The clinical and immunological features of leprosy

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Leprosy is a granulomatous disease affecting the skin and nerves caused by *Mycobacterium leprae*. It continues to be a significant public health problem. Multidrug therapy (MDT) cures the infection, but immunological reactions may occur and neuropathy may lead to disability and deformity. It is important that the manifestations of the condition are recognized as early as possible so that early nerve damage can be identified and treated rapidly.

Keywords: leprosy; immunology; reactions; treatment

Introduction

Leprosy is a chronic granulomatous infection principally affecting the skin and peripheral nerves caused by the obligate intracellular organism *Mycobacterium leprae* [1].

The disease causes skin lesions and neuropathy. Complications secondary to the neuropathy can result in deformity and disability. Leprosy remains a stigmatizing disease. However, multidrug therapy (MDT), which cures the infection, has led to the understanding that leprosy can be effectively treated before disability develops [2]. Since 1985, 14 million individuals have received MDT [3].

Epidemiology

In all, 407,791 new cases of leprosy were diagnosed and reported to World Health Organization (WHO) in 2004 [3].

It continues to be an important health problem worldwide, but the highest new case detection rates are in India, Brazil, Democratic Republic of Congo, Tanzania, Nepal, Mozambique, Madagascar, Angola and the Central African Republic. The disease burden in India represents 64% of all new cases worldwide [3].
Transmission of \( M. \ leprae \) is from untreated lepromatous patients. The organism can persist outside the body under various environmental conditions [4]. It is hypothesized that in endemic areas most people have encountered it and have mounted an immune response against it [5].

\textbf{Mycobacterium leprae}

\textit{Mycobacterium leprae} is an obligate intracellular pathogen, and attempts to culture it in axenic medium have failed since it was first identified by Armauer Hansen in 1874 [6]. It can be obtained following prolonged growth in the mouse footpad and the nine-banded armadillo, which is a natural reservoir of the organism.

In 2001 the genome of \( M. \ leprae \) was sequenced. The organism appears to have undergone extensive reductive evolution with considerable downsizing of its genome compared with \textit{Mycobacterium tuberculosis}. Almost half of the genome is occupied by pseudogenes [7].

A greater understanding of the genome of \( M. \ leprae \) will provide an insight into mechanisms by which the organism avoids immune surveillance, which metabolic pathways it requires the host cells it infects to provide and allow the development of techniques to culture the organism.

\textbf{Classification of leprosy}

Classification of the patients is important to determine the appropriate treatment. Classification also enables the clinician to predict those at risk of complications and to give as accurate a prognosis as possible.

There are two systems used to classify leprosy patients. The Ridley–Jopling system [8] uses clinical and histopathological features and the bacteriological index. The different categories correlate with the activity of the host immune response (Fig. 1). It is useful as the borderline states are unstable immunologically and can be complicated by reactions.

A simple classification based on the number of skin lesions is used in the field when slit-skin smears are unavailable. It is a quick and useful tool that can be employed by a wide variety of health care providers (Table 1).

\textbf{Genetics of susceptibility}

There have been studies demonstrating higher concordance rates for leprosy among monozygotic compared with dizygotic twins [10]. Various genes and regions in the human genome have been linked to or associated with
susceptibility to leprosy per se or with a particular type of leprosy. These are not all reproducible in different populations, which may be unsurprising.

Mira et al. [11] have identified that certain alleles in the PARK2 and PACRG region on chromosome 6 are associated with susceptibility to leprosy in Vietnamese and Brazilian cohorts. PARK2 is expressed by both Schwann cells and macrophages. It is an ubiquination E3 ligase and is involved in the delivery of polyubiquinated proteins to the proteosome complex involved in protein degradation [12].

An Indian cohort studied demonstrated that homozygotes for the different alleles of the vitamin D receptor (VDR) gene were associated with tuberculoid or lepromatous disease [13]. Upregulation of the VDR gene on macrophages is associated with increased intracellular killing of M. tuberculosis [14].

Polymorphisms of the tumour necrosis factor (TNF)-α promoter region were shown to be associated with increased susceptibility to lepromatous leprosy [15], whereas in a cohort from southern Brazil the same allele
was protective against leprosy per se [16]. A study of Malawians did not find any association of this TNF promoter with leprosy [17].

Brazilian and Indian groups have demonstrated that polymorphisms of the interleukin (IL)-10 promoter are associated with resistance to leprosy [18, 19].

