Leprosy

for medical practitioners and paramedical workers

S. J. Yawalkar

Eighth revised edition, 2009

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Leprosy

for medical practitioners and paramedical workers

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Eighth revised edition, 2009
First published in 1986

Foreword

When the first edition of this book was published in 1987, leprosy was still a public health problem in 122 countries. The global number of patients was estimated at between 10 million and 12 million. In the past, leprosy was – and in some places continues to be – a stigmatized disease, and those affected were isolated in leprosaria or segregated villages for fear of infection. As a consequence of prejudice and lack of knowledge, leprosy patients were ashamed of their condition and tried to hide the disease – their only way to escape social repercussions. The consequent lack of treatment or delayed treatment resulted in an increased risk of disabilities, which in turn strengthened and perpetuated the stigma of the disease – a vicious circle.

The development of multidrug therapy (MDT) changed the face of leprosy dramatically. The treatment consists of three drugs, two of which were developed in the research laboratories of Novartis. MDT made it possible to cure patients, interrupt the transmission of leprosy, and thus – most important for the social perception of the illness – prevent disabilities. Even patients with the severest form of the disease show visible clinical improvement within weeks of starting treatment. In 1981, the World Health Organization (WHO) recommended MDT as the standard treatment against leprosy.

Over the past 20 years more than 14 million people have been cured of leprosy – the global burden of this disease has been reduced by 95%. In 2008, worldwide prevalence was estimated at fewer than 250,000 cases. Leprosy has been eliminated on the national level in all but three countries – Brazil, Timor Leste, and Nepal. This is one of the greatest and most underrated success stories in global public health. This admirable result became feasible through the work of countless health workers, committed governments, and dedicated non-governmental leprosy organization all over the world – enabled by pharmaceutical innovation.

Novartis and its Foundation for Sustainable Development have contributed extensively to the successes achieved. Since 1986, the Novartis Foundation has been committed to the fight against leprosy. And since 2000, Novartis – the only supplier of quality MDT – has donated MDT free of charge to leprosy patients worldwide. This donation helped cure approximately 5 million patients by 2009. The Novartis Foundation pioneered innovative and unconventional approaches such as social marketing, supports WHO in the distribution of the donation, and fosters dialogue among the stakeholders engaged in leprosy control.

Foreword

The downside of this dramatic reduction in leprosy is the decreasing knowledge about the disease worldwide. This is especially undesirable in developing countries where there are still undetected pockets of infected patients. Due to the small number of leprosy patients, many medical practitioners do not come across the disease anymore, they do not receive medical training on leprosy, and they lack basic knowledge on how to cure and manage it. To better disseminate knowledge on leprosy, the Novartis Foundation decided to publish this eighth edition of **Leprosy – for medical practitioners and paramedical workers**. With this book we would like to contribute to sustaining knowledge about leprosy and to ensuring high-quality diagnosis and quality patient care in all endemic countries.

Though there is still further work to be done, I am certain that we are in the "last mile" in the fight against this biblical disease. I would like to thank Dr. S. K. Nordeen and Dr. Atul Shah for reviewing and updating this book according to the latest state-of-the-art knowledge. I am confident that this eighth edition will be the last one – and that leprosy will be eradicated once and for all.

Daniel Vasella, MD
Chairman and CEO Novartis AG
Basle, 2009

Preface

Leprosy, one of the major public health problems in some developing countries, is well known for the strong stigma associated with it. The treatment of leprosy sufferers throughout history is one of the darker examples of man's inhumanity to man.

The principle of reducing the load of infection in society, to break the chain of infection, is the cornerstone of leprosy control work today. It implies early diagnosis and early adequate drug treatment to make the patient non-infectious. In 1982, the World Health Organization recommended multidrug therapy (MDT) regimens for the treatment of patients with leprosy. MDT is now recognized as the key to the control and elimination of the disease. Over 14 million people have been cured of leprosy with MDT and leprosy has been eliminated as a public health problem from 122 countries. Yet, every year about 250,000 new cases are detected worldwide as the coverage of leprosy services widens. Finding and treating these previously undetected cases is essential to stop the spread of the infection and ultimately eliminate the disease.

A considerable number of patients first consult medical practitioners. The cooperation of medical practitioners is therefore essential for the control and elimination of leprosy. The purpose of this monograph is to provide basic information on leprosy and its treatment. It is hoped that the monograph will be of practical value, especially to medical practitioners, medical students and paramedical workers, and that it will stimulate their interest in the subject and help elimination of leprosy.

Basle, Switzerland
S. J. Yawalkar

The plight of a leprosy sufferer in the Middle Ages. All his wife could say was: "Praise God and die!"

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"Leprosy work is not merely medical relief;
it is transforming frustration of life into joy of dedication,
personal ambition into selfless service..."

Mahatma Gandhi

Mahatma Gandhi nursing Parchure Shastri, the great Sanskrit scholar,
who suffered from leprosy

1 Introduction

Leprosy, caused by Mycobacterium Leprae, is an age-old disease which until recently affected millions of people in Asia, Africa and Latin America. Although it was once widely prevalent in Europe, it is practically non-existent today. Leprosy is feared mainly because of the deformities it produces and the consequent social stigma and discrimination. The disease primarily affects the skin and peripheral nerves. It can also affect the upper respiratory tract, eyes, liver, testes, muscles and bones.

The word signifying leprosy in different languages is: Aussatz (German), Lèpre (French), Lepra (Spanish), Prokaza (Russian), Mafung (Chinese), Raibyo (Japanese), Judham (Arabic) and Kushtha (Hindi). In many languages leprosy is called "the great disease".

Today leprosy is no more a dreaded disease as it is curable through multidrug therapy (MDT) and the disease is capable of being eliminated as a public health problem through organized case detection and treatment. A major continuing need in leprosy is that of the physical and socio-economic rehabilitation of patients, particularly those patients cured in the past. During the past fifteen years, over 14 million leprosy patients have been cured through MDT. Through early detection and prompt treatment, over 3 million people are estimated to have been prevented from getting deformities.

The best way to prevent the spread of leprosy and eliminate it as a public health problem is to ensure diagnosis and treatment for all patients with MDT. WHO has defined "elimination" as a prevalence rate of less than 1 case per 10,000 inhabitants. Leprosy has been eliminated as a public health problem from all but three countries in the world.

Fig. 1 By using MDT for all patients with leprosy there is now a real possibility that children will grow up in a world from which leprosy has been eliminated as a public health problem

2 Historical Background

Leprosy is one of the oldest diseases of mankind which most probably originated in India. The laws of Manu, stated in the Vedas written as early as 1400 BC in India, included instructions for the prevention of leprosy. Leprosy was referred to as "Kushtha" in ancient India. The first authentic description of leprosy and its treatment with chaulmoogra oil is given in "Sushruta Samhita", a treatise written in India in 600 BC by an eminent surgeon "Sushruta". According to Vagbhata (600 AD), the name "Kushtha" was derived from "Kushnati", which means "eating away" in Sanskrit.

In China, leprosy was first recorded in the Nei Jing, one of the earliest Chinese medical classics (400 BC), in which its clinical features were described under the name "Da Feng"[4]. The earliest Japanese references to leprosy are also from the 4th century BC[5].

The first indisputable evidence of bone involvement due to leprosy was found in an Egyptian mummy of the 2nd century BC. Pompey's soldiers returning from Egypt (62 BC) are said to have brought leprosy to Italy.

The disease was probably brought to the Mediterranean region by the soldiers of Alexander the Great returning from their Indian Campaign in 327–326 BC. The earliest description of true leprosy in Europe was recorded by Aretaeus in about 150 AD in Greece. Hippocrates (circa 460–377 BC) most probably did not know true leprosy, since his description did not mention neurological manifestations of the disease. The term leprosy is derived from the Greek word **lepros**, which means scaly. Leprosy was most probably unknown at the time of Moses and the word **'tsara'ath** in the Old Testament did not mean leprosy. It is possible that some references in the New Testament are to leprosy because the disease certainly existed at the time of Jesus.

At the beginning of the 13th century, leprosy was rampant in Europe, from Iceland to Italy, and at that time there were about 19,000 leprosaria in Europe. Møller-Christensen demonstrated the characteristic changes found in leprosy, namely the destruction of the alveolar process of the maxilla and the anterior nasal spine, as discovered in the skulls excavated at the site of a medieval leprosarium which existed between 1250 and 1500 AD in Naestved, Denmark. In the Middle Ages, the leprosy sufferer was considered as unclean not only by society but also by the Church and he was expected to live in a lazar house or hospital situated outside the city wall. Leprosy started decreasing in Europe from the 15th century.

During the Middle Ages, leprosy probably spread to Africa from the Middle East along the trade routes. It was first introduced into America in the middle of the 16th century by immigrants from Europe. Later, slaves from Africa took leprosy to the Americas, especially Brazil. Most probably, leprosy was introduced into Hawaii by immigrants from China. The Hawaiian word for leprosy is "Mai Pake" meaning the Chinese sickness.

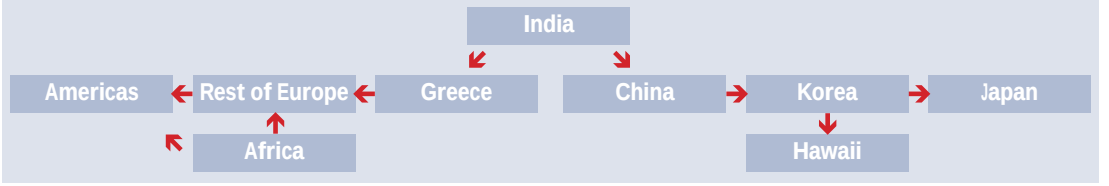


Fig. 2 Possible routes of spread of leprosy

3 Bacteriology

Leprosy is caused by **Mycobacterium leprae**, discovered in 1873 by Hansen (Fig. 3) at Bergen in Norway. In those days, leprosy was thought to be a hereditary disease, a punishment from God. Hansen's discovery was accepted six years later by Albert Neisser of Germany, who in 1879, at the young age of twenty-four, stained the organism with fuchsin and gentian violet. This was before Robert Koch discovered the tubercle bacillus. **M. leprae** is an obligate intracellular acid-fast bacillus (AFB) multiplying mainly inside the macrophages of the skin (histiocytes) and of the nerves (Schwann cells). It closely resembles the bacillus causing tuberculosis. However, **M. leprae** is less acid-fast than **M. tuberculosis**.

After the discovery of the leprosy bacilli, Hansen not only tried hard to grow them on artificial media in the laboratory but also made repeated, unsuccessful attempts to infect himself as well as his Chief and father-in-law, Dr. Danielssen, with material from leprosy patients. Danielssen had four inoculations and all ended in negative results because leprosy is not easily communicable.

Fig. 3 G. H. A. Hansen (1841–1912)

The **Mycobacterium leprae** belongs to the:

Class	**Fungus**
Order	**Actinomycetalis**
Family	**Mycobacteriacae**
Genus	**Mycobacterium**
Species	**Leprae**
Variety	**Mycobacterium leprae**
Common name	**Bacillus of Hansen**

Leprosy bacilli are pleomorphic, straight or slightly curved, rod-like, Gram-positive bacteria. They may appear ovoid, fragmented or granular. In stained skin smears or sections, they are seen lying singly, in clumps or in compact masses known as globi (Fig. 4). In smears stained by the Ziehl-Neelsen method, living leprosy bacilli appear as solid staining, i.e. bright pink rods with rounded ends and uniformly stained throughout their entire length (Fig. 6). The length of presumably living leprosy bacillus varies between 3 and 8 microns. **M. leprae** is unique among pathogenic mycobacteria due to its dopa-oxidase activity. The life span of a normal leprosy bacillus is about six months. Leprosy bacilli may be fragmented (showing small gaps in the stain) or granular (Figs. 5, 6), showing unstained zones across the width of the bacillus.

Leprosy bacilli are extremely scanty in lesions of paucibacillary leprosy, but are present in enormous numbers in the lesions of multibacillary leprosy. One gram of lepromatous tissue may contain as many as 7,000 million leprosy bacilli. Although the discovery of leprosy bacilli was reported as early as 1873, they could not yet be grown in artificial culture media. The generation time of **M. leprae** in the mouse footpad is 12 to 13

days (the longest of any known bacterium) during the phase of logarithmic growth, while its overall mean generation time ranges from 18 to 42 days[8]. In comparison with this, the generation time of **M. tuberculosis** is only 20 hours.

The habitat of the leprosy bacillus in nerves is the Schwann cell or occasionally the axon which it ensheathes. Under adverse conditions, it may at times find a retreat in a nerve, for which it has great affinity and in which it is not readily detected by the immunological mechanism[9]. Not only the Schwann cells of the peripheral nerves but also smooth and striated muscles are sites of multiplication of leprosy bacilli. They are found in the arrectores pilorum in the skin (Fig. 7), hair follicles (Fig. 8), sweat glands (Fig. 9), muscular media of arterioles as well as in the endothelial lining of small blood vessels[5], dartos muscle (Fig. 10) of the scrotum and in the smooth muscle of the iris. Nasal secretions (Fig. 11), nasal mucosa (Fig. 12), erosions, ulcers and blisters of lepromatous and borderline patients and of patients in reactional states also contain leprosy bacilli. They are also found in the sputum, semen, sweat, sebum, tears and breast milk of persons with untreated lepromatous leprosy.

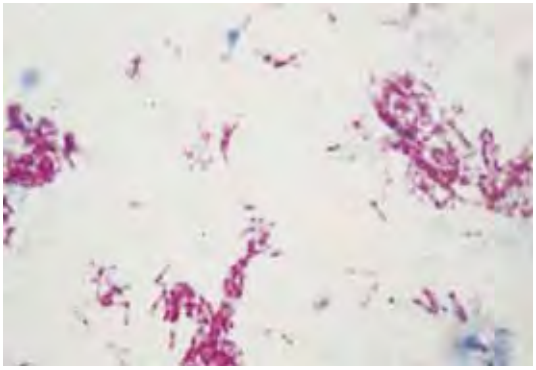


Fig. 5 Fragmented **M. leprae**

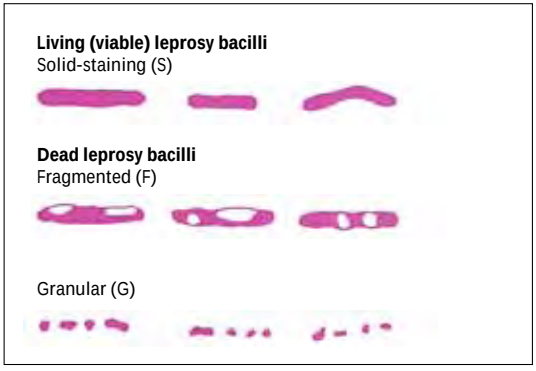


Fig. 6 Solid-staining, fragmented and granular **M. leprae**

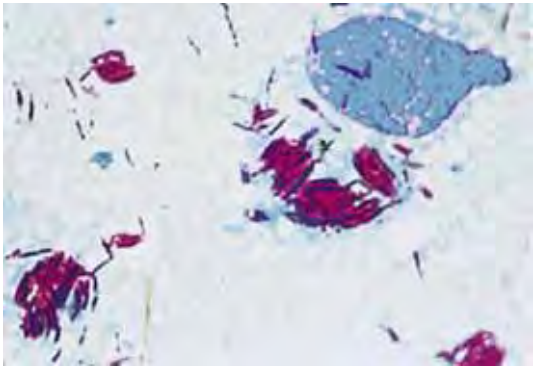


Fig. 4 **M. leprae**, singly and in globi

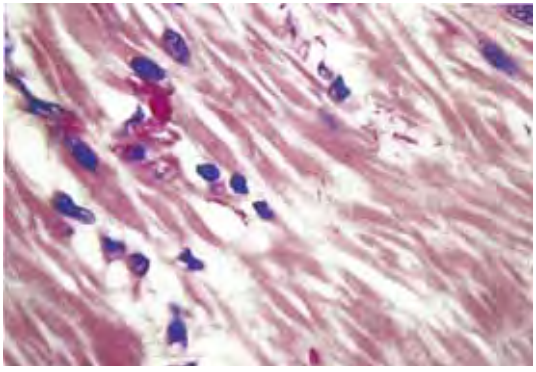


Fig. 7 **M. leprae** in the arrector pili muscle

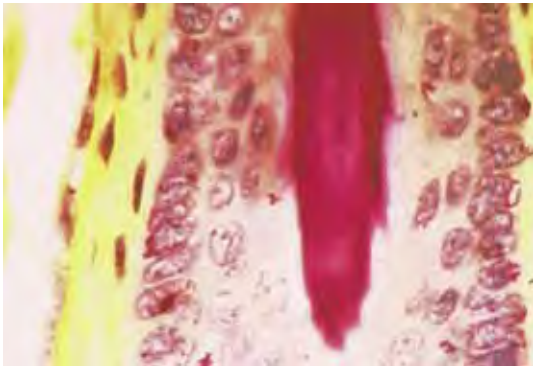


Fig. 8 **M. leprae** in a hair follicle

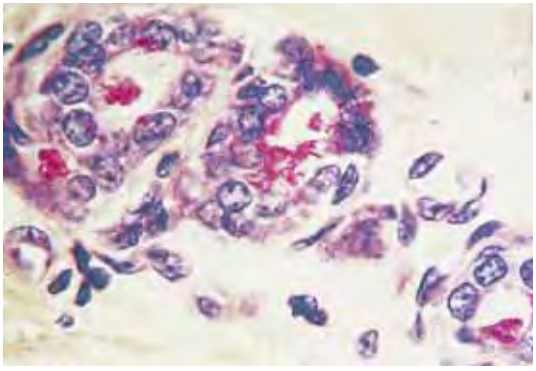


Fig. 9 **M. leprae** in sweat gland cells and ducts

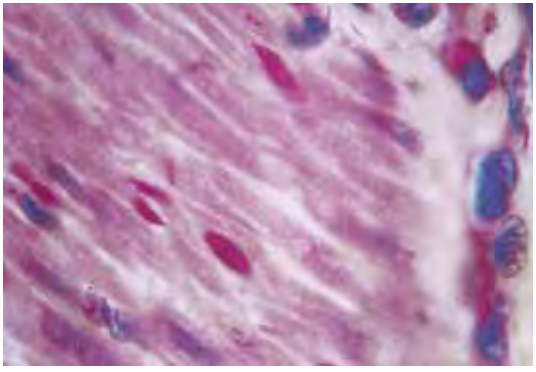


Fig. 10 **M. leprae** in the dartos muscle

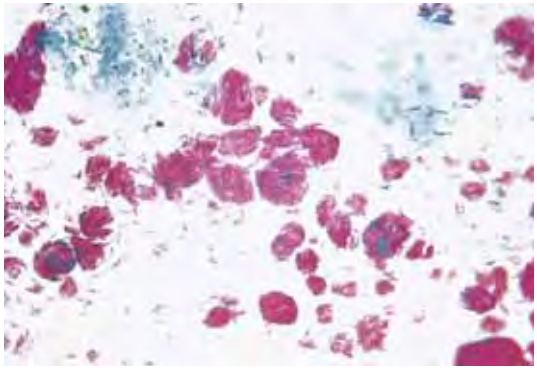


Fig. 11 **M. leprae** in the nasal mucus

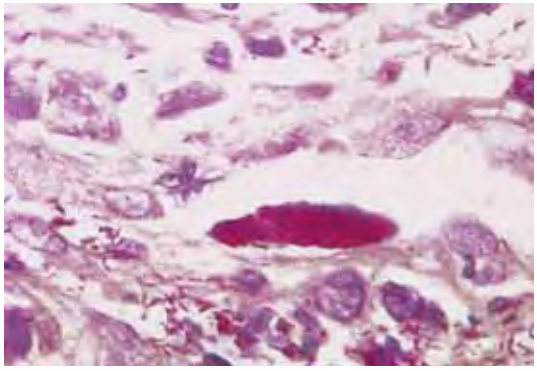


Fig. 12 **M. leprae** in the nasal mucosa

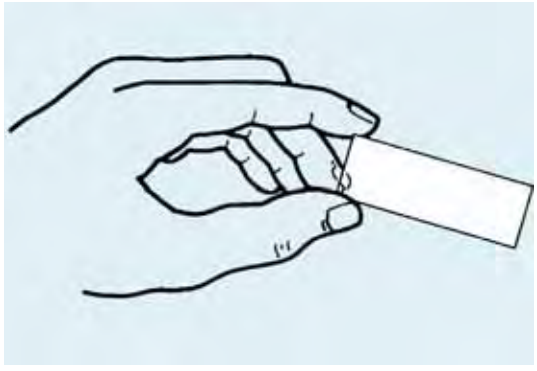


Fig. 13 How to hold the slide

Techniques of Bacteriological Examination

Slit-Skin Smears

Before taking the smear, the lesion must be thoroughly cleaned with alcohol or ether. The smear should be taken from the most active-looking part of the lesion. The site of the smear should be gripped between the thumb and forefinger to press out the blood. The pressure should be maintained to render the area bloodless until the smear has been taken. With a sterile small-bladed scalpel (e.g. size 15 Bard Parker blade), an incision 5 mm long and about 2–3 mm deep is made between the fingers. The blade is then turned until it is at right angles to the incision and the wound is scraped firmly 2 or 3 times in the same direction so that a drop of dermal tissue collects on its tip. This drop of tissue fluid and pulp is gently smeared over a circular area of about 7 mm in diameter on a clean, new, unscratched glass slide. Slides should always be held by the edges (Fig. 13). Skin smears should not contain blood because blood may interfere with the staining[10]. Therefore, wipe away if any blood is seen after making an incision.

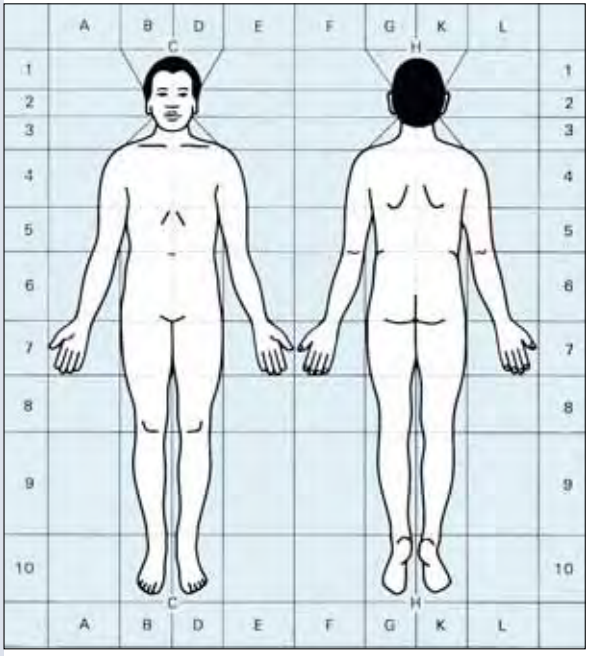


Fig. 14 Body diagram and grid system for charting the position of lesions and the sites from which slit-skin smears are taken

Six smears can conveniently be made on one microscope slide. In patients with active lesions, six smears should be taken, one from each ear lobe and four from active lesions. The sites of the smears should be accurately recorded so that the same sites can be used for successive sets of smears made for assessing the effect of treatment (Fig. 14). Do not re-use slides for making skin smears, as organisms from previous smears may give false-positive results.

The slide with the smear is immediately warmed over an open flame and fixed before it is stained. The patient's name and number and the date of the smear are written on the slide using a diamond-pointed stylus. The smears should not be exposed to sunlight as this will impair the capacity of **M. leprae** to take up the carbol fuchsin stain[11]. Before taking the next smear, the blade should be wiped with cotton wool soaked in methylated spirit and passed slowly through a spirit-lamp flame for about three seconds. After taking all smears from one patient, the blade should be cleaned to remove traces of tissue from previous specimens, and then sterilized.

Ziehl-Neelsen method of staining **M. leprae** in smears:

1. Carbol fuchsin in 1% aqueous solution is poured over the already fixed smear and heat is applied beneath the slide to cause steam to rise from all parts of the slide. Boiling must be avoided[11].

2. The stain is left for 15 minutes without further heating.
3. The stain is tipped away and the slide held under a gentle stream of running water, until the water is no longer coloured pink.
4. The acid-alcohol mixture is poured on the slide and left for 3 to 5 seconds, depending on the thickness of the smear. The acid-alcohol mixture is then washed away with running water. The smear should now appear faint pink. If it is deep pink, a second treatment with acid-alcohol mixture for about 2 seconds is necessary. The acid-alcohol mixture contains 1% hydrochloric acid in 70% alcohol.
5. The faint pink slide is then counterstained with 1% methylene blue for about 10 seconds.
6. The slide is washed in running water and is allowed to dry in the air; it is then examined under an oil-immersion objective.

Reading of Smears

Bacteriological Index (BI)

The Bacteriological (or Bacterial) Index indicates the density of leprosy bacilli in smears and includes both solid-staining and fragmented or granular bacilli. According to Ridley's logarithmic scale, it ranges from zero to 6+ and is based on the number of bacilli seen in an average microscopic field of the smear using an oil-immersion objective[10] (Fig. 15).

0 No bacilli in any of the 100 oil immersion fields
1+ 1–10 bacilli, on average, in 100 oil immersion fields
2+ 1–10 bacilli, on average, in 10 oil immersion fields
3+ 1–10 bacilli, on average, in each oil immersion field
4+ 10–100 bacilli, on average, in each oil immersion field
5+ 100–1000 bacilli, on average, in each oil immersion field
6+ More than 1000 bacilli, on average, in each oil immersion field

The BI of the patient is calculated by adding up the index from each site examined and dividing the total by the number of sites examined.

(e.g. Right ear 5+ Left ear 5+
Back 4+ Chin 4+)

$$\text{Bacteriological Index:} \quad \frac{5+5+4+4}{4} = \frac{18}{4} = 4.5+$$

Morphological Index (MI)

The Morphological Index is the percentage of presumably living (complete or full) bacilli in relation to the total number of bacilli in the smear. It is calculated after examining 200 pink-stained, free-standing (i.e. not in clumps) bacilli. This is first recorded separately for each smear. The percentages are then added up and divided by the number of smears to give the MI of the patient. Accurate evaluation of the MI requires much skill and experience.

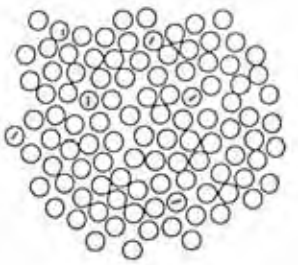
Transmission to Animals

Mouse

In 1960, Shepard first reported that the leprosy bacillus may multiply in the mouse footpad in a limited way and the era of experimental leprosy was thus ushered in[12]. By suppressing the immune mechanism with a thymectomy and whole-body 900 r X-ray irradiation (T/900 r), Rees and Weddell were able to increase the

BI 1+

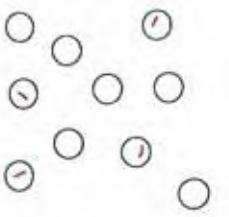
1–10 bacilli, on average, in 100 oil immersion fields



Examine **100** oil immersion fields

BI 2+

1–10 bacilli, on average, in 100 oil immersion fields



Examine **100** oil immersion fields

BI 3+

1–10 bacilli in an average oil immersion field

Examine **25** oil immersion fields

BI 4+

10–100 bacilli in an average oil immersion field

Examine **25** oil immersion fields

BI 5+

100–1000 bacilli in an average oil immersion field

Examine **25** oil immersion fields

BI 6+

Over 1000 bacilli (many globi) in an average oil immersion field

Examine **25** oil immersion fields

Fig. 15 Diagrammatic representation of the Bacteriological Index (BI) of slit-skin smears according to Ridley's logarithmic scale

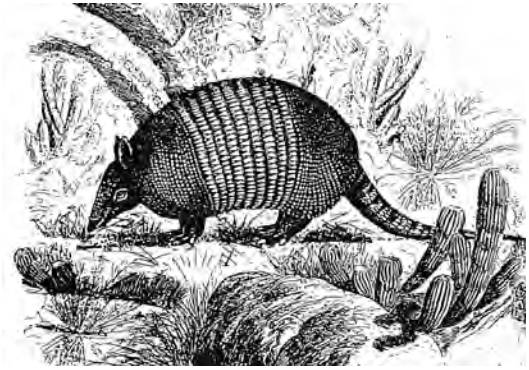


Fig. 16 Nine-banded armadillo (Dasypus novemcinctus)

yield of leprosy bacilli per footpad up to 1000-fold[13]. More than 200 strains of **M. leprae** derived from patients from all over the world have produced an identical type of infection when inoculated into the footpads of mice.

The mouse footpad model has been very useful for:

1. Identifying a strain of mycobacteria as being **M. leprae** by the characteristic multiplication of the injected organisms.
2. Determining the generation time of **M. leprae**.
3. Understanding the pathogenesis of leprosy in man. The main findings are the haematogenous spread and the multiplication of **M. leprae** in sites of predilection.
4. Screening antileprosy drugs for bactericidal or bacteriostatic properties and for determining their minimum inhibitory concentrations.
5. Monitoring drug trials – a loss of 99% of the pretreatment rate of viable (i.e. living and capable of multiplying) bacilli can be detected in the mouse model as against 90% by determining the morphological indices (MI). Mouse footpad inoculation is ten times more sensitive than skin smears for detecting **M. leprae**[8].
6. Detecting drug-resistant strains.

The mouse footpad model has provided the first convincing proof of the emergence of resistance to dapsone.

Nude Mouse

In 1976, Colston and Hilson, and Kohsaka et al. first reported on the growth of **M. leprae** in the footpad of the nude (athymic and with no hair) mouse. The nude (hairless) mouse is deficient in T-cells and is extremely sensitive to infection with **M. leprae**. The nude mouse model can detect as little as 100 viable bacilli among an inoculum of 108 dead bacilli. A heavy infection of skin, ears, testes, liver, lymph nodes and spleen is present in the nude mouse. The organisms can grow up to a load of 1010 per gram of tissue. In addition to the subcutaneous or intradermal routes of inoculation, leprosy can be experimentally transmitted to nude mice through the nasal mucosa, either by aerosols or direct application[8].

Armadillo

In 1971, Kirchheimer and Storrs[14] reported a disseminated experimental **M. leprae** infection in the nine-banded armadillo (Fig. 16). Some of the biological features of this animal are particularly interesting for leprosy investigations, namely: low body temperature (30–36°C) and a long life-span (12–15 years). Some 40% of the armadillos inoculated with **M. leprae** develop leprosy-like systemic infection after about 1 year. The infected armadillo's liver may contain as many as

1000 million (10^9) bacilli per gram of tissue. **M. leprae** can also be transmitted to the seven- and eight-banded armadillo species. The large quantities of **M. leprae** which can be obtained from infected armadillos are used for immunological studies. The armadillo is also a suitable animal model for leprosy research.

Monkeys

Gormus and his associates (USA) transmitted leprosy to 24 mangabey monkeys, 7 rhesus monkeys and 5 African green monkeys. All of the monkeys had the multibacillary type of leprosy and approximately 50% of them developed sequelae due to damage to peripheral nerves.

M. leprae Genome

The genome sequence of a strain of **M. leprae**, originally isolated in Tamil Nadu and designated "TN", was found to contain 3,268,203 base-pairs (bp) and to have an average G+C content of 57.8%. These values are much lower than the values for **M. tuberculosis**, which are 4,441,529 bp and 65.6% G+C. There are 1,500 genes which are common to both **M. leprae** and **M. tuberculosis**[15]. The comparative analysis suggests that both mycobacteria have derived from a common ancestor and, at one stage, had gene pools of similar size. Information from the completed genome can be useful to develop diagnostic skin tests and to identify drugs to treat leprosy and its complications.

4 Epidemiology

Geographic Distribution of Leprosy

It is difficult to accurately estimate the actual number of cases of leprosy in the world. Case diagnosis and definition are not always consistent and the enumeration of cases in some parts of the world is incomplete. Despite these difficulties, estimates were made by WHO from time to time. The WHO estimates for 1966 and 1976 were 10.8 and 10.6 million cases respectively. In 1991, the estimate was 5.5 million. In 1993, following widespread control efforts, including through implementation of MDT, WHO estimated the global burden of leprosy to be about 3.1 million, whereas the number of registered cases was only 2.3 million. In 1996, the estimated number was 1.3 million. Subsequently WHO gave up estimating the number of cases as the number of registered cases increasingly reflected the actual situation.

With regard to the number of registered cases, there was a very steady increase between 1966 and 1985: 2.83 million for 1966, 3.60 million for 1976, and 5.37 million for 1985. Since then, the number of registered cases has steadily declined to 3.74 million in 1990, 1.29 million in 1995, 0.75 million in 2000, 0.29 million in 2005, and 0.22 million in 2008.

The distribution of registered cases, the prevalence rates (P.R.), new cases detected and case detection rates (CDR) by continents as of 2008 are shown in Table 1. Prevalence of leprosy by countries is shown in the map (Fig. 17).

