Common late complications of longitudinal forefoot amputations in neuropathic foot treatment

Objective: To describe and quantify the complications arising in consecutive neuropathic patients undergoing partial longitudinal amputations of the foot.
Method: A retrospective study was conducted with data collected from the medical records of patients monitored at the Insensitive Foot Clinic of the Foot and Ankle Group of our institution who underwent partial amputation of foot rays from 2000 to 2016.
Results: A total of 28 patients met the inclusion criteria, with a total of 31 amputated/partially amputated feet. Of these, 18 (58.1%) feet were amputated/partially amputated due to diabetes, seven (22.6%) due to leprosy, two (6.5%) due to alcoholic neuropathy, two (6.5%) secondary to traumatic peripheral nerve injury, and two (6.5%) due to other causes. Fifth ray amputation was the most frequent type (n=12). The cause of amputation was the presence of an infected ulcer in 93.6% of the samples. At a mean follow-up time of 60 months, 13 (41.9%) feet required new amputations—five (38.5%) transtibial, five (38.5%) transmetatarsal, two (15.4%) of the toes, and one (7.7%) at Chopart's joint. Patients with diabetes had a 50.0% reamputation rate. Patients who initially underwent amputation of the fifth ray had a 58.3% reamputation rate.
Conclusion: Partial longitudinal amputation of the foot in neuropathic patients exhibited a high reoperation rate, especially in patients with diabetes or in patients with initial amputation of the peripheral rays.
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amputation • complications • debridement • diabetes • diabetic foot ulcers • forefoot • foot rays • leprosy • neuropathic • peripheral neuropathy • toes • trauma • wound • wound healing

Major advances in amputation surgical techniques and prostheses-making have been achieved in the last few decades, but there are still divergences regarding the evolution of lower limb amputations, especially in patients with peripheral neuropathy undergoing partial amputation of the foot.[1,2] Studies demonstrate variations in positive outcomes ranging from 50.0–93.3% in partial amputations of the diabetic neuropathic foot.[1–3]

When the level of the amputation is more proximal, changes in gait physiology are more severe, and there is greater energy expenditure and dependence on more sophisticated prostheses, causing greater impact on and limitations to the patient's quality of life.[4–6] Therefore, neuropathic feet that require resection should be carefully evaluated for the possibility of partial amputations as distal as possible.[7,8]

Several options are available for partial amputation of the foot, each with their own technical and functional peculiarities. The most common are amputations of the toes and transmetatarsal, and Lisfranc, Chopart, Boyd, Pirogoff and Syme amputations. The amputation may be classified according to the direction of the resection, namely, transverse or longitudinal, and the latter is further defined as partial or total resection of one to four rays.[9]

Svensson et al.[10] demonstrated that salvage of the limb can be achieved in up to two-thirds of patients undergoing partial longitudinal amputation of the rays or transmetatarsal amputation. However, another study demonstrated high rates of complications in these amputations in patients with neuropathic foot ulceration, thus limiting their indication.[11] These observations highlight the controversies regarding the evolution and indication of partial longitudinal amputations of insensitive feet.[12–15]

Randomised studies comparing complications of various amputation levels in this group of patients are not available. Thus, the indication for amputation is subjective and assessed on a case-by-case basis, according to the clinical characteristics of individuals, the magnitude of the ulcerated lesion and the extent of infection.

The objective of the present study is to describe and quantify complications in consecutive neuropathic patients undergoing partial longitudinal amputations of the foot.

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Methods

This is a retrospective study conducted with data collected from the medical records of patients treated at the Insensitive Foot Clinic of the Foot and Ankle Group of our institution who underwent partial longitudinal amputation of the foot rays in the period from 2000 to 2016. Data were collected from the medical descriptions found in patients' medical records.

Data on the following parameters were collected: age, sex, decreased sensitivity aetiology, comorbidities, type and cause of longitudinal partial amputation performed and new surgeries related to the first procedure. Type of partial longitudinal amputation performed refers to the amputated ray(s) and associated surgical procedures. New surgeries performed refers to the new surgical procedures performed during the postoperative follow-up that were necessary as a result of the amputation.

Inclusion and exclusion criteria

The following inclusion criteria were applied:

- Skeletal maturity (defined as closure of the physeal plate on radiography)
- Patients with decreased sensitivity in the distal lower limbs identified by lack of plantar sensitivity using the 10-g monofilament test and tuning fork according to the criteria of the American Diabetes Association[16]
- Patients submitted to partial longitudinal amputation of the foot rays, which was defined as amputation of one to four metatarsals up to the level of their proximal metaphyses[3,9]
- Presence of pedal and tibial pulses after physical examination
- Postoperative follow-up time >12 months

The following exclusion criterion was considered:

- Absence of sufficient data in the medical records for analysis of the evaluation parameters.