The differing and sometimes conflicting results of genetic studies may be attributed to differences in study design and sample size. It is also possible that different populations have distinct genetic susceptibilities.

**Immunology of leprosy**

*Mycobacterium leprae* probably enters the body via the nose and then spreads to the skin and nerves via the circulation.

The immunological response mounted by the host dictates the clinical phenotype that develops. People with leprosy show a spectrum of clinical types. Experimentally, the polar forms of the disease are said to conform to an immunological paradigm. Tuberculoid disease is the result of high cell-mediated immunity with a largely Th1 type immune response. Lepromatous leprosy however is characterized by low cell-mediated immunity with a humoral Th2 response [20].

Intracellular pathogens are recognized by the innate immune system.

The highly conserved Toll-like receptors (TLRs) on the surface of monocytes and macrophages recognize mycobacterial lipoproteins [21]. In the case of *M. leprae*, this appears to takes place mainly through the TLR2/1 heterodimer and leads to monocyte differentiation into macrophages and dendritic cells [22, 23]. The latter presents antigen and causes the activation of naive T cells by IL-12 secretion [24]. The IL-12βR2 portion of the IL-12 receptor is expressed more on Th1 lymphocytes preferentially shifting the immune response further towards a Th1 response.

TLR stimulation also activates the nuclear transcription factor NF-κB, which modulates the transcription of many immune response genes [25].

In tuberculoid disease, interferon (IFN)-γ, IL-2 and lymphotoxin-α are secreted in lesions and these result in intense phagocytic activity [26]. Macrophages under the influence of cytokines, particularly TNF together with lymphocytes, form granulomas [27]. CD4+ cells are found mainly within the granuloma and CD8+ cells in the mantle area surrounding it [28]. T cells in tuberculoid granulomas produce the antimicrobial protein granulysin [29].

Lepromatous disease is characterized by poor granuloma formation. mRNA production is predominantly for cytokines IL-4, IL-5 and IL-10 [30]. IL-4 has been shown to downregulate TLR2 on monocytes [21], and IL-10 will suppress production of IL-12 [31]. This is associated with a preponderance of CD8+ lymphocytes in lepromatous lesions.
The borderline part of the spectrum is immunologically dynamic, and movement between the two polar forms occurs. These shifts in the immunological response underlie the reactions that are a feature of the borderline states.

The balance and complex interaction of cytokines, chemokines, adhesion molecules, their receptors and the cells of the innate and adaptive immune system all play a role in ultimately determining the particular immune response of the individual to the organism.

**Immunology of leprosy reactions**

Type 1 reactions are delayed hypersensitivity reactions that occur in borderline disease (see later) [32]. *Mycobacterium leprae* antigens have been demonstrated in the nerves and skin of patients experiencing type 1 reactions. The antigens were localized to Schwann cells and macrophages [33].

Schwann cells have been shown to express TLR2 [34]. *Mycobacterium leprae* infection may lead to the expression of major histocompatibility complex (MHC) II on the surface of the cells, and this may give rise to antigen presentation, which triggers CD4 lymphocyte killing of the cell [29]. Immunohistochemistry studies show greater TNF staining in the skin and nerves during type 1 reaction compared with non-reactional controls [35]. There is a shift towards increased Th1 immunity, and lesions in reaction express the pro-inflammatory cytokines IFN-γ, IL-12 and the oxygen free radical producer inducible nitric oxide synthase [36]. The expression of mRNA of various chemokines including IL-8, monocyte chemoattractant protein 1 and regulated upon activation, normal T-cell expressed, and secreted (RANTES) is higher in the skin during reaction [37].

Interestingly, the levels of circulating cytokines do not reflect the local changes taking place in the skin during type 1 reaction. Treatment of the reaction causes clinical improvement, but changes in the inflammatory cytokines lags behind by some considerable time and in some may remain unchanged [38]. A similar seemingly paradoxical finding has also been demonstrated in tuberculous meningitis [39].

Type 2 or erythema nodosum leprosum (ENL) reactions occur in borderline lepromatous and lepromatous disease. High levels of circulating TNF have been demonstrated in the plasma of some individuals with type 2 reactions [40]. *In vitro* peripheral blood mononuclear cells from individuals with ENL secrete increased amounts of TNF following stimulation [41].

The use of thalidomide and pentoxifylline have been shown to reduce the levels of TNF *in vivo* in subjects whose ENL has shown clinical
improvement [42, 43]. However, a recent study by Haslett et al. [44] has demonstrated low TNF levels in individuals with milder ENL reactions, and paradoxically these levels increased during therapy with thalidomide. This effect has been noted in toxic epidermal necrolysis as well as other diseases [45]. The authors postulate that type 2 reactions with systemic involvement may produce the high circulating TNF levels previously seen and that this may not be the case in milder forms of the condition.