Table 1
Leprosy situation by continent 2008*

Continent (Popn. in millions)	Registered Cases (000s)	Prevalence Rates per 10,000	New Cases (000s)	Case Detection Rates per 10,000
Africa (934)	38	0.41	37	0.40
Americas (903)	50	0.55	42	0.46
Asia & Oceania (4036)	131	0.32	179	0.44
Europe (730)	0.2	0.00	0.1	0.00
Total World (6603)	219	0.33	258	0.39

* Data derived from WER No. 33, 15 Aug 2008, pp 293–300, and WER No. 50, 12 Dec 2008, pp 459

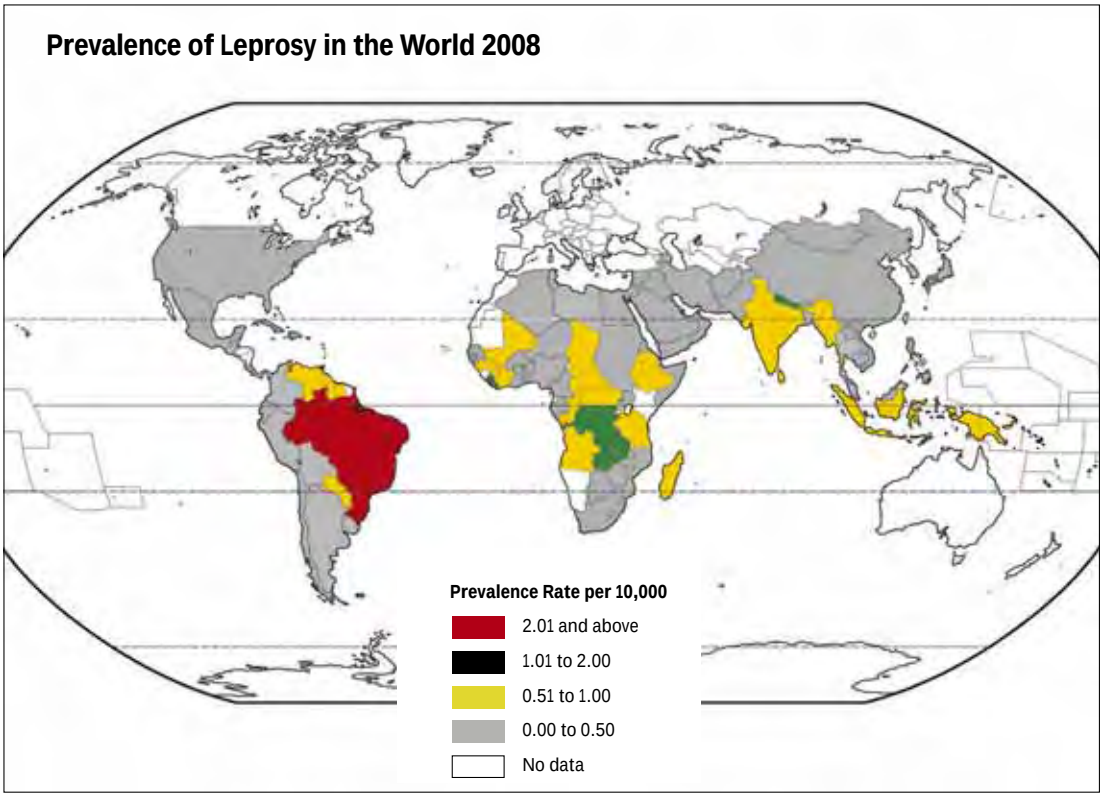


Fig. 17 Map based on information available in WER No. 33, 15 Aug 2008, pp 293–300, and WER No. 50, 12 Dec 2008, pp 459

In countries where leprosy is endemic, the prevalence rates of registered cases show marked variations, with rates ranging from below 0.1 per 10,000 to over 3.2 per 10,000 in 2008. Considerable variation in prevalence is known to exist within countries and even between adjacent areas. In fact, the uneven nature of the distribution of the disease appears to be a characteristic of leprosy.

An interesting feature of leprosy is the geographic variation seen in the occurrence of MB leprosy, as indicated by the proportion of MB cases over total cases. This rate varies from below 35% to over 90% in different countries of the world. There does not appear to be any correlation between total prevalence of leprosy in an area and the proportion of MB cases. However, in areas where leprosy is dying out, the few cases that occur do have a preponderance of MB leprosy.

Age Distribution

Most studies on age distribution of leprosy are based on prevalence data, and only a few are based on incidence data. Furthermore, information on disease occurrence is mostly based on age at detection rather than age at onset of disease. In a chronic disease like leprosy, information based on prevalence data or data on age at detection may not fully reflect the age-specific risks.

Leprosy is known to occur at all ages ranging from early infancy to very old age. The youngest age reported for occurrence of leprosy is 3 weeks in Martinique[16]. The occurrence of leprosy, presumably for the first time, is not uncommon even after the age of seventy. In many high endemic areas, there is a peak at ages 10–14 followed by a depression which in turn is followed by a

rise and a plateau covering ages 30–50. The bimodal curve in high endemic areas suggests the possibility of two distinct experiences, one among children and the other among adults. However, in the majority of situations the peak occurrence of leprosy appears to be in mid-adult life. A pattern observed in very low endemic areas where the disease is dying out is the occurrence of the bulk of the cases among older adults. This shift to the right as seen in age distribution graphs has been observed in Japan, the United States and northern Europe.

Sex Distribution

Although leprosy affects both sexes, in most parts of the world males are affected more frequently than females, often in the ratio of 2:1. From their studies in the Philippines, Doull et al. have pointed out that the difference is a true difference due to higher incidence among males, and not due to differing duration of disease for the two sexes[17]. The sex difference in leprosy is often attributed to ascertainment bias. However, this cannot explain all the difference that is seen, and the difference appears to be a true one.

Occurrence of Leprosy in Clusters

The occurrence of leprosy more frequently in certain clusters, particularly family clusters, is well recognized. However, the most debated point is whether this is due to the clusters sharing the same environment or the same genetic predisposition, or a combination of both. The two factors within the family are so closely interrelated that it is difficult to study one in disassociation from the other.

The Prevalence Pool

The prevalence pool of leprosy in any population is in constant flux resulting from inflow and outflow. The inflow is contributed by the occurrence of new cases, relapse of cured cases, and immigration of cases. The outflow is mainly through spontaneous cure, death and migration.

Where leprosy treatment facilities exist, cure due to specific treatment is an important mode of elimination of cases from the prevalence pool. Even in the absence of specific treatment, a majority of patients, of PB leprosy, tend to get cured spontaneously. A study involving long-term follow-up of a high endemic population showed that among newly detected PB cases of all ages and both sexes, the rate of spontaneous cure was 10.9% per year[18].

Mortality in leprosy is often not considered important since the disease is rarely an immediate cause of death. However, leprosy patients are exposed to increased mortality risks due to its indirect effects including poverty. A study in southern India[19] showed that the standardized death rate for MB patients was 3.5 times that of the general population, the PB patients themselves having a mortality risk twice that of the general population.

It is well recognized that socio-economic factors play an important role in leprosy. One of the striking features of the decline of leprosy in many parts of the world is its association with improved socio-economic conditions. The failure of imported leprosy cases to produce secondary cases in Europe is partly attributed to high socio-economic levels.

Transmission of Leprosy

There are several constraints in studying the transmission of leprosy. Unlike many other communicable diseases, there is considerable difficulty in leprosy in identifying the three reference points of onset of exposure, infection and disease. At present there is no dependable test to measure subclinical infection with sufficient sensitivity and specificity for use in epidemiological studies. Until such a test becomes available the epidemiological picture of leprosy will remain incomplete.

Reservoir of Infection

The human being is the only known reservoir of infection in leprosy, except for the fact that naturally occurring disease with organisms indistinguishable from **M. leprae** has also been detected among wild armadillos in parts of the southern United States[108]. Up to 5% of armadillos in Louisiana have been found to have clinical disease, with about 20% having serological evidence of **M. leprae** infection[109]. The epidemiological significance of the armadillo is generally considered to be negligible in spite of occasional cases reported among individuals giving a history of handling armadillos[110]. Among human beings it is the MB cases that carry the largest load of organisms, the maximum load reaching over 7 billion organisms per gram of tissue.

Portal of Exit of M. leprae and its Viability Outside the Human Host

The two portals of exit of **M. leprae** often discussed are the skin and the nasal mucosa. However, the relative importance of these two portals is not clear. Although there are reports of AFB being found in the desquamating epithelium of the skin, Weddell et al.[111] have reported that they could not find any AFB in the epidermis, even after examining a very large number of specimens from patients and contacts.

Regarding the nasal mucosa, the quantity of bacilli from nasal mucosal lesions in MB leprosy has been demonstrated by Shepard as large[112]. Pedley has reported that the majority of lepromatous patients showed leprosy bacilli in their nasal secretions as collected through the nose blow[113]. Davey & Rees have indicated that nasal secretions from MB patients can yield as many as 10 million viable organisms per day[114] and that **M. leprae** from such nasal secretions can survive outside the human host for several hours. Desikan has reported on the survival of **M. leprae** in nasal secretions under tropical conditions for up to 9 days[115]. Such survival of the organisms suggests the possibility of contaminated clothing and other fomites acting as sources of infection.

Portal of Entry of M. leprae

The portal of entry of **M. leprae** into the human body is not definitely known. However, the two portals of entry seriously considered are the skin and the upper respiratory tract. Leprosy through accidental inoculation has been reported by more than one investigator, although experimental attempts on human volunteers appear to have failed to produce the disease through inoculation. With regard to the respiratory route of entry of **M. leprae**, the evidence in its favour is on the increase. Rees & McDougall have succeeded in the experimental transmission of leprosy through aerosols containing **M. leprae** in immune-suppressed mice, suggesting a similar possibility in humans[116].

Subclinical Infection in Leprosy

In spite of the fact that as yet there is no simple immunological test to identify subclinical infection with sufficient specificity and sensitivity, evidence accumulated in the past few years has clearly indicated that subclinical infection does occur in leprosy as in many other communicable diseases. This evidence has mainly come from serological tests for detecting humoral antibodies such as the one based on phenolic glycolipid-I (PGL-1).

Incubation Period

In leprosy, both the reference points for measuring the incubation period, i.e. the time of infection and the time of onset of disease, are difficult to determine. The minimum incubation period reported is as short as a few weeks and this is based on the very occasional occurrence of leprosy among young infants[117]. The maximum incubation period reported is as long as 30 years or over, as observed among war veterans known to have been exposed for short periods in endemic areas, but otherwise living in non-endemic areas. It is generally believed that in the vast majority of cases, the incubation period is between 3 and 5 years.

Method of Transmission of Leprosy

The exact mechanism of transmission of leprosy is not known. At least until recently, the most widely held belief was that the disease was transmitted when there was skin-to-skin contact between cases of leprosy and healthy persons. However, the possibility of transmission by the respiratory route is gaining ground steadily. There are also other possibilities such as transmission through insects, which cannot be completely ruled out.

The term "contact" in leprosy is generally not clearly defined. All that we know at present is that individuals who are in close association or proximity with leprosy patients have a greater chance of acquiring the disease. Whether it necessarily involves skin-to-skin contact or some kind of inunction is not clear. However the entry of the organisms through broken skin appears to be more probable than through intact skin.

In general, closeness of contact is related to the dose of infection, which in turn facilitates transmission. Of the various situations that promote close contact, contact within the household is the one that is easily identified. The increased risk for household contacts of leprosy as compared with others is generally about four times that of non-contacts.

In endemic areas, the observance of high risk for contacts should not lead to underestimation of the importance of the non-contact population in terms of their contribution to the total yield of new cases. Even with a relatively low risk, the non-contact population contribute to a larger share of new cases solely because of its large size in comparison with the contact population.

It is well recognized that contacts of MB leprosy run a higher risk of getting the disease than contacts of PB leprosy, whose risk in turn is higher than that of non-contacts.

The relatively high risk for contacts of MB cases can be very well explained by the heavy bacillary load of the index cases. Studies have also shown substantially

increased risk for contacts exposed to smear-positive MB index cases compared to smear-negative MB cases. In general, the longer the exposure of contacts to index cases the greater is the chance of getting the disease. While direct contact is expected to be more effective than indirect contact, the possibility of indirect contact playing an important role in the transmission of leprosy cannot be ruled out.

HIV Infection and Leprosy

It is now well recognized that HIV infection has created a serious situation with regard to the incidence of tuberculosis. Studies in several parts of the world have clearly shown that the substantial increase in pulmonary tuberculosis is attributable to HIV infection. This is also true for atypical mycobacterioses. Although a similar situation was considered possible with regard to leprosy, studies and observations so far have not indicated any significant increase in the occurrence of leprosy as a result of HIV infection.

5 Evolution of Leprosy Lesions

Most individuals who have been in contact with persons suffering from multibacillary leprosy develop a subclinical infection which may be compared to the "Ghon focus" in tuberculosis. However, in more than 95% of such persons, the infection fails to establish itself and they never develop any manifestation of the disease[20]. In the remaining small percentage of contacts, a single or a few ill-defined hypopigmented or faintly erythematous patch(es) of indeterminate leprosy may develop.

Indeterminate leprosy is often the clinical beginning of the disease and it may be easily overlooked. Lesions of indeterminate leprosy may heal spontaneously or may persist as indeterminate leprosy or develop into one of the definite (determinate) types of the disease (Fig. 18). Some patients may develop definite types of leprosy without passing through an indeterminate phase. Spontaneous regression may also occur in other paucibacillary cases of leprosy.

Only a few of those in contact with leprosy sufferers develop recognizable lesions (Table 2).

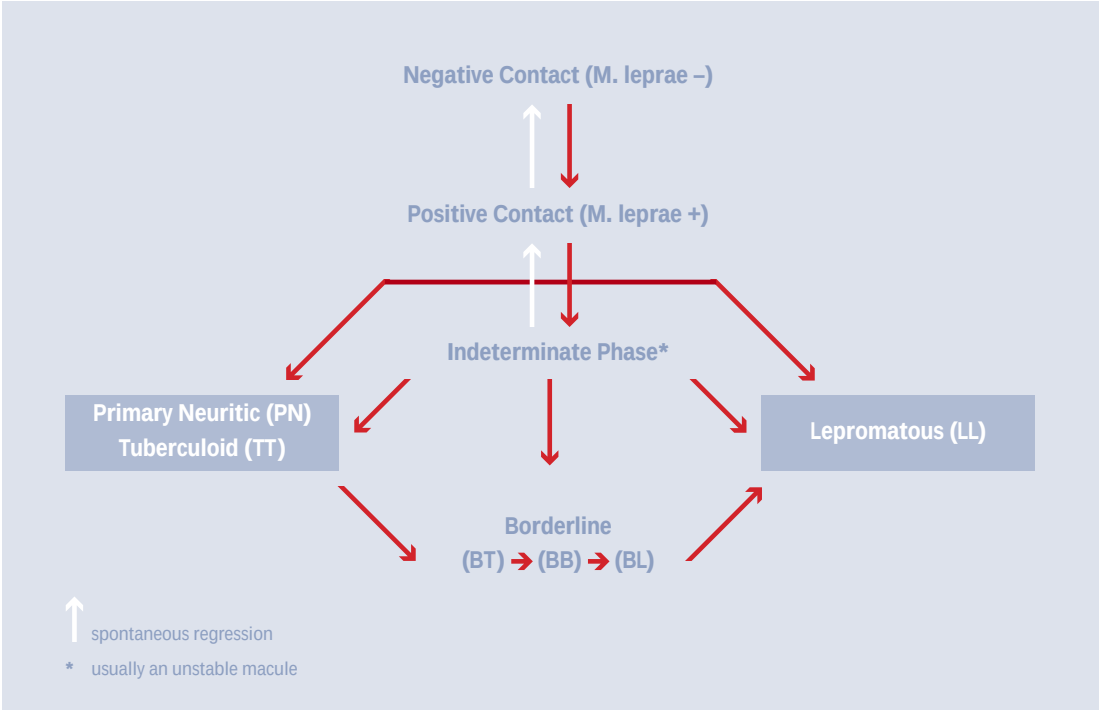


Fig. 18 The evolution of leprosy lesions [19]

Table 2
Range of clinical manifestations depending on the infected individual's resistance to leprosy bacilli

Host's Resistance	Clinical Manifestations of Leprosy	
Excellent	None (no infection)	
Good	None (subclinical infection showing spontaneous regression)	
Fair	Indeterminate leprosy (I) Primary neuritic leprosy (PN)* Tuberculoid leprosy (TT) Borderline-tuberculoid leprosy (BT)	→ **Paucibacillary (PB) leprosy** (up to 5 lesions)
Poor	Mid-borderline leprosy (BB) Borderline-lepromatous leprosy (BL)	→ **Multibacillary (MB) leprosy** (more than 5 lesions)
Very poor/none	Lepromatous leprosy (LL)	

* Asymmetric nerve involvement with no skin lesions and usually of tuberculoid origin

6 Clinical Features

Depending on the infected individual's resistance to the disease (cell-mediated immunity), leprosy presents an astonishingly broad spectrum of non-itching clinical lesions, ranging from a small solitary hazy macule (Fig. 19) to widespread multiple shiny nodules (Fig. 53). Indeed the manifestations of leprosy are so varied and divergent that it is hard to believe that they are caused by one and the same microorganism. However, there is no evidence to show that the leprosy bacillus occurs in a number of strains with different degrees of virulence. The onset of leprosy is usually gradual and insidious. **Mycobacterium leprae** does not produce any toxins. Therefore, most patients even with billions of leprosy bacilli do not manifest any toxic symptoms. However, some patients develop reactions showing painful skin lesions accompanied by fever, malaise and other symptoms. Most frequently, the first signs of leprosy develop on the skin but when the neural aspect of the disease predominates over that of the skin, the first evidence may be numbness, tingling or pain in an extremity. Occasionally the first evidence of the disease is an enlarged, painful peripheral nerve.

Fig. 19 Hypopigmented macule of indeterminate leprosy

Fig. 20 Hypopigmented macules of indeterminate leprosy on the face

Indeterminate Leprosy (I)

Indeterminate leprosy presents as single, slightly hypopigmented (pale) or faintly erythematous and usually ill-defined (hazy) macules on the skin. Sensation on the affected area is slightly impaired, while sweating and hair growth are usually unaffected. The peripheral nerves are normal. Slit-skin smears are mostly negative[10]. Indeterminate leprosy is usually self-limiting or self-healing, but may progress to other forms of leprosy. It is often difficult to diagnose indeterminate leprosy with certainty. In such circumstances, the patients should be examined at three- or six-monthly intervals to assess the progress of the lesions, and a skin biopsy may be performed (Figs. 19, 20).

Fig. 21 Hypopigmented macule of indeterminate leprosy on the back

Tuberculoid Leprosy (TT)

In 1898, Jadassohn, a Swiss-German dermatologist, first used the term "tuberculoid" to describe a form of leprosy in which the histopathological features resemble non-caseous tuberculosis. **M. leprae** are phagocytosed and digested by macrophages which form epithelioid cells. The skin lesion of tuberculoid leprosy is usually single, but there may be two or three asymmetrical lesions. They are seldom over 10 cm in diameter. Tuberculoid lesions may be reddish or brownish or hypopigmented. Hypopigmentation is due to a marked reduction in the number of normal melanocytes[21]. The hypopigmented tuberculoid leprosy lesion is never completely depigmented as in vitiligo. The skin lesions of tuberculoid leprosy are usually oval or rounded in shape and are well demarcated from the normal surrounding skin by a distinct edge. Sensation is markedly impaired or lost in tuberculoid lesions. Well-defined edges and sensory loss, i.e. loss of feeling for pain and/or touch and temperature, are characteristic features of tuberculoid leprosy.

The entire patch may be distinctly raised above the level of the surrounding skin. The affected area is symptomless (e.g. no itching), rough and either hairless or with sparse hairs and may show central healing. The surface of the lesion is drier than the surrounding skin because sweating is markedly impaired on the affected area. In a few cases scaling is present and the plaques appear psoriasiform. Satellite lesions indicate local spread of the disease occurring due to a decrease in the patient's defence mechanism (cell-mediated immunity) and are characteristic of borderline leprosy.

In some cases, an enlarged cutaneous nerve may be seen entering the lesion at one end and emerging at the other. The examiner should run his finger nail lightly around the edge of the patch to detect the enlarged nerve. The related peripheral nerve trunk is usually enlarged, e.g. the ulnar nerve is affected if the lesion is near the elbow. In order of frequency, the affected nerves are: the ulnar nerve immediately above the elbow, the posterior tibial nerve near the medial malleolus of the tibia, and the lateral popliteal nerve where it winds round the neck of the fibula. In addition, the median, facial, trigeminal, great auricular, supraorbital and other nerves in the vicinity of cutaneous lesions are usually involved. Damage to nerves may result in loss of feeling, pain, tingling and muscle weakness or paralysis. The locally enlarged nerve may undergo caseation and liquefaction degeneration and a cold abscess may thus be formed. The nerve abscess occurring in leprosy is analogous to the cold abscess in tuberculosis. It is much more common in paucibacillary leprosy (Figs. 35, 36) than in multibacillary leprosy.

A painless nodular swelling in the epididymis due to tuberculoid leprosy has been reported[22]. Tuberculoid leprosy is generally stable, although a few patients may develop exacerbations and downgrade to borderline leprosy.

Fig. 22 Patch of tuberculoid leprosy on the face

Fig. 25 Well-defined, large patch of tuberculoid leprosy

Fig. 23 Well-defined, hypopigmented patch of tuberculoid leprosy

Fig. 26 Well-defined, hypopigmented, scaly patch of tuberculoid leprosy on the arm

Fig. 24 Well-defined, large patch of tuberculoid leprosy

Fig. 27 Early tuberculoid lesions with a slightly raised edge

Fig. 28 Discoid tuberculoid lesion with a distinct edge

Fig. 31 Uniformly raised, slightly scaly lesion of tuberculoid leprosy on the face

Fig. 29 Well-defined tuberculoid lesion near the nipple

Fig. 32 Well-defined, raised, erythematous, scaly plaque of tuberculoid leprosy on the thigh

Fig. 30 Tuberculoid lesion with a markedly raised edge

Fig. 33 Psoriasiform scaly lesions of tuberculoid leprosy

Primary Neuritic Leprosy (PN)

Primary neuritic leprosy is a form of leprosy with no evidence or history of skin lesions. This variety is not uncommon in India[5]. According to Noordeen, 6% of early lesions in southern India belong to this type of leprosy.

M. leprae is the only bacterium that is able to invade nerves. Leprosy bacilli can enter the nerve through several channels. During bacteraemia, **M. leprae** can escape from the intraneural capillaries into the nerve. The macrophages containing **M. leprae** may infiltrate the perineurium and then enter the nerve. Leprosy bacilli may also invade the naked nerve endings in the dermoepidermal junction and migrate centripetally along the axon.

This type of leprosy is characterized by neuritic manifestations caused by the involvement of usually one or, at times, several peripheral nerve trunks. The ulnar nerve is most commonly affected. In most cases, the underlying changes in the affected nerves in primary (or pure) neuritic leprosy are due to tuberculoid or borderline leprosy.

Sensory changes occur earlier than motor changes. As a rule, the deep reflexes are retained until the nerve damage has become extensive. As in tuberculoid leprosy, sensations of light touch and temperature are usually lost earlier than sensations of pain and pressure. Heaviness, tingling and numbness can be present. In a reactional state, the affected nerve will be tender to palpation or spontaneously painful. Neuritic leprosy may lead to paresis, hypotonia and atrophy, particularly of the muscles of the hands and feet. Paralysis of muscles leads to deformities such as claw hand, claw toes, wrist-drop, foot-drop, lagothalmos, etc.

Other changes include anhidrotic, dry, glossy skin, blisters, and painless ulcers. As in tuberculoid leprosy, spontaneous regression may occur in early cases of primary neuritic leprosy[23]. Primary neuritic leprosy lacks two diagnostic signs of leprosy, i.e. the typical skin lesions and the presence of acid-fast bacilli in skin smears. A biopsy of the cutaneous nerve near the site of the neurological deficit may be of diagnostic help in some cases. Histopathological changes due to tuberculoid, borderline-tuberculoid and borderline-lepromatous leprosy have been described in primary neuritic leprosy.

Fig. 34 Psoriasis-like scaly lesion of tuberculoid leprosy

Fig. 35 Great auricular nerve abscess

Borderline Leprosy

Borderline leprosy is the most commonly encountered type of leprosy (Figs. 37–51). If untreated, this unstable type of leprosy may pass into the lepromatous end of the spectrum. It may be subdivided into borderline-tuberculoid (BT), mid-borderline (BB) and borderline-lepromatous (BL). Borderline leprosy lesions may be erythematous or copper-coloured infiltrated patches, raised in the centre (dome-shaped) and sloping towards the periphery, presenting an inverted saucer appearance (Fig. 49). Annular lesions in leprosy are mostly borderline. Skin lesions of borderline leprosy (BT and BB) usually have asymmetrical distribution. Depending on the patient's position in the borderline spectrum, the macular and other lesions vary greatly in number, size and shape. The nearer the patient is to the lepromatous end of the spectrum, the more numerous, more shiny, less well defined, less asymmetrical and less anaesthetic they are. Hypoaesthesia and impairment of hair growth on the lesions are characteristics of borderline leprosy (Table 3). These features are more marked in borderline-tuberculoid (BT) than in borderline-lepromatous (BL) leprosy. The damage to nerves is widespread and frequently leads to crippling deformities. It is in this type of leprosy that the most extensive and serious effects of nerve damage are seen.

In the lesions themselves, bacilli may usually be demonstrated by the slit and scrape method, their concentration increasing from very few found in the near-tuberculoid lesions to the large number seen in the near-lepromatous lesions.

Fig. 36 Scars following ulnar nerve abscesses in a patient with borderline-tuberculoid leprosy

Fig. 37 Well-demarcated, annular patch of borderline-tuberculoid leprosy and a satellite lesion

Fig. 38 Raised, fairly well-defined lesions of borderline leprosy and an enlarged greater auricular nerve

Table 3
Characteristics of sub-types of borderline leprosy

Characteristics	Borderline-Tuberculoid (BT)	Mid-Borderline (BB)	Borderline Lepromatous (BL)
Skin lesions: Number	Few	Some	Many
Distribution	Asymmetrical	Asymmetrical	Roughly symmetrical
Description	Usually well-demarcated, somewhat dry. May be annular with clearly defined outer border. Surface may be scaly.	Less well-demarcated, somewhat shiny lesions. Often annular lesions with characteristic, punched-out appearance (the outer border is vague, while the inner border is clearly defined).	Shiny macules, papules, nodules and plaques with sloping edges (Figs. 48, 49).
Sensory impairment in lesions	Marked	Moderate	Slight
Impairment of hair growth in lesions	Marked	Moderate	Slight
Peripheral nerve involvement	Widespread or asymmetrical	Widespread and asymmetrical	Widespread and less asymmetrical
Bacterial Index (Ridley's scale) in skin lesions	Nil*	2+ to 3+	4+ to 5+
Paucibacillary or multibacillary	Paucibacillary	Multibacillary	Multibacillary
Reactions	Reversal (Type 1)	Reversal (Type 1)	Reversal and/or ENL (Type 2)

A patient may have BT/BB or BL/LL lesions[20].

* Any smear-positive case of TT, BT or indeterminate leprosy should be classified and treated as a case of multibacillary leprosy, even if it is only 1+ positive.

Fig. 39 Marginally raised, hypoaesthetic lesion of borderline-tuberculoid leprosy near the angle of the mouth

Fig. 42 Borderline-tuberculoid leprosy on the scrotum

Fig. 40 Marginally raised, large patch of borderline-tuberculoid leprosy and satellite lesions on the face

Fig. 43 Well-defined, exceptionally large anaesthetic patch of borderline-tuberculoid leprosy

Fig. 41 Multiple, well-defined, raised, erythematous, scaly patches of borderline-tuberculoid leprosy on the face. Skin smears were negative for **M. leprae**

Fig. 44 Raised, copper-coloured plaque of borderline-tuberculoid leprosy with central depression and satellite lesions on the back

Fig. 45 Typical borderline leprosy lesion with central "immune area"

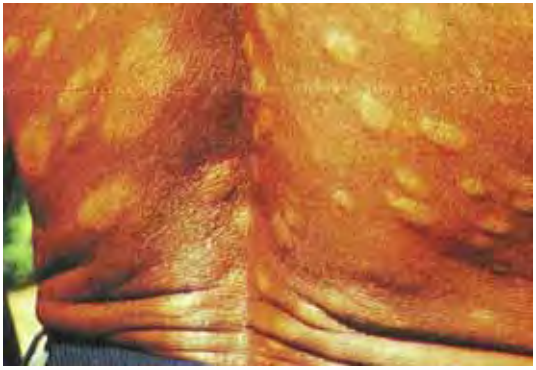


Fig. 48 Numerous, widespread, shiny, raised patches of borderline-lepromatous leprosy, sloping towards the periphery

Fig. 46 Numerous, well-defined, scaly plaques of borderline-tuberculoid leprosy

Fig. 49 Numerous, copper-coloured, raised patches of borderline-lepromatous leprosy, sloping towards the periphery

Fig. 47 Numerous, widespread, hypopigmented, hypoaesthetic macules of borderline leprosy

Fig. 50 An Indonesian patient with borderline-lepromatous leprosy

Fig. 51 Several shiny nodules and plaques of borderline-lepromatous leprosy

Lepromatous Leprosy (LL)

Lepromatous leprosy patients are specifically anergic to **M. leprae** and their tissues are ideal for the multiplication of leprosy bacilli. However, patients with lepromatous leprosy do not have a general immune deficiency. The mechanism underlying the selective absence of cellular response to the antigens of **M. leprae** in patients with lepromatous leprosy is unclear. Various hypotheses have been put forward, e.g. interleukin-1 (IL-1) or interleukin-2 (IL-2) deficiency, a decrease in IL-2 receptors, the presence of suppressor macrophages, the excess of suppressor T-lymphocytes, a deficiency of antigen-specific T-lymphocytes, and receptor blockade. Multiple factors may be responsible for the cellular anergy in lepromatous leprosy.

Diffuse redness of the face becoming worse on exposure to sunlight, erythema nodosum leprosum, nasal discharge with or without blood and nasal stuffiness may be early manifestations of lepromatous leprosy. Ulceration on the nasal mucosa is a common finding, and the nasal septum is a site of predilection. Saddle-nose deformity may develop. Leprosy bacilli and lepromata are also found in lymph nodes, spleen, liver, bone marrow, adrenal glands, smooth and striated muscles, tooth pulp and testes. Nose, testes and eyes are frequently affected in lepromatous leprosy.

Eye complications seriously threaten a patient's quality of life[24]. Involvement of testes leads first to sterility, while gynaecomastia and impotency are later developments. Even at an early stage, the peripheral nerves are laden with leprosy bacilli and may be enlarged at the sites of predilection. As the disease advances, the nerve trunks are liable to become fibrosed and paralysed, resulting in extensive anaesthesia, claw hand and foot-drop. Anaesthesia usually begins in the hands and/or feet and eventually affects all four limbs. Ichthyosis and chronic oedema of the legs (which becomes more pronounced in the evening) are usual in patients with lepromatous leprosy.

Macules appear in the early phase of lepromatous leprosy and are usually small, multiple and symmetrical in distribution (Table 4). They have a smooth, shiny surface, while their margins are indistinct and merge imperceptibly with the surrounding skin. Lepromatous macules may appear faintly erythematous on fair skins and copper-coloured on dark skins. They become more evident after exposure to sunlight. There is no loss of sensation in the lesions. Eyebrow hair is sparse. As lesions are hazy, indistinct and asymptomatic, they may not be noticed by the patient.

Infiltrated lepromatous leprosy is the stage which succeeds the macular form. The infiltrated skin is thickened, erythematous and shiny. Infiltrated plaques are glossy, soft and slope towards the periphery. Sensory loss is slight or negligible in the infiltrated areas. The eyebrows are usually lost, starting in the lateral third (Fig. 56).

Fig. 52 Ill-defined, coalescing, hypopigmented patches of multibacillary leprosy studded with multiple nodules

Fig. 53 Numerous, highly bacilliferous, shiny, glossy nodules of lepromatous leprosy

Nodular lesions are present in still more advanced lepromatous leprosy and are due to marked aggregation of the infiltrate. Usually starting on the ears, they appear on the face, extremities, trunk, joints and very rarely on the genitalia. Nodules may be of the normal skin colour (Fig. 54) or erythematous (Fig. 53) or copper-coloured (Figs. 55, 56). They may be small or large, soft or hard, sessile or pedunculated and might appear in an annular pattern. Multiple nodules on the face lead to "facies leonina", a lion-like appearance. Nodules are in the skin and not in the subcutis (therefore the skin cannot be moved over them). Not all patients pass through an initial macular phase, and in such patients the first indication of leprosy infection may be the development of nodules on the face, especially on the ears[25].

