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SPECIAL REPORT

Reports from the workshop on the Neurologically Impaired Foot: 5–9 June 2000, Green Pastures Hospital, Pokhara, Nepal

Assessment and examination of the neurologically impaired foot

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Introduction

Foot impairments continue to be an important 'issue' in leprosy hospitals and community based programmes. Many persons both on treatment and released from (drug) treatment have, and often continue to have, foot impairments. Much time and money is spent on foot care that could have been prevented by early detection and more effective care, including teaching patient self-care. For most people in leprosy endemic countries, mobility is essential for socio-economic stability. Few can afford the loss of earnings that would result from the

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necessity to rest an ulcerated foot. Many are forced to accept the dilemma that if the foot is not rested there may be deterioration, giving rise to further impairments.

In the management of the neurologically impaired foot (NIF), it is important to know, and practise effective management that will benefit all persons with NIF. The areas of knowledge to be stressed are essentially related to the absence of pain perception, which frequently means that the patient neglects trauma and allows complications to develop. It is also important to address areas where knowledge is lacking or incomplete, for further study or research.

An International workshop was conducted at Green Pastures Hospital, Pokhara, Nepal (5–9th June 2000) to review and discuss issues relevant to the NIF. Participants consisted of small but broad-based group of health professionals, with experience in problems associated with NIF. Experience was primarily in leprosy but the issues raised are transferable to NIF from any aetiology, e.g. diabetes, trauma or hereditary motor sensory neuropathy. Those attending included reconstructive and plastic surgeons, physiotherapists and podiatrists. There are many important aspects related to the NIF. Expertise and skills from different disciplines are required to care for the foot at risk. This document is an attempt to give an overview of the 'state of the art' aspects of the care of the NIF.

The aims of the workshop were four-fold:

1. To clarify terminology.
2. To discuss and summarize relevant issues relating to NIF.
3. To present management updates.
4. To indicate areas for further research.

This is not a 'how to' document. This report does not attempt to be a comprehensive guide to management of problems associated with NIF. People that have no previous experience in the care and management of NIF are advised to undergo an in-service training or follow a formal course.

The recommendations are by consensus agreement and may not be the specific views of all the individuals present.

Terminology

INTRODUCTION

The terminology and dimensions of the International Classification of Functioning and Disability (ICIDH-2) were adopted as a guide to the discussions in the workshop and the writing of this report.[20]

DISCUSSION

The terms neuropathic foot and Charcot foot were found to be confusing in their meaning and application. These terms were defined for this report, with the hope that in others adopting these terms, uniformity in terminology will facilitate communication and research. The term neurologically impaired foot (see below) was coined to draw together a number of historically used terms in an attempt to clarify this terminology. It is hoped this term will be

accepted to achieve uniformity of language and thereby facilitate communication, between researchers and workers in this field.

Definitions

a. Neurologically impaired foot (NIF)
A neurologically impaired foot, is a foot with any degree of impairment of motor, sensory and/or autonomic, function. In leprosy varying degrees of impairment of all three types of nerve fibre are common. The primary impairment is the direct result of the nerve damage and examples of these include paresis and paralysis, sensory impairments such as the inability to feel pain, hypersensitivity and/or dry skin. The term neurologically impaired lower limb (NILL) may be used depending on the context.

b. Neuropathic foot
We suggest that for this paper, the term 'neuropathic foot' should be reserved for the foot which has impairment secondary to nerve impairments (e.g. ulcers, deformity, bone disorganization) as a result of primary impairments or damage to nerves. In other words, the neuropathic foot is the foot that is neurologically impaired and has developed secondary impairments or damage.

c. Neuropathic bone disorganization (NBD)
The term 'Charcot' joint/foot should preferably not be used to describe the many impairments that may occur in neuropathic bones in people affected by leprosy.