Patients were advised to remain non-weightbearing on the amputated limb until healing had occurred. Once healed, full weightbearing wearing a walking boot was permitted. The boot was discontinued after eight weeks and the patients were instructed to wear rigid soled shoes whenever walking.

Ethical approval and patient consent

The study was approved by the Ethical Commission For Analysis Of Research Projects (CAPPesq), Hospital das Clínicas HCFMUSP, Faculty of Medicine, University of São Paulo, Brazil. Patient consent was not required for this study because only retrospective records data, without intervention or questionnaire application, were analysed.

Results

In this study, 28 patients met the inclusion criteria, with a total of 31 feet amputated/partially amputated (three patients had both feet amputated). Of the patients, 19 were male and nine were female. The age ranged from 28–85 years with a mean of 59.5 years.

Evaluation of the associated diseases revealed that, in addition to the underlying pathology causing the peripheral neuropathy, 18 patients had at least one additional associated disease with a mean of 1.5 comorbidities per patient. Causes of foot insensitivity included: diabetes (n=18), leprosy (n=7), alcoholic

Fig 1. Frequency of insensitive foot causes

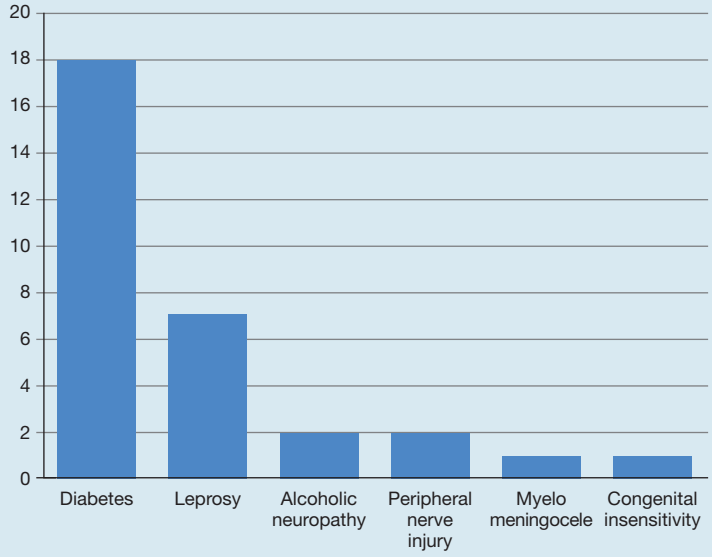
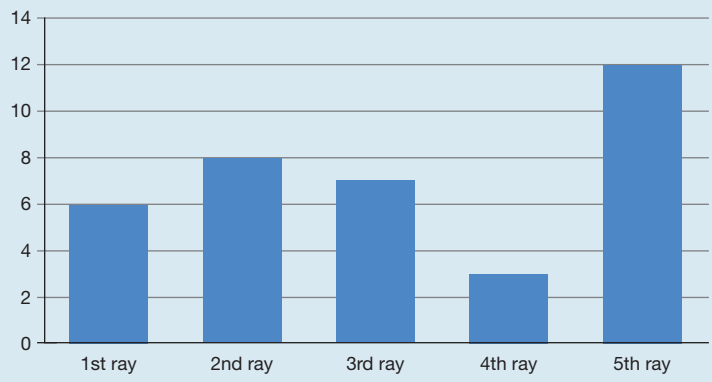


Table 1. Associated diseases found in the diabetes and leprosy subgroups

Diabetes		Leprosy	
Comorbidity, n	**Frequency, n**	**Comorbidity, n**	**Frequency, n**
Hypertension	10	Hypertension	2
Coronary artery disease	5	Diabetes	1
Smoking	4	Stroke	1
Dyslipidaemia	3	Liver transplant	1
Hypothyroidism	3		
Chronic kidney disease	2		
Obesity	2		
Osteonecrosis of the femoral head	1		
Liver transplant	1		
Lower limb venous insufficiency	1		
Diabetic retinopathy	1		
Total	35	Total	5
Mean	2.2	Mean	0.8

Fig 2. Ray amputated in the first surgery



neuropathy (n=2), secondary to traumatic peripheral nerve injury (n=2) and other causes (n=2) (Fig 1).

Analysis of the two most prevalent subgroups of the study—diabetes and leprosy—revealed that 50.0% of patients with decreased sensitivity of the foot due to leprosy had at least one additional associated comorbidity, with a mean of 0.8 diseases. Among patients with diabetes, 81.2% had at least one associated disease, with a mean of 2.2 comorbidities per patient (Table 1).

Of the 31 feet amputated/partially amputated, 28 (90.3%) feet were initially subjected to amputation of only one ray, and three (9.7%) feet had two or more rays amputated (second to fifth ray on one foot, and fourth and fifth ray on two feet), totalling 36 rays. Fifth ray amputation was the most frequent with 12 cases, and fourth ray amputation was the least frequent, with threecases (Fig 2).