Lepromatous leprosy is usually a generalized disease. However, there have been rare reports of lepromatous leprosy presenting a single plaque or nodule with a high Bacteriological Index (BI) and characteristic histopathological features.

Fig. 54 Skin-coloured nodules of lepromatous leprosy on the ear

Fig. 55 Shiny, glossy, copper-coloured nodules of lepromatous leprosy on the chin

Fig. 56 Glossy, copper-coloured nodules and diffuse lepromatous infiltration of the face, with loss of eyebrows

Fig. 57 Multiple lepromatous nodules on the face

Fig. 58 Multiple lepromatous nodules on the face leading to "facies leonina"

Special Forms of Lepromatous Leprosy

Lucio leprosy (diffuse lepromatosis, Latapi) is a special form of lepromatous leprosy first described in 1852 by Lucio and Alvarado in Mexico. It is characterized by a diffuse widespread infiltration (Fig. 60) of the skin (without formation of nodules), loss of body hair, loss of eyebrows and eyelashes and widespread sensory loss. The skin contains numerous leprosy bacilli. In older patients, diffuse dermal infiltration may smooth out the wrinkles on the face, resulting in a youthful appearance, sometimes called "lepra bonita" (pretty leprosy)[20]. Lucio leprosy is due to the total lack of host resistance and is rare outside Mexico and Central America.

Histoid leprosy is characterized by the formation of firm, erythematous or copper-coloured, glistening nodules and/or plaques in the skin and subcutis of multibacillary patients who have discontinued the treatment, or because leprosy bacilli have become drug-resistant (Figs. 61, 62). This term was introduced by Wade in 1963. It is called histoid because biopsy shows elongated or spindle-shaped histiocytes containing bacilli and showing a whorled arrangement (Fig. 63). Globi are absent. Histoid lepromas (neural histoid), occurring in the peripheral and cutaneous nerves, may be mistaken for a nerve abscess[26]. A family comprising three generations, in which eight members were suffering from histoid leprosy, has been reported from Libya.

Fig. 59 An Indonesian patient with glossy, diffuse lepromatous infiltration of the face, and loss of eyebrows

Fig. 60 Highly bacilliferous, diffuse lepromatous leprosy, with no nodule formation

Fig. 61 Multiple nodules of histoid leproma in a patient with borderline-lepromatous leprosy

Fig. 62 Multiple (in places crusted) nodules of histoid leprosy in the same patient (Fig. 61)

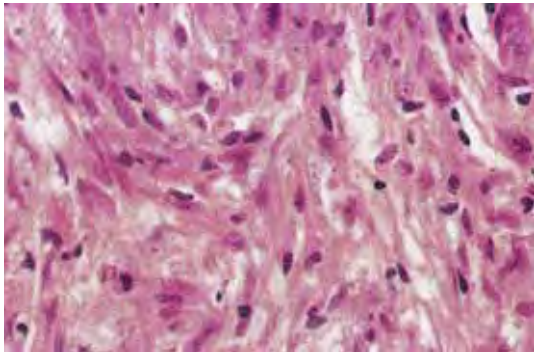


Fig. 63 Histoid granuloma with spindle-shaped histiocytes, HE stain

Table 4
Characteristic features of different types of leprosy

	Indeterminate (I)	Primary (or Pure) Neuritic (PN)	
Skin lesions	Usually single, ill-defined, hypopigmented or faintly erythematous macule	Skin lesions are absent	
Sensory impairment	Slight	Marked in the affected areas	
Peripheral nerves	Normal	Mostly asymmetrical enlargement of single or at times several nerve trunks, resulting in anaesthesia; paresis, deformities and trophic changes; nerve abscesses may be formed.	
Skin smear	Negative		
Skin biopsy	May reveal acid-fast bacilli in dermal nerve fibrils infiltrated with lymphocytes. Usually there is no granuloma.	Biopsy of a sensory cutaneous nerve twig may confirm the diagnosis; the underlying changes are in most cases due to tuberculoid or borderline leprosy.	
Course and prognosis	May regress or progress to other definite types of leprosy.	May shift either way but usually to tuberculoid type; this variety is not uncommon in India.	

Tuberculoid (TT)	Borderline	Lepromatous (LL)
Single or few, asymmetrical, well-defined, hypopigmented, erythematous or copper-coloured patches; the entire patch or only its edge is raised above the surrounding skin; or well-demarcated, hypopigmented patches not raised above the level of the surrounding skin.	A few or several, asymmetrical, hypopigmented, erythematous or copper-coloured, partly well-defined patches; annular and punched-out lesions are characteristic.	Very numerous, symmetrically distributed, erythematous or copper-coloured, shiny macules, papules and nodules; macules are ill-defined; patient may have leonine face, loss of eyebrows and eyelashes.
Marked	Slight to marked	None in early cases Extensive in late stages
Peripheral nerve trunk related to the lesion may be enlarged; nerve abscess may be formed.	Several peripheral nerves become asymmetrically enlarged; serious widespread neuropathy may occur.	Many peripheral nerves are affected and result in extensive anaesthesia.
Negative	Positive (1+ to 5+)	Always positive (5+ to 6+)
Foci of lymphocytes, epithelioid cells and Langhans giant cells are seen in the dermis. Nerves are densely infiltrated and often destroyed by the granuloma.	In BT the tuberculoid granuloma is more diffuse than in TT. In BB there is a diffuse, epithelioid-cell granuloma; giant cells are absent. In BL the granuloma is composed of macrophages with varying numbers of lymphocytes. A granuloma-free, subepidermal zone is seen in all types of borderline leprosy.	The epidermis shows thinning and flattening of rete ridges. A granuloma-free clear zone is seen. Diffuse, highly bacilliferous granuloma in the dermis consists of macrophages. Vorchow's cells (lepra cells) with vacuolated, foamy cytoplasmare characteristic of lepromatous leprosy.
Relatively benign and stable type of leprosy.	Unstable, may progress to subpolar lepromatous (LLs) leprosy; prognosis is variable; prone to reactions.	Principal source of infection, prone to ENL reactions; if untreated prognosis is poor.

7 Eye Involvement in Leprosy

The eyes are frequently affected in leprosy and most eye complications occur in advanced lepromatous cases. **Leprosy is a leading cause of blindness worldwide. Blindness in persons suffering from leprosy is an irreversible double tragedy, since often such persons can neither see nor feel**[27]. Therefore, involvement of the eye seriously affects the patient's quality of life and causes an additional intolerable burden on him and his relatives.

The anterior (front) segment of the eye, which is cooler than its posterior segment, is one of the parts of the body most commonly affected by leprosy. The lesions are confined to the cornea, conjunctiva, eyelids, episclera, sclera, iris, ciliary body and front part of the choroid. Leprosy lesions in the posterior segment are very rare and may manifest as yellowish nodules on the retina. Direct infection of the eye by **M. leprae** occurs mainly in lepromatous leprosy and is mainly bloodborne. **M. leprae** may also reach the eye from the skin of the eyelids, the meibomian glands or from the nose, via the lacrimal drainage system. Fortunately, most of the significant changes can be easily detected with relatively unsophisticated instruments, such as a corneal loupe and a penlight, during clinical examination of the eye, which can be done in a few minutes.

When examining the eyes of a person with leprosy:

- Ask him/her about pain in the eye and blurring of vision
- Examine each eye, beginning with the eyebrows, followed by eyelids, eyelashes, conjunctiva, sclera, cornea, iris and pupil
- Observe for blinking
- Palpate the eye through closed eyelids, to check for tenderness and to feel the intraocular pressure, with the tips of both index fingers
- Test ability to close the eyes, pupillary reaction with the penlight, corneal sensitivity with a wisp of sterile cotton wool, record the visual acuity and if possible determine intraocular pressure with a tonometer and evaluate the cornea by fluorescein staining.

Since eye lesions develop insidiously, often without pain and other symptoms, it is essential that the eyes of every leprosy patient are examined both in the field clinics and in the hospitals. It should be borne in mind that not only leprosy but other conditions, e.g. glaucoma, trachoma, nutritional deficiencies, etc., could also be the cause of the detected eye lesions. Blindness due to leprosy is largely preventable if the eye complications are detected early and provided the patient receives regular and adequate treatment, and follows instructions given to him by the physician or paramedical worker.

Anatomy of the Eye

In order to understand the eye lesions in leprosy and to detect them in time, health workers need to know the basic anatomy of the eye (Figs. 64, 65).

Eyelids: The eyelids serve to protect the eye. The skin of the lids is loose and elastic, permitting enormous swelling in inflammatory and traumatic conditions. The tarsal plates consist of dense fibrous tissue lined posteriorly by conjunctiva. There are two sets of muscles in the eyelids. The levator palpebrae, innervated by the third cranial nerve, opens them, and the orbicularis oculi, innervated by the zygomatic and temporal branches of the seventh cranial (facial) nerve, closes them. The glands that are situated in the lids are the meibomian glands and the glands of Moll and Zeis. The meibomian glands, which are embedded in the tarsal plate and open on the free margin of the lid very

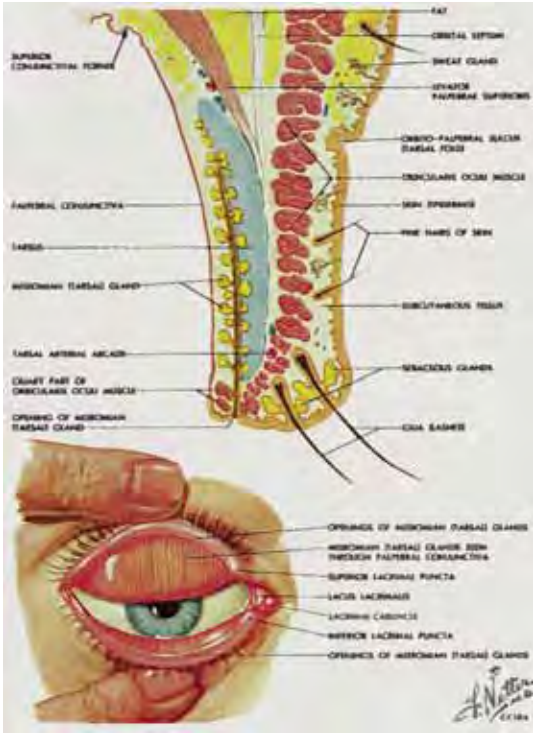


Fig. 64 Anatomy of the eyelid

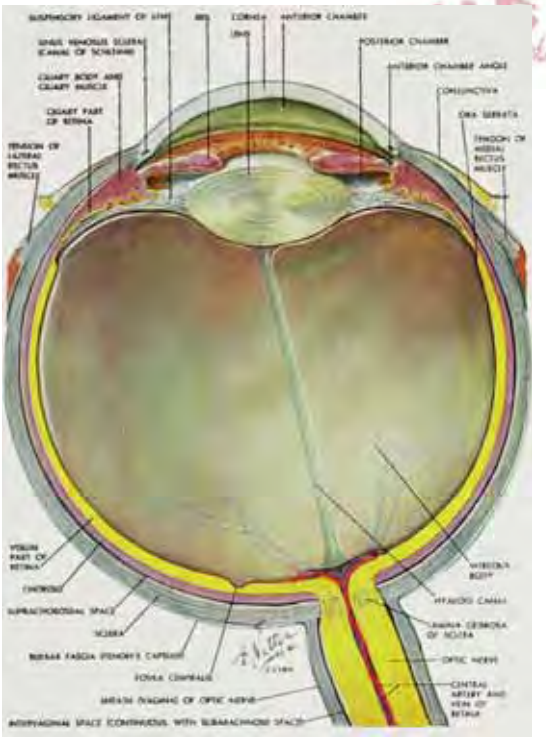


Fig. 65 Anatomy of the eyeball

close to its posterior border, produce mucolipid secretion which forms an oily layer over the tear film. This oily layer prevents surface evaporation of the watery lacrimal secretion.

Lacrimal apparatus: This consists of lacrimal gland, accessory lacrimal glands, lacrimal puncta, canaliculi, lacrimal sac and nasolacrimal duct. The lacrimal gland is located in the anterosuperior temporal portion of the orbit. The tears pass down over the cornea and conjunctiva, wetting these surfaces, and drain into the lacrimal canaliculi through the puncta at the nasal ends of the upper and lower lids. These two canaliculi join to form a single canaliculus which opens into the lacrimal sac. The sac lies in the bony lacrimal fossa. The downward continuation of the sac is the nasolacrimal duct which opens into the inferior meatus in the nose.

Conjunctiva: This transparent, thin mucous membrane lines the posterior surface of the lids and the anterior portion of the sclera. Anteriorly it is continuous with the corneal epithelium. That portion lining the lids is called the palpebral portion and that which lines the sclera is the bulbar portion.

Cornea: This transparent and avascular tissue acts as a refractive and protective window through which light rays pass to the retina. The avascular cornea receives its nourishment mainly from the aqueous humour and also from the lacrimal secretion and capillaries at the limbus.

Sclera and episclera: The sclera is the dense fibrous outer coating of the eye and consists of collagen and elastic tissue, which is anteriorly continuous with the

Fig. 66 Bilateral lagophthalmos

Fig. 67 Lagophthalmos corrected by Thangaraj's technique

cornea and posteriorly with the dural sheath of the optic nerve. The limbus is the junction between cornea and sclera. The episclera is a fibroelastic structure and the vascular coat on the surface of the sclera, providing part of its nutrition.

Eyeball: The eyeball proper has 3 layers. The outer protective coat consists of the posterior five-sixths, called sclera, and the anterior one-sixth, known as cornea. The middle layer is the uveal tract. The inner layer is the retina. The anterior chamber is the space between the iris-lens and the posterior surface of the cornea. It and the posterior chamber (the small narrow space between the iris and the lens) contain aqueous humour. Behind these chambers is the vitreous body, consisting of a globe of transparent gel, the vitreous humour.

Uveal tract: The iris, ciliary body and choroid form a continuous structure called the uveal tract. The iris is the anterior extension of the ciliary body. It is a muscular diaphragm with a round aperture in the centre called the pupil, which functions like a camera aperture. The ciliary body extends forward from the choroid to the iris for a distance of about 6 mm. The contraction and relaxation of the ciliary muscles result in the lens becoming more or less convex, for near or distant vision respectively. The choroid lies between the sclera and the retina. It consists of blood vessels and provides nourishment to the outer one-third of the retina.

Lesions of the Eye and Neighbouring Structures

Eyebrows: Thinning or baldness of the eyebrows is an early sign of lepromatous leprosy and is due to the deep-seated infiltration. This often leads, in advanced stages, to complete loss of eyebrows and this condition is called madarosis.

Eyelashes: Lepromatous infiltration may cause loss of some lashes and atrophy of the tissues supporting the remaining lashes which then hang limply against, or actually turn in towards the eye. The condition is known as trichiasis. Trichiasis causes irritation which may lead to corneal vascularity and opacity. The patient should be advised to refrain from rubbing the

eye. Treatment of trichiasis is by manual epilation (of temporary benefit) or electrolysis of the eyelashes. Plastic surgery to correct the inversion of the lid margin (entropion) may be necessary.

Eyelids: In persons suffering from multibacillary leprosy, the eyelids may be infiltrated and show a few nodules which resolve with multidrug therapy (MDT). **The most common eye problems in leprosy are lagophthalmos and corneal insensitivity**, which can occur in all types of the disease. In the borderline and tuberculoid types they occur early in the course of the disease, in association with skin lesions on the face and especially during Type 1 lepra reaction, while in lepromatous cases such changes manifest late in the course of the disease and the lagophthalmos is usually bilateral (Fig. 66). Lagophthalmos is caused by the paralysis of the orbicularis oculi muscle. Lagophthalmos may be partial or complete, unilateral or bilateral. The patient is unable to close the eyes and this results in a staring look, with the lids wide open (unblinking stare). He is prone to develop conjunctivitis, exposure keratitis and corneal ulceration resulting from failure of eyelid function, e.g. cleaning the cornea and keeping it moist. Lagophthalmos accompanied by corneal anaesthesia may lead to corneal ulceration and blindness, if not properly treated. However, with proper treatment, blindness due to lagophthalmos is totally preventable.

Investigations:

1. Ask the patient if he has pain, itching or any other symptoms.
2. Ask the patient to close the eyes, at first gently, as in sleep, and then tightly with maximum effort.
3. Look for roughening of the cornea or inflammation indicating keratitis or conjunctivitis. In spite of severe symptoms of dryness (burning, irritation and excessive tearing) the eye may look fairly normal.
4. Check for corneal anaesthesia with a wisp of sterile cotton wool.
5. Evaluate the cornea by fluorescein staining.

Treatment: Dryness due to exposure should be prevented by wearing goggles. Tear substitutes, such as 1% methyl cellulose, are helpful as eyedrops for daytime use. For protection during sleep, oily drops, e.g. castor oil or liquid paraffin, or bland ointments are better, and for extra protection a simple eyeshield should be taped over the affected eye. Tarsorrhaphy, performed to reduce the palpebral fissure, is required in severe cases, particularly with corneal anaesthesia. Gillies' or Thangaraj's temporalis muscle tendon transfer operation (Figs. 66, 67) provides an artificial blink and may be performed.

Lacrimal apparatus: In patients with nasal ulceration and scarring, the lower end of the nasolacrimal duct may become blocked. These patients are susceptible to infection of the lacrimal sac. This condition is known as dacryocystitis. This may be acute, subacute or chronic. It is necessary in all cases to test the patency of the nasolacrimal duct. Chronic dacryocystitis is most commonly seen. On pressing the area over the sac, the infected material may be squeezed out through the puncta. This condition is treated with systemic antibiotics and regular irrigations with saline and appropriate antibiotic solution. In extreme cases, surgery is performed to establish a new drainage system or to excise the sac.

Conjunctiva: Continued exposure often leads to chronic conjunctivitis. Lepromatous nodules and erythema nodosum leprosum lesions may appear on the conjunctiva. Conjunctivitis due to exposure may be treated with bland wetting drops, topical antibiotics

and temporary closure of the eyes with a tape or by tarsorrhaphy.

Sclera and episclera: In persons with advanced lepromatous leprosy, smooth-surfaced nodules of a yellowish-pink tinge may develop on the sclera near to, or at the limbus. They may be plaque-like or globular in shape and are painless unless some associated inflammation is present. A very large nodule may overshadow the cornea and interfere with the normal function of the eyelids, of spreading the tears over the cornea. A small strip of cornea may then become dry and ulcerated. In the case of a large nodule, its excision by trained personnel to restore normal eyelid function is advisable. Scleritis and episcleritis may occur as manifestations of Type 2 lepra reaction. The attacks may be repeated. Episcleritis is characterized by very tender red patches. Corticosteroid eye drops should be instilled hourly, initially, and the frequency reduced as quickly as the condition permits. Corticosteroid eye ointment is useful for night-time use.

Scleritis is less common than episcleritis. It is a serious complication which may result in scleral perforation. It is characterized by very tender discrete red patches. The patient complains of severe, deep circumorbital pain radiating back to the temple. Management comprises topical corticosteroid drops, subconjunctival corticosteroid injections and/or systemic corticosteroids.

Cornea: Corneal lesions due to direct infection by **M. leprae** occur in lepromatous leprosy. In some advanced cases, corneal lepromas (nodules) may be seen at the lateral part of the corneascleral junction (Fig. 68). Early lesions are located in the corneal nerves and the superficial layers of the cornea in the upper temporal quadrant. Later on, other quadrants, the pupillary area and deeper layers of cornea are affected. The infiltrates are discrete at first but coalesce as the disease progresses. To begin with they are avascular, but secondary lepromatous pannus may follow if the disease progresses. Infiltrates consist mainly of macrophages full of **M. leprae**. The lesions are first seen as faint, circumscribed (discrete) opacities close to the margin of the cornea (superficial punctate keratitis).

Later on they coalesce to form a diffuse haze. Discrete lesions caused by newer infiltrates may be seen at the advancing margin of the diffuse haze. In some cases, tiny denser opacities appear in the affected area. These consist of clumps of globi, full of leprosy bacilli in their initial stage, some of which become calcified. Macroscopically they resemble chalk dust. These are called lepromatous “pearls” and are pathognomic of the disease. These specific corneal infiltrates are symptomless unless the pupillary area is involved, causing visual impairment[28]. In Type 2 lepra reaction the avascular cornea is not affected unless it has been vascularized by the previous disease process. Type 2 lepra reaction affects predominantly vascular structures, e.g. the episclera, the iris, the ciliary body and at times the sclera. Severe iridocyclitis may cause oedematous, dull-looking, cloudy cornea.

Corneal sensation is impaired if terminal branches of the ophthalmic division of the 5th cranial (trigeminal) nerve are damaged. Patients with corneal hypoaesthesia (partial anaesthesia) ignore injuries, dryness of the cornea, infections and inflammations. They do not blink as often as necessary, due to the absence of pain, and are prone to develop keratitis and corneal ulcers. There may be varying combinations and degrees of damage to the trigeminal and facial nerves. Both paucibacillary and multibacillary cases can be affected. In

all patients with lagophthalmos, corneal sensation should be tested with a wisp of sterile cotton wool. **The eye is in serious danger if lagophthalmos is associated with corneal insensitivity**.

Exposure keratitis following lagophthalmos usually involves the lower exposed portion of the cornea and can lead to corneal ulceration. The healing of the ulcer is rather slow in persons with impaired corneal sensation. The extent of the ulcer and also the improvement with treatment can be determined by the use of fluorescein which stains the ulcer light green or yellow (Fig. 69). Immediate referral to an eye specialist is advisable. The treatment consists of topical antibiotics (ointment or drops), systemic antibiotics, 1% homatropine ointment or drops, and temporarily closing the eye with an adhesive tape or occasionally by suture of the lids.

Iris and ciliary body: Early lesions due to direct infection by **M. leprae** are characterized by microlepromata or pearls resembling chalk particles on the iris, first seen near the pupillary margin. Larger, hypopigmented nodules may occasionally be seen in highly active longstanding multibacillary leprosy. Large pearls can be easily seen with a corneal loupe, while small ones require a corneal microscope (slit lamp).

In Type 2 lepra reactions, acute iridocyclitis (iritis, anterior uveitis) is commonly reported. Recurrent attacks of acute iridocyclitis may occur over several years. Clinical features include “red eye”, in which the inflammation is maximal around the limbus rather than peripheral or generalized as in conjunctivitis, pain, blurring of vision and diminution in visual acuity, photophobia with increased lacrimation, constriction of the pupil which does not respond readily to light, and cloudiness of the anterior chamber. Cloudiness of

Fig. 68 Corneal leproma in a patient with lepromatous leprosy

Fig. 69 Corneal ulcer stained with fluorescein, and hypopyon

Fig. 70 Corneal opacity in a patient with lepromatous leprosy

the anterior chamber is due to inflammatory exudation of white cells floating in the aqueous humour. This is the very earliest sign of iridocyclitis but unfortunately it can only be detected with the use of a slit-lamp microscope. These cells form keratic precipitates on the cornea. **Occasionally, an attack of iridocyclitis may be the first sign of lepromatous leprosy.** Between the acute exacerbations, chronic low-grade inflammation may persist and result in adhesions of the iris to the lens (posterior synechiae), irregular pupil, secondary glaucoma, cataract, iris and ciliary body atrophy, and finally in a soft, blind eye (phthisis bulbi). **Chronic iridocyclitis is one of the principal causes of blindness in persons suffering from leprosy.**

In both the acute and chronic types of iridocyclitis, atropine and corticosteroids can be given in the form of drops or ointment. Subconjunctival mydriatics and/or corticosteroids are also given. If the intraocular pressure is high, Diamox (acetazolamide) can be given until it returns to normal. If the posterior synechiae have formed a complete ring round the pupil, an iridectomy is recommended to prevent secondary glaucoma. In cases of cataracts due to iridocyclitis, one should wait at least six months after the last attack of iridocyclitis before attempting surgery.

Reaction in the eye will usually be part of a general Type 2 lepra reaction which may demand systemic anti-inflammatory treatment. Systemic corticosteroids are effective when given in adequate dosage. Clofazimine will control both the acute exacerbation and underlying lepromatous infection. **Beware of a leprosy patient who presents with a "red eye". The first thing to suspect is acute iridocyclitis.** Two other conditions, namely acute conjunctivitis and acute glaucoma, should be excluded. In conjunctivitis the patient complains of mucoid or purulent discharge with matting of the eyelids in the morning, but with no loss of vision. The cornea is clear and pupillary reactions are normal. Acute congestive glaucoma is an extremely painful condition. Watering of the eyes is present and on digital palpation the eyeball will feel hard. The cornea will appear cloudy and the pupil is oval, irregular, dilated and does not react to light. There will be marked impairment of vision, and the intraocular pressure is raised. It is important to differentiate these conditions, and it is best to refer these cases to an ophthalmologist.

Practitioners and paramedical workers can help a great deal in detecting early lesions. They should always have a penlight and magnifying lens (corneal loupe) at hand so that they can examine the eyes of all leprosy patients. **The eyes should be examined every time the patient attends the clinic for his medication** and special attention should be given to patients with long-standing lepromatous leprosy, since they are at the greatest risk. **They should be warned to report immediately any pain or redness in the eye, and the doctor himself should watch for premonitory signs.** Often the patient may not complain, since some early lesions do not cause any symptoms, or the eye may be hypoaesthetic. In these cases, early detection of eye lesions by routine examination is of enormous value in preventing progression of the disease.

8 Differential Diagnosis

Leprosy presents under various guises and mimics a variety of entirely unrelated diseases. The diseases for which leprosy may be mistaken are thus many and varied.

Differential Diagnosis of Skin Lesions

The skin lesions in question may be described under three groups, namely macular (flat), infiltrated (raised) and nodular lesions.

Differential Diagnosis of Macular Lesions

Vitiligo: The developing lesions of this disease, with incomplete loss of pigmentation, may be mistaken for hypopigmented macular lesions of leprosy. Since sensation in the vitiliginous patches is normal, careful examination clears the confusion. Typical lesions of vitiligo, being milk-white in colour, are quite easy to diagnose. The lesions do not show changes in skin patterns. In several countries, in spite of its harmlessness, vitiligo unfortunately often shares the same prejudices as leprosy. Some persons even consider it a form of leprosy[29].

Occupational leucoderma: Hypopigmentation and depigmentation have been reported from contact with rubber footwear, rubber gloves and condoms. Hypopigmented lesions from contact with these substances, and simulating the macules of leprosy, are also encountered in developing countries[29]. Unlike leprosy, sensation and sweat function are normal in these lesions. Moreover, the history of any occupational contact with one of the aforementioned substances is of diagnostic help.

Tinea versicolor or Pityriasis versicolor: This common cutaneous fungal disease in tropical countries is characterized by the formation of superficial pigmented, scaly, irregular-sized patches located predominantly on the trunk and neck. Pseudoachromia, an apparent hypopigmentation, is due to non-tanning of the skin covered with the fungus; at times it is mistaken for the macular lesions of leprosy. The causative organism, **Pityrosporon orbiculare (formerly Malassezia furfur)**, can easily be demonstrated in the skin scrapings, and the sensation in the affected area is normal. Tinea versicolor lesions fluoresce under Wood's light.

Fig. 71 Hypopigmented lesion of vitiligo

Pityriasis alba or Pityriasis simplex facei: This skin disease is characterized by the formation of round or oval hypopigmented macules, with fine furfuraceous scales. The face, neck and shoulders are the sites of predilection. Sensation in the affected area is normal. Pityriasis alba may resemble indeterminate leprosy.

Post-kala-azar dermal leishmaniasis (PKDL): This is a sequel of visceral leishmaniasis with chronic dermal granulomatous changes. About 85% of the cases of PKDL have a past history of kala-azar. Hypopigmented patches, with or without erythema at the edges, appear on the trunk and face. They may be mistaken for the macular lesions of borderline or lepromatous leprosy.

Sensation in the affected area is normal and skin smears do not reveal AFB. The hypopigmented macular type is the earliest form of PKDL. Infiltrated patches and nodules appear later. The characteristic cell in the infiltrate is a macrophage containing Leishman-Donovan (LD) bodies. Most of the cases of PKDL have been reported from North-East India.

Nutritional dyschromia: Scaly, hypopigmented facial lesions, due to lack of balanced diet, are frequently seen in children in the tropics. They may be associated with intestinal parasites or gastrointestinal disturbances. In phrynoderma, the skin is dry, feels like a nutmeg grater, and pale scaly patches are seen at times. It may be due to a deficiency of vitamin B complex and/or essential fatty acids. In the lesions of nutritional dyschromia, sensation is normal.

Onchocerciasis (Craw-Craw): In areas where onchocerciasis is common, hazy hypopigmented areas on the back and thighs may be mistaken for lepromatous macules. Demonstration of the microfilariae of Onchocerca volvulus in skin snips, the absence of AFB in skin smears and the absence of sensory impairment

Fig. 73 Symptomless, indolent, verrucous plaque of lupus vulgaris on the left arm

Fig. 74 The same patient (Fig. 73) after 4 months' treatment with streptomycin and isoniazid in 1964

Fig. 72 Well-demarcated, scaly and warty plaque of tuberculosis verrucosa cutis in an African patient

Fig. 75 Well-defined, erythematous, infiltrated patch of lupus vulgaris on the right earlobe and adjacent area

Fig. 76 Well-defined, exceptionally large patch of lupus vulgaris

in the lesions are of diagnostic value. This disease is endemic in Guatemala, West and Central Africa, the Sudan and Mexico.

Herpes zoster: On healing, some cases of herpes zoster may leave a hypopigmented atrophic patch in which sensation may be impaired. The history of herpes zoster gives a diagnostic clue in such cases.

Naevus anaemicus or Naevus achromicus: These naevi are usually present at birth and do not show sensory loss or enlargement of the regional nerves.

Scars: Superficial hypopigmented scars from burns, scalds or abrasions may sometimes cause alarm in the minds of persons who have a history of contact with leprosy patients. The character of the scar and the history of its origin help in the diagnosis. In superficial scars, the regional nerves are neither enlarged and tender nor is sensation impaired.

Differential Diagnosis of Infiltrated (Raised) Lesions

Tuberculosis verrucosa cutis: The majority of lesions are found on the fingers or hands, and are caused by Mycobacterium tuberculosis. The infection commonly occurs at the site of an injury. The initial lesion is usually a papule which becomes thickened, encrusted and warty. Later, thick, sharply demarcated plaques may develop. The lesion may persist for several months or years and may resolve, leaving a scar. The disease usually occurs in adult persons who are caring for patients with tuberculosis, and in farmers or butchers who handle infected animals.

Lupus vulgaris: This is a prototype of skin tuberculosis, and its lesions may mimic the tuberculoid form of leprosy. As in leprosy, the lesions are erythematous, infiltrated, indolent, well defined and symptomless, but there is a tendency to ulceration and scar formation. The lesions tend to heal at one edge and spread from another, rather than healing centrally as in leprosy. However, enlargement of the regional nerves and sensory impairment are absent. On diascopy, "apple-jelly" nodules may be seen. Any part of the body may be affected, but the face, neck and gluteal region are sites of predilection (Figs. 73–77).

Lupus erythematosus: This collagen disease of unknown aetiology may be mistaken for reacting or non-reacting lesions of leprosy. In the discoid form, there are typical "batwing" lesions with erythema, atrophy, follicular plugging and adherent scales. The histology is characteristic. The cardinal signs of leprosy (e.g. sensory impairment, enlargement and tenderness of nerves and the presence of acid-fast bacilli in the lesions) are not found. Lupus erythematosus usually affects women of 30–50 years of age (Figs. 78, 79).

Fig. 77 Lupus vulgaris in an African patient

Fig. 78 Chronic discoid lupus erythematosus

Granuloma annulare: This disease may resemble the tuberculoid form of leprosy, but it is a relatively uncommon condition, affecting mainly children and young adults. It is usually characterized by the formation of papules or nodules in an annular pattern. The lesions are indolent and symptomless. The histology is characteristic, while the cardinal signs of leprosy are absent (Figs. 80, 81).

Granuloma multiforme: The first case of this disease was seen in a leprosy settlement in Western Nigeria, and was presented as a typical tuberculoid leprosy not responding to sulphones[30]. The early lesions are papulnodular; later they develop into well-defined plaques of various shapes and sizes. After some months, the lesions may subside spontaneously, leaving some hypopigmentation. The dermis shows an infiltrate composed of histiocytes, epithelioid cells, lymphocytes and foreign-body giant cells; Langhans cells may be present. Sensation in the affected area is normal. The cause is unknown.

Pellagra: Patches of this disease may simulate scaly, reacting tuberculoid or borderline leprosy. The lesions are usually symmetrical, symptomless and are associated with mental changes, malnutrition, alcoholism, stomatitis and diarrhoea. Sensation in the affected areas is normal. Pellagra is commonly seen in the Tropics, and the lesions respond rapidly to nicotinic acid (Figs. 83, 84).