Use of the eponym 'Charcot' and the term neurarthropathy should be avoided on the following grounds:

1. What Charcot described as a neuro-arthropathic joint was a grossly deformed, unstable, hydroarthrotic joint the severity of which is rarely seen in leprosy, unless grossly neglected.
2. The diagnosis 'Charcot joint' often carries with it (in leprosy, but especially in diabetic foot care), the connotation that the foot/condition is untreatable, that nothing worthwhile can be done to treat the problem.
3. All feet with destructive bone changes tend to be labelled as Charcot joints. However, many lesions on radiograph, at least initially, do not involve the joints but are isolated to bones, e.g. fractures.[21]
4. Charcot joint is a misnomer, as in neuropathies from any cause the initial lesion is usually seen in bones (stress fracture) and the joint is secondarily involved. The term Charcot foot may be more applicable to a grossly deformed foot as an end result of healed bones/disintegrated joints. It is suggested that the acronym NBD should be used: neuropathic bone disorganization (or deformity). This is relevant for various stages of neuropathic involvement from any aetiology.

NBD can be defined as: sign(s) and symptom(s) of skeletal disorganization in combination with primary neurological impairment(s).

NBD is a disorganization of bone that may impair function. It is usually the result of trauma, which, because of reduced pain perception, is often neglected, so that continued use prevents healing. Resultant inflammation causes osteopenia, weakening the bones leading

to fracture, further deformity and/or disintegration with continued use. The first signs are local heat and swelling. If an affected limb is adequately rested and protected the bone lesions will heal in the position in which they are immobilized.

d. Protective sensation
The foot (as tested on the plantar surface) has definite loss of protective *touch* sensation, when at 2 or more locations on the sole of the foot (excluding the heel) a 10 g filament is not felt, or if on any one site firm pressure with the ball point pen (or heaviest filament, thick red) is not felt.[13]

Following discussion, the word *touch* has been added to what normally is referred to as protective sensation only.

Some patients, especially in diabetes and leprosy, appear to have intact touch sensation but decreased pain modalities. These patients may be at greater risk of developing NBD. It needs to be recognized that nerves are infected early in leprosy and it should be accepted that every leprosy patient already has some degree of neurological deficit at diagnosis, even if not clinically detectable. All clinical tests of sensation will help us understand how much nerve function impairment is present, and enable us to chart improvement, or otherwise, but apparently negative clinical tests may not always indicate absence of neural deficit.

e. Preventative rehabilitative surgery (PRS)
The term preventative rehabilitative surgery (PRS) is defined as surgery that is aimed at the prevention and correction of primary and secondary impairments due to nerve function loss or due to the disease itself (loss of eyebrows, nose deformity etc.).

Pedal biomechanics

INTRODUCTION

The role of pedal biomechanics and the affect of abnormal gait on the NIF foot are poorly understood. However, this remains a key area, both in the understanding of ulcer development and in the development of appropriate orthoses and shoes in the treatment and prevention of ulcers.[3,9]

DISCUSSION

Due to common congenital and developmental factors up to 85% of people have feet which do not function according to the ideal kinematic pattern.[5] Such abnormalities do not cause gross aberrations in gait patterns but result in moderate repetitive stress. In the non-compromised foot, this may not present as a serious problem because the integrity of the foot is maintained by safety information relating to current conditions of the substratum. Sensory feedback (at sub-threshold level) will cause the body to compensate for factors that cause excessive stress of the foot. If the sensory modalities are lost, due to neurological changes, the body will be unable to respond to such stresses and tissue integrity will be compromised.

A key factor influencing the integrity of the forefoot is the action of the subtalar joint. If the subtalar joint is forced to pronate aphasically, to compensate for an extrinsic abnormality, the effects include destabilization of the talo-navicular joint leading to

incompetence of the first ray and the plantar fascia. A further effect can be that motion around the first MTPJ is impeded due to functional hallux limitus. The consequence for the foot thus compromised include an uneven distribution of force leading to foci of high pressure under the second or third metatarsal heads, and shearing stress under the first metatarsal head. Excessive stress beneath the proximal phalanx of the hallux may lead to ulceration.[1]

When the subtalar joint is supinated aphasically, the effects include excessive rigidity of the foot. An abnormal plantar flexion of the first ray and a compromised anterior talofibular ligament are common secondary effects. The consequences for the foot thus compromised include foci of pressure beneath the forth or fifth metatarsal heads and in some cases high pressure beneath the first metatarsal head. 'Ankle' sprains may lead to chronic instability of the foot. There are also common forefoot aberrations from the ideal (e.g. forefoot varus, forefoot equinus) which will compromise the integrity of the plantar soft tissues.