Thalidomide has costimulatory effects on lymphocytes as well as inhibiting macrophage TNF production, which may explain the increase in TNF during treatment in this setting.

Clinical features

The clinical features of the disease are determined by the host response to *M. leprae*.

Patients commonly present with skin lesions, numbness or weakness caused by peripheral nerve involvement or more rarely a painless burn or ulcer in an anaesthetic hand or foot. A leprosy reaction may be a presenting feature of the disease [46]. Nerve pain misdiagnosed as joint pain may result in a person being labelled as having arthritis.

In non-endemic areas, the diagnosis is frequently delayed because leprosy is not considered and patients may present to a wide range of specialists [47].

Tuberculoid disease is characterized by a single or very few lesions. These are macules or plaques with well-defined edges (Fig. 2). In dark skin, hypopigmentation predominates over the erythema or copper colour more usually seen in lighter skin. The lesions are frequently scaly, dry, hairless and anaesthetic. The anaesthesia is due to destruction of dermal nerve fibres. This form carries a good prognosis and lesions will often self-heal. Damage to peripheral nerves is limited.

Lepromatous disease may be present for many years before diagnosis, and the early skin changes are widely and symmetrically distributed macules. They are poorly defined with mild hypopigmentation and erythema. Flesh coloured or occasionally erythematous papules and nodules may be present. Peripheral oedema of the legs and ankles due to increased stasis occurs. The skin if left untreated thickens due to dermal infiltration giving rise to the ‘leonine facies’ (Fig. 3). Hair is lost from affected skin notably from eyelashes and eyebrows (madarosis).

Lepromatous involvement of the nasal mucosa gives rise to the sensation of nasal stuffiness and epistaxis. Infiltration of nasal structures may lead to a saddle deformity due to septal perforation and destruction of the anteriornasal spine.
Fig. 2 Well-defined hypopigmented tuberculoid lesion.

Fig. 3 The leonine facies of lepromatous disease.
Laryngeal involvement, although extremely rare nowadays, was life threatening before effective chemotherapy was available.

Lepromatous disease may be complicated by type 2 reactions in as much as 50% of individuals [48].

The involvement of other systems seen in lepromatous disease is due to bacillary infiltration of structures and organs. Testicular atrophy results from infiltration and also the acute orchitis of type 2 reactions. Elderly men with hypogonadism are more likely to have osteoporosis [49].

Borderline leprosy shows skin lesions intermediate between the two polar forms. The morphology of lesions may be macular, papulo-nodular, plaques, annular or a geographic appearance.

Nerve involvement

Nerve involvement in leprosy affects sensory, motor and autonomic function of peripheral nerves. Sensory loss is the earliest and most frequently affected modality but a predominantly motor loss can also occur.

In tuberculoid disease, granulomatous inflammation of peripheral nerves causes palpable enlargement, which may or may not be painful and causes sensory and motor loss in the distribution of the affected nerve. There is enlargement and infiltration of fascicles, which may show caseous necrosis [32]. Enlarged nerves can also be damaged because of entrapment within fibro-osseous tunnels. Reactions cause further nerve damage.

In lepromatous disease, the destruction of dermal nerves leads to a glove and stocking neuropathy; peripheral nerve involvement tends to occur late. There is bacterial proliferation within the Schwann cells, which leads to foamy degeneration of the cells which lose the ability to regenerate [32].

Leprosy most commonly affects the posterior tibial nerve causing anaesthesia on the soles of the feet followed by the ulnar, median, lateral popliteal and facial nerves [50]. Other nerves affected by the disease include the greater auricular, radial and the radial cutaneous nerves.

The presence of a skin lesion overlying a major nerve trunk is associated with a significant increase risk of impairment in that nerve [51].

Pure neuritic leprosy (PNL) affects peripheral nerve trunks in the absence of cutaneous signs. PNL may be any disease type.

Silent neuropathy is an insidious deterioration in sensory or motor function without signs or symptoms of inflammation [52].

The effect of the disease on nerves leads to disability and deformity. This occurs through impaired sensation leading to trauma and secondary infection (including osteomyelitis), which causes tissue damage. Loss
of motor function produces disability, and the increased dryness of the involved skin makes it more vulnerable to damage.