Annular syphilides occurring in late secondary syphilis may be mistaken for the annular lesions seen in leprosy. The serological tests for syphilis (e.g. VDRL) are positive in patients with annular syphilides and the therapeutic response to penicillin is rapid. Cardinal signs of leprosy are absent.

Seborrhoeic dermatitis: The lesions are usually associated with dandruff and are found on the areas of maximum seborrhoeic activity, e.g. face, interscapular and presternal regions. Lesions are itchy and sometimes oozing. The cardinal signs of leprosy are absent. Therapeutic response to corticosteroid topicals is good.

Post-kala-azar dermal leishmaniasis: The erythematous, infiltrated, raised lesions of PKDL (Brahmachari's

disease) may resemble borderline leprosy. The absence of sensory impairment and of enlarged and tender regional nerves and the demonstration of LD bodies in the smear clear any clinical confusion. A past history of kala-azar is helpful. Circumoral lesions are common in PKDL.

Oriental sore: This tropical skin disease, caused by Leishmania tropica, is mainly seen in Iraq, Iran, Pakistan, India and the Sudan. The lesions may appear as discoid, indurated and infiltrated patches, which gradually increase in size and become ulcerated in the centre. The cardinal signs of leprosy are absent, while Leishmania tropica can be demonstrated in the smear. "Delhi boil", "Aleppo boil", "Baghdad boil" and "Kandahar sore" are synonyms for this condition, depending on the region in which it is found.

Tinea circinata: Ringworm or tinea circinata is common in tropical countries and may resemble tuberculoid leprosy. The lesions are pruritic and fungus can be demonstrated in the skin scrapings. The raised edge is often inflamed and may contain vesicles or crusts which are very rare in leprosy. Sweating and sensation are normal in the lesions. The regional nerves are neither enlarged nor tender.

Sarcoidosis: Infiltrated (raised) lesions of sarcoidosis may resemble tuberculoid or borderline leprosy, but sensation in the affected area is normal. The Kveim test is positive in sarcoidosis. The lymph glands, liver and spleen are enlarged in most cases. Sarcoidosis is relatively uncommon in tropical countries (Fig. 86).

Psoriasis: A well-defined, erythemato-infiltrated plaque of psoriasis, especially when denuded of scales by treatment, may resemble tuberculoid leprosy, while the lesions of reacting tuberculoid or borderline leprosy may appear psoriasiform. In psoriasis, the cardinal signs of leprosy are absent and the removal of silvery scales reveals small bleeding points. Psoriatic lesions are usually pruritic, multiple and symmetrical (Fig. 87). Histology is characteristic. The nails may show discrete punctate pits on the surface ("thimble nails").

Pityriasis rosea: The typical patient is an adolescent or young adult. Characteristically, lesions are red with a collarette of fine bran-like scales facing towards the centre. The Greek word "pityriasis" means bran. The

Fig. 79 Typical "bat-wing" lesions of discoid lupus erythematosus

Fig. 80 Disseminated lesions of granuloma annulare

herald patch is usually 1 or 2 cm in diameter. It may be confused with tuberculoid leprosy. However, histological changes are non-specific and there is no anaesthesia in the lesion. In a few days the herald patch is usually followed by lesions which are widely distributed, often along creases in the skin, and are concentrated on the trunk (Fig. 88).

Scars: Scars resulting from injuries may sometimes present themselves as hypopigmented patches even with some degree of sensory loss. However the history of injury and absence of other characteristic signs of leprosy will be able to clinch the issue.

Differential Diagnosis of Nodular Lesions

Post-kala-azar dermal leishmaniasis: An advanced case of PKDL with nodules on the face, neck and extremities may closely resemble lepromatous leprosy, but the absence of acid-fast bacilli and the presence of Leishman-Donovan (LD) bodies in the lesions are diagnostic. In addition, there is a positive history of kala-azar (Figs. 89, 90).

Cutaneous leishmaniasis: The disseminated anergic form of cutaneous leishmaniasis may be confused with lepromatous leprosy because nodules are numerous but they are teeming with LD bodies (Fig. 91).

Syphilis: Nodular and nodulo-ulcerative lesions may appear in the late phase of syphilis. Unlike lepromatous leprosy, syphilitic nodules are usually few and asymmetrical. A biopsy shows granulomatous inflammatory reaction with large numbers of plasma cells and varying numbers of histiocytes, lymphocytes, fibroblasts, epithelioid and giant cells. Smears from syphilitic nodules are negative for M. leprae, while the serological tests for syphilis are usually positive and the response to PAM (penicillin-G aluminium monostearate) or benzathine penicillin is rapid.

Onchocerciasis: This disease is prevalent in Central America and in tropical Africa. Nodules contain adult male and female Onchocerca volvulus. Puncture of the nodules reveals immature microfilariae and is diagnostic. The nodules may grow to the size of a hen's egg. The trochanters, sacrococcygeal region, knees, and the occipital and temporal areas are the sites of predilection.

Fig. 81 Localized lesions of granuloma annulare

Fig. 82 Granuloma multiforme

Fig. 83 Casal's necklace due to pellagra with the tooth-like hyperpigmented scales at the edge

Fig. 84 Pellagra patches on the trunk and arms

Fig. 85 Well-defined, pruritic and scaly lesion of tinea circinata

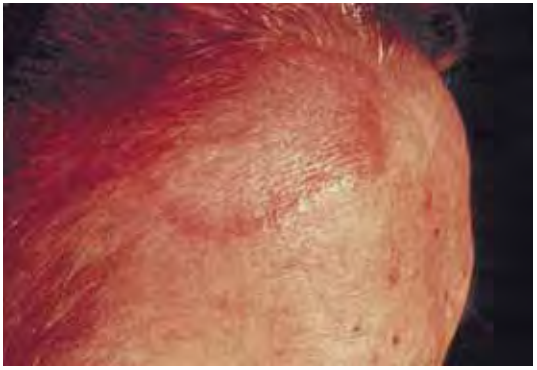


Fig. 86 Circinate sarcoidosis

Fig. 87 Well-defined, scaly plaques of psoriasis

Fig. 88 Herald patch of pityriasis rosea

Sarcoidosis: In this uncommon generalized disorder of unknown aetiology, papules, plaques and nodules are formed and the Kveim reaction is positive. Lymph glands are enlarged in 85% of the cases. The lungs are involved in 75% of the cases, while bones, especially of the fingers and toes, are frequently affected with a diffuse rarefaction (osteitis multiplex cystoides). The absence of acid-fast bacilli in slit-skin smears is of diagnostic help.

Leukaemia cutis: During the course of all types of leukaemia, but particularly in chronic lymphatic leukaemia, nodules and diffuse infiltrations of the skin may occur. Nodules of chronic lymphatic leukaemia may clinically resemble lepromatous leprosy. However, leukaemic lesions are pruritic and smears made from them are negative for acid-fast bacilli (AFB). The diagnosis is confirmed by blood examination. Leukaemic nodules are usually bluish red, rubbery in consistency and may grow to the size of a hen's egg. Raised plaques are also seen. The face, neck, shoulders, breasts and extensor surfaces are the sites of predilection.

Mycosis fungoides: A typical case of mycosis fungoides (granuloma fungoides, cutaneous T-cell lymphoma) with intensely pruritic plaques and red shiny tumours on the face and trunk may resemble lepromatous leprosy. The presence of mycosis cells permits a specific diagnosis. Granuloma fungoides is an uncommon, chronic and usually fatal disease occurring mostly in adult males (Figs. 92–94).

Nodules of von Recklinghausen's neurofibromatosis (Figs. 95–97) and of Kaposi's sarcoma may resemble lepromatous leprosy. A biopsy should distinguish the conditions, since histology is characteristic.

Fig. 89 Nodular lesions of post-kala-azar dermal leishmaniasis

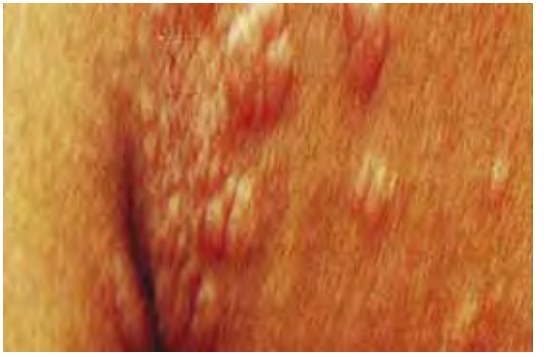


Fig. 90 Nodular lesions of post-kala-azar dermal leishmaniasis near the posterior axillary fold

Fig. 91 Disseminate cutaneous leishmaniasis

Fig. 92 Well-defined, pruritic, psoriasis-like scaly plaques of mycosis fungoides

Fig. 95 Nodules of von Recklinghausen's neurofibromatosis affecting the great auricular nerve

Fig. 93 Multiple plaques of mycosis fungoides

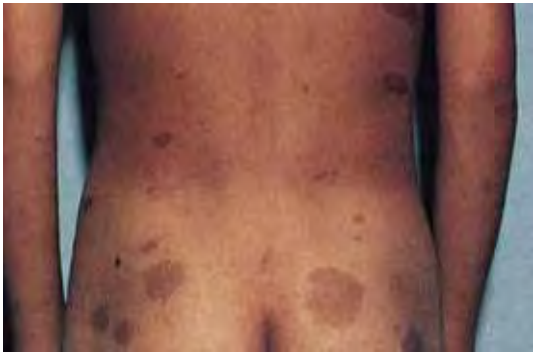


Fig. 96 The same patient (Fig. 95) with cafe au lait spots due to von Recklinghausen's disease

Fig. 94 Multiple, shiny nodules due to mycosis fungoides on the face of the same patient (Fig. 92)

Fig. 97 Multiple nodules of von Recklinghausen's disease

9 Diagnosis

Although leprosy is readily recognizable in the late stages, diagnostic difficulties may arise in the early stages, when clinical manifestations are developing.

Cardinal Signs of Leprosy

1. Hypopigmented or erythematous, well-defined skin lesions, e.g. macules or plaques, with definite loss of sensation.
2. Signs of peripheral nerve damage, such as sensory loss, paralysis or sudomotor dysfunction with or without nerve enlargement.
3. Finding acid-fast bacilli in the skin smears and/or biopsies taken from the skin lesions. It is important not to make the diagnosis unless the evidence is definite. Leprosy should be correctly diagnosed in its early stage, before irreversible damage to nerves has occurred. The diagnosis and successful treatment of leprosy can be one of the most rewarding and gratifying experiences in clinical medicine.

Clinical Examination

After taking the patient's case history with regard to complaints, past treatment, where the patient has lived, family contact with leprosy and his work, etc. the entire body should be examined in a good light. Suspected hazy areas must be viewed both directly and obliquely. The physician should look for symptomless, hypopigmented (pale) areas, pink or copper-coloured macules, infiltrations (raised patches) and nodules. Sensory loss is present in the majority of leprosy patients and often occurs in the following order: temperature and light touch › pain and pressure.

Sensory loss in the patches and/or in the distal parts of the extremities should be determined by touching the skin lightly with a wisp of cotton wool, a nylon thread or the tip of a ballpoint pen. This provides a more sensitive test than stroking. The test must be explained to the patient by first carrying it out with his eyes open. Touch the skin to be tested, e.g. with a nylon thread and ask the patient to point with his index finger to the exact spot where he feels the touch. Once the patient is familiar with the test procedure, it should be carried out with the eyes fully closed. As the acuity of sensation varies from one part of the body to another, the skin of the contralateral side should be examined for comparison. Heat sensation is tested with two test tubes – one containing hot water and the other cold – and pain sensation is tested by pinprick.

All three modalities of sensation, e.g. touch, temperature and pain, should be tested. Because of the rich nerve supply to the skin of the face, sensory changes may be relatively less evident there than in other areas of the body. The diagnosis of paucibacillary and especially of tuberculoid leprosy depends on these simple procedures. The presence of one or more chronic skin lesions associated with anaesthesia or hypoaesthesia should suggest leprosy.

Examination of Nerves

The great auricular, supraorbital, ulnar, median, radial, lateral popliteal and posterior tibial nerves should be palpated for tenderness, consistency and size. Affected nerves may be cord-like (Fig. 98) or beaded and may show thinning or abscess formation. In a reactional state, the nerve will be tender to palpation or spontaneously painful. To examine the great auricular nerve, the head should be turned to the opposite side,

while ulnar nerves are best palpated at the inner aspect of the elbow, with the elbow joint semiflexed. The radial nerve should be rolled in its groove on the humerus posterior to the deltoid muscle insertion. The median nerve is best felt in front of the wrist when the wrist joint is semiflexed. The lateral popliteal nerve should be palpated behind the neck of the fibula, with the knee joint semiflexed. The posterior tibial nerve should be palpated near the medial malleolus of the tibia. In the healthy subject most peripheral nerves are palpable. Tenderness should be noted and nerves on both sides should be compared. The muscles innervated by the affected peripheral nerves should then be tested for weakness (see page 102). The muscles most frequently involved are the intrinsic muscles of the hands and feet, the dorsiflexors of the ankle and the orbicularis oculi.

Fig. 98 Cord-like enlargement of the great auricular nerve

Bacteriological Examination

Skin smears should be taken from all patients suspected of having multibacillary leprosy. They should be made by the slit and scrape method from the most active-looking edge of a skin lesion and from ear lobes (see chapter 3). Gloves should be worn when taking skin smears. This investigation is not necessary if sensory loss is present.

Histological Examination

Skin biopsy: Histopathological evaluation is essential for accurate classification of leprosy lesions[31]. Skin biopsy is advisable:

1. If multibacillary (e.g. lepromatous or borderline-lepromatous) leprosy is considered likely but no acid-fast bacilli are seen in the skin smears; the examiner's scalpel may not have penetrated localized pockets of bacilli located deep in the dermis.
2. In the case of paucibacillary (especially in early tuberculoid or indeterminate) leprosy, if sensory impairment is not marked. Skin biopsy may be of diagnostic value in children in whom sensory deficit cannot be verified with certainty. Skin biopsies should include the full depth of the dermis and should be taken from the most active edge of a lesion. If a punch biopsy is performed, a 6-mm punch is recommended. Sections are usually stained with haematoxylin and eosin for histology. The following modification of Fite's method, which was developed in the Histopathology Laboratories of the Armed Forces Institute of Pathology, Washington, D.C., gives excellent results as a rule, especially after fixation in neutral formalin, and can be considered as the method of choice for staining AFB:
   1. Remove wax in 2 changes of xylene peanut oil (3:1) mixture, 7 minutes each change.
   2. Wipe off excess oil from back of slide.
   3. Blot section very gently with fine filter paper, 3 times.

4. Wash in running water for 5 minutes.
5. Rinse in distilled water.
6. Stain in carbol-fuchsin, 30 minutes.
7. Wash in running tap water, 2 minutes.
8. Decolorize in 1% acid alcohol until the section is pale pink.
9. Wash in running tap water, 2 minutes.
10. Counterstain in 0.15% methylene blue, 5 or 6 dips.
11. Wash in running water until section is pale blue, about 3 minutes.
12. Dehydrate quickly in absolute alcohol, 3 changes.
13. Clear in xylene, 2 changes, and mount.

The characteristic histological findings are as follows:

Indeterminate leprosy: The epidermis is normal. In the dermis there are scattered small clusters of mononuclear cells (mainly lymphocytes and a few histiocytes) around blood vessels, nerves and dermal appendages, with selective involvement of the neurovascular bundles. Usually there is no granuloma. In sections stained for acid-fast bacilli, few bacilli can usually be demonstrated in dermal nerve fibrils and/or arrectores pilorum muscles. Indeterminate leprosy is a diagnostic problem both for the clinician and for the pathologist because the clinical picture is vague and the pathological changes are non-specific. However, a careful correlation of the clinical and histological findings is helpful in the diagnosis of most patients with indeterminate leprosy.

Tuberculoid leprosy: Typical tubercles comprising epithelioid cells, Langhans giant cells and a surrounding zone of lymphocytes are found in the dermis (Figs. 99, 100). The granuloma may extend into and erode the basal layer of the epidermis. Cutaneous nerves are infiltrated and often destroyed. Very rarely, caseous necrosis of the nerve may be seen.

Borderline leprosy: As in lepromatous leprosy, in all types of borderline leprosy, especially in BL and BB cases, there is a granuloma-free, clear subepidermal zone in which leprosy bacilli are rarely seen. This zone was first described by a German dermatologist, P.G. Unna. In patients with borderline leprosy (BT to BL), the histological evidence may precede clinical manifestations by several weeks[9].

In borderline-tuberculoid (BT) leprosy there is a tuberculoid granuloma comprising epithelioid cells, giant cells and lymphocytes in the dermis and extending to the subcutaneous tissue. In some cases, lymphocytes may be fewer in number and the tubercle formation less evident. Giant cells are scanty. Dermal appendages and nerves are infiltrated by the granuloma. Because the destruction of the nerves is not as complete as in tuberculoid leprosy, partially destroyed nerves are often seen. A clear subepidermal zone is the most important feature which differentiates BT from tuberculoid leprosy.

In mid-borderline (BB) leprosy there is a clear subepidermal zone. The epithelioid cell granuloma is diffusely spread and not focalized by lymphocytes. Lymphocytes are scanty and diffusely scattered. Giant cells are absent. Cutaneous nerves may be fairly normal.

In borderline-lepromatous (BL) leprosy there is a clear subepidermal zone. The granuloma is mainly composed of macrophages, which are large cells with a granular cytoplasm and a large round or oval nucleus. Some of these macrophages have a foamy cytoplasm. Varying numbers of lymphocytes and epithelioid cells

are present with the macrophages. The cutaneous nerves show perineural inflammation.

In lepromatous leprosy, the epidermis shows thinning and flattening of rete ridges (Fig. 101). The characteristic histological finding is a diffuse, highly bacilliferous granuloma (leproma) in the dermis. The granuloma mainly consists of macrophages which fail to differentiate into epithelioid cells. Instead they become mere sacs containing multiplying leprosy bacilli. Lymphocytes are absent or scanty and there is no attempt to surround macrophages. In the late stages, the cytoplasm of macrophages undergoes fatty changes resulting in the formation of Virchow's foamy (lepra) cells, with a characteristic soap-bubble appearance and containing globi (Fig. 102). In lepromatous leprosy, the cutaneous nerves show perineural inflammation. In the early stages, the nerve parenchyma may appear normal, but as the disease advances it is replaced by hyalinized fibrous tissue.

Nerve biopsy: Biopsy of a thickened cutaneous sensory nerve may be of diagnostic help in primary neuritic leprosy. In such cases, it usually shows typical tuberculoid or borderline histology, together with bacilli in most borderline cases (Figs. 103–106). Cutaneous sensory nerves suitable for biopsy are: the radial cutaneous nerve just above the wrist, one of the nerves coursing over the dorsum of the hand, any nerve twig in the region of the elbow or the knee, the sural nerve at the back of the leg or at the lateral border of the foot, or a superficial peroneal nerve on the dorsum of the foot. There is no risk of motor damage, since these nerves do not contain motor fibres. A small sliver of a thickened cutaneous sensory nerve may be removed under local anaesthesia, fixed, sectioned, stained and examined both for the presence of acid-fast bacilli and for a histological picture of one or other forms of leprosy.

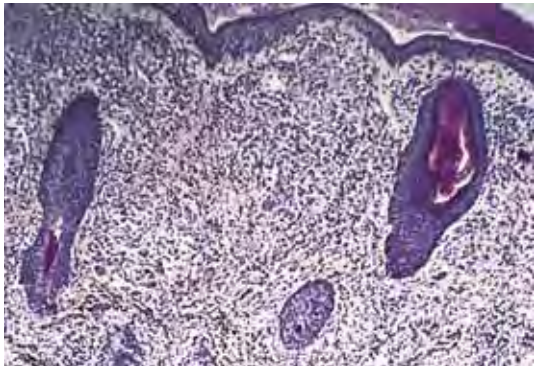


Fig. 99 Extensive tuberculoid granuloma in the dermis

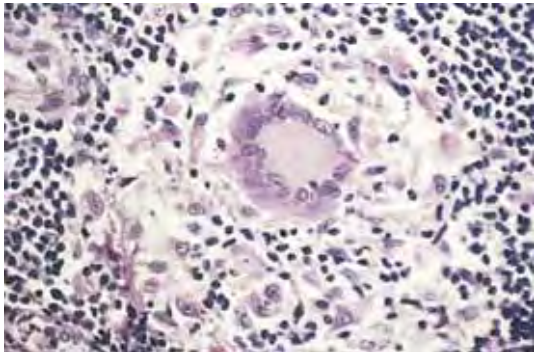


Fig. 100 Langhans giant cell surrounded by epithelioid cells and lymphocytes in the tuberculoid granuloma

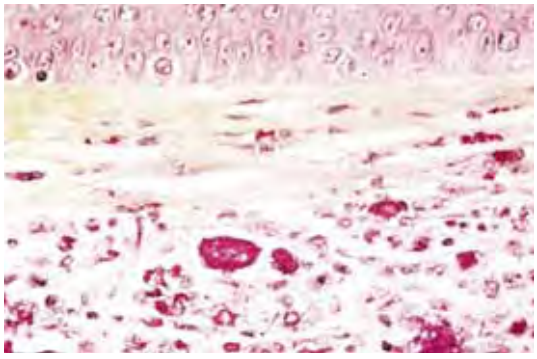


Fig. 101 Highly bacilliferous granuloma in the dermis due to lepromatous leprosy; granuloma-free, subepidermal zone of Unna is seen

Sweat Function Tests

These may be helpful in the diagnosis of non-lepromatous cases of leprosy, especially in children in whom sensory impairment cannot be determined with certainty. In 1889, Father Joseph Damien de Veuster first observed that perspiration was absent on the macules of leprosy which had developed on his skin. Pilocarpine nitrate and acetylcholine sweat function tests are some of the sudomotor tests helpful in the diagnosis of leprosy[32, 33].

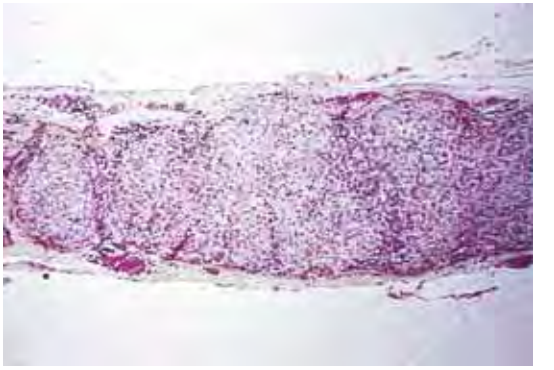


Fig. 104 Nerve tissue replaced by a round-cell granuloma due to tuberculoid leprosy

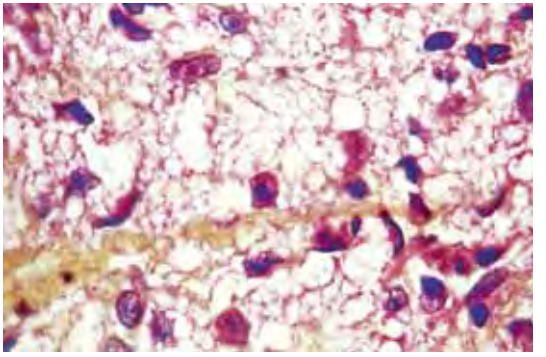


Fig. 102 Numerous foamy cells of Virchow are seen in the lepromatous granuloma

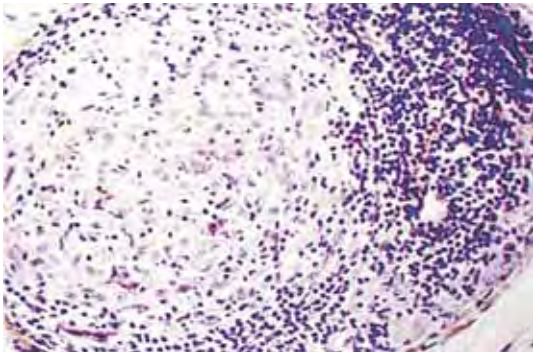


Fig. 105 Nerve showing cellular infiltration by lymphocytes and epithelioid cells in tuberculoid lepros

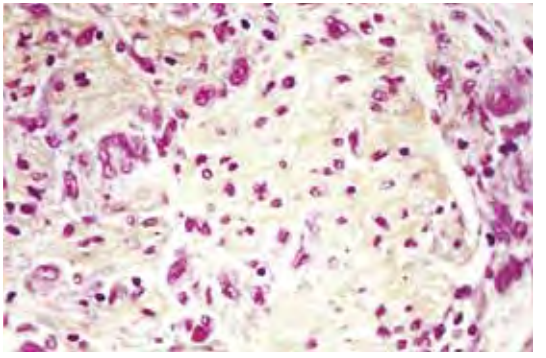


Fig. 103 Nerve fibres destroyed in borderline leprosy

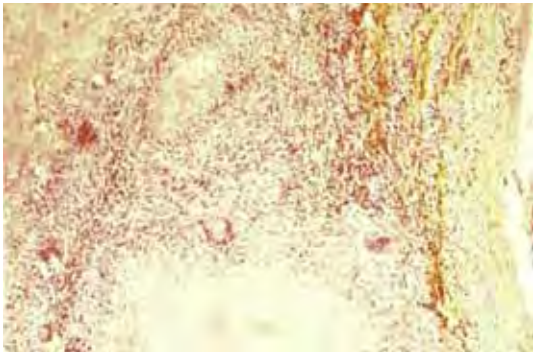


Fig. 106 Total destruction of a nerve in tuberculoid leprosy, with caseation

10 Treatment

Leprosy continues to be curable with multidrug therapy (MDT) recommended by WHO since 1982. Leprosy patients should be treated with patience, perseverance and understanding. Besides the medical treatment, the leprosy patient needs support and reassurance from the family and friends so that he can gain self-confidence and self-respect in order to lead a normal life. Proper attention should be paid to diet and general health. If the patient's haemoglobin is below 10 g/100 ml, the cause should be investigated and the anaemia treated.

Chemotherapy

Until 1941 there was no really effective anti-leprosy drug, since hydnocarpus (chaulmoogra) oil which had been used in India and China for centuries was of little value. In 1941, Guy Faget first used a disubstituted derivative of dapsone (Promin®) intravenously in treating patients with leprosy at the National Leprosarium, Carville, USA. At present, dapsone, rifampicin and clofazimine are the principal anti-leprosy drugs. With the judicious use of these drugs, leprosy can be cured in the individual and controlled in the community. The progress is impressive when it is remembered that at the first International Leprosy Congress held in Berlin in 1897 the only thing about leprosy on which every participant agreed was its incurability. Due to the advances in the chemotherapy of leprosy, the dictum "Once a leprosy sufferer always a leprosy sufferer" has become a saying of the past.

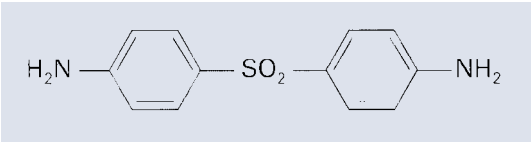


Fig. 107 The structural formula of dapsone

Dapsone: It is 4:4'-diaminodiphenyl sulphone (DDS) and was synthesized by Fromm and Wittmann at Freiburg, in Germany, in 1908 (Fig. 107) for treating patients with tuberculosis. In 1946, it was first used for the treatment of patients with leprosy (in oily suspension, intramuscularly) by Cochrane in India. In 1947, Lowe first tried dapsone orally in Nigeria[8].

Dapsone is almost completely absorbed after oral administration. The plasma half-life of orally administered dapsone varies from 9 to 53 hours. In the mouse, the minimum, inhibitory concentration (MIC) of dapsone in the serum is 0.003 µg/ml[34]. It is essentially bacteriostatic and weakly bactericidal in action. The mechanism of action of dapsone is thought to be an interference in folic acid synthesis through competition with para-aminobenzoic acid.

Dapsone or any anti-leprosy drug should never be used alone due to risk of drug resistance. Depending on the body weight, adult patients should therefore receive a daily dose of 100 mg dapsone (1–2 mg/kg body weight)[35] regularly from the very beginning of treatment, as a component of combination regimens. Such a dosage results, after about four hours, in peak serum levels that exceed the minimum inhibitory concentration (MIC) of dapsone against **M. leprae** by a factor of about 500. Such high levels of the drug will inhibit the multiplication of mutants of **M. leprae** with low or even moderate degrees of dapsone resistance. The full dosage should, therefore, be given from the outset of treatment and should not be reduced during lepra reactions[35].

In the currently recommended daily dosages, dapsone is remarkably well tolerated. Side effects in patients with leprosy are rare. It may occasionally lead to malaise, weakness, haemolytic anaemia, leucopenia,

Fig. 108 Dapsone-resistant lesions of lepromatous leprosy on the face

Fig. 109 Dapsone-resistant nodules of lepromatous leprosy

methaemoglobinaemia, drug fever, nephritis, acute peripheral neuritis, fixed drug eruptions, toxic epidermal necrolysis, exfoliative dermatitis, hepatitis and acute psychosis. Dapsone is unrelated to iron-deficiency anaemia. Haemolysis of red blood cells is the most common of the adverse effects. It is dose-dependent and should be suspected if a patient taking dapsone develops anaemia.

Significant haemolysis is uncommon except in very old or young patients, or in patients with glucose-6-phosphate dehydrogenase (G-6-PD) deficiency[36, 37]. A few cases of fatal "fifth-week dapsone dermatitis" with fever, exfoliative dermatitis, nephritis and hepatitis have been reported. Motor paralysis has been reported in patients taking very large doses of dapsone for other skin diseases, such as dermatitis herpetiformis.

Rifampicin (**Rimactane®**, Novartis formerly Ciba): This is a semisynthetic derivative of a fermentation product of Streptomyces mediterranei (Fig. 110), with an estimated minimum inhibitory concentration (MIC) of 0.3 µg/ml[38]. Rifampicin acts by inhibiting bacterial ribo-nucleic acid (RNA) synthesis. It is the most potent bactericidal anti-leprosy drug available today. A single dose as low as 600 mg will kill the great majority (about 99.9%) of leprosy bacilli within a few days, so rendering the patient with multibacillary leprosy non-infectious.

Tolerability of rifampicin is fairly good. The most common side effect is a red coloration of urine due to the excretion of the drug. It may also cause skin rashes, gastrointestinal symptoms, drowsiness, weakness and dizziness. Rarely, rifampicin may result in hepatitis, thrombocytopenia, psychosis, porphyria cutanea tarda, pemphigus vulgaris and Stevens-Johnson syndrome.

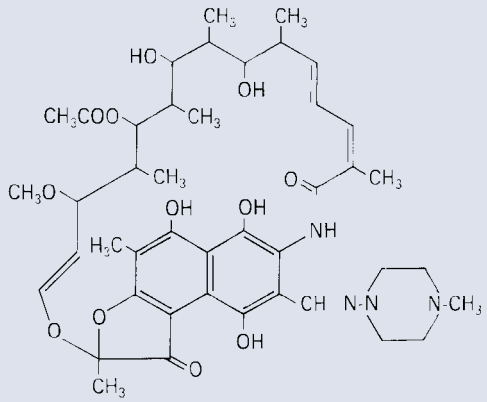
The first results of treatment of leprosy patients with rifampicin were published in 1970[39, 40]. In the 1970s, there were wide differences of opinion about rifampicin dosage (150–900 mg daily), dose-intervals (daily, twice weekly, weekly or on 2 consecutive days every 4 weeks) and duration (from a single dose up to 7 years) of treatment.

In THELEP controlled WHO clinical trials in patients with lepromatous leprosy, rifampicin was given either

600 mg daily for the duration of the trial or 900 mg once weekly for the first three months, or 1500 mg in a single initial dose, in combination with antileprosy drugs. The commonly recommended dosage of rifampicin was 450–600 mg daily. Regimens with daily rifampicin being very expensive, only a small percentage of patients could take advantage of this treatment. Moreover, it was not practicable to give daily rifampicin under supervision to patients, therefore misuse of this expensive drug could not be prevented.

Based on the results of a single-blind, comparative trial performed according to the trial plan of Ciba-Geigy, Basle, Languillon et al. were the first to report on the high efficacy, good tolerability and practicability of the supervised, once-monthly 1200 mg single-oral-dose rifampicin schedule as a component of the combination regimen for the treatment of patients with lepromatous leprosy[41]. Later, Yawalkar et al. confirmed these findings on the basis of Ciba-Geigy's international, multi-centre, single-blind, comparative trial carried out in Brazil, India and Senegal[42]. In this trial, the clinical, bacteriological and histophathological effects of adding Rimactane® 450 mg daily or 1200 mg once monthly in a supervised single dose to dapsone 50 mg daily in 93 patients with previously untreated lepromatous leprosy were practically identical. Moreover, contrary to expectations based on experience with intermittent rifampicin therapy in tuberculosis, once-monthly administration of rifampicin did not cause the "flu" syndrome, anuria, oliguria, thrombocytopenia or anaphylactic shock.

