orthop Relat Res 2003; (414):322-8.
6. Nather A, Wong KL, Lim AS, Zhaowen Ng D, Hey HW. The modified Pirogoff's amputation in treating diabetic foot infections: surgical technique and case series. Diabet Foot Ankle 2014; 5.
7. Langeveld AR, Meuffels DE, Oostenbroek RJ, Hoedt MT. The Pirogoff amputation for necrosis of the forefoot: surgical technique. J Bone Joint Surg Am 2011; 93 Suppl 1:21-9.
8. Nather A, Wong KL. Distal amputations for the diabetic foot. Diabet Foot Ankle 2013; 4.
9. American Diabetes Association. Peripheral arterial disease in people with diabetes. Diabetes Care 2003; 26:3333-41.
10. Pirogoff NI. Resection of bones and joints and amputations and disarticulations of joints. 1864. Clin Orthop Relat Res 1991; (266):3-11.
11. Rijken AM, Raaymakers EL. The modified Pirogoff amputation for traumatic partial foot amputations. Eur J Surg 1995; 161:237-40.
12. Langeveld AR, Oostenbroek RJ, Wijffels MP, Hoedt MT. The Pirogoff amputation for necrosis of the forefoot: a case report. J Bone Joint Surg Am 2010; 92:968-72.
13. den Bakker FM, Holtslag HR, van den Brand JG. Pirogoff amputation for foot trauma: an unusual amputation: a case report. J Bone Joint Surg Am 2010; 92:2462-5.
14. Frykberg RG RG, Abraham S, Tierney E, Hall J. Syme amputation for limb salvage: early experience with 26 cases. J Foot Ankle Surg 2007; 46:93-100.