MANAGEMENT RECOMMENDATIONS

Any person presenting with an anaesthetic foot due to posterior tibial nerve impairment and or motor loss due to lateral popliteal nerve impairment should undergo a basic biomechanical examination of the foot. Ideally the foot should be examined:[4,6]

i) In a *non-weight bearing* position to assess alignment between forefoot and the rear foot. This is done with the subtalar joint in neutral position.
ii) *Weight bearing* in stance to assess whether there is an inverted or everted hind foot. These impairments will result in compensations more distal in the foot during stance and push-off resulting in increased pressures at specific sites.
iii) *During gait*,[2,3] (and unpublished data).

The outcome should be used to decide whether podiatric orthoses might be used to maximize foot function, and prevent skin breakdown or ulceration. Where the foot is compromised by ulceration, an orthosis may be indicated as a therapeutic option.[2]

Gait analysis after tibialis posterior transfer (TPT) surgery for foot-drop correction should be extended to ascertain the extent and timing of subtalar pronation. In normal gait tibialis posterior acts to restrain excessive pronation. Removal of this mechanism may cause the subtalar joint to pronate without restraint. Excessive subtalar pronation may compromise the integrity of the talo-navicular joint and the forefoot.

Where it is deemed that the foot is at risk, due to excessive pronation, an orthotic intervention may be used to compensate for the loss of the posterior tibial restraining mechanism.

AREAS FOR RESEARCH

- To what extent does the subtalar joint hyperpronate following TPT and does it have significant clinical effects?
- Establish the level of inter- and intra-observer reliability of subtalar joint alignment assessment.
- Assess the effect of foot orthoses on force/pressure related parameters.

- A longitudinal prospective study on the effects of foot biomechanics as a cause of ulceration.
- Assess the acceptance and compliance of the wearing of prescribed footwear.

Assessment and recording

INTRODUCTION

The need for standard registration and recording forms was identified. This form should include level of impairment and ulcer classification/grading.

DISCUSSION

Registration form

Modification of the form as developed by the Dutch Neuropathic Foot Society, designed primarily to be used in people with diabetics, is potentially useful in the management of feet of leprosy affected persons. Such a form will facilitate communication between projects and may be very useful for research purposes. In projects in which only leprosy affected persons are seen, the section on location-deformity could be simplified by leaving out the sections on pulsation's which refer to persons who may have foot ulcers due to diabetes or other causes. With such a form, it is possible to code location, presence and type of ulcer, and presence of foot deformity, which may be related to the site and aetiology of the ulcer.

Hot spots

There is evidence that 'hot spots' can be reliably assessed by experienced health workers.[16] There is also evidence that areas of increased temperature can be reliably identified by persons affected by leprosy (Faber and 't Velt, personal communication). A hot spot is an area of localized heat and swelling when compared with adjacent tissues. In the absence of pain, hot spots serve as a reliable warning that there is internal pathology for which the patient needs treatment. A hot spot should be considered to indicate a bone lesion until proved otherwise.

Nerve function status

This should be part of a foot status registration form. In most leprosy programmes there will usually be a separate nerve function status (VMT-ST) form which can be referred to/consulted for information regarding the sensory and motor status of the foot (see below).

Nerve function impairment

a. *Motor function.* There is as yet no test that has proven reliability for grading the strength of the intrinsic muscles of the foot (posterior tibial nerve). Srinivasan suggests three different tests for the intrinsic muscles of the foot.[19] Other tests have also been used, e.g. fanning of the toes and gripping a piece of paper between the first and second toe (adduction).