The efficacy of once-monthly administration of rifampicin in patients with leprosy could be attributable to its very potent bactericidal effect, related to the long generation time of leprosy bacilli. It is the most potent component of the MDT recommended by the



Empirical formula: $C_{43}H_{58}N_4O_{12}$;
chemical name: 3-(4-methyl-1-piperazinyl-iminomethyl)-rifamycin SV.

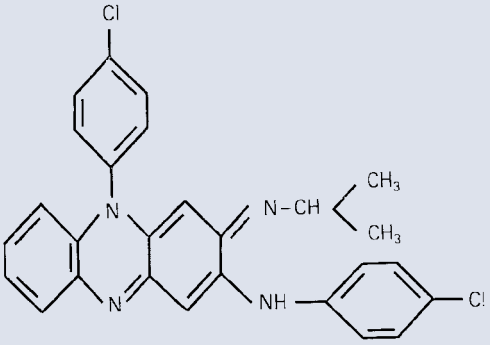
Fig. 110 The structural formula of rifampicin

WHO since 1982. The once-monthly single rifampicin dose represents a substantial cost reduction in the treatment of leprosy and can be administered easily under medical or paramedical supervision.

Clofazimine (**Lamprene®**, Novartis formerly Geigy): The active ingredient in Lamprene® is a substituted, iminophenazine bright-red dye synthesized in 1954 by Vincent Barry et al. in Dublin in collaboration with Geigy (Fig. 111).

In 1962, Browne and Hogerzeil[43] first reported on the efficacy of Lamprene® in leprosy patients in Nigeria. The overall antileprosy effect of clofazimine is about the same as that of dapsone[44]. Clofazimine, however, has a slower onset of action than dapsone. The drug is mainly bacteriostatic and weakly bactericidal. It has been suggested that Lamprene® interacts with mycobacterial DNA. It does not show cross-resistance with dapsone or rifampicin. Although this drug has been on the market since 1969, no case of confirmed clofazimine-resistant leprosy has so far been reported.

Lamprene® is highly lipophilic and tends to be deposited predominantly in the fatty tissue and in cells of the



3-(p-Chloro-anilino)-10-(p-chlorophenyl)-2,
10-dihydro-2-(isopropylimino)-phenazine
(= clofazimine)

Fig. 111 The structural formula of clofazimine

reticuloendothelial system. The mean half-life of elimination of plasma clofazimine following single and multiple oral administration of 50 and 100 mg Lamprene® capsules to healthy volunteers was 10 days[45]. It is not possible to determine the minimum inhibitory concentration (MIC) of clofazimine against leprosy bacilli in animals since the drug is not homogeneously distributed in the tissues and because of marked tissue accumulation[46]. Determination of the MIC of clofazimine against leprosy bacilli **in vitro** is not yet feasible.

Lamprene® is the only anti-leprosy drug possessing an anti-inflammatory effect[47, 48] which, if given in high doses, is clinically valuable in controlling erythema nodosum leprosum (ENL) reactions occurring in patients with multibacillary leprosy. Clofazimine-mediated, anti-inflammatory and immunosuppressive activity may be due to its stimulating effect on the synthesis of anti-inflammatory and immunosuppressive prostaglandin E2 by human polymorphonuclear leucocytes (PMNL), monocytes and macrophages in response to pro-inflammatory stimuli[49]. A combination of Lamprene® and dapsone causes clinical and bacteriological improvement in patients with lepromatous leprosy, and is useful in reducing the incidence and severity of ENL reactions.

Lamprene® is an important component of the MDT recommended since 1982 by WHO for patients with multibacillary leprosy.

For multibacillary cases, the WHO Study Group on Leprosy recommended a once-monthly supervised dose of 300 mg Lamprene® in addition to the daily dose of 50 mg Lamprene® [34].

In adult patients with ENL, Lamprene® should as a rule be given in a dosage of 300 mg daily for a period not exceeding three months. In very severe ENL, clofazimine may not be as effective as the corticosteroid[50]. However, unlike corticosteroids, Lamprene® not only acts on lepra reactions but also exerts a specific therapeutic effect on leprosy itself. Moreover, its side effects are less dangerous than those of prednisolone[51].

In general, Lamprene® is well tolerated and virtually non-toxic when administered in dosages not greater than 50 mg daily. Daily doses exceeding 100 mg should be given for as short a period as possible (< 3 months) and only under supervision[44]. Reversible, dose-related pink to brownish-black discolouration of the skin, especially on the exposed parts, is the most commonly observed side effect. Reversible dryness of the skin, ichthyosis, itching, abdominal pain and diarrhoea, phototoxicity and skin rashes have been reported and are also dose-related. A Ciba-Geigy retrospective survey, based on information (received from 31 leprosy institutions) on 2034 patients with ENL reactions and 4261 patients without ENL reactions, has confirmed the good tolerability of Lamprene® [52]. This survey has also shown that skin discolouration, ocular pigmenta-

tion, abdominal pain and diarrhoea are dose-related phenomena. Clofazimine has no embryotoxic, teratogenic or mutagenic effects.

Multidrug Therapy (MDT)

Until 1981, the chemotherapy of patients with leprosy relied almost entirely on dapsone monotherapy. Dapsone monotherapy was first used on a large scale in the 1950s. Secondary resistance, usually appearing in a patient after 5–15 years of therapy, was first demonstrated in the mouse footpad test in the 1960s[53]. Primary resistance, present in previously untreated patients, was first observed in the 1970s[54] and rates as high as 40% have been reported[55].

It is well known that simultaneous administration of several different antibacterial agents may prevent the emergence of drug-resistant mutants. The only way to prevent the spread of drug-resistant leprosy is to use multiple anti-leprosy drugs simultaneously, in full dosages for an adequate period and without interruption. In order to prevent and/or overcome the emergence of drug resistance (primary and secondary), to help reduce bacterial persistence and to achieve the more rapid arrest of transmission of the disease, in 1982 the WHO Study Group recommended multidrug regimens for the treatment of patients suffering from paucibacillary (PB) and multibacillary (MB) leprosy. Multidrug regimens, recommended by the WHO Leprosy Elimination Group since 2000, are given in Tables 6–8.

All drugs should be given in full doses from the beginning of treatment and are to be administered without interruption in pregnancy and even during reversal and ENL reactions. When prescribing the WHO-recommended drug regimen for patients with leprosy, the importance of the regular self-administration of the drugs must be explained to patients. If patients do not take these drugs regularly and in full doses, they are at risk of relapsing with rifampicin-resistant leprosy. This would not only be a disaster for their recovery but also ultimately threaten the whole strategy of controlling leprosy by multidrug therapy (MDT).

Fig. 112 Lesions of lepromatous leprosy on the face before starting the treatment

Fig. 113 The same patient (Fig. 112) after receiving Lamprene® 100 mg three times per week for two years and rifampicin 600 mg twice monthly for six months

Table 6 Multidrug chemotherapeutic regimens for adult patients currently recommended by the WHO Leprosy Elimination Group[56]

Type of Leprosy	Paucibacillary	Multibacillary
Number of lesions	1–5	>5
BI according to the Ridley scale	Negative	Positive
Regimen	Daily: Dapsone 100 mg	Daily: Dapsone 100 mg Clofazimine Lamprene® 50 mg
	Once monthly supervised: Rifampicin 600 mg	Once monthly supervised: Rifampicin 600 mg Clofazimine Lamprene® 300 mg
Duration of treatment	6 blister packs	12 blister packs

Table 7 The dosage of anti-leprosy drugs for children with paucibacillary leprosy

Age Group	Dapsone Daily Dose	Rifampicin Monthly Dose
10–14 years	50 mg	450 mg
15–18 years	100 mg	600 mg
Duration of treatment	6 blister packs	6 blister packs

Table 8 The dosage of anti-leprosy drugs for children with multibacillary leprosy

Age Group	Dapsone Daily Dose	Rifampicin Monthly Dose	Clofazimine	Clofazimine Monthly Dose
10–14 years	50 mg	450 mg	50 mg every other day	150 mg
15–18 years	100 mg	600 mg	50 mg daily	300 mg
Duration of treatment	12 blister packs	12 blister packs	12 blister packs	12 blister packs

Children should receive monthly doses under supervision of parents.
For children under 10 years, the dose must be adjusted according to body weight.

The duration of treatment should be extended in patients with multibacillary leprosy who have not responded satisfactorily to the MDT given for one year. If a patient has active pulmonary tuberculosis, these regimens alone will not be sufficient because of the risk of the patient developing rifampicin-resistant Mycobacterium tuberculosis. Such patients should receive appropriate chemotherapy for active pulmonary tuberculosis in addition to the aforementioned regimens.

The WHO-recommended MDT is designed for the treatment of all categories of patients, including:

1. Previously untreated patients;
2. Patients who have not responded satisfactorily to previous dapsone monotherapy;
3. Patients who have relapsed while on dapsone monotherapy or after its withdrawal.

MDT can cure and prevent drug resistance in all patients, whether or not they are infected with dapsone-resistant **M. leprae**.

Multidrug therapy (MDT) is a very effective weapon in the fight against leprosy (Figs. 114–123). The priority

Fig. 114 Lesion of paucibacillary leprosy on the arm before starting MDT

Fig. 115 The same lesion (Fig. 114) after 6 weeks' multidrug therapy (MDT)

Fig. 116 Lesions of multibacillary (BB) leprosy before starting MDT

Fig. 117 The same lesions (Fig. 116) after 24 months' multidrug therapy (MDT)

Fig. 118 Lesions of multibacillary (BB/BL) leprosy on the face before starting MDT

Fig. 119 The same lesions (Fig. 118) after 12 months' multidrug therapy (MDT)

Fig. 120 Lesions of multibacillary leprosy (LL) on the face

Fig. 121 The same patient (Fig. 120) after 12 months' treatment

Fig. 122 Lesions of multibacillary leprosy before MDT

Fig. 123 The same patient after 12 months' MDT

must be to detect and treat all cases. Staff should be appropriately trained and updated in this field. Skin smears are not a prerequisite for starting MDT. If reliable facilities for skin smears are available, all suspected MB patients should have one examination at the start of treatment. This is to prevent an MB case being treated as PB.

In patients where clinical deterioration/relapse is suspected, skin smears should be taken from the most active sites. It needs to be emphasized that differentiation between multibacillary (MB) and paucibacillary (PB) leprosy is not always easy. In such problem situations the bacteriological examination should be repeated and carefully evaluated. There is general concern that some MB patients could be wrongly classified as PB and would subsequently receive inadequate treatment. **In difficult situations where there is a doubt, the patient should be classified and treated as an MB case. All patients with more than five lesions should be treated with the regimen recommended for multibacillary cases of leprosy.**

The WHO/MDT regimens have received worldwide acceptance by government and contributing agencies. In most MDT programmes, the efforts made to ensure appropriate drug delivery (Fig. 124) and good patient compliance have been successful. India has the largest MDT programme in the world.

The MDT donation – providing free treatment to all patients in the world through WHO

Novartis committed itself in an Memorandum of Understanding with WHO to:

– provide sufficient quantities of high quality MDT, in blister packs, free of charge to WHO over the six year period (2000–2005) to treat and cure leprosy patients worldwide.
– maintain buffer stocks in order to respond to fluctuations of demand for MDT and to emergency requests from countries.
– provide WHO with the necessary funds for the shipment of MDT and independent quality control. These funds are calculated at 9% of the value of the MDT to be shipped, based on the 1999 prices of MDT. [125]

In 2005, Novartis decided to extend the MDT donation for an additional five year period until the end of 2010.

97% of the global supply of MDT is provided by WHO/Novartis. From 2000 to 2008, Novartis has donated over 40 million blister packs worth USD 60 million, curing over 4.5 million patients.

Novartis is on record for being willing to extend its contribution until leprosy is eradicated globally.

Achievements following the implementation of WHO/MDT in 1982

1. By 2008 over 14 million leprosy patients had been cured by MDT and currently more than 97% of registered cases are receiving MDT. The cost of treatment has been significantly reduced due to the once-monthly use of rifampicin.
2. MDT has been effective in arresting the transmission of the disease.
3. It is effective in preventing and overcoming dapsone resistance.
4. It is well tolerated and is safe in pregnancy.
5. The occurrence of leprosy reactions has decreased.

6. Deformities and disabilities have been prevented in about 2–3 million persons. The risk of disabilities and deformities has been significantly reduced due to the efficacy of MDT and reduced occurrence of lepra reactions[57].
7. The overall relapse rates after completion of MDT are about 0.1%, which is less than one-tenth of the rate observed after completion of dapsone monotherapy[57]. Therefore, it is no longer necessary to continue routine post-MDT surveillance. Instead, patients should be taught, at the time of release from treatment, to recognize early signs of possible relapses or reactions and to report promptly for treatment.
8. Treatment completion rates have improved considerably in most countries and vary between 60% and 90%.
9. The effectiveness of MDT in stopping the spread and curing the disease has been producing positive changes in public attitude towards patients with leprosy.
10. The dictum "Once a leprosy sufferer, always a leprosy sufferer" has now become a saying of the past. MDT can cure leprosy; the disease has been eliminated as a public health problem from all but 3 countries and the global leprosy burden has been reduced by 95%. Every year about 250,000 new cases are detected worldwide.

At the initiative of the World Health Organization, the Global Alliance for Leprosy Elimination was set up in November 1999. The alliance aims to detect and cure all remaining leprosy cases. Increasing community awareness about the disease and its curability through information, education and communication (IEC) is extremely important to improve the chances of early diagnosis and maximum compliance by the patients, both in taking the drugs and care of the limbs and eyes. The programme of IEC should run in parallel with the other activities of the MDT programme. Community participation will contribute further to the success of MDT and will help in changing the negative image of the disease.

Novartis has produced blister packs (BPs) for MDT, as recommended by WHO for patients (adult and children) with paucibacillary and multibacillary leprosy.

Blister packs offer several advantages:

1. They are easy to use, handy and of convenient size. They provide a complete treatment and thus eliminate the possibility of incomplete treatment due to the non-availability of one or more components of multidrug therapy.
2. They improve clinic attendance by the patients and their compliance with self-administration of drugs at home. They are more suitable for blind patients than bottled drugs.
3. The drugs are better protected against moisture, heat and accidental damage.
4. They relieve the clinic staff from the time-consuming and tedious work of counting tablets for a large number of patients and ensure much quicker dispensing of drugs, thus enabling the staff to devote more time to clinical problems, disability prevention and communication with patients.
5. BPs can be safely dispensed by nonmedical persons and even by social workers in the community if access to the clinic is restricted, for example by distance, harvest seasons or tropical rainy seasons.

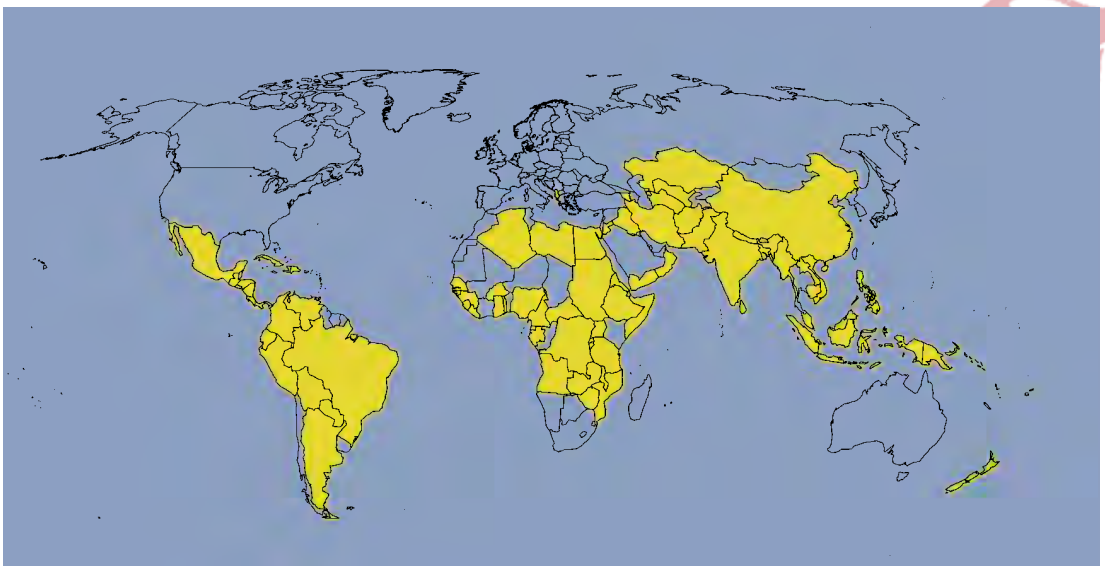


Fig. 124 Countries supplied with MDT by WHO: 1995–2000. Reproduced by the permission of the World Health Organization, Geneva, from The Elimination of Leprosy as a Public Health Problem, Status Report 2000

Accompanied MDT

Accompanied MDT has been designed to ensure that patients get the full course of treatment. Patients often have to interrupt their treatment because of a shortage of drugs at the health centre, poor access to the health services or simply because no one is at the health centre when they go to collect the drugs.

Accompanied MDT gives patients a choice: they can collect their blister packs at regular intervals from the health centre or take the entire course with them when diagnosed.

Patients should choose someone close to them to accompany them when they go for treatment and supervise monthly drug administration.

The first MDT dose is given at the health centre. Patients are then asked if they want to take all the blister packs with them or if they would prefer to collect them at regular intervals.

If they choose accompanied MDT, 6 PB blister packs are given to paucibacillary (PB) patients and 12 MB blister packs are given to multibacillary (MB) patients.

It is made sure that every patient and accompanying person understand the treatment and how to take the drugs as well as possible problems, e.g. discolouration of urine and darkening of the skin.

They are instructed to go immediately to a health centre if they have pain, fever, malaise, new lesions and/or muscle weakness.

They are also instructed to keep the blister packs in a dry, safe and shady place, e.g. in a wooden box and out of the reach of children.

They are informed that they will be cured of leprosy if they take the drugs in the blister packs regularly as advised and they can lead normal lives. They are asked to return for a check-up after they complete their treatment[56].

New Drugs

Quinolones: These drugs work by inhibiting DNA synthesis during bacterial replication, probably by interference with DNA gyrase activity. Ofloxacin, a fluorinated quinolone, could be a promising new drug in the treatment of leprosy. It displayed very marked antileprosy activity in the mouse footpad model. Oral ofloxacin is 98% bioavailable. The elimination half-life of ofloxacin is about five to eight hours. It was used in a clinical trial in a dose of 400 mg daily in patients with leprosy[58].

Adverse reactions to ofloxacin have included skin rash, visual disturbances, vasculitis, psychosis, haematuria and glycosuria. Because quinolones, including ofloxacin, cause cartilage erosion in young dogs and rats, these drugs are not recommended for patients less than 18 years old or for pregnant or nursing women[59]. Drugs containing iron or zinc may interfere with the absorption of ofloxacin, which is very expensive at present.

Its bactericidal activity when given alone to previously untreated multibacillary patients is manifestly more rapid than that of either dapsone or clofazimine, but it is less effective than rifampicin. Its antileprosy activity is currently being investigated by the WHO.

It may prove useful against **M. leprae** strains resistant to the drugs currently in use, especially the strains resistant to rifampicin. In 1991–92, WHO launched a large-scale multicentre field trial to evaluate the efficacy and safety of ofloxacin containing combined regimens in a multicentre, randomized, double-blind controlled clinical trial in both multibacillary and paucibacillary leprosy patients.

One of the test regimens is a combination of rifampicin plus ofloxacin daily for four weeks for both MB and PB leprosy.

The other two test regimens for MB leprosy are the WHO-recommended MDT for one year with or without being supplemented by daily ofloxacin during the first four weeks.

The control regimen is the standard WHO-recommended MDT regimen for 24 months.

Fifteen centres from eight endemic countries are participating in this trial. The intake of nearly 4000 newly-diagnosed leprosy patients was completed in 1994. The treatment phase was completed in December 1996.

Patients will be followed up for a period of five to seven years after the completion of treatment to detect relapse if any. The final results will be available by mid-2004[60].

Ansamycins: Rifabutin is a newer addition to the ansamycin group of antimicrobials whose activity against **M. leprae** has been demonstrated in the mouse footpad and whose minimal effective dose is lower and half-life longer than that of rifampicin[61]. Rifabutin (300 mg daily) has rapid, bactericidal activity and is more potent than rifampicin, which is the most potent currently used antileprosy drug. Rifabutin could have a role similar to rifampicin in the treatment of leprosy. It has been used extensively to treat **M. avium-intracellulare** infections in patients with acquired immunodeficiency syndrome, and it appears to be well tolerated.

Minocycline: This is the most lipid-soluble of the tetracyclines and inhibits bacterial protein synthesis. It is a

semisynthetic derivative that became available in 1972. Minocycline is active against **M. leprae** in mice and is consistently bactericidal. In clinical trials, the clearance of viable **M. leprae** from the skin by minocycline was faster than that reported for dapsone or clofazimine, similar to that for ofloxacin and slower than that for rifampicin. The safety record of minocycline in its long-term use for two decades, primarily for other diseases, supports its application in the treatment of patients with leprosy[62].

Multidrug therapy for single-lesion paucibacillary leprosy

There is some evidence to suggest that single-lesion paucibacillary leprosy is a clinical entity[57]. It refers to those patients who have only one hypopigmented or reddish skin lesion with definite loss of sensation but without nerve trunk involvement. It accounts for a significant proportion of newly diagnosed cases, e.g. 20–30% in Malawi and nearly 60% in India.

The efficacy of a single dose of a drug combination (ROM) consisting of
- 600 mg of rifampicin
- 400 mg of ofloxacin and
- 100 mg of minocycline

has been proved in a multicentre, double-blind field trial in 1,483 patients in India[63].

A single dose of ROM was marginally less effective than the standard MDT regimen for 6 months. A single dose of ROM could be an alternative regimen for patients with single-lesion paucibacillary leprosy. Before recommending a single dose of ROM drug combination, the entire body of the patient should be examined in a good light to exclude more than one lesion and nerve trunk involvement. Patients receiving a single-dose ROM regimen should be followed up for at least 6 months. A single skin lesion as an unusual presentation of lepromatous leprosy has been reported by Yoder et al[64]. Therefore, **lepromatous leprosy should be excluded as the possible cause before recommending a single-dose ROM regimen**.

Immunotherapy

Persons suffering from lepromatous leprosy do not possess cell-mediated immunity (CMI) to **M. leprae**. The precise nature of the immune defect in lepromatous leprosy is not yet fully understood. It seems that this is a specific defect towards **M. leprae** since lepromatous cases do not present clinical complications due to generalized immunodeficiency. The lepromin test, lymphocyte transformation test (LTT) and leucocyte migration inhibition test (LMIT) are negative in lepromatous cases. It has been found that 10% of lepromatous leprosy patients, irrespective of the drug regimen used, continue to harbour drug-sensitive viable bacilli in nerves and blood, known as persisters. One of the ways to speed up the clearance of the bacterial load is to augment the patient's cell-mediated immunity. Some progress in this regard has been made with the use of MDT along with a vaccine consisting of BCG alone or BCG plus killed **M. leprae**, or killed ICRC bacilli or killed Mycobacterium W. or Mycobacterium Vaccae. There are still some problems to be sorted out. These include non-conversion of lepromin unresponsiveness in about 33% of vaccinated lepromatous patients, and the chance of nerve damage and development of erythema nodosum leprosum. Immunotherapy is not likely to play a significant role in leprosy control programmes[65].

11 Reactions in Leprosy

During the usually chronic course of leprosy, acute episodes (reactions) may occur. Any type of leprosy, except an early indeterminate form, may undergo a sudden inflammatory phase of exacerbation. Reactions are more common in patients with multibacillary leprosy. Reactions may occur spontaneously or may be precipitated by intercurrent infections (viral, malaria, etc.), anaemia, mental and/or physical stress, puberty, pregnancy, parturition or surgical interventions. Before the introduction of MDT, treatment with anti-leprosy drugs had been one of the precipitating causes of reactions. Reversal reactions usually occur in the first 6 months of starting treatment. Other drugs such as progesterone, potassium iodide, vitamin A, etc. may precipitate reactions. The precipitating factors may not be obvious in some cases. Two kinds of hypersensitivity are believed to underlie the bewildering clinical manifestations (Figs. 125–137) that may appear during reactions (Table 9).

Type 1 or reversal lepra reaction is an example of Type IV hypersensitivity (allergic) reaction (Coombs and Gell).

Type 2 lepra reaction (erythema nodosum leprosum) is humoral hypersensitivity and it is an example of Type III hypersensitivity (allergic) reaction (Coombs and Gell). It is not associated with alteration in the cell-mediated immunity (CMI). Erythema nodosum leprosum (ENL) was originally described by Murata in Japan in 1912.

During reactions, inflamed skin lesions and nerves may be extremely painful and tender. Acute neuritis may cripple patients with borderline leprosy overnight, while acute iritis may rapidly result in blindness. In patients with borderline-lepromatous leprosy, Type 1 and Type 2 lepra reactions may occur simultaneously[66].

Type 1 lepra reaction is considered severe if the pain and tenderness in the nerves is severe, if paralysis or anaesthesia threatens to follow the neuritis, and if the skin is so severely inflamed that it is likely to ulcerate.

Type 2 lepra reaction (ENL) may be intermittent or continuous.

Intermittent Type 2 lepra reaction: This may be mild or severe. Mild intermittent Type 2 reaction is characterized by attacks of ENL lasting for about two weeks and followed by a reaction-free period of a month or two. In such cases, ENL may be associated with mild nerve pain or tenderness without loss of function. There is often some fever and malaise. Intermittent Type 2 lepra reaction is graded as severe if it is accompanied by high temperature and general malaise; if the skin lesions become pustular and/or ulcerate; if the nerves become painful or if loss of nerve function develops or if there is evidence of iridocyclitis, orchitis, joint swelling or persistent albuminuria[50]. Often there is non-pitting oedema of the face, hands and/or feet.

Continuous Type 2 lepra reaction: Attacks of ENL come in quick succession and therefore there is no reaction-free period. Such reactions are commonly severe and need almost continuous treatment with corticosteroids for 2–3 months. Continuous Type 2 lepra reaction may persist for several months.

Erythema nodosum leprosum (ENL) lesions can be mistaken for erythematous papulonodules which may develop in relapsing cases of multibacillary leprosy. In patients with multibacillary leprosy, relapse may manifest as a clinical worsening of existing lesions or the appearance of new lesions which may resemble erythema nodosum leprosum. However, ENL nodules or plaques develop suddenly in crops, are evanescent and

Table 9 Characteristic features of Type 1 and 2 lepra reactions

	Type 1 Reaction (Reversal)	Type 2 Reaction (Erythema nodosum leprosum, ENL)
Types of leprosy involved	Mostly borderline (BB, BT, BL); may occur in tuberculoid leprosy.	Mostly lepromatous (LL); occasionally borderline-lepromatous (BL).
Onset	Reversal reaction usually occurs during the first six months of therapy in BT and BB patients, but longer intervals have been observed in BL patients.	ENL tends to occur later during the course of treatment when skin lesions appear quiescent.
Cause	Associated with alteration in cell-mediated immunity (CMI); reversal reactions are due to sudden increase in CMI.	Immune-complex syndrome due to precipitation of antigen and antibody complexes in tissue spaces and in blood and lymphatic vessels.
Clinical	Some or all of the existing leprosy lesions show signs of acute inflammation (pain, tenderness, erythema and oedema). Look like erysipelas. Necrosis and ulceration occur in severe cases. Lesions desquamate as they subside. New lesions might appear occasionally.	Existing leprosy lesions do not show clinical aggravation. Sudden appearance of crops of evanescent (lasting for a few days), pink-(rose) coloured tender nodules or plaques. May become vesicular, pustular, bullous, gangrenous and break down (erythema nodosum necroticans). ENL may be the first manifestation of leprosy.
Systemic disturbances	Unusual	Fever and malaise common, patient may be toxic.
Associated features	Rapid swelling of one or more nerves with pain and tenderness at the site of nerve swelling; oedema of hands, feet or face may be present; nerve abscesses may form. Claw hand, foot-drop, facial palsy may occur suddenly. If inadequately treated, these paralyses are likely to be permanent.	Often there is oedema of hands, feet or face. Paralyses may occur but in Type 2 reactions, nerve damage does not threaten so quickly as in Type 1 reactions. Commonly associated features are: iritis, iridocyclitis, epistaxis, muscle pain, bone pain (usually confined to tibiae), nerve pain, joint pain, lymphadenitis, epididymo-orchitis, proteinuria.

Table 9 continued

	Type 1 Reaction (Reversal)	Type 2 Reaction (Erythema nodosum leprosum, ENL)
Special feature	Very severe reaction may be characterized by considerable necrosis and deep ulceration. Called "Lazarine leprosy" in the past.	Lucio phenomenon is a peculiar and severe form of Type 2 reaction observed in untreated cases of diffuse leprosy of Lucio and Latapi. Characterized by painful and tender purpuric patches which become necrotic and ulcerated (with or without bullae) and leave superficial scars. It is produced by multiple necrotizing vasculitis[67].
Histology	Reversal reaction: Increase in lymphocytes, epithelioid cells and giant cells. The number of bacilli decreases.	ENL lesions contain large numbers of polymorphs. Bacilli may be numerous and are mostly fragmented and granular. ENL may show features of vasculitis.
Main haematological findings	Nil	Polymorphonuclear leucocytosis. Increased gammaglobulins (IgG, IgM), C2 and C3.
Course	Seldom persists for more than a few months.	Mild ENL usually disappears rapidly but severe ENL may persist for years in chronic recurrent form.

tend to disappear within a few days. They are usually painful and blanch on pressure.

Reversal reactions have to be differentiated from relapse in paucibacillary leprosy. It is essential that this distinction is made correctly so that proper treatment can be given. Individuals with the highest risk of relapse are those who have received inadequate chemotherapy. The large majority of relapses occur with drug-sensitive organisms. The diagnosis of relapse must be confirmed by slit-skin smear examination (and preferably by biopsy). In paucibacillary patients it is often difficult to distinguish between relapse and reversal reactions. The differences are shown in Table 10. A therapeutic test with corticosteroids given orally for two to four weeks may be helpful in distinguishing a relapse from reversal reactions. In reversal reactions, improvement is seen within four weeks while in patients with relapse the lesions are unaffected[68].

Table 10 Distinguishing features between reversal reactions and relapse

Feature	Reversal Reaction	Relapse
Onset	Sudden (within a few hours)	Slow and insidious (weeks or months)
Time of onset	Generally occurs during chemotherapy or within six months of stopping treatment.	Generally occurs several months after chemotherapy is discontinued.
Old lesions	Some or all of the existing lesions become erythematous, shiny and swollen.	Unaffected
New lesions	Rare	Frequent
Ulceration	Sometimes	Nil
Scaling	Lesions desquamate as they subside.	Absent
Nerve involvement	Common; many nerves may rapidly become painful and tender; disturbances develop rapidly.	Nerves may become involved; disturbances develop very slowly.
General condition	Fever and malaise are unusual.	Not affected
Response to cortico-steroids	Excellent	No change
Drug compliance	May have been good.	May have been poor.

Treatment of Lepra Reactions

The key to successful management of lepra reactions is early diagnosis and the timely initiation of anti-inflammatory measures. The possible precipitating factor should be removed and MDT should be continued in full dosage without interruption.

The cardinal principles of treatment are as follows: Rest, both physical and mental, if necessary with appropriate sedation is most essential.

Analgesics and anti-inflammatory drugs: Aspirin (acetylsalicylic acid) is still the cheapest effective drug for controlling moderate degrees of pain and inflam-

mation. A dose of 600 mg may be given up to 4 times daily with meals. The dosage is reduced slowly as signs and symptoms are controlled.

Lamprene®: The use of Lamprene® (clofazimine) is indicated for reactions in patients who cannot be weaned from corticosteroids or who suffer from persistent ENL. In adult ENL cases, Lamprene® should be given in a dose of 300 mg daily for up to three months, and gradually reduced. Lamprene® not only acts on lepra reactions but also exerts a specific therapeutic effect on leprosy itself.

Corticosteroids: Corticosteroid therapy is most effective in controlling the most serious aspects of lepra reactions, e.g. neuritis in Type 1 lepra reaction, and iritis, neuritis when muscle paralysis is threatened or real, epididymo-orchitis and erythema nodosum necroticans in Type 2 lepra reaction. Prednisolone (preferably enteric-coated tablets) is a suitable preparation. The initial dose should be large enough to relieve the pain and tenderness in the nerves within 24–48 hours, and the maintenance dose should be sufficient to prevent the recurrence of nerve pain[69].