Of the patients, four underwent resection arthroplasty of metatarsal heads, all performed simultaneously—in three patients combined with amputation of the second ray, and in one patient combined with amputation of the first ray.

The cause of partial longitudinal amputation in 29 (93.5%) operated feet was the presence of an infected ulcer. Only two (6.5%) feet were operated on because of uninfected ulcers.

Follow-up time ranged from 11–169 months, with a mean of 60 months. Of the patients, eight (28.6%) did not require any intervention after the initial amputation, 12 (42.8%) patients required additional amputation, and the remaining eight (28.6%) patients underwent additional surgical procedures other than amputation.

Among the patients, 12 underwent an additional amputation, with 13 additional amputations in total (one patient had both feet amputated). Additional amputations included: transtibial (n=5, 38.5%), transmetatarsal (n=5, 38.5%), toe amputations (n=2, 15.3%) and Chopart's joint (n=1, 7.7%). Of the 12 patients, diabetes was the cause of neuropathy in eight patients, so the rate of additional amputations in the diabetic group was 50.0%. Additional amputations were performed after a mean time of 32.9 months. The main cause was infection in 12 (92.3%) cases (Table 2).

Table 2. Amputations occurring as a complication of the amputated ray based on the insensitive foot aetiology and proximate cause of the amputation

Insensitive foot aetiology	Initial amputation	Cause of initial amputation	Secondary amputation	Cause of secondary amputation	Time elapsed between procedures, months
Diabetes	5th ray	Infected ulcer	Transtibial	Infection	5
Diabetes	5th ray	Infected ulcer	Transtibial	Infection	18
Diabetes	3rd ray	Uninfected ulcer	Transmetatarsal	Uninfected ulcer	71
Diabetes	2nd ray	Infected ulcer	Transmetatarsal	Infection	56
Diabetes	1st ray	Infected ulcer	Transmetatarsal	Infection	4
Diabetes	1st ray	Infected ulcer	Transmetatarsal	Infection	9
Diabetes	4th and 5th rays	Infected ulcer	Chopart	Infection	99
Diabetes	5th ray	Infected ulcer	Fourth toe	Infection	56
Diabetes	2nd ray	Infected ulcer	Third toe	Infection	2
Alcoholic neuropathy	5th ray	Infected ulcer	Transtibial	Infection	16
Congenital insensitivity	5th ray	Infected ulcer	Transtibial	Infection	49
Peripheral nerve injury (sciatic nerve)	5th ray	Infected ulcer	Transtibial	Infection	28
Peripheral nerve injury (congenital clubfoot sequela)	1st ray	Infected ulcer	Transmetatarsal	Infection	15

Table 3. Additional procedures occurring as a complication of the amputated ray based on insensitive foot aetiology

Insensitive foot aetiology	Initial amputation	Secondary amputation	Time elapsed between procedures (months)
Diabetes	2nd ray	Lavage and debridement	1
Diabetes	2nd ray	Medial sesamoidectomy + gastrocnemius stretching	6
Diabetes	3rd ray	Lavage and debridement	9
Leprosy	5th ray	Valgisation osteotomy of the calcaneus + percutaneous Weil 2/3/4	27
Leprosy	5th ray	Tenotomy + DuVries 2/3/4 + hallux interphalangeal arthrodesis	11
Leprosy	4th and 5th rays	Hoffman 1/2/3	28
Leprosy	3rd ray	Hoffman 2/4/5 + Mayo resection of the hallux + sesamoidectomy + hallux interphalangeal arthrodesis	25
Alcoholic neuropathy	5th ray	Akin osteotomy of the hallux proximal phalanx + DuVries of the 2nd toe	18

Of the eight patients who underwent additional surgical procedures other than amputation, two had infected wounds and underwent debridement and lavage of the affected site. The remaining six patients required surgeries for mechanical rebalancing of the foot (Table 3).

The reamputation rate according to the ray initially amputated was increased for the 5th ray, with seven (58.3%) additional amputations in 12 cases (Table 4).