It is of the utmost importance that a complete motor and sensory neurological assessment is carried out to ensure that nerve function is not deteriorating especially as this can be asymptomatic.

Eye involvement

Leprosy is the cause of blindness in 3.2% of those affected by the disease [53]. Blindness can have devastating consequences for those who probably already have sensory loss of the hands and feet. The disease compromises the eye through nerve damage and by direct bacillary invasion of the skin or eye itself. These factors can occur in combination and result in the four main causes of visual loss: lagophthalmos (an inability to close the eyes normally), corneal ulceration, acute or chronic iridocyclitis and secondary cataract.

Lagophthalmos usually results in damage to the zygomatic and temporal branches of the facial (VIIth) nerve. It gives rise to exposure keratopathy. Reduced corneal and conjunctival sensation due to involvement of the ophthalmic branch of the trigeminal (Vth) nerve predisposes to corneal ulceration.

Type 1 (reversal) reactions

Type 1 reactions occur in borderline disease, and 30% of individuals with borderline leprosy are at risk of type 1 reaction [54]. A type 1 reaction is characterized by acute inflammation in skin lesions (Fig. 4) or nerves or both. The skin lesions become acutely inflamed and oedematous and may ulcerate. Oedema of the hands, feet and face can also be a feature of a reaction, but systemic symptoms are unusual.

Acute neuritis leads to nerve function impairment, which if not treated rapidly and adequately leads to permanent loss of nerve function causing peripheral sensory and motor neuropathy. Type 1 reactions are frequently recurrent and this can lead to further nerve damage [54]. Type 1 reactions can occur at any time but are frequently seen after starting MDT or during the puerperium.

Type 2 (ENL) reactions

Type 2 reactions affect ~50% of lepromatous and 10% of borderline lepromatous cases [48]. The greater the infiltration of the skin and the
higher the bacterial index (BI), the greater risk of developing type 2 reactions [55]. Type 2 reactions are a systemic disorder affecting many organ systems. The onset is acute, but it may pass into a chronic phase and it can be recurrent.

ENL produces fever and in the skin painful and tender red papules or nodules (Fig. 5), which occur in crops often affecting the face and extensor surfaces of the limbs. The lesions may be superficial or deep causing a panniculitis. Bullous ENL has been described [56] and lesions may ulcerate. Subcutaneous tissue involvement may lead to tethering and fixation to joints causing loss of function. ENL reactions may also produce uveitis, neuritis, arthritis, dactylitis, lymphadenitis and orchitis. The recurrent inflammation of organs can lead to blindness and sterility.

Pregnancy

A systematic literature review of the interaction between leprosy and pregnancy highlighted an association between the development of type 1 reactions and neuritis and parturition when cell-mediated immunity returns to the prepregnant level [57].
ENL reactions occur throughout pregnancy and lactation, and the onset of nerve damage is earlier than in those who are not pregnant.

There is little evidence that pregnancy promotes infection or relapse of the disease.

**Leprosy and human immunodeficiency virus**

The fear that human immunodeficiency virus (HIV) infection would increase susceptibility to *M. leprae* does not appear to have been realized, nor does it alter the clinical features of leprosy. Leprosy in HIV-positive individuals does not appear to be shifted to the lepromatous pole, nor does it develop quicker. The response to MDT is also unaffected.

*Mycobacterium leprae* does not appear to accelerate the decline in immune function in HIV disease, which tuberculosis seems to do.

Reactions in individuals with co-infection may occur with increased frequency, but there are conflicting data concerning the response to treatment in this group.

Latent leprosy infections may be unmasked as immune reconstitution disease following the initiation of antiretroviral therapy. The improvement in immune function restores the host ability to form granulomas.

A recent detailed review highlighted that all reported cases have been borderline cases complicated by type 1 reaction [58].
The contrast between the interaction of *M. leprae* and HIV and that of *M. tuberculosis* and HIV is striking. Research addressing the interactions of these mycobacteria with HIV may provide important insights into all three diseases.

**Diagnosis**

The diagnosis of leprosy remains a clinical one. The presence of skin lesions with definite sensory loss or thickened peripheral nerves or the demonstration of *M. leprae* on slit-skin smears or on histology of tissue (skin or nerve) is diagnostic (Table 2).

**Differential diagnosis**

The manifestations of leprosy are protean and the differential diagnosis is therefore wide. The consideration of leprosy as a diagnosis and adherence to the clinical criteria for diagnosing leprosy will facilitate a correct diagnosis.