The most rapid control of neuritis is essential with corticosteroids in patients with a Type 1 lepra reaction. Prednisolone should be started with a single daily dose of 40–60 mg (maximum 1mg/kg body weight) according to severity. After some days, the daily dose should be reduced by 5–10 mg every two to four weeks, according to therapeutic response, ending with 5 mg daily for at least two weeks. For field use, a regimen of 40 mg prednisolone daily reducing by 5 mg every two weeks is advisable. The prednisolone dosage should be taken as a single morning dose along with the usual anti-leprosy drugs.

Fig. 125 Single large patch of tuberculoid leprosy, acutely inflamed due to Type 1 lepra reaction

Fig. 126 Reversal reaction in a patient with borderline leprosy; lesions are scaly in places

Fig. 127 Plaques of borderline leprosy (BB) in Type 1 lepra reaction

Fig. 128 Erythema nodosum leprosum

Fig. 131 ENL lesions on the face

Fig. 129 Erythema nodosum leprosum (ENL) lesions, pustular in places

Fig. 132 Pink-coloured ENL lesions on the face of a fair-complexioned person

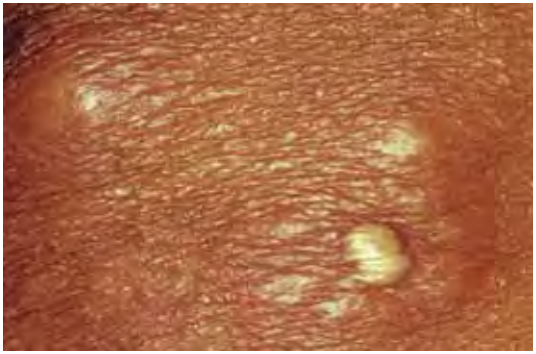


Fig. 130 Close-up view of pustular ENL lesions

Fig. 133 Pink-coloured ENL lesions on the back

Fig. 134 Reversal reaction in a patient with borderline (BT) leprosy

Fig. 135 The same patient (Fig. 134) after 2 months' treatment with prednisolone and Lamprene®

In severe Type 2 lepra reaction, prednisolone should be started at a dose of 20–40 mg/day and the dose adjusted according to therapeutic response.

If the Type 2 lepra reaction is severe, the patient may need treatment with prednisolone for 2–3 months. In addition, clofazimine may be given in doses up to 300 mg daily for one month, and then gradually reduced. Clofazimine may help wean the patient from corticosteroid dependence.

The patient should be provided with a corticosteroid treatment card and should be instructed to show it to any doctor in attendance in case of injury or illness[11]. Untoward effects of corticosteroids, particularly in long-term use, are: haematemesis, peptic ulcer, oedema due to sodium retention, hypokalaemia, hypertension, diabetes, spinal osteoporosis, striae, moon face and steroid purpura.

Due to its known teratogenic effects, the WHO does not recommend the use of thalidomide to treat erythema nodosum leprosum.

Management of neuritis: Neuritis is characterized by pain together with swelling and tenderness of the nerve. It may be associated with sensory loss and/or muscle paralysis. Corticosteroids reduce intraneural oedema and relieve pressure on nerve fibres (medical decompression). In reversal reactions, in addition to oedema, the intraneural granuloma resulting from cellular reaction causes pressure on nerve fibres. Therefore it is essential to continue anti-leprosy drugs so that the intraneural granuloma is slowly absorbed. In severe reactions, immobilisation of the affected limb with a well-padded splint is helpful to relieve pain and to stimulate healing. Splints may be made of plaster of Paris, Plastazote® or Modulan® and are padded with cotton wool and secured with bandages or belts. Joints should be splinted in a functional position. Where the hand is affected, the wrist should be slightly-to-moderately extended, while all other finger joints are moderately bent and the thumb abducted and opposed to the fingers since this is the position that the hand assumes when it is engaged in many activities of daily living.

Fig. 136 Reversal reaction in a patient with borderline (BT) leprosy

Fig. 137 The same patient (Fig. 136) after treatment with prednisolone

The splint should be left in position 24 hours a day until the inflammation begins to subside, being removed only for exercise. To begin with, gentle, passive exercises are carried out daily. Later on, active exercises are gradually introduced to stimulate muscle recovery and prevent stiffness in the joints.

Perineural injections of a suspension containing lignocaine, hyaluronidase and hydrocortisone can be given for the relief of severe nerve pain.

In general, the need for surgical decompression, either by incizing the nerve sheath or by excizing it (neurolysis), has declined due to the use of corticosteroids, and clofazimine. Neurolysis may be combined with perineural corticosteroid injections. Incisions in the epineurium relieve the nerve from compression. If any fluctuating nerve abscess develops, it should be aspirated through a wide-bore needle, otherwise, it may open spontaneously and result in a long-standing sinus. Small abscesses may subside spontaneously.

Acute iridocylitis: Daily inspection of the eyes is advisable during Type 2 lepra reaction. Acute iridocyclitis is a medical emergency. Treatment comprises hourly instillation of corticosteroid eyedrops (e.g. 1% hydrocortisone) by day and the application of a corticosteroid eye ointment at night. Eyedrops containing 1% homatropine must be instilled twice a day to keep the pupil as dilated as possible and prevent adhesions. Complete iridectomy may be advisable in neglected cases.

Acute epididymo-orchitis: Patients with acute epididymo-orchitis need bedrest, analgesics, oral corticosteroids; the scrotum should be supported by a suspensory bandage.

12 Deformities and their Management

Terminology

Anesthesia/ Hypoesthesia	The complete or partial impairment of tactile sensibility (touch, pain and temperature).
Impairment	Any loss or abnormality of psychological, physiological or anatomical structure or function[122]. Example: loss of sensation or deformity due to nerve involvement.
Deformity	Deformity is the visible alteration in the form, shape or appearance of the body due to impairment produced by the disease process. Examples: claw hand, loss of eyebrows, etc.
Disability	Any restriction or lack of ability (resulting from impairment) to perform an activity considered normal for a human being. Examples: difficulty in walking due to foot-drop; slipping of a pen from the hand due to loss of sensation.
Handicap	Handicap is the disadvantage for a given individual resulting from an impairment or disability that limits or prevents fulfillment of a role that is normal depending on the patient's age and sex as well as relevant social and cultural factors. Examples: inability to earn a living on account of disability or needing help in performing activities of daily life.
Dehabilitation	The progressive loss of social status and isolation from society.
Destitution	The final stage of total isolation, deprived of food and shelter.
Prevention of Disabilities (POD)	The common term used to describe various measures offered to any leprosy-disabled individual to prevent primary or secondary disabilities.
Prevention of Worsening of Disabilities	Some leprosy programmes use the term POWD to emphasize that measures offered are in effect to prevent the worsening of the disability in a person who has already developed disabilities.

Deformity Care Programme/ Disability Care Programme	These are colloquial terms often used synonymously and in general include activities related to caring for leprosy-disabled persons. Programmes are aimed at prevention, correction and care of various disabilities in leprosy-affected person. In a holistic approach, it also includes socio-economic rehabilitation of the leprosy-disabled persons.
Medical Rehabilitation	Medical rehabilitation is a broad term involving any treatment, whether medical or surgical, aimed at providing relief from the signs and symptoms of leprosy. In the holistic approach adopted by non-government organisations, it also includes social and economic rehabilitation.

Deformity is defined as any deviation from the normal appearance of any part or parts of the body. Deformity can become a handicap for a person's whole lifetime. It may or may not be accompanied by disability. Disability means the inability of a person to do his normal work. For example, a person with sensory loss is unable to handle fine things as a normal person does. The fear and the strong stigma associated with leprosy are mostly due to the gross deformities and mutilations generally regarded as essential features of the disease.

It is estimated that approximately 25% of patients who are not treated at an early stage of the disease develop anesthesia and/or deformities of the hands and feet[70]. As a single disease entity, leprosy is one of the foremost causes of deformities and crippling. Several factors are associated with deformities in leprosy (Table 11). Table 12 shows deformities occurring in patients with leprosy.

Primary and Secondary Deformities

Deformities in leprosy are of two main types: primary and secondary. They may also be of the mixed variety. The primary deformities are directly caused by the tissue reaction to infection with **M. leprae**, e.g. loss of eyebrows and eyelashes, facies leonina, gynaecomastia, flat-nose, claw hand, wrist-drop, etc. The secondary deformities occur as a result of damage to the anesthetic parts of the body. Plantar ulcers, loss of toes and fingers, corneal ulcers and Charcot joints are some examples of secondary deformity. **Lagophthalmos (inability to close the eye) is a primary deformity and corneal ulcer is a secondary deformity following loss of sensation in the cornea or due to exposure keratitis.**

Deformities arise due to tissue infiltration and nerve damage. Loss of eyebrows, depressed nose and wrinkled skin of the face are deformities due to tissue infiltration. These are commonly seen in lepromatous leprosy (cases which need MB-MDT).

Sensory fibres	→	hypoesthesia or anesthesia	→	ulcers on hand and foot, corneal ulcers, corneal opacities
Motor fibres	→	muscle weakness or paralysis	→	claw hand, foot-drop, etc.
Autonomic nerve fibres	→	lack of sweat and sebum	→	dry skin, cracked skin, ulcers etc.

Fig. 138 Sequelae of damage to different peripheral nerve fibres

M. leprae is the only bacillus which is known to infect peripheral nerves. The peripheral nerves consist of sensory, motor and autonomic nerve fibres, damage to which results in anesthesia (loss of sensation), muscle weakness or paralysis and lack of sweat and sebum, causing dry skin (Fig. 138).

This nerve damage is due to the leprosy bacilli which affect peripheral nerves at a particular site; sometimes within the nerve itself only a few funicles (bundles of nerve fibres) are affected. Sensory and motor loss is distal to the affected site. The nerve involvement may be partial or total, i.e., only sensory impairment or both sensory and motor impairment, while autonomic fibres are generally involved in both cases. The resulting paralysis is almost always chronic and never immediate as in nerve injury.

Sensory impairment or loss may be confined to the skin lesions of leprosy and/or to the sensory distribution of an infected nerve trunk. The nerve trunks are usually affected where they lie subcutaneously. Deep nerves are not paralysed in leprosy. The common sites of nerve damage (Fig. 139) are:

- Ulnar nerve: at the elbow, above the medial epicondyle of the humerus;
- Median nerve: above the wrist joint;
- Radial nerve: above the elbow joint, in the radial groove;
- Lateral popliteal nerve: at the neck of the fibula;
- Posterior tibial nerve: near the medial malleolus of the tibia;
- Facial nerve: above the zygomatic arch.

The nerves are affected in approximately the following order of frequency: ulnar, posterior tibial, lateral popliteal, median, facial and radial[5].

Nerve impairment results in loss of sensations in the neural territory of the affected peripheral nerve, paresis or paralysis of muscles (lagophthalmos, facial palsy) and instability at the joints, producing characteristic deformities like claw hand, “ape thumb”, foot-drop and claw toes.

Nerve damage is a common term for ‘neuropathy’ indicating clinical or sub-clinical damage to a nerve, which may be reversible or irreversible. Nerve damage can be said to be progressive in stages, from involvement to damage to destruction. Involvement is characterized by thickening (enlargement), tenderness and pain, but no loss of function. Reversible damage is when recovery is possible in terms of getting the

Table 11
Factors associated with deformities in leprosy[19]

Types of disease	Deformities/disabilities are commonly found in patients with borderline leprosy. Most of them follow reactions in such cases.
Duration of disease	The incidence of deformities in a patient population and also the number of deformities per patient increase the longer the disease lasts. Deformities may develop earlier and during Type 1 lepra reactions.
Nerve thickening	Nerve thickening has often been associated with deformities. However, it is not uncommon to find patients with deformities, but without any appreciable thickening or tenderness of the nerve concerned.
Age	Deformities due to leprosy are more frequent in the 20 to 50-year age group. However, they may develop in any age group.
Sex	Deformities are less common in women than in men.
Occupation	Deformities and disabilities are more commonly found among manual workers, since they are more frequently exposed to injuries and infections.

Table 12
Deformities occurring in leprosy

Face	Facies leonina, lagophthalmos, loss of eyebrows (superciliary madarosis) and eyelashes (ciliary madarosis), corneal ulcers and opacities, perforated nose, depressed nose, ear deformities, e.g. nodules on the ear and elongated lobules.
Hands	Claw hand, wrist-drop, ulcers, absorption of digits, thumb-web contracture, hollowing of the interosseous spaces and swollen hand.
Feet	Plantar ulcers, foot-drop, inversion of the foot, clawing of the toes, absorption of the toes, collapsed foot, swollen foot and callosities.
Other deformities	Gynaecomastia and perforation of the palate.

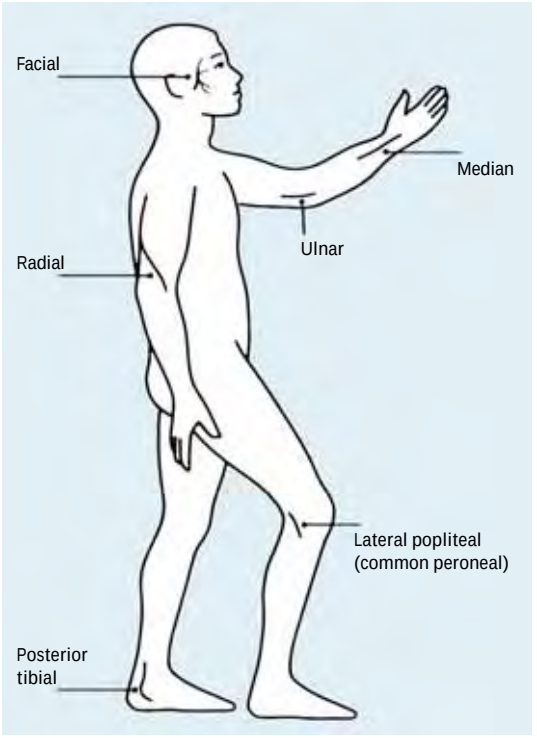


Fig. 139 Common sites of nerve damage resulting in motor paralysis

sensation and/or motor power back. If no recovery is possible, it is a stage of destruction, generally one year after the damage stage.

The signs of gradually progressive damage are frequent tingling and numbness, altered sensibility towards temperature, pain and touch sensations, and muscular weakness, which will also be noticed in the form of deformities.

Deformities of Hands and Feet

Damage to motor fibres of the peripheral nerves may result in weakness and paralysis of the muscles supplied by the nerve, producing deformities such as claw hand (Figs. 142, 143), wrist-drop, foot-drop, claw toes, mask face, lagophthalmos, etc. These are examples of primary deformity (Table 13).

Claw hand: In claw hand, the metacarpophalangeal joints become unstable and are hyperextended, resulting in compensatory flexion at the proximal interphalangeal joints. In the ulnar claw hand, the little and ring fingers are affected. Clawing of all fingers and the thumb occurs when high ulnar and low median nerve paralysis occur together. In the early stages, the claw hand is mobile, i.e. by flexing the hyperextended metacarpophalangeal joints with assistance, the proximal interphalangeal joints can be extended and the fingers straightened. It is possible to save these hands by physiotherapeutic measures and tendon transfer surgery.

Due to loss of sweating and sebaceous secretion, the skin becomes dry. This dryness leads to cracks on the hands and feet. Even when these become deep, the patient does not take care and continues to walk, as he has no pain. Deep cracks may become infected and develop into ulcers. As the infection spreads, it damages deep tissue, resulting in destruction of bone and other deformities.

In neglected cases, skin contractures may develop across the middle skin creases on fingers. Volar capsular contractures and loss of joint space in proximal interphalangeal joints in the late stages rule out the benefits of tendon transfer surgery. Stiff fingers can be loosened with oil massage, wax baths and gentle exercises. Contracted fingers are gently opened up and splinted. It is mainly splinting which can straighten contracted fingers. Scar contractures in front of the fingers can be improved with full-thickness skin grafts.

Wrist-drop is due to radial nerve paralysis or paresis. In this condition, the patient is unable to extend the wrist and fingers. This can result in the wrist being in a flexed position for most of the time and becoming

Table 13
Primary deformities due to paralysis of the nerves

Nerve	Deformities	Associated Sensory Changes	Associated Motor Changes
Ulnar nerve	Claw hand with hyperextended metacarpophalangeal joints and flexion of interphalangeal joints of ring and little fingers (Fig. 142).	Anesthesia of little finger, ulnar half of ring finger, ulnar side of hand and forearm.	Wasting of hypothenar eminence and hollowing of interosseous spaces.
Median nerve	Clawing of index and middle fingers. Association with ulnar paralysis produces clawing of all fingers (Fig. 143).	Anesthesia of the lateral half of the palm.	Wasting of the hand and of the radial side of the thenar eminence.
Radial nerve	Wrist-drop. Inability or difficulty in extending the wrist and fingers.	Sensory loss confined to a small area proximal to the index finger on the back of the hand.	Paralysis of thumb, fingers and wrist extensors.
Lateral popliteal nerve	Foot-drop. Patient drags the foot while walking and has a high-stepping gait due to inability or difficulty in dorsiflexing the foot.	Anesthesia of the dorsum of the foot and outer side of the leg.	Paralysis of the peroneal muscles and dorsiflexors of the foot.
Posterior tibial nerve	Clawing of the toes and collapse of foot arches.	Anesthesia of the sole of the foot.	Paralysis of almost all the intrinsic muscles of the foot.
Facial nerve	Lagophthalmos (patient is unable to close the eyes following paralysis of the zygom atic branch of the facial nerve); mask face.	None	Paralysis of orbicularis oculi; paresis of orbicularis oris.

Fig. 140 Burn wounds on the anesthetic fingers due to smoking

contracted in that position. A wrist-drop splint is recommended in such cases to keep the wrist extended and to prevent the contracture and overstretching of the muscles on the back of the forearm.

Foot-drop is due to the paralysis of the lateral popliteal (common peroneal) nerve at the neck of the fibula, leading to paralysis of the dorsiflexors and evertors of the foot. Occasionally, the evertors may remain free from paralysis. In such cases, there will be foot-drop without the associated inversion deformity. Patients with foot-drop have a "high-stepping gait". A foot-drop shoe with an anterior spring should be used until reconstructive surgery is carried out. This will prevent the forefoot and toes from dragging on the ground with resulting injuries, and prevent over-stretching of the muscles. Foot-drop is the commonest deformity of the foot requiring tendon transfer surgery. The usual procedure is to transfer the tendon of the posterior tibial muscle to an insertion on the dorsum of the foot.

Claw toes result from posterior tibial neuritis resulting in hyperextension of the metatarsophalangeal joints and flexion of the interphalangeal joints. Some normal people have claw-toe-like deformity, but the presence of sensory loss on the sole of the foot normally accompanies claw toes due to leprosy. This deformity exposes the tips of the toes to possible damage and makes the problem of shoe-fitting difficult. Mobile claw toes can be corrected by physiotherapy and tendon transfer surgery, while stiff claw toes need arthrodesis at the interphalangeal joints.

Other Primary Deformities

Facies leonina: This is due to multiple nodules appearing on the face in patients with lepromatous leprosy and responds well to multidrug therapy (MDT). Mycosis fungoides, leukaemia. Sezary's syndrome, post-kala-azar dermal leishmaniasis and sarcoidosis may also lead to facies leonina.

Sagging face: This is due to rapid disappearance of the lepromatous infiltrate following treatment with anti-leprosy drugs and destruction of elastic and collagen fibres in the dermis[71]. The defect produces an appearance of premature ageing. Preauricular or naso-labial face-lift is indicated in selected cases.

Loss of eyebrows: The loss of the lateral parts of the eyebrows is a common primary deformity in lepromatous cases. It is due to the lepromatous infiltrate destroying the hair follicles[71]. Free graft from the scalp or a temporal artery island flap usually gives satisfactory results. Ciliary madarosis (loss of eyelashes) may occur in multibacillary leprosy.

Nasal deformities: These are due to the invasion and destruction of the nasal tissues by **M. leprae**. Depressed nose is mainly due to the destruction of the nasal septum. The septal perforation is caused by non-specific infection destroying the cartilage. Nasal deformities are the most prominent stigmas of leprosy. In advanced cases, the nasal mucosa is replaced by scar tissue which pulls the nose inwards.

In a saddle nose defect, if the tip of the nose is in the normal position, a bone or cartilage graft would be the operation of choice. In advanced cases, a post-nasal inlay graft over a stent mould is to be preferred. The nasal cavity is approached through the upper labial sulcus and the mould is retained in position by means of a cap splint to the upper teeth. A bone graft is added after a few months. In rare cases, with total destruction of the nose, a forehead rhinoplasty is the method of repair.

Perforation of the palate: In leprosy, either the hard or the soft palate or both might be affected. The patient may complain of regurgitation of food and may have the typical speech of a patient with incompetent palate. Perforation needs repair by local flaps or by a skin tube pedicle.

Gynaecomastia or enlargement of the male breast: This causes a lot of embarrassment to the patient. This condition occurs in lepromatous leprosy. Destruction of seminiferous tubules of the testis by lepromatous granuloma results in hormonal imbalance producing gynaecomastia. It may follow testicular atrophy resulting from the orchitis of Type 2 reaction. Gynaecomastia in leprosy may be unilateral or bilateral (Figs. 145, 146); it may or may not be associated with pain. Gynaecomastia is well known in male patients with cirrhosis of the liver, interstitial tumours of the testis, diseases of the pituitary or hypothalamus, adrenal tumours, and following stilbestrol therapy for carcinoma of the prostate. Isoniazid, ethionamide and digitalis may cause gynaecomastia. This deformity can be corrected by a modified Webster's technique[72].

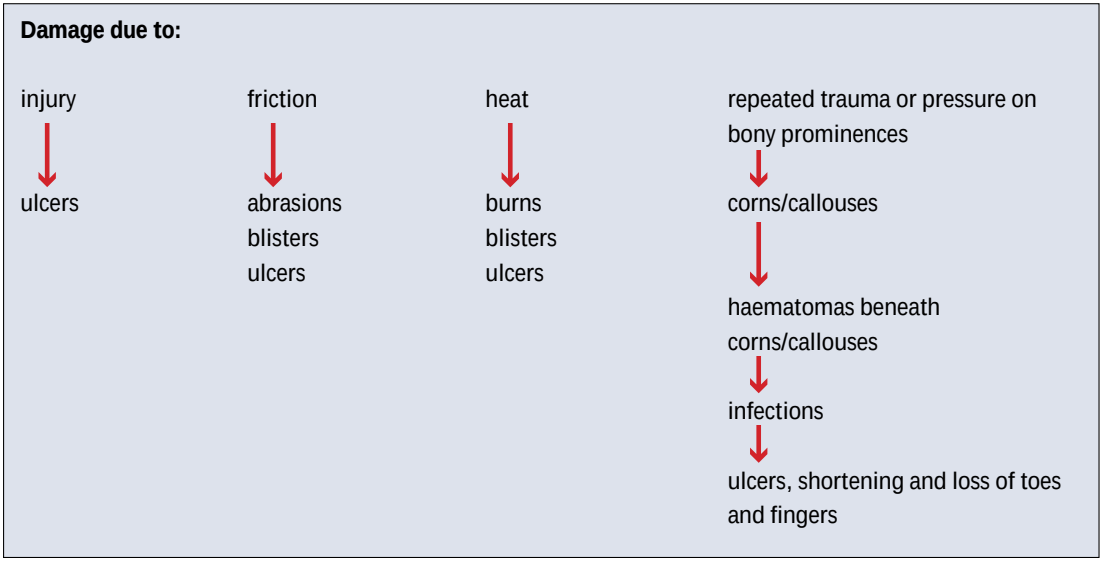


Fig. 141 Consequences of damage to anesthetic hands and feet

Fig. 142 Clawing of little and ring fingers due to paralysis of the ulnar nerve

Fig. 143 Claw hand due to paralysis of both ulnar and median nerves

Fig. 144 Collapsed nose of a patient with lepromatous leprosy

Secondary Deformities

Corneal ulcers (chapter 7). Plantar ulcers (chapter 13).

A normal person feels pain due to injury from thorns, nails, cuts, burns, heat, etc. and therefore he takes care to protect his limbs. Due to loss of sensation, a person with anesthesia does not notice injury (Fig. 140).

Such injuries, when infected, lead to ulcers and cause damage to soft tissues, joints and bones, resulting in loss of toes and fingers and other secondary deformities. The secondary damage resulting from impaired or lost cutaneous sensation can be due to:

- Lack of knowledge, awareness and health education regarding protection of anesthetic limbs from constant injury and infection;
- Neglect on the part of the patient to take care of his anesthetic hands and feet;
- Accidental injury

Results of secondary damage to anesthetic hands and feet are shown in Fig. 141. A patient with loss of sensation on the conjunctiva and cornea, due to damage to the ophthalmic branch of the trigeminal nerve, does not feel dust or foreign bodies entering the eye and is prone to get ulcers, causing scarring of the cornea and impaired vision.

Contractures and Joint Stiffness

The uncorrected clawing of fingers eventually gives rise to tendon and skin contractures at the joints which are in flexion like PIP joints. The joint stiffness starts early, particularly if fingers are not exercised daily to maintain the range of motion. Often, the little finger is known to have

more stiffness at the PIP joint, making it difficult to achieve the result of reconstructive surgery. If fingers cannot be extended fully after keeping metacarpophalangeal joint in flexion, it may be due to damage to extensor expansion or even due to volar skin contracture. When fingers cannot be opened out passively in the Bouvier's manoeuvre, it can said that there is volar skin contracture. Similarly, contracture of thumb web is seen in the median nerve paralysis. In the lower limb, the effect on the claw toes is not very severe, but the presence of ulcers on the tips of the phalanges point to contractures.

Neuropathic bone disintegration: Bones and joints without nerve supply are exposed to severe strain. The lesion begins with destruction of the articular cartilage and later involves the bone, which disintegrates. Disintegrating bone lesions will heal if adequately immobilized – it may take about six months – and can result in a functional foot that can wear a normal shoe, if proper care is taken in the acute stage. Prolonged immobilization results in osteoporosis and this predisposes to stress fractures which, if neglected, can result in marked deformity and disability.

Grading of deformities/disabilities: The three-grade WHO classification of deformities/disabilities, intended primarily for collection of general data on this subject, is very suitable for paramedical workers in the field (Table 14).

Each hand and foot should be assessed and graded separately. "Damage" includes ulceration, shortening, disorganization, stiffness and loss of part or all of the hand or foot.

Each eye is to be assessed and graded separately. Eye problems due to leprosy include lagophthalmos, corneal anesthesia and iridocyclitis.

If any disability or damage observed is due to causes other than leprosy, this fact must be noted.

The highest deformity/disability grade for any part of the body is taken as the overall leprosy deformity/disability grading.

Table 14
The three-grade WHO classification of deformities/disabilities

Grade	Hands and Feet	Eyes
Grade 0	No anesthesia. No visible deformity or damage.	No eye problems due to leprosy. No evidence of visual impairment.
Grade 1	Anesthesia present. No visible deformity or damage.	Eye problems due to leprosy are present. Vision 6/60 or better, the patient can count fingers at six metres.
Grade 2	Visible deformity or damage present.	Severe visual impairment (vision less than 6/60, the patient is unable to count fingers at six metres), lagophthalmos, iridocyclitis and corneal opacities.

Fig. 145 Bilateral gynaecomastia due to lepromatous leprosy, front view

Fig. 146 Bilateral gynaecomastia, side view

Disability Prevention

Nerve Damage

Nerve damage is characterized by the loss of sweat, loss of sensation and motor paralysis. The earlier the detection of damage, the better the chances of instituting prevention activities. Two common methods for detection of early nerve damage are testing for sensations and motor power.

Sensory Testing

There are many different techniques to test the loss of sensations in the hands and feet, however, a quick method is to test the area supplied by the nerve with a ball-point pen.

Motor Testing

Deformities arise due to loss of power in certain groups of muscles supplied by the affected nerve. The unopposed action of the normal muscles of the opposite group (extensors in case of flexor paresis) produces instability at the joints, giving rise to characteristic deformities.

Tests to detect early nerve damage are as follows:

Ulnar nerve: Ask the patient to abduct the little finger against resistance (Fig. 148) and test for anesthesia of the medial third of the palm.

Median nerve: Ask the patient to place the back of the hand and fingers flat on a table and abduct the thumb vertically upwards, at right angles to the palm of the hand, against resistance. Test for anesthesia over the lateral two thirds of the palm.

Radial nerve: Ask the patient to close his fist and extend the wrist against resistance and test for anesthesia of the dorsum of the hand.

Lateral popliteal nerve: Ask the patient to dorsiflex his foot against resistance (Fig. 149).

Posterior tibial nerve: Test for anesthesia of the sole of the foot.

Facial nerve: Ask the patient to close his eyes and then try to open them against resistance.

Management

From the point of view of public health, the primary objective is to reduce the occurrence of disabilities in

Fig. 147 Swollen and deformed foot of a leprosy patient

leprosy, which effectively means control of the disease. In other words, finding new cases as early as possible and getting them cured with treatment. MDT is considered an effective weapon to control leprosy. WHO estimates that MDT has prevented disabilities in nearly 2 million cases. Early detection and regular treatment with MDT will itself prevent a large number of cases developing leprosy-related disabilities. Thus, it is necessary to ensure total MDT coverage of the area and a hundred percent cure rate.

However, a mixture of cases of the types given below exists in any geographical area.

- Cases who have developed deformities during the monotherapy era
- New cases detected with deformities generally due to late detection
- Cases who develop "reactions" affecting nerves during or after treatment
- Cases with primary nerve involvement

For these cases, the following principles of management may apply:

Group 1 – Nerve function recovery possible

This group includes cases in which nerve damage is of recent origin. It is generally believed that up to six months from the onset of the nerve damage (not the disease), nerve function recovery is possible. Since the nerve impairment may occur before, during or even after completion of treatment, it is necessary to understand and note when the nerve impairment has occurred. Generally, cases with reactional episodes involving nerve trunks and those with painful, tender and thickened nerves can be identified as high-risk cases for disability prevention activities. These cases need to be evaluated for sensory and motor deficit, and offered steroid therapy. Additionally, nerve decompression performed surgically, where facilities are available, may also help in achieving recovery and preventing disabilities. MDT and proper management of reactions can prevent occurrence of leprosy-related disabilities to a great extent.

Group 2 – Established deformity, nerve function recovery not expected

When nerve function recovery is not possible, the deformity is permanent. In this instance, reconstructive surgery, performed at the earliest opportunity, will enable a person to get cosmetic and functional correction albeit without restoration of sensory loss.

Group 3 – Permanent sensory loss

Even after reconstructive surgery, there is permanent loss of sensation. Similarly, there are cases of lepromatous leprosy in whom there is loss of sensation in the hands and feet without deformity, generally referred to as "glove and stocking" anesthesia. It is important that all these cases are advised properly on how to take care of anesthetic hands and feet to prevent burns and injuries which otherwise would result in wounds and ulcers on the hands and feet.

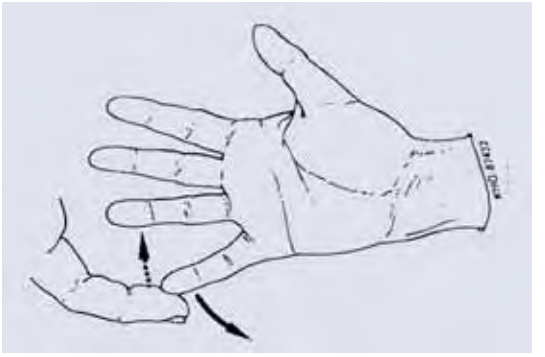


Fig. 148 Method of detecting damage to the ulnar nerve. Reproduced by permission of the World Health Organization

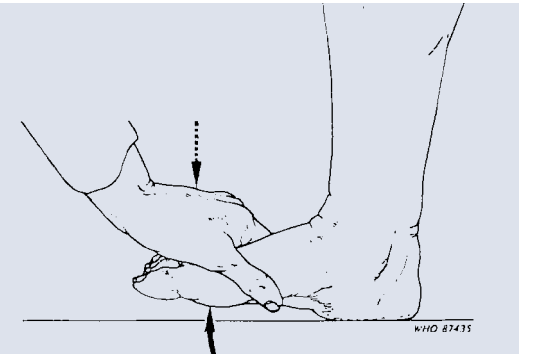


Fig. 149 Method of detecting damage to the lateral popliteal nerve. Reproduced by permission of the World Health Organization

Management of Nerve Damage

Medical Treatment

Should any of the aforementioned tests point to nerve damage, measures should be taken immediately to prevent further deterioration. The patient should be instructed to continue taking his anti-leprosy drugs regularly and in full dosages. The affected nerve should be rested by means of a suitable sling, splint or plaster cast. Keeping the affected nerve warm, by using warm clothing, woollen bandage or a warm lining to the splint, may limit further damage and promote healing[73].