One test that seems promising, in the sense that its strength can possibly be reliably

graded on a three-point scale, is abduction of the great toe. Voluntary abduction of the great toe is often not possible but contraction of the muscles can be 'triggered'.

The person rests their lateral calf on the thigh (hip, knee flexed, with the foot not resting on the thigh). The person is then asked to abduct the great toe. This movement is guided/triggered by giving some resistance in the direction of the movement that is required. The muscle belly of abductor hallucis can be clearly palpated (often seen contracting) when the muscle is functioning.

Standard VMT of all muscles below the knee should be checked and recorded at diagnosis and regularly thereafter, as a routine method of documenting changes in neural function.[10,11,15]

b. *Sensation.* Loss of protective touch sensation is a risk factor (not a cause) for plantar ulceration. Several studies have shown that the ability to feel a 10 g filament corresponds with the threshold for protective (touch) sensation.[13,18]

Research indicates that fewer than 10 sites can possibly be used to evaluate and monitor sensation of the sole of the foot without compromising sensitivity/specificity of the test.[12] With implementation of 'site reduction' for this nerve, sites for sural nerve and lateral popliteal nerve could be included still reducing total assessment time.[7,17] It should be taken into account whether the study looks into site reduction and/or filament reduction for screening purposes (loss of protective sensation) or if the purpose is for evaluating and monitoring function in sensory status.[15]

c. *Vibration, pain and thermal sensory modality.* At the time of writing this report, the ILEP supported INFIR (ILEP Nerve Function and Immunology of Reaction cohort study) is underway. This is a multi-centre study in which different nerve function assessment techniques are being used and compared for their sensitivity in the diagnosis, and responsiveness in the monitoring of nerve function impairment (NFI). Vibration and thermal sense perception are included. This study will show if vibrometry, thermal testing and electroneurophysiological testing is of additional benefit in the diagnosis and monitoring of NFI. In the testing of diabetic patients it has been shown that altered vibrations sensitivity is an indicator of risk of ulceration. However, results need to be considered in light of age and other factors. Often it is better to do a few tests fully and correctly than many tests that are incomplete and often meaningless and time consuming.

MANAGEMENT RECOMMENDATIONS

In a standard foot screen, besides general information, e.g. birth date, residence, leprosy status, screening should include the items shown in Table 1. It is recommended that the foot risk classification as proposed by Birke is part of a foot registration form.[8]

The type of (recommended) footwear and justification for its use should also be an essential item on a foot registration form.

It is recommended, when feasible/practical, to include assessment of sensation of the dorsum of the foot (lateral popliteal nerve) and lateral border of the foot (sural nerve) to evaluate and monitor sensory function of these nerves.

Table 1. Items for standard foot screen

	Basic	Detail
1. Nerve function status of the foot	VMT (3 grades)	Extrinsics; 6 grades Intrinsics (see text)
	ST (ballpoint pen/single filament)	More filaments and/or locations other tests Other nerves (e.g. sural, lateral popliteal)
2. Footwear	Y	Y
3. Marking impairments on foot diagram (cracks, claw toes, absorption etc.)	Y	Y
4. Risk categories of foot	N	Y
5. Localization of ulcer	Descriptive	Coded/graded as on the form/ulcer measured
6. Structural deformities	Y	Y
7. Biomechanical examination (functional impairments)	N	Y

Y = yes, N = no.

AREAS FOR RESEARCH

- It remains to be studied if, and to what extent, ulcer classification and deformity categories on a modified Dutch form are useful in the management of feet in leprosy endemic countries. Do categories need to be modified?
- Studies are needed, and other instruments may have to be developed, to be able to assess the impact of foot impairments on the degree of limitation of normal activities.
- Studies are needed that look into the reliability of the various tests that are/can be used for assessing the motor function of the posterior tibial nerve.
- Further research is needed to determine which filament to use (or what other tests should be performed regularly) and preferred sites, to detect early sensory loss. What are the sensitivity, specificity (validity) and reliability of each test, in the diagnosis of early nerve function loss, versus loss of protective sensation?
- Studies are needed to determine the relevance of sensory testing for sural nerve and lateral popliteal nerves.
- It needs to be determined to what extent proprioception/joint position awareness could be reliably assessed. Which joint(s)/movement(s) should be tested?
- It remains to be studied if, and to what extent, other sensory modalities (pain, temperature) can be affected in the presence of normal touch sensation.
- To what extent thresholds for definite diminished touch sensation (early loss) and loss of definitive touch sensation (protective) differ between the different parts of the foot (e.g. toes versus heel).