Vitiligo is depigmented rather than hypopigmented. Pityriasis alba can be difficult to distinguish from early disease. Pityriasis versicolor and dermatophyte infection may both cause diagnostic difficulty.

In some parts of the world, leprosy is a commoner cause of granulomatous skin lesions than sarcoid, granuloma multiforme, cutaneous tuberculosis and granuloma annulare.

Nerve thickening is a feature of hereditary sensory motor neuropathy type III and Refsum’s disease. Amyloid which itself can complicate leprosy can cause nerve thickening.

**Diagnosis in non-endemic areas**

Leprosy can be a difficult diagnosis to remember especially in non-endemic regions or where the prevalence is very low. In non-endemic regions, it is important for physicians to consider the diagnosis in

<table>
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<th>Table 2 Diagnostic features of leprosy</th>
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<tr>
<td>Skin lesions with definite sensory loss*</td>
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<tr>
<td>Thickened peripheral nerves</td>
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<tr>
<td>Acid-fast bacilli on skin smears or tissue biopsy</td>
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*Skin lesions at the borderline lepromatus leprosy/lepromatous leprosy end of the spectrum may not have demonstrable sensory loss.*
migrants from areas where the disease is endemic. Individuals have been reported to present with leprosy many years after leaving an endemic area [59].

An affected person may present to one of a number of specialities such as dermatology, neurology, internal medicine, orthopaedics, rheumatology, ophthalmology and urology [47, 60].

In the United Kingdom where the diagnosis of leprosy is often delayed, 68% of individuals have at least WHO grade 1 disability at the time of diagnosis [47] compared with 51.5% of multibacillary (MB) patients in north India [8].

**Investigations**

The diagnosis is usually made clinically but is supported by slit-skin smears and skin biopsy [46]. *Mycobacterium leprae* cannot be cultured *in vitro*.

The BI is a logarithmic scale (1–6) quantifying the density of *M. leprae* on a slit-skin smear and is used to assess response to treatment.

Rarely nerve biopsy may be needed to confirm the diagnosis and should be performed on a purely sensory nerve (e.g. radial cutaneous or sural nerve).

**Treatment—chemotherapy**

All patients should receive a multidrug combination, and the first-line agents are rifampicin, clofazimine and dapsone. MDT was introduced in 1982 following the emergence of resistance to dapsone-only regimes [61]. Since then, there has been debate over how long MB MDT should be taken for.

The WHO reduced the recommended treatment period for MB disease from 24 to 12 months [8], but this remains under review and many authors advocate 24 months for patients with a BI >4 at diagnosis until further evidence becomes available.

The MB group is very heterogeneous potentially including individuals with all forms of borderline disease and those with polar lepromatous disease. This may lead to over-treatment as more than 60% of MB patients (those with more than five skin lesions) have a negative BI (see later) and so only require two-drug MDT rather than three-drug MDT [51] (Table 3).

Relapse rates following MDT vary from 0 to 2.5% in paucibacillary disease. In MB disease, the published rates of relapse are between 0 and 7.7% [62]. The study with the highest relapse rate in MB patients demonstrated that 90% of relapses occurred in patients with a BI >4.
Patients should be advised of the common side effects of these drugs to avoid unnecessary anxiety and inappropriate cessation of therapy.

Rifampicin causes an orange-red discoloration of body fluids for 48 h after ingestion.

Clofazimine causes red-brown skin and conjunctival discolouration and darkening of involved skin, which can range from red to purple or black [63]. This unpleasant effect may make the drug unacceptable to some patients particularly if cosmetically sensitive sites are affected. The discolouration fades slowly on withdrawal of the drug. Clofazimine also causes an ichthyosis on the shins and forearms [63]. Clofazimine crystals may be deposited in tissues—and in the bowel can cause an enteropathy [64].

Dapsone causes haemolysis, which may be severe especially in individuals with glucose-6-phosphate dehydrogenase deficiency [65] and is associated with a severe hypersensitivity syndrome.

In individuals unable to take clofazimine or dapsone, other agents such as minocycline, clarithromycin, ofloxacin or pefloxacin are active against *M. leprae* [2] and can all be used as second-line agents. Minocycline causes slate-grey skin discolouration in some individuals [66].

Nerve damage can occur before, during or after MDT, and so it is essential that monitoring for this is carried out. Patients with MB disease, nerve impairment before MDT or both should be followed for 2 years [67].