Patients with neuritis should be treated with both physiotherapy and medical treatment. Exercises play an important role in the management of neuritis. Active exercises are taught to the patient to strengthen the muscles and keep the joints mobile. In acute neuritis, active exercises should be started as soon as the pain subsides.

A course of corticosteroids, e.g. prednisolone, is effective in the treatment of patients with neuritis. Prednisolone should be given in doses sufficient to control the acute reaction in nerves, then tapered off as rapidly as possible (chapter 11). Nerve damage (impaired function) with or without nerve pain and tenderness, and of recent onset, is the usual indication for corticosteroids.

Surgery as an Aid to Recovery/Prevention

Surgical decompression is indicated in:

1. Intractable pain not relieved by medical treatment;
2. Nerve abscess;
3. Entrapment of the nerve by a constricting band.

Prevention of Deformities

This can be achieved by early detection of nerve damage and early and adequate treatment of persons suffering from leprosy[73].

Management of Primary Deformities

Most of the deformities due to paralysis can be partially corrected by reconstructive surgery and the results are excellent provided the limbs are kept mobile by exercises and free from ulceration and stiffness[74, 75]. Surgery can restore part of the lost function and provides cosmetic improvement (Figs. 150, 151). It should be emphasized that surgery cannot restore lost sensation. The tendon transfer surgery, first initiated by Paul Brand in India, has altered the outlook for leprosy patients enormously. It consists of moving one of a group of strong muscles to a new position, where it replaces a group of paralysed muscles[74]. After some

Fig. 150 Claw hand, before reconstructive surgery

Fig. 151 Claw hand, after reconstructive surgery

Fig. 152 Preparing "chapaties", using a pair of tongs to avoid burn injury to anesthetic hands

weeks in plaster, the patient learns to train the muscle to work in its new position, thereby regaining the function he had lost. The possibilities of reconstructive surgery have brought renewed hope to deformed leprosy sufferers. However, it should be performed only in selected patients. Surgery performed on unstable deformities in patients subject to exacerbations of the disease or to reactions is likely to be followed by deterioration of the deformity.

Nerve repair with denatured, autologous muscle grafts, a technique developed for the repair of injured nerves, has been reported to be helpful in improving sensation and sweating in the affected area[76].

Management of Secondary Deformities

Anesthesia: Educate and convince the patient that injuries can be prevented (Fig. 152). The importance of regular daily examination of the hands and feet for injuries and prompt treatment of any injuries found must be explained to him[77]. He should be instructed to always use his eyes in order to compensate for the loss of sensation and not to touch hot things (including hot food and hot drinks) with unprotected hands. For holding hot drinks, a wooden tumbler holder or a piece of cloth should be used. The fact that "minor injuries can become major disasters" should also be explained. He must be given a sense of personal responsibility to care for himself. Adapted tools and appliances should be provided after proper training.

Paralysis: The aim should be to prevent joints becoming stiff by carrying out passive exercises. Education of the patient and members of his family is important because movements which cannot be performed actively must be done by some outside help, often the patient's other hand or possibly by his relatives. Exercises should be done slowly, carefully and regularly every day. A splint to hold the joints in the corrected position may be supplied, to be bandaged on at night.

13 Plantar Ulcers

Introduction

The plantar (neuropathic or perforating) ulcer is a common disabling complication occurring in roughly up to 10% of patients with leprosy. Due to the loss of pain sensation, the patient has no natural awareness to protect himself from the dangers that normally cause pain and discomfort. Paralysis of the posterior tibial nerve plays an important role since it not only causes anesthesia of the sole but also paralyses the intrinsic muscles of the foot, which can result in clawing of the toes and distortion of foot arches, especially the transverse metatarsal arch. Plantar ulcers develop in both paucibacillary and multibacillary types of leprosy. They may be localized or extensive, single or multiple (Figs. 153–155). The loss of sensation in the sole of the foot permits various types of trauma to injure the foot unnoticed. Neuropathic ulcers can also occur on the hands (Fig. 156).

Location

The location of plantar ulcers depends on mechanical factors. Plantar ulcers are most frequently located on the forefoot since this bears most of the force exerted to move the body forwards in the step-off phase (Fig. 157) during walking and running. They usually occur at the pressure points, namely the big toe, especially underneath the proximal phalanx, beneath the heads of metatarsal bones, the base of the fifth metatarsal and the heel. The Harris mat, developed by Dr. Harris in Toronto, is suitable for assessing the pressure points under the sole. Ulcers on the lateral part of the sole and under the fifth metatarsal base and on the heel have a high risk of severe complications[78]. The common sites of plantar ulceration have been reported as follows (Fig. 158)[79].

Fig. 153 Localized neuropathic ulcer on the big toe

Fig. 154 Deep neuropathic ulcer and dry, cracked skin on sole of the foot

Fig. 155 Extensive neuropathic plantar ulcers

Fig. 156 Localized neuropathic ulcer on the thumb

- Forefoot 79% (big toe 13.7%)
- Midfoot 7%
- Hindfoot 14%

Predisposing Factors

The predisposing factors for the development of plantar ulcers are the following:

- Insensitive sole of the foot.

- Deformities of the foot, e.g. clawing of the toes and associated paralysis of intrinsic muscles. Due to clawing of the toes, the heads of the metatarsals tend to project below where they can often be felt through the sole. The tips of the toes are more likely to be damaged because they come in contact with the ground instead of the pulp of the toes (Fig. 159).

- Scars of plantar ulcers: Newly-healed plantar ulcers leave unstable scars which have a poor blood supply and are prone to breaking. Therefore, ulcers should not be subjected to weight-bearing until at least weeks after the scabs have come off by themselves.

- Calluses (callosities): In an insensitive foot, the callus (the area of thick and hard skin) does not cause discomfort or pain, and necrosis takes place in the softer tissues underlying the callus due to pressure, which may lead to ulceration. The ulceration is usually recognised when necrotic fluid escapes from a break in the tissue around the callus. The only way to prevent the development of the callus is to avoid subjecting the foot to repeated localized heavy pressure and friction. If the callus is not scraped down and thick callus splits due to weight-bearing, a crack occurs. Once a small crack is formed, continued walking may cause it to go deeper and deeper until the torn tissue reaches the bone.

- Walking barefoot predisposes the foot to injuries.

Precipitating Factors

Take-off and strike: The weight of the body is borne by a small area of the foot during the walking cycle. The stress is directly proportional to the length of stride, the speed of walking and the distance walked. The repetitive moderate stress caused by normal walking ranges from 2 to 5 kg per sq cm[78]. It is not dangerous in a normal foot as pain warns if too much force is exerted. However, if the area is insensitive, destruction of cells located between the bone and skin due to excessive force, remains unnoticed. The damage due to further walking results in a necrosis blister in the subcutaneous tissue. The blister remains sterile so long as the skin is not broken. If blisters are covered to keep them clean and rest is taken, they will dry up without rupturing. Repeated pressure during walking can cause deep trauma to tissues which may first be obvious by slight oedema and swelling that is warmer than usual. If neglected, these so-called “hot spots” develop into ulcers[80]. A hot

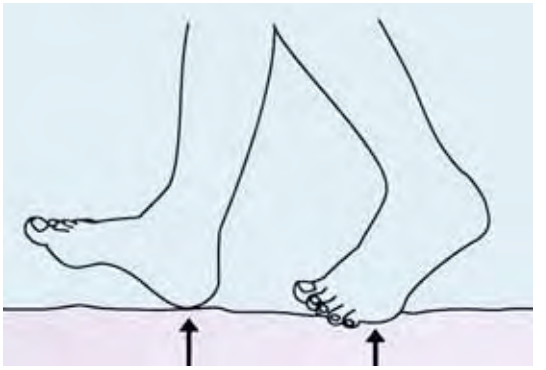


Fig. 157 The forefoot bears most of the force exerted to move the body forwards in the step-off phase

Fig. 158 Common sites of plantar ulceration

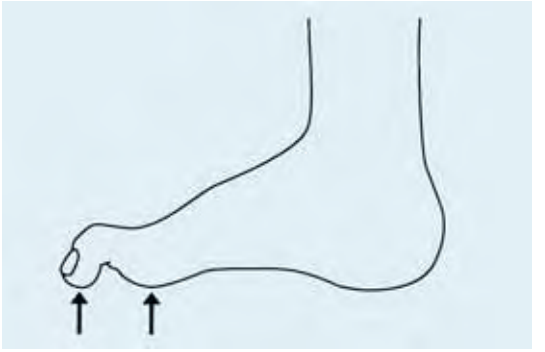


Fig. 159 Clawed toes are prone to injury at the sites marked by arrows

spot (more accurately, a "warm spot") occurs after activity and persists during at least 2 hours of rest. The patient should learn to look for redness and swellings and feel for hot spots. If such signs are found, he must take them seriously, rest his foot until all signs of inflammation have gone, and limit his walking. Resting the hot spot is the best way to prevent plantar ulcers[80].

Shear: The strain produced by pressure in the tissue when its successive layers are shifted laterally over each other. If a foot is scarred, the fibrous tissue makes the layers of the skin and subcutaneous tissue lose their ability to shift laterally. Thus the tissue gets torn during use, e.g. walking or running, and the trauma may precipitate ulceration[80].

Penetrating injury: Puncture wounds due to pointed objects, e.g. nails or thorns and cuts due to sharp stones or broken glass are hardly noticed by patients with insensitive feet. Fever, swelling of the foot and painful inguinal lymphadenitis help to attract the attention of the patient to the injury so that he treats it. Without treatment, subcutaneous necrosis may develop.

Friction: Rubbing between the skin of the foot and ill-fitting footwear, wrongly applied bandages and splints may cause blisters followed by ulceration.

Heat: Too hot a bath or walking barefoot for too long on a road that has become hot, especially in summer, can cause blisters and plantar ulcers.

Different types of plantar ulcers are seen in patients with leprosy. Unbroken blisters represent the pre-ulcer stage. Table 15 shows types of plantar ulcers and their characteristic clinical features, on the basis of the data provided by Dr. Grace Warren.

Fig. 160 Soaking the feet in water to make the skin moist

Fig. 161 Health worker explaining the importance of applying any cooking oil to the feet after they have been soaked in water

Table 15
Types of plantar ulcers and their characteristic features

Superficial ulcer	Merely a break in the skin, e.g. a minor cut or abrasion.
Simple (uncomplicated) acute ulcer	A recent, not infected cut or wound in the skin.
Simple (uncomplicated) chronic ulcer	Long-standing ulcer with minimal discharge of blood-stained fluid (no pus). It may be punched out or have undermined edges and may be shallow or deep. The floor is covered by clean granulation tissue. No lymphadenitis, no deep sinus, no warmth and swelling in adjacent tissues.
Complicated ulcer	Persistent, usually infected and associated with inguinal lymphadenitis. Local tissues are inflamed, hot and swollen. There is much discharge, often pus with a foul smell. There is often some necrotic tissue, e.g. muscle, fascia, bone or skin in the wound.
Deep sinus	Usually chronic, base is not visible and track/s may not form straight lines. Probing may reveal dead bone at the base. Edges are usually fibrotic. Sinuses may radiate out from a central deep ulcer, e.g. in the heel. Simple deep sinuses have little or no discharge, while complicated deep sinuses are associated with local inflammation and discharge pus.
Malignant ulcer	Characterized by an elevated margin, irregular hard floor with a cauliflower-like appearance and a bad smell. There is often secondary infection. Local lymphadenitis may be due to infection or malignancy.
Recurrent ulcers	Ulcers developing on the same site, often due to lack of self-care and/or to ill-fitting footwear. It may be due to an underlying abnormality, e.g. a bone spur, deep scarring, or lack of adequate subcutaneous tissue.

Differential Diagnosis

Plantar ulcers may develop in patients with peripheral neuropathy and are particularly common in patients with diabetes. They may also develop in other diseases, e.g. yaws, tabes dorsalis, Buerger's disease, spina bifida, syringomyelia, hereditary sensory radicular neuropathy, diastemetomyelia and congenital sensory neuropathy (see Chapter 8).

Management

Prevention

Every insensitive foot is in danger of developing a plantar ulcer and its common cause is an unnoticed and/or neglected injury. It is much easier, cheaper and better to prevent a plantar ulcer than to cure it. The prevention of the first ulcer should take top priority since once a foot has an ulcer recurrence is very likely.

Every patient with an insensitive foot should be helped to determine the cause of every injury. He himself can save his foot by taking simple, self-care measures. The patient should be instructed to:

- Recognize and acknowledge his lack of normal sensation.
- Inspect his feet regularly every day to note redness and swelling (warm or hot spots), cracks, dry and/or hard skin and injuries. The patient may use a mirror which is placed on the floor to inspect his feet.
- Press deeply on the parts of the sole that take pressure during walking and are the common sites of plantar ulceration, to find sore spots. If a warm/sore spot (the pre-ulcer state) is found, it may be possible to prevent an ulcer by resting before it breaks.
- Soak feet in clean water at room temperature for about 30 minutes every day and pat dry, inspect and apply Vaseline or any type of cooking oil to prevent dry skin and cracks.
- When the skin is soft after soaking, rub off dead, hard skin with pumice or a piece of stone used for skin-rubbing.
- Use properly-fitting footwear throughout the day, preferably with a soft, elastic microcellular rubber (MCR) insole and a tough undersole. Any footwear is better than none but nails or wire must never be used to make or repair footwear for people with insensitive feet.
- Shake out the shoes before you put them on to make sure there are no stones or insects in them.
- Walk carefully and slowly by taking short steps for short distances; i.e. stop now and then to rest feet.
- Never run or jump or walk long distances.
- Use a bicycle or public transport to minimize the walking distance.
- Bear in mind that "minor injuries can become major disasters". If any injury is noticed, clean it, apply adhesive zinc oxide plaster, take rest, and report to the doctor or clinic if it has not healed within a few days. If you start to treat an ulcer correctly, the day it occurs, it will heal as quickly as in a normal person.

The patient should be told that a plantar ulcer is not fully healed for six months to a year after the wound is closed. During this late phase of wound-healing, collagen realigns into a denser and stronger scar in response to a gradual increase in stress. Plantar wounds will reulcerate if walking stresses are increased too quickly. Raised temperature (compared to the other foot) and/or discolouration in the foot indicate that walking must be reduced. Every patient with insensitive feet should always keep a few pieces of gauze or cloth, sticking plaster and two or three rolls of bandages. Old clothing may be used to make bandages. He must always bear in mind that walking with footwear carefully and slowly by taking short steps is the cheapest and easiest way to protect his insensitive feet.

Different Types of Ulcers And Their Treatment

Blisters: Blisters may develop due to heat (burns), friction (e.g. due to ill-fitting footwear), excessive walking or running and/or pressure. An intact blister should not be broken or punctured. It should be cleaned gently with soap and water, mopped dry with a piece of clean cloth and covered with a layer of clean (if possible sterile) gauze or cloth and bandaged[81]. The patient should be instructed to rest the foot for at least 72 hours. The blistered foot should not be made to bear weight by using crutches during walking. The patient should keep the foot elevated when lying down. If the blister breaks open, it should be treated as an ulcer and managed with **self-care** practices.

If there is no history of burns or of excessive walking or running, the blister is most probably due to breakdown of deep tissue due to walking without appropriate footwear. In such cases, the foot should be rested in a plaster of Paris walking cast for three weeks. Thereafter, protective footwear with tough soles and soft microcellular rubber (MCR) insoles should be used.

Superficial plantar ulcer: This is merely an abrasion or a minor, superficial raw area or a cut in the skin and and should be managed with **self-care**.

Simple plantar ulcers: Rest is most essential for healing of all ulcers. But when pain is reduced or absent, the patient has no inclination to rest his foot. Time for healing depends on the depth of the ulcer, its surface, size of the simple (uncomplicated) ulcer. Chronic, i.e. long-standing ulcers, heal within 6 weeks if well rested, while recent (acute) ulcers heal quicker. Antibiotics are not the treatment for simple ulcers since most ulcers will heal with dressings and without antibiotic treatment if rested enough.

Rest is most essential, since even one step per day is enough to delay healing. Therefore patients with foot ulcers should use deterrent splints and crutches. Crutches and deterrent splints are the cheapest and most effective means of healing ulcers, where correctly used. This will encourage healing at maximum speed. The time required for healing can be used to teach the patient **self-care**. If he cannot use crutches, other means of limiting weight bearing should be insisted upon, e.g. walk with a stick, limp, use a trolley seat in hospital or just stay in bed. Alternatively, application of a plaster of Paris (POP) walking cast with a rocker or a walking splint is recommended. The bandage should not become wet or dirty. This can be achieved by protecting it with a plastic wrapping. Relatively clean ulcers need to be dressed twice weekly.

Complicated ulcer: These ulcers are usually infected and the local tissues are inflamed. The foot is washed well with soap and water, removing all traces of dirt. The foot is soaked for 10 minutes in water to which boric acid and calcium hypochlorite (bleaching powder), 2.5 grams of each to 1 litre of water, have been added[81]. Dirt and foreign bodies are removed from the ulcerated area using clean forceps. Any pockets of pus are opened up. The ulcer is dressed daily, e.g. with hypertonic magnesium sulphate (25%) + glycerine (25%) solution or with hypertonic saline solution to reduce inflammation and swelling. The dressing promotes natural healing by keeping the ulcer clean, protecting it from flies and dirt, absorbing the discharge and reducing the bacterial infection and bad smell. If possible, a radiograph is taken to determine damage to the bones and a swab is taken for culture and sensitivity tests. Systemic antibiotics are given if the infection is severe and does not subside with local treatment. Strict bed rest (not even one step per day) with the foot elevated and immobilized, is essential until all signs of inflammation have disappeared. **After 5–10 days, the trimming of the overhanging edges and removal of the hard skin around the ulcer is often essential to convert the septic wound into a clean ulcer.**

Deep sinus: This is usually chronic. When the patient is first seen, splint, elevate and rest the foot as for complicated ulcers. Use saturated magnesium sulphate solution to localize infection around the ulcer (sinus). Use a curette to increase the size of the opening into the sinus so that it can drain better. Just before surgery, inject gentian violet solution in alcohol into the sinus by using a small intracath cannula. During surgical excision remove all the necrotic and gentian violet-stained tissues. Many sinus tracks pass across the weight-bearing surface. If possible, pass a probe along the track and cut down onto it by the best route. It is necessary to check whether there is dead or infected bone at the bottom of the sinus. If present, it should be removed. At the end of the procedure all rough bone should be smoothed off. Systemic antibiotics are administered. The wound is then packed and the foot is splinted, elevated and rested completely (not even one step is permitted). The packs are changed about twice weekly. If there is still frank pus another debridement may be needed. The time required for healing will depend on the depth of the tracks.

Recurrent ulcers: Since the scar is the only part of the skin which is not able to move over the bone, the scar serves as an anchor and it absorbs all the forces of the shear stress... thus tissues are torn.[119] If ulcers frequently develop at the same site, the following points should be checked:

- Is the patient taking self-care measures, i. e. soaking, scraping and oiling his feet daily?
- Is he using proper footwear and walking slowly and shorter distances?
- Is there deep scarring and/or lack of adequate subcutaneous tissue, especially over the metatarsal heads?
- Are there rough projections of bone beneath the skin that cause ulcers?

In the event of recurrent or persistent heel ulcer, the X-ray can show whether any downwardly projecting spur of calcaneum is the cause. If a spur is found, it has to be removed and the weight-bearing surface of the bone smoothed off. Such removal should not be done

through the ulcer. A separate incision should be made around the back of the heel extending to the side of the heel laterally or medially[77].

Malignant ulcer: In some cases, a chronic plantar ulcer of long duration may undergo a malignant change. Malignant transformation is more common in chronic plantar ulcers located on the proximal third of the foot[84]. A deep biopsy should be taken to reach the base and the edge of the lesion. The squamous cell carcinoma should be differentiated from an excessive growth of granulation tissue due to pseudoepitheliomatous or atypical pseudo-epitheliomatous hyperplasia which is more commonly seen in chronic plantar ulcers.

Pseudoepitheliomatous hyperplasia is histopathologically characterized by hyperplasia of the epidermis and its finger-like projections extending into the dermis. No abnormal mitotic figures are seen. In atypical pseudoepitheliomatous hyperplasia, a few mitotic figures and some individual cell dyskeratoses are seen but this is not significant enough to diagnose malignant disease[84]. Malignant plantar ulcers are often instances of low-grade squamous cell carcinoma with clear evidence of breach in the basement membrane. Once the diagnosis of malignancy is confirmed, amputation is the only effective treatment.

Self-care Empowerment In Foot Care

Empowering patients to care for their feet is the only practical and sustainable solution to care for the trophic changes in the skin following denervation, and to heal wounds or ulcers. Motivating individuals with anesthetic hands and feet to care for their limbs as part of their daily tasks requires a change in their behaviour. Experience shows that this requires more than verbal advice and health education. Self-care practice needs to be embedded in their daily tasks, like dental care or basic hygiene. For example the Novartis Comprehensive Leprosy Care Association's (NCLCA) project of providing a self-care kit and teaching patients self-care has helped trigger this behaviour change. This project to empower leprosy patients in foot care has shown tremendous results. The kit is attractive and patients are motivated to use it. Regular use of the materials in the kit leads to a visible improvement in the skin condition as well as in the ulcers within a short time frame, e.g. pliability of the skin improves, the bad smell disappears, the discharge from ulcers decreases and signs of healing are observed. This motivates the patients to continue caring for their feet on a daily basis using the kit and creates a virtuous cycle with conditions conducive to healing.

The introduction to the self-care kit is carried out using a "camp approach", i.e. many patients are taught together. This highly participative, hands-on approach has the clear advantage of people learning together, getting actively involved in their own care, as well as motivating each other. As patients learn how to use the materials within the self-care kit under guidance, they gain confidence and realize that they can heal their ulcers. The close interaction with healthcare staff also helps motivate patients. The kit itself is given free of charge by NCLCA and the travel costs are reimbursed. The price for an individual is his or her time.

The self-care kit gives patients the tools to care for their disabilities and motivates them to care for and cure their disabilities on a daily basis. It also complements care at home with locally available materials. The 'kit' enables patients to understand the solutions to problems like care of dry or ichthyotic skin and the im-

portance of keeping the skin margin of the ulcer supple with scraping for optimal healing. It also substitutes, to a large extent, the routine dressings carried out for them at hospitals. By regularly cleaning their wounds and dressing them on their own, the patients save themselves travel, time and money. Of particular importance is the avoidance of the walking involved in reaching the dispensary for dressings, thus providing rest to the feet indirectly. However, patients are not advised complete bed rest at home as the self-care kit provides an effective solution for healing wounds and ulcers while working.

Self-care Camp

A camp approach involves calling the patients who have been selected to a suitable place such as a primary health centre, base hospital or community health centre. The patients are called by means of a letter or by the healthcare staff during their home visits. Experience indicates that the ideal number of patients in a session is 20. Each session generally lasts for 3 hours and includes hands-on demonstrations to teach patients how to clean and care for their ulcers. They also receive the materials to continue care at home. During discussions with patients, the practical problems that they might face in adopting the given advice are identified and solutions are jointly developed. There is a greater emphasis on why the ulcer occurred and how to prevent it from re-occurring.

The Self-care Kit

The self-care kit is a transparent plastic zip bag containing the following items:

1. Foot scraper about 20 cm long, 6 X 3 cm scraping surface
2. Scissors
3. Savlon© antiseptic liquid
4. Neosporin©/Betadine©/Wokadine© skin ointment
5. Dermiguard© moisturizing cream
6. Sterilized gauze packs of 5 X 5 cm
7. Bandages 3" width X 3 metres
8. Johnsonplast© adhesive tape

In addition, a plastic tub (20" diameter and 8" height) is given separately as part of the kit to all patients. The materials are enough for 30 applications and replaced after a month if necessary. All patients are also given MCR footwear at the end of the session.

Procedure

1. Soak the feet

Aim: To get water into the dry skin.

Fill the tub with tap water, leaving one inch from the brim. Add two to three capfuls of Savlon. Remove any dressings and immerse the affected foot/feet in the tub. Soak for 10 minutes. If the skin of the lower leg is also dry, pour water over it to wet it.

2. Scrape the sole of the foot

Aim: To remove the dry skin, callosities and the hard margin surrounding the plantar ulcer.

Wet the metal part of the scraper. Lift one foot, place it over the opposite knee and scrape the skin of the sole. Dip the scraper occasionally in the water and shake it to remove the scrapings of the skin collected in it. Also dip the foot in the tub to wash away the debris at regular intervals. Do the same with the other foot if it is affected. This step can take about 10 minutes and a thorough job must be done.

3. Apply antiseptic ointment on the ulcer

Aim: To treat and prevent infection in the ulcers. Apply the antibiotic/antiseptic ointment on the affected area of the ulcer.

If an antibiotic ointment is used initially, then on improvement of the ulcer change over to an antiseptic ointment while dressing. The ulcer can also be dressed with only sterile gauze after a few days when it shows signs of improvement.

4. Apply moisturizing cream

Aim: To prevent the skin from becoming dry again by sealing in the hydration absorbed during soaking and to absorb moisture from the air and keep the skin hydrated for a longer period.

Apply a 1–2 mm-thick layer of Dermiguard moisturizing cream from the toes to just below the knee (except on the ulcer). The whole leg should appear white. Massage the leg and the foot lightly till the whiteness disappears. This moisturizes the dry skin.

5. Apply the dressing on the ulcer

Aim: To protect the ulcer from continued contamination and to reduce the spread of bacteria.

Cover the ulcer with two to four sterile gauze pieces. Wrap the bandage around the foot 4–5 times to hold the gauze in place. Cut a 1" piece of the sticking plaster tape and use this to fix the end of the bandage. Do not use too many turns of bandage as it only precludes good aeration and promotes conditions for growth of bacteria. Do not tie the bandage ends as you may tie it too tight on the insensitive foot. This could lead to swelling, diminished circulation, and delayed healing. If the dressings get soiled due to excessive discharge from the wound, change the whole dressing again. Do not wrap another clean bandage over the soiled part to hide it.

6. Wear Protective Footwear

Aim: To protect the damaged foot from external injuries and to distribute the pressure of the body weight while walking.

Protective MCR footwear, designed with adjustable forefoot straps to accommodate any swelling (edema) and dressings, should be used. The adjustable forefoot straps help to maintain a proper fit and can be adjusted according to the gradually decreasing swelling.

Important Points During the Group Therapy Session

1. Patients should concentrate on scraping the hardened areas, borders of the cracks, ulcer margins and callosities on the thicker skin of the sole of the foot. On no account should they scrape the thin pigmented skin on the dorsum of the foot or else it will cause a new wound. Scraping is not advised for ulcers on the malleolus or dorsum of the foot, only dressing needs to be carried out daily.

2. Patients should use the scraper themselves. If they cannot hold the scraper due to an advanced deformity, consider applying Modulan grip-aid on the scraper to increase the gripping surface. Only in rare cases does a family member need to help with scraping.

3. Instruct patients to stop using the ointment and moisturizing cream if they have an adverse reaction like itching, swelling, redness or skin eruptions. Dressing should only be done with dry sterile gauze and the nearest health centre contacted for advice and management of any adverse reaction.

4. Tell them that follow-up visits and redistribution of required materials will be carried out at regular intervals (at least once a month) and ask them to attend a follow-up camp. Once the wounds/ulcers have healed, patients should discontinue using the kit but should continue to follow the basic self-care techniques (e.g. check their feet daily for injuries, soak and moisturize the skin using other materials like cooking oil, etc.).

5. Patients must understand the importance of the use of MCR footwear as an adjunct in healing ulcers and also as an aid to preventing recurrence. They should obtain a replacement once in 6 months to help ensure that new wounds do not occur. They can discontinue using MCR footwear if feet are ulcer-free for more than a year.

6. Encourage patients to ask questions, clarify issues that are not clear and talk freely about their situation, and explain, in simple and understandable terms, how they themselves can prevent recurrence.

Fig. 162 Group therapy session for empowerment in care of feet with ulcerations, cracks and dryness

Fig. 163 Ulcerations on deformed foot before using self-care kit

Fig. 164 Foot with healed ulcer area

Ancillary Management

Plaster casts: The application of a plaster of Paris walking cast for ulcers is a very specialized job and technicians need special training to learn how to do it correctly so that it does not produce rubbing. A wrongly applied plaster cast may cause ulcers. No walking is permitted for at least 24 hours until the plaster cast is completely dry. Crutches should be used until the plaster is completely dry. Thereafter, the patient is instructed to walk slowly by taking short steps and only for short distances. Every plaster cast should be signed by the technician who puts it on, and dated. The plaster cast is usually removed after six weeks. It is removed earlier if it becomes loose or causes discomfort, fever and/or lymphadenitis in the groin. The plaster cast promotes healing by giving rest to the foot and minimizing stress at the ulcer site by redistributing plantar pressure from the lesion to the remaining foot[82]. It is important that the cast fits well so that there is no rubbing inside. Therefore, firm protective padding is used. If an ulcer has improved but not completely healed, a second plaster cast may be applied. Most ulcers heal within six weeks (Figs. 165 + 166). However, the skin over the newly healed ulcer is thin and liable to tear due to shear stress or injuries. Therefore, a training period for walking is essential. The patient is instructed to always use protective footwear and to walk slowly and as little as possible, taking short steps, during the first few weeks. He is also instructed to check his foot for redness, swelling and/or an increase in temperature, and to rest his foot if these signs are present. Should these signs of inflammation be absent, the patient is advised to gradually increase his activities during the following six months.

The walking splint provides an alternative to clinicians who are inexperienced with casting techniques or reluctant to use the plaster cast[82]. Pre-made splints made of PVC or polyethylene are cheaper and lighter and can be kept ready to apply as soon as an ulcer is seen. Patients using the walking splint are taught how to remove and replace the device carefully. The splint should be removed twice a day during the first 48 hours for skin inspection. After 48 hours, the splint can be removed once daily for dressing changes or less often if there is minimal drainage. Otherwise, the splint should be worn continuously[82].

Fig. 165 Plantar ulcers in a patient with leprosy

Fig. 166 Plantar ulcers (Fig. 165) healed after the application of a plaster of Paris cast for three weeks

Footwear: All persons with insensitive feet should ideally wear protective footwear with tough outer soles, soft and elastic rubber inner soles or MCR inner soles and adequate fixation, preferably by means of a heel strap or heel counter. MCR is much more resilient than usual foam rubber[80]. Nails or wire must not be used in footwear for patients with insensitive feet. If the foot is basically normal, a good canvas shoe with MCR insole may provide an alternative. Canvas shoes are socially acceptable and are helpful in hiding bandages and/or any deformities of the toes. Added rubber or MCR insoles often convert ordinary shoes to adequate ones for insensitive feet. An arch support may be needed if there is forefoot scarring. In the case of a definite arch collapse, a moulded rigid rocker shoe may reduce ulcers. But if the sole has collapsed and become flat and smooth, a moulded shoe is not necessary but a rocker may make walking easier. Measurement for footwear must be taken after the swelling due to inflammation has disappeared but before a plaster cast is applied. This is essential in order to provide the patient with the footwear immediately after the plaster cast has been removed.

Definitive Surgery

Assessing the wound depth: Assessing the wound depth using a sterile probe. The probe is used to gently examine the wound for tracts and the possible feel of bony tissue at its base.

Trimming: Trimming of the overhanging edges and removal of the hard skin around the ulcer reduces pressure along the wound margins and promotes epithelialization from adjacent healthy tissues, and can be done on the first day after soaking. It enables removal of the roof of any necrotic blisters and excision of necrotic material around the edges of the ulcer.

Excision of sinus: Removal of any dead tissue, e.g. bone (sequestrum), fascia, tendon or joint capsule, using clean forceps, and laying open the sinus tracks and draining of deep abscesses is undertaken at the time of trimming, generally without anesthesia.

Fig. 167 Foot with plantar graft taken from instep area and ulcer on heel debrided to receive graft

Fig. 168 Foot healed in a month's time after application of plantar graft

Fig.169 Ulcer on 1st MTH

Skin grafting on raw area: When an ulcer has become perfectly clean, there is no deep sinus, all the slough has disappeared and if the area without skin is still large, it may be worth applying a **free split skin graft** over the ulcer area to speed up the healing. A free skin graft may be obtained from the leg or inner aspect of the thigh. However, the author's work on "plantar graft" has revived the interest in using the plantar skin as a donor area with several advantages. The instep area provides the donor site without much morbidity.

Healing was observed at the follow-up and reasonably good outcome was noticed. Plantar skin graft is a simple procedure even if the graft acts as a biological dressing, given the fact that the majority of plantar ulcer cases are neglected in the rural areas. The technique has the potential of being carried out at the community health centre level with little training.

Adjacent area flaps: The commonest flap is the triangular subcutaneous pedicle advancement flap from the adjacent skin. Alternatively, rotation or transposition flaps can be opted for. In large defects it may be advisable to go for an advanced myocutaneous flap like Flexor Digitorum Brevis for heel ulcers or Neurovascular Island Subcutaneous Pedicle Flap from the lateral aspect of the great toe for providing sensate skin to the area of the first or second metatarsal head region.