Table 4. Rate of reamputations according to the ray initially amputated

Ray initially amputated	Total number, n	Reamputations, n (%)
1st ray	6	3 (50.0)
2nd ray	8	2 (25.0)
3rd ray	7	1 (14.3)
4th ray	3	1 (33.3)
5th ray	12	7 (58.3)

Discussion

Partial longitudinal amputation is a natural pathway in the surgical treatment of patients with severe infections in the forefoot because it attempts to preserve the osteoarticular structures as much as possible, in contrast to terminal amputations. In comparison to proximal leg amputations, longitudinal amputation requires less energy for walking, and as no prosthesis is needed, the patient is more likely to remain ambulatory after the surgery. This is especially important in patients with diabetes because of commonly associated cardiovascular disease.[4–6]

However, the present study demonstrated that 71.4% of the patients required at least one additional surgical procedure, of which 42.8% were additional amputations, and 28.6% were corrective surgeries, indicating that the initial type of surgery performed does not provide definitive results in neuropathic patients. These rates are similar to those described by Snyder et al.,[17] who reported 52.0% additional amputations in patients with diabetes or vascular pathology undergoing amputation of the forefoot, 64.0% of which were partial longitudinal amputations. Of these patients, 23.0% underwent additional amputations of the same forefoot within 10.9 months on average, whereas 29.0% underwent ipsilateral transtibial or transfemoral amputation within an average of 5.5 months.

Of our 12 patients who underwent an additional amputation, eight had diabetes, and of these all but one had an infected ulcer as the cause of the second amputation. Analysis of the second largest group from an aetiological point of view, namely, patients with leprosy, showed that none required additional amputation, suggesting the isolated role of diabetes in the high rate of complications observed in the study sample.

It is assumed that factors other than insensitivity may contribute to an increased rate of complications in patients with diabetes, such as autonomic neuropathy, microvascular injury and immunosuppression.[18] The increased rate of associated diseases (81.2% with 2.2 comorbidities per patient) in the group of patients with diabetes compared with the group of patients with leprosy (50.0% with 0.8 comorbidities per patient) may also have contributed to this difference.

This hypothesis is supported by the work of Izumi et al.,[12] who studied mortality rates in patients with diabetes undergoing amputation and who were followed for 10 years. In that study, increased mortality was noted for major amputations (defined as Syme, transtibial, transfemoral or hip disarticulation) in the 10 years of follow-up. However, this increased mortality occurred only in the first 10 months, with sepsis being the major cause of mortality. In addition, when separately assessing the association between mortality and comorbidities, a stronger association was observed in patients who were initially subjected to more distal amputations, such as amputations of the toes or rays.[12]

Suh et al.[19] compared the results of transmetatarsal and longitudinal forefoot amputation in 59 patients with diabetes. In patients in the longitudinal forefoot amputation group, the first ray was always preserved. The authors found no difference in the number of additional surgical procedures but patients in the longitudinal forefoot amputation group had a statistically significant better functional result, measured by the maximum achieved ambulatory function (on a scale of 0–5): bedbound (0); wheelchair bound (1); limited household (2); unlimited household (3); limited community (4); and unlimited community (5).[19] However, we were not able to reproduce these results in the present study.

We believe that the mechanical imbalance caused by resection of one or more rays of the forefoot was one of the causes of the high rate of additional surgeries. The long average time of 32.9 months elapsed between the first and second amputation suggests that the initial problem was solved, and the affected foot again became ulcerated and infected (Table 2). As all patients in the present study had palpable pulses in the affected foot, the formation of new ulcers was strongly related to the development of hyperpressure points created by the absence of one of the rays, the appearance of new deformities or some extrinsic factor. In the analysis of patients who underwent additional surgeries other than amputation, we found only two cases of lavage and debridement surgery, and the remaining surgeries were related to mechanical rebalancing of the amputated foot (Table 3).

In our patients, we observed an increased number of amputations of the 5th ray relative to the other rays. These patients also had a reamputation rate of 58.3%, which was the highest among the five rays (Table 4). Loss of the support from the head of the fifth metatarsal leads to a forefoot supination deformity, which subsequently causes hindfoot varus and consequently greater mechanical stress at the base of the amputated metatarsal. This lateral overload, which is characteristic of cavovarus feet,[20] is responsible for the appearance of new ulcers. An inverse mechanism may be responsible for the second highest rate of additional amputations resulting from the resection of the first ray (50.0%) with forefoot pronation followed by calcaneal valgus and medial overload.

Based on these findings, we believe that partial longitudinal amputations of the peripheral rays should be performed more sparingly, either by choosing more balanced terminal amputations or by correcting any hindfoot deformities, even small deformities.

Limitations

Limitations of the present study include the small sample size and the retrospective nature of the study as data from medical records were used. Thus, the study was subject to information bias.

Conclusion

Partial longitudinal amputation of the foot in neuropathic patients had a high rate of reoperations, including realignment surgery or additional amputation, especially in patients with neuropathy secondary to diabetes with initial amputation of the peripheral rays. **JWC**

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Reflective questions

- What are the reamputation rates after a partial longitudinal forefoot amputation in neuropathic foot ?
- Why are the recurrence rates high in patients with insensitive foot undergoing partial amputations?
- Why do patients with insensitivity due to diabetes have higher rates of reamputations and other complications compared to other subgroups (for example, leprosy)?
- What, if any, are the differences in reamputation rates when comparing different amputated rays?