**Table 3** WHO-recommended MDT regimes

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<tr>
<th>Type of leprosy</th>
<th>Drug treatment</th>
<th>Duration of treatment (months)</th>
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<tbody>
<tr>
<td>Paucibacillary</td>
<td>Rifampicin 600 mg</td>
<td>Dapsone 100 mg</td>
</tr>
<tr>
<td>Multibacillary</td>
<td>Rifampicin 600 mg, clofazimine 300 mg</td>
<td>Clofazimine 50 mg, dapsone 100 mg</td>
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</table>

MDT, multidrug therapy; WHO, World Health Organization.

**Treatment—management of reactions**

Leprosy reactions should be managed by a specialist. Reactions may be a presenting feature of the disease or occur during MDT or even after it has been completed.

The treatment of type 1 reactions is aimed at controlling the acute inflammation, easing pain and reversing eye and nerve damage. MDT should be continued during a reaction. Moderately inflamed skin plaques or neuritis are treated with oral corticosteroids. Different regimes have been employed; we suggest prednisolone 40 mg daily decreased by 5 mg every 2–4 weeks after demonstration of improvement. Despite prolonged
oral prednisolone, only 60% will show improvement in nerve function [68]. Skin lesions readily respond.

A recent randomized study of different steroid regimes suggested that duration rather than dose of treatment with prednisolone may be more important in controlling type 1 reactions [69]. Prednisolone 30 mg tapered slowly to zero over 20 weeks was superior to prednisolone 60 mg tapered over 12 weeks.

A 4-month course of prophylactic steroids has been tried in the prevention of type 1 reactions, and they were effective early on, but at 12-month follow-up the protective effect had been lost [70]. The management of silent neuropathy is similar to that of type 1 reactions.

The majority of ENL reactions require immunosuppression. The more severe ones require high doses of corticosteroids, usually starting with prednisolone 60 mg daily [67]. The recurrent nature of the condition means that steroid-induced side effects may become a significant problem. Thalidomide 300–400 mg daily has a dramatic effect in controlling ENL and preventing recurrences. Its use is limited because of teratogenicity (phocomelia) and possible neurotoxicity (although this does not appear to be a problem in leprosy patients). Clofazimine and pentoxifylline have both been used in ENL, but they are less effective than prednisolone or thalidomide [43, 71]. Colchicine and chloroquine have also been used with limited effect.

It remains to be seen whether TNF blockade with biological agents will have a role to play in the management of ENL but tuberculosis and cost may limit their use especially in endemic areas.

**Education**

Education of the affected individual and their family plays a crucial role in the management of leprosy. It is important to carefully explain the nature of the disease and that it is curable. It should be emphasized that deformity and disability are not inevitable. Individuals can be reassured that MDT renders lepromatous patients non-infectious within 72 h. A completely normal social life should be encouraged. It should be made clear that transmission of the disease is not hereditary and does not occur through sexual contact. The majority of people diagnosed with leprosy do not have a history of contact with another affected individual.

**Prevention of disability**

The early detection of deterioration in nerve function and the rapid introduction of steroid therapy are essential to minimize nerve damage and thus preventing disability.
Secondary damage to neuropathic areas is must be prevented. It is important to make the patient aware of activities that put these areas at risk and to give advice about orthotics and protective footwear. Individuals should be taught self-examination and to recognize any areas of trauma. It has been demonstrated that training people in self-care can reduce the requirement for admission to hospital with plantar ulceration [72].

Damaged neuropathic areas should be protected from further damage by resting the area and any secondary infection treated with appropriate antibiotics. Surgical intervention may be required to debride necrotic tissue and allow drainage of any collection.

Reconstructive surgery may have a role in trying to improve function if contractures occur, if there is foot drop or when there is eye involvement.

**Socioeconomic rehabilitation**

General community-based projects involving family and the wider community have been shown to help best with rehabilitation [73]. The development of these has been assisted by International Association for Integration, Dignity and Economic Advancement (IDEA).

**Eradication of leprosy**

The eradication of leprosy has not been achieved despite over 20 years of MDT. Lepromatous patients are infectious and the organism can remain viable outside a human host for many months. The mean incubation time of lepromatous disease is 10 years. These factors make it difficult to completely eradicate the disease.

It must be remembered that dealing with leprosy is not simply a matter of treating the infection of *M. leprae* with MDT. It also requires the prompt management of reactions that cause further damage which may occur even after a course of MDT has been finished and the organism is dead. Dealing with the complications of neuropathy and minimizing the impact of the disease on physical, psychological and social well-being are vital.

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Conflicts of interest

None.

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