Fig. 170 Neurovascular subcutaneous island pedicle flap raised

14 Physical Therapy, Aids and Appliances

Basis of Physiotherapy

Physiotherapy (physical therapy) plays a major role in the management of deformities and disabilities occurring in leprosy. The sooner physiotherapy is started in a leprosy patient, the less likely he/she is to develop complications. Physiotherapy should therefore be started as soon as possible in order to achieve optimum results.

It is helpful in:

1. Restoring the normal tone of muscles and preserving the physiological properties of paralysed or paresed muscles;
2. Preventing muscle atrophy and the overstretching of paralysed or paresed muscles;
3. Preventing contractures and keeping joints mobile by improving the range of movements;
4. Maintaining and improving blood circulation and
5. Making the skin soft and supple.

Types of Therapy and Indications

Physiotherapy comprises exercises, oil massage, wax baths, hydrotherapy, splinting, electrical stimulation of muscles, shortwave diathermy, ultrasonics and acupuncture. Physiotherapy is very useful in the management of deformities and is essential in both pre- as well as post-operative care of deformity patients. Reconstructive surgery requires the patient to use a different muscle in place of the paralysed muscle. Therefore, cooperation of the patient and the active involvement of the physiotherapist trained in leprosy are essential before surgery is performed. Post-operative physiotherapy is also important, since sensation is not restored by tendon transfer surgery.

The operated part is still vulnerable, and the patient needs post-operative muscle training and instructions in the use of anesthetic extremities. Both the pre- and post-operative assistance of a trained physiotherapist is thus essential for the success of reconstructive surgery in leprosy.

The four main pillars of physiotherapy are oil massage, wax baths, exercises and splinting. Physiotherapy plays an important role in preventing, arresting and correcting deformities. The stigma and fear associated with leprosy is mainly due to deformities occurring in this disease. Deformities also hinder a patient's social and economic reintegration in the community.
Physiotherapy is started as early as possible in the management of leprosy.

Exercises: Exercises form one of the most important components of physiotherapy and comprise passive, assisted-active and active movements. In leprosy, a motor nerve may not be completely destroyed, thus leaving the muscles it supplies weak but still functioning. In such cases, active exercises or assisted-active exercises enable the muscle to regain strength. The patient with paralysed muscles starts with passive exercises, while active exercises are introduced later when function is regained. Exercises which put the joints through their full range of movement prevent contractures. Exercises should be performed during three to five sessions per day and each exercise should be repeated thirty times. Exercises which cannot be performed actively must be done by outside help, often the patient's other hand or possibly by his relatives. The education of the patient and members of his family is therefore important. In the case of lagophthalmos due to partial paralysis, the patient should be instructed to close his eyes as tightly as he can 40 times, three times daily.

Massage: Gentle but firm massage with any oil helps to increase local circulation, stimulates muscles and makes the skin smooth and supple. It also helps to reduce stiffness and prevents contractures. Massage should be done for a few minutes in a downward direction, e.g. from the base of the finger down to its tip. It is preferable to give oil massage immediately before the exercise programme and before the application of splints.

Wax baths: Hands are dipped in molten wax kept at a temperature of 120° F (49° C). After taking hands out of the wax bath, they are covered with grease-proof paper and wrapped in a woollen blanket. The wax is removed after 20 minutes. The wax baths increase blood circulation by the application of heat. In addition, absorption of the oily substances from the wax has a softening effect on the skin. Wax baths help to loosen and relax soft tissue contractures. Wax baths are contraindicated in patients with allergy to wax or heat. Hands with dermatitis, blisters, wounds and ulcers should not be subjected to wax therapy. The hands should be inspected after wax baths to detect any mild burns or blisters which may have been caused by the wax.

Hydrotherapy: Hands are dipped in warm water at 109° F (42° C) for ten minutes. During this period, gentle massage is given. Warm water softens the skin and improves the blood circulation. In the absence of wax bath facilities, hydrotherapy can be carried out by the patient at home. It produces the same effect.

Soaking in water for dry skin: Due to a reduction in perspiration and sebum formation, leprosy patients often develop dryness of the skin, which may lead to scaling and fissuring of the skin. The fissured skin is infected more readily than normal skin. In patients with dry skin, the hands and feet should be soaked in water for about 30 minutes every day, then patted dry, and vaseline or any vegetable oil applied to reduce the evaporation of water from the skin. The oil or vaseline should only be applied to dry skin after it has first been soaked in water. In patients with generalized dry skin, a daily bath followed by the application of oil is necessary.

Electrical Stimulation: Electrical stimulation of the muscles, shortwave diathermy and ultrasonics are also used in physiotherapy. A single faradic unit fitted with two electrodes can be used for the electrical stimulation of the muscles and to prevent their atrophy. It should be done twice daily. Electroacupuncture is reported to produce electric impulses similar to nerve impulses which stimulate paralysed muscles and prevent disuse atrophy.

Occupational Therapy

Occupational therapy aims at physical rehabilitation of the patients. The exercise regimen is such that it trains the patient to become self-reliant in some occupation. The therapist assesses the patient's deformities and identifies tools for daily living and working to improve function and prevent disability. All splints, aids and appliances are made by the occupational therapist.

Aids and Appliances

Splints: Splints constitute an essential aspect of physiotherapy in leprosy patients with deformities. They are simple devices made of plaster of Paris, aluminium, plastic (polyethylene), Plastazote, Modulan, rexin, metal wire, rubber bands, etc.

Splints are recommended for:

1. Immobilization,
2. Prevention of deformities,
3. Correction of deformities,
4. Restoration of function, and
5. Maintaining the improvement made by exercises, massage, wax baths and surgery.

Splinting is an effective way to manage ulcers and trauma of neuropathic limbs. For a complicated plantar ulcer or an ulcer with foot-drop, a plaster of Paris back-slab is used to immobilise the foot, while a walking plaster is recommended for about six weeks for uncomplicated, non-infected foot ulcers without bone involvement. A shoe with a special spring is advisable for foot-drop. The ability to heal is basically normal in a neuropathic foot unless there are associated conditions such as diabetes and arteriosclerosis. The normal process of healing is, however, interrupted by repeated trauma that may be caused by rubbing, pressure and/or injury. Therefore, if the limb is protected and rested in a splint, the trauma is reduced to a minimum and the limb heals faster than a limb undergoing repeated trauma. The splint can also hold the limb in the optimum position during healing.

It has been shown that of the four main physiotherapeutic methods of treatment (wax bath, oil massage, exercises and splinting), it is splinting that can sufficiently mobilize moderately contracted joints and tissues. Splinting can often prevent joint deformities from occurring. For example, in the presence of an isolated radial nerve paralysis with wrist-drop, there is a strong likelihood that a flexion contracture of the wrist will develop unless it is prevented by splinting the wrist in extension.

Prior to a surgical operation, splinting can often restore function. For example, in the presence of paralysed thumb muscles, the vital opposition of the thumb, so necessary for precision pinching and grasping, can be accomplished only by splinting. Of the four main physiotherapy procedures, splinting is usually carried out last.

The most frequent indications for splinting are the following:

1. Proximal interphalangeal flexion contractures, and claw hand,
2. Interphalangeal flexion contracture of the thumb,
3. Thumb web contracture,
4. Paralysis of short muscles of the thumb,
5. The reaction hand,
6. Open wounds at the finger flexion creases,
7. Foot ulcers, foot-drop and
8. Wrist-drop.

Splints used in patients with leprosy are: a) static splints and b) dynamic splints. A static splint does not permit either active or passive movement of the joint, e.g. a plaster of Paris splint. A dynamic splint is defined as any splint which incorporates qualities of elasticity or principles of recoil and permits active and/or passive movements in the joint. Dynamic splints need constant observation and supervision to ensure correct fitting, and require technical skill for their manufacture.

In severe lepra reactions, immobilization of the affected limb with a well-padded splint is helpful to relieve pain and stimulate healing, while unsplinted limbs are prone to develop contractures and deformities. Splints are very helpful in the mechanical correction of the claw hand, a deformity very commonly seen in patients with leprosy. Splints enable tendons of non-paralysed

Fig. 171
Abduction deformity of the little finger

Fig. 172
Adductor band splint made of rexin and felt, applied. Neurolysis was performed for surgical decompression

Fig. 173
Results after three months

muscles to act effectively and thereby prevent and correct deformities. In patients with a mobile claw hand, the proximal interphalangeal joints can be extended and the fingers can be straightened by flexing the hyperextended metacarpophalangeal joints with assistance. Mobile claw hands are suitable for splinting, exercises and tendon transfer surgery, while tendon transfer surgery is not indicated in fixed claw hands. The mobile claw hand is, in general, the most commonly seen deformity in patients with leprosy.

In order to prevent a mobile claw hand from becoming the complicated stiff claw hand, physiotherapeutic measures such as exercises, wax baths, and plaster of Paris splints are used in hospitals. In order to help patients in rural areas, Atul Shah has developed the gutter splint, the opponens splint, the adductor band and the finger-loop splint. They are made of durable and easily available material like PVC hose pipe, rexin, felt and rubber bands. These splints are easy to make, light in weight and patients can be easily instructed in their use. Therefore, they can be incorporated in the prevention and treatment of deformities in field conditions. These splints, in conjunction with appropriate exercises, are successfully used in the Comprehensive Leprosy Care Project in collaboration with the Government of Gujarat, India[85]. Table 16 shows indications for the use of these prefabricated splints, developed with support received from the British Leprosy Relief Association (LEPRA).

At the Bandorawalla Leprosy Hospital in Kondhwa, Pune (India), splints made of aluminium strips padded with sponge, sometimes equipped with finger loops attached by rubber bands, are succesfully used by Jadhav and colleagues in patients with mobile claw hands (Figs. 178–180).

The splints are durable and not expensive. Since these splints are extremely light, they are very suitable for hands with anesthesia. Moreover, the splinted fingers can be exercised. The splints are easily removable and are used until the patient can achieve and maintain the lumbrical position unaided.

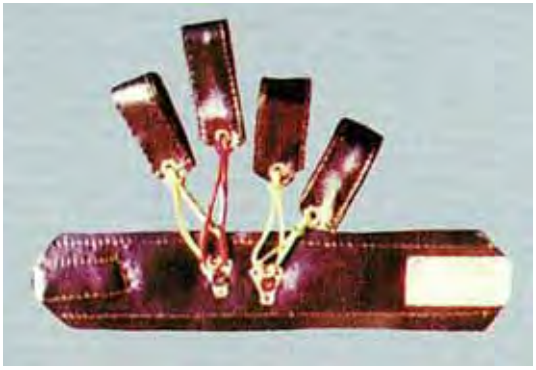


Fig. 174 The finger-loop splint

Table 16
Indications for the use of prefabricated splints*

Deformities	Splints
Abduction deformity of the little finger (Fig. 171)	Adductor band ("A" splint) should be used (Fig. 172).
Mobile ulnar claw hand	Finger loop splint ("L" splint) should be used. Use finger loops for the ring and little fingers.
Mobile total claw hand (Fig. 175) (clawing of the thumb and four fingers)	Finger loop splint (Fig. 174) and the opponens splint ("O" splint) should be used. All fingers are splinted with 4 finger loops, and the thumb is kept in abduction by the loop of the opponens splint.
Claw hand with stretchable stiffness of proximal interphalangeal (PIP) joints or in cases where there is an increase in deformity on waking up in the morning. Claw hand with contractures	Finger loop splints should be used by day and the gutter splints ("G" splints) at night. Use gutter splints until contracture is overcome. If PIP joints show some active extension, follow up with the finger loop splints or alternate both "G" and "L" splints, but remember to always use "G" splints at night.
Thumb-web contracture, if it is not too tight	Use the opponens splint ("O" splint)

* Designed by Dr. Atul Shah, Grant Medical College, Mumbai, India

Fig. 175 The patient had ulnar and median neuritis resulting in paralysis of the hand

Fig. 176 Fingers were splinted with four finger loops and the thumb with opponens splint loop. Medical treatment and exercises were continued

Fig. 177 The same patient (Figs. 167, 169) after three months when almost all functions of the hand had been restored

Crutches

Crutches are to be used by patients who are not to bear weight on their feet, e.g: complicated plantar ulcers under daily dressings treatment; plantar ulcer patients until walking cast is given; plantar ulcer patients who have not yet received MCR footwear or specialized footwear.

Contraindications and Precautions

Do not use splints for claw hands without any action of the proximal interphalangeal (PIP) joints, i.e. if fixed flexion deformity of the PIP joints is present.

Since leprosy patients have anesthesia of the extremities and because even the slightest excess pressure might lead to ulcers, splinting should be carried out with care by a physiotherapist trained in leprosy. The selection of patients should also be made by a physiotherapist trained in leprosy.

The use of splints should be discontinued if pain, redness, swelling and/or blisters develop at the site of application.

The patient should be referred to a specialist if the regular use of splints for 3 months does not result in substantial improvement.

If splints are used appropriately, along with suitable exercises, claw hands become normal in the majority of early cases.

Fig. 178 The U-splint made of aluminium used to correct mild clawing of the finger

Fig. 179 An aluminium splint with a wrist support, used in patients with weak thenar muscles, does not need any additional bandage

Fig. 180 The dynamic, lumbrical, aluminium splint is provided with a wrist support to prevent excessive flexion of the wrist joint caused by the pulling action of the rubber bands which assist in achieving the lumbrical position

Fig. 181 Hand in the lumbrical position

The time taken to respond ranges from 6–12 weeks. Regular exercises are essential to restore mobility of the fingers. Appropriate splinting, in conjunction with suitable and regular exercises, can play an important role in the prevention and correction of deformities, especially in rural areas where facilities for reconstructive surgery are rarely available and the prevalence of deformities is high.

Grip-aids

Novartis, former Ciba-Geigy, in technical collaboration with the City of London Polytechnic, has developed made-to-measure Modulan® grip-aids for leprosy patients with deformity of the hand. The concept of epoxy resin grip-aids for leprosy patients was developed by Don Caston and Ganapati in 1979. The beneficial effects of grip-aids moulded from epoxy resin putty in 25 patients with deformities of the hand due to leprosy were first reported from India by Ganapati et al. in 1983[105].

Modulan putty is better in consistency and colour. The yellow putty contains epoxy resin, while the blue putty contains a hardener. Equal amounts of the two components, Modulan blue and Modulan yellow are then mixed using gloves, to produce homogeneous green putty. The putty is applied to the handle of the patient's

Fig. 182 A patient with deformed hands pouring water into his mouth from a distance

Fig. 184 Two-component, epoxy-resin putty

Fig. 183 The same patient drinking water in a normal way after the Modulan grip-aid had been fitted to the tumbler

Fig. 185 Modulan grip-aids to facilitate writing and the use of personal utensils

tool or utensil and moulded roughly into shape. The patient's hand is then coated with the protective cream provided and he or she grasps the tool as though to use it, pressing the putty to fill all gaps. The patient's hand is then removed, the fingers being lifted carefully one by one, sharp edges are rounded off by the paramedic and the tools or utensils are left to stand for the putty to cure.

Fig. 186 Deformed hand holding a ballpoint pen with the help of the Modulan grip-aid

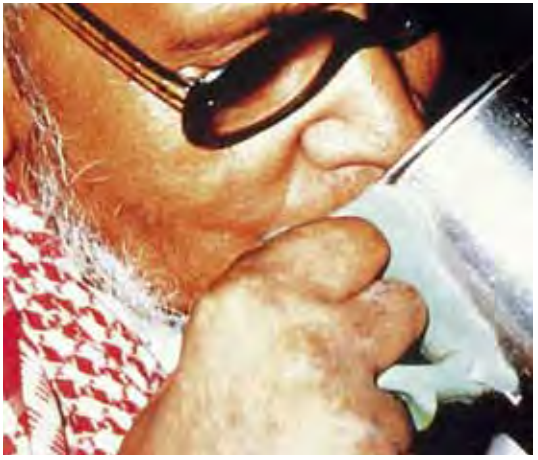


Fig. 187 Deformed hand holding a tumbler with the help of the Modulan grip-aid

Modulan grip-aids can be recommended for[106]:

- Patients with grossly deformed hand(s) due to partial or total loss of fingers/thumbs, which limits their capacity to hold any object firmly and compel them to use both palms to grasp objects.
- Patients with fixed contractures of the fingers (irreversible claw hand) which cannot be corrected even by reconstructive surgery.
- Patients who may or may not have any visible deformity, have good muscle power, but who suffer from loss of sensation resulting in objects slipping from their hands.
- Patients with a total claw hand where the thumb is also paralyzed, leaving only a limited opening for the "key pinch".
- Occasionally patients with a mobile claw hand may not be able to grasp objects firmly. In such instances, Modulan grip-aids may prove helpful.

Modulan grip-aids can be fitted to almost any tool or utensil used in the course of ordinary daily life by a person with deformity of the hands. Apart from pens, spoons, toothbrushes, briefcase-handles and screw drivers, a variety of articles can be made easy to handle for a handicapped person, with the help of these grip-aids. In order to improve the person's ability to function, those in charge of his workplace accommodation must consider the equipment with which he has to work, and facilitate his job, whether paid or unpaid.[120]

Modulan adheres well to almost any surface, e.g. wood, metal, plastic, glass, etc. However, it is not suitable for surfaces with a greasy texture. The Modulan

grip-aid does not shrink and it retains its shape. It is washable and can even be autoclaved. It is extremely durable but can be altered by filing. The made-to-measure Modulan grip-aid can be used by those with crippled hands, but it also affords protection from pressure and abrasions.

- A grip-aid moulded by the user's hand results in even distribution of pressure during its use.

- It prevents the hand from slipping and thus accidental injuries are avoided, e.g. the use of a knife with a grip-aid can prevent the hand slipping against the blade.

Instant Grip-aids

The Modulan grip-aids or grip-aids to be made from epoxy resin take time and have to be made for each patient individually. The concept of providing prefabricated grip-aids, like that of prefabricated splints, was developed by Novartis CLC Association.

The activities selected for improvement depends not on the deformity but on the fitting of the grip-aid. Occupational activities were considered unsuitable for this type of “instant grip-aid”. The activities of daily life like dental hygiene, combing the hair, eating with a spoon and drinking, bathing or using a water container for the Indian-style toilet were considered as essential to one’s daily life. The “Instant Grip-aid” as it was called, because of ease of application and immediate use by a crippled patient, made these activities comfortable.

Fig. 188
Modulan grip-aids to facilitate the use of different tools

This type of grip-aid is made from Velcro and rubber. It is applied with rubber on the volar aspect wrapped around the stump of hand or just below the stiff and absorbed fingers. The pocket on the volar aspect holds the handle of various articles.

Patients are able to use it as soon as it is applied. There were dramatic results after application of these grip-aids. The majority of patients when asked said they were much happier with these grip-aids though sometimes they needed assistance to apply them. A research paper based on this was presented by Neela Shah and Atul Shah at the 17th International Leprosy Congress at Hyderabad and samples of the same have been sent to many countries.

Fig. 189 Instant Grip-Aid Kit from Novartis CLC Association

Fig. 190 Instant Grip-aids can be used to hold tooth brush, spoon, glass and comb – this new grip-aid obviates making multi-purpose grip-aid handle from Modulan

15 Reconstructive Surgery in Leprosy

Two important organs of the body are damaged in leprosy, the skin and the nerves. The common sites of nerve involvement in the upper extremities are ulnar nerve at elbow, median nerve at wrist, radial cutaneous nerve at wrist, radial cutaneous nerve at forearm and rarely radial nerve at humeral groove. In the lower extremity, the common sites are lateral popliteal at the neck of fibula, posterior tibial at ankle and sural nerve at ankle. In the head and neck, the common sites are the facial nerve at preauricular region and greater auricular nerve in the neck. Nerve lesions produce the characteristic deformities like claw hand, foot-drop, etc. when motor fibres are involved. The affection of autonomic fibres and sensory fibres generally precedes the motor loss, thereby resulting in anesthesia in the affected territories and loss of perspiration.

Reconstructive surgery in leprosy is carried out on nerves with the aim of sensory and motor recovery in early cases with nerve impairment, or to evacuate nerve abscesses and release the nerve from compression of the caseous materials occurring due to antigen antibody reaction. In all other instances, it is aimed at correction of the deformities either for functional or for aesthetic reasons.

Reconstructive surgery of the nerves has been proven to be beneficial if undertaken at an early stage. Decompression of the nerve from its course in the fibrous tunnel to prevent the compression and consequent anesthesia or paresis aims at surgical release of the fibrous tunnel which is called external neurolysis. If the nerve is also surgically opened from its epineural sheath, it is called epineurotomy. As shown by Antia, epineurotomy can help only until the nerve is encased with edema. It is of doubtful value in the later stage when the fibrosis has already taken place. If there is an abscess in the nerve it should be curetted and epineu-

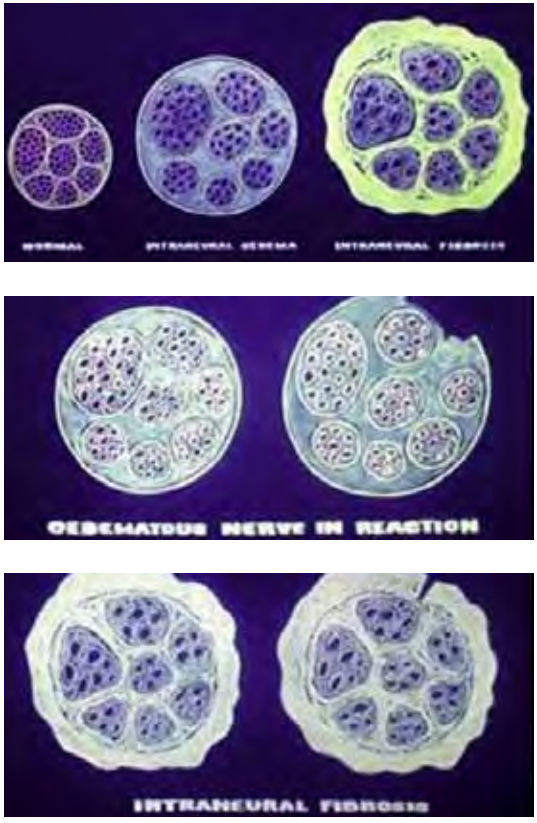


Fig. 191 Diagrammatic representation of effect of incision on nerve during edematous stage and fibrosis stage

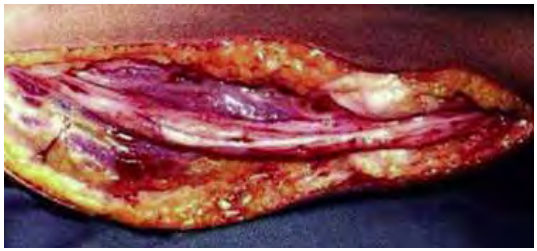


Fig. 192 Epineurotomy of ulnar nerve

Fig. 193 claw deformity in a young girl

Fig. 194 Claw correction after author's technique

rotomy may be performed. An excellent monogram on operation on nerves has been produced by Salafia.

The lesions in the ulnar nerve produce partial claw hand. The correction is required for cosmetic purpose, powerful pinch and for fine functions. Median nerve affection invariably follows ulnar nerve affection and the combined effect of both produces either subtotal claw hand in which all four fingers are affected or a total claw hand in which besides clawing of all the fingers, the thumb is also paralysed. The reconstruction of such a hand enables the patient to have good pinch and grasp necessary for the activities of daily life.

Fig. 195
Operation trac (transverse arch correction by author enables good hypothenar lift and five-finger pinch

Uncorrected, the primary deformities may lead to secondary deformities like flexion contracture of the volar skin, boutonniere deformity, which is damage to the extensor expansion at the PIP joint, and thumb-web contracture due to contracted adductor fascia. Unless the secondary deformities are corrected adequately, the results of the correction of primary deformities may be inadequate.

Reconstructive surgery for correction of claw hand aims at stabilizing the MP joint and allowing independent flexion of MP extension of I. P. joints. The author prefers the use of FDS lasso, depending on the clinical presentation of the leprosy claw hand [121]. Median nerve paralysis not only produces clawing of the index and middle fingers but also affects the thumb, which loses abduction and opposition, converting the pinch type to key pinch. With this deformity, the patient's working capacity and activities of daily life are hampered. Brand's abductor and opponens replacement using flexer digitorum sublimis of ring finger routed along the correct axis gives vary satisfactory results.

Deformities of feet are less common than those of the hands except for the ulcers resulting from minor trauma on anesthetic feet and its subsequent neglect. Besides explaining the care of the anesthetic feet and providing footwear to prevent further damage, reconstructive surgery can be done for foot-drop and the claw toes. The tibialis posterior muscle is transferred and its tendon is attached to the extensors of feet in the dorsiflexed position under tension. Intensive physiotherapy is required to re-educate the patient for a successful result. The surgery for ulcer has been described earlier.

Deformities of lepromatous leprosy are easily recognizable and project an image of the diseased person which is abhorrent to most individuals.

Lagophthalmos is due to damage to the superior branch of the facial nerve. The temporalis musculofacial sling is one of the standard procedures for reactivation of eye closure voluntarily. This decreases the chances of damage to the cornea, exposure keratitis and subsequent blindness.

Laxity of facial skin is due to regression of nodular swellings chiefly in the nasolabial region. It is associated with perioral wrinkles and markedly enlarged earlobes. The operation of nasolabial facelift with placation of underlying soft tissue gives the patient a youthful appearance and feelings of rejuvenation. Perioral wrinkle can be treated by the elliptical excision of wrinkled skin whenever required.

Loss of eyebrows occurs due to infiltration of the skin of the face with leprosy bacilli, which destroy the hair follicles. Reconstruction of the eyebrow is often essential as the patient looks abnormal and identifiable as suffering from leprosy during his participation in social events. Reconstruction is undertaken either by free grafts from the scalp or pedicle graft. The island flap based on the anterior branch of the superficial temporal artery is a good alternative to pedicle graft, making it a one-stage procedure. Usually after an operation involving free grafts, hairs fall out after 2 to 3 weeks and start growing again after 6 months.

The nose is involved in 25% of all cases with facial deformities. The nose deformity in leprosy may vary from slight depression to gross collapse. Lepra bacilli primarily cause destruction of the mucosa. Ulceration of the mucosa leads to exposure and loss of blood supply to the underlying cartilage, causing collapse. The skin is invaded but rarely destroyed. The alar cartilages are covered by the skin lining on both sides, hence tip and ala are seen preserved. Thus, destruction is chiefly in the middle third of the nose. Correction is achieved by placing the lining and by providing support. Post nasal epithelial inlay or the nasolabilal flaps for lining are the most suitable operations in gross collapse of the dorsum of the nose.

Fig. 196 reconstruction of eyebrow, nose and facial skin before and after appearance of patient

In summary, reconstructive surgery helps functional as well as cosmetic correction of the deformities in leprosy. Reconstructive surgery also helps to remove the stigma by correcting deformed body parts, and enables a patient to reintegrate into society. However, it is important not only to reconstruct but also to offer rehabilitation following reconstructive surgery, as is practised by Novartis Comprehensive Leprosy Care Association.

16 Rehabilitation in Leprosy

The meaning of rehabilitation has changed over time. While some years ago, rehabilitation merely meant provision of food and shelter, it now aims at the total re-integration of the leprosy patient into the community in which he lives, taking part in all its activities as a contributing member of society. In this respect, the Second Leprosy Expert Committee of the WHO defined it as follows:

"By rehabilitation is meant the physical and mental restoration, as far as possible, of all treated patients to normal activity, so that they may be able to resume their place in the home, society and industry. To achieve this, treatment of the physical disability is obviously necessary, but it must be accompanied by the education of the patient, his family and the public, so that not only can he take his normal place, but society will also be willing to accept him and assist in his complete rehabilitation."

Prevention of Deformity

It should be emphasized that every effort should be made to detect the disease early and bring the patient under regular treatment. Early diagnosis followed by regular and complete treatment prevents deformity. WHO estimates that between 2 and 3 million persons are permanently disabled due to leprosy. For many of these individuals the programme failed to reach them in time with multidrug therapy. The occurrence of visible deformities and disabilities is the main reason why leprosy is such a fearsome disease. Since deformity disfigures and stigmatizes, and results in rejection of the leprosy sufferer by society, its prevention should form part of every leprosy control programme. "The rehabilitation services which cater to the needs of other disabled people in the community should be available to the leprosy patient." Early detection of nerve damage and measures to prevent primary deformity will avoid social dislocation of the patient from the community. Measures should be taken to prevent secondary deformity to the already anesthetic-deformed extremities. Surgery plays a major role with respect to motor function and appearance, provided it is performed in suitable patients. However, it does not influence sensory loss and therefore the patient should be instructed in the care of the hands and feet.

Education of the Community and the Patient

One of the most basic factors in rehabilitation is education. The patient must be carefully educated so that he learns how to work without damaging his most valuable tools, i.e. his hands, feet and eyes. The community should be educated to regard leprosy not as a curse or a punishment for misdeeds in a previous incarnation but as any other disease. In areas where leprosy services are integrated within the primary health care systems, treatment facilities have been expanded and more and more patients are being brought under treatment. The easy and free-of-charge access to treatment with MDT, combined with the educational programme, has helped cure over 14 million patients. The disease profile has changed and complications due to advanced untreated disease have become a thing of the past. For example, we no longer see patients with laryngeal stenosis, which was a common feature in former times. Thanks to improved leprosy control activities, both the deformity rate and eye complications have decreased considerably. All these visible results have led to a better understanding of leprosy by the community in general.

However, in countries where leprosy is endemic, many areas are not fully covered by disease-control services and there are already large numbers of deformed patients in the community. The rehabilitation of the leprosy patients will therefore remain a big problem for some years. Therefore, solutions to the problems of leprosy-affected persons should be viewed in the general context of development. This will mean that leprosy-affected persons should have equal access to all the existing programmes for poverty alleviation and development, welfare and community-based rehabilitation.

Rehabilitation through Occupational Therapy

To make it possible for handicapped people to earn higher incomes, rehabilitation activities in engineering trades may be started, but these need much greater investment per job-place and supervisory personnel with the necessary experience. When starting these engineering trades or crafts, one has to find out about the availability of raw materials and the marketing prospects for the finished products. For example, a mechanized mat-weaving industry should not be started where the raw materials will have to be imported from distant places; nor should production of good furniture be started where the furniture produced cannot be sold. It is always a good policy to find a local market for the products in and around the area of production.

The occupational rehabilitation activities generally include:

1. **Crafts (for the self-employed or for groups)**
   Crafts can be started either by the self-employed or by groups. Recently, some voluntary organizations have been encouraging people handicapped by leprosy to remain in their villages or towns and start self-employment schemes. There are many crafts which can be started by these people in their own homes, e.g. cloth-weaving, handloom weaving (Figs. 197, 198), computer training, setting up a cycle repair shop, a tailoring shop (Fig. 199), poultry or dairy farming, etc. This requires capital investment. Therefore voluntary organizations and governments should come forward in a big way with monetary assistance or assist these people in getting loans from the banks. It should be emphasized here that those who have been gainfully employed do not have any serious problem in integrating. They are able to get rented accommodation, often marry non-disabled spouses and do not seem to suffer from isolation. Occupational training and economic self-reliance play an important role in the process of rehabilitation.

2. **Co-operative ventures**
   Co-operative ventures can be started in order to provide services or products which bring in a very reasonable income for the handicapped. These should be encouraged and the necessary finance provided. Handicapped persons living with their families can be gainfully employed in these co-operative ventures, for example milk and poultry co-operatives, printing, book-binding, shoe-making (Fig. 200), handlooms, handicrafts, two-wheeler and three-wheeler transport services (Fig. 201), etc.

3. **Industrial ventures**
   Here too, proper consideration has to be given regarding the availability of raw materials, trained personnel, development of skills, marketing possibilities, etc. With proper training, handicapped people can produce work which is equal to that of

normal persons. When properly trained, these people afflicted with leprosy will be able to find employment in small-scale units and other industries. One of the good things in recent years is that most of those afflicted with leprosy who seek training and employment today are much less deformed than those who sought employment about ten years ago.

Many occupational rehabilitation centres have now been set up and some of them are doing very well, proving that if such centres are properly located, managed by efficient people and the trades suitably selected, they cannot only be self-supporting but can also help these individuals to become useful members of society. Jal Mehta has established an industrial rehabilitation centre in Pune. In this modern centre, the patients, as well as disabled ex-patients, manufacture motor car parts using computerized lathes, milling machines, electric saws, etc. The products are purchased by TATA for assembling trucks. TATA Industries have done a commendable service for the rehabilitation of leprosy patients in India.

Other Rehabilitation Programmes

It is always advisable for a disabled person to return to his original occupation, provided this does not expose him to injury and further damage to his hands and feet. There is no need for a leprosy patient to change his occupation if he has no deformity or anesthesia