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References

Pedal biomechanics

[1] Birke JA, Franks BD, Foto JG. First ray joint limitation, pressure, and ulceration of the first metatarsal head in diabetes mellitus. *Foot Ankle Int*, 1995; **16:** 277–284.
[2] Cross H, Sane S, Dey A, Kulkarni VN. The efficacy of podiatric orthoses as an adjunct to the treatment of plantar ulceration in leprosy. *Lepr Rev*, 1995; **6:**: 144–157.
[3] Cross H. Plantar ulceration in patients with leprosy. *J Wound Care*, 1996; **5:** 406–411.
[4] Cross H. A Biomechanical examination of the foot. Unpublished document. Available from the author.
[5] Inman VT, Ralston HJ, Todd F. *Human walking*. Williams and Wilkins, Baltimore, 1981.
[6] Root ML, Orien WP, Weed JH. *Biomechanical examination of the foot*. Clinical Biomechanics Corporation, Los Angeles, 1971.

Assessment and recording

[7] Anderson AM, Reed NK, Brakel WH van *et al*. Optimisation of a monofilament test for sensibility for use in a field programme of prevention of impairment. *Int J Lepr*, 1998; **66:** 69A.
[8] Birke JA, Patout CA, Foto JG. Factors associated with ulceration and amputation in the neuropathic foot. *J Orthop Sports Phys Ther*, 2000; **30:** 91–97.
[9] Brand PW. *Insensitive feet: a practical handbook on foot problems in leprosy*. The Leprosy Mission, London, 1998.
[10] Brandsma JW. Monitoring motor function in leprosy patients. *Lepr Rev*, 2000; **71:** 258–267.
[11] Brandsma JW, Brakel van WH. Protocol for motor nerve function assessment in leprosy and related research questions. *Ind J Lepr*, submitted.
[12] Birke JA, Brandsma JW, Schreuders TAR, Piefer A. Sensory testing with monofilaments in Hansen's disease and normal subjects. *Int J Lepr*, 2000; **68:** 291–298.
[13] Birke JA, Sims DS. Plantar sensory threshold in the insensitive foot. *Lepr Rev*, 1988; **57:** 261–267.
[14] Brakel WH, Khawas JB, Gurung KS *et al*. Intra- and interreliability in sensory testing in Leprosy. *Ind J Lepr*, 1996; **64:** 287–298.
[15] Deursen van RWMJ, Simoneau GG. Foot and ankle sensory neuropathy, proprioception, and postural stability. *J Orthop Sports Phys Ther*, 1999; **29:** 718–726.
[16] Hoeksma AF, Faber WR. Assessment of skin temperature by palpation in leprosy patients: inter-observer reliability and correlation with infrared thermometry. *Int J Lepr*, 2000; **68:** 65–66.
[17] McGill M, Molyneaux L *et al*. Possible sources of discrepancies in the use of the Semmes–Weinstein monofilament: impact on prevalence of insensate foot and workload. *Diabetes Care*, 1999; **22:** 598–602.
[18] Mueller MJ. Identifying patients with diabetes mellitus who are at risk for lower extremity complications: use of Semmes–Weinstein monofilaments. *Phys Ther*, 1996; **76:** 68–71.
[19] Srinivasan H. *Prevention of disabilities in patients with leprosy: a practical guide*. WHO Geneva, 1993.
[20] World Health Organization. *The international classification of functioning and disability, the ICDIH-2* (beta draft for field trials). WHO, Geneva, 1998.
[21] Warren AG. Radiographic examination of the feet. *Lepr Rev*, 1973; **44:** 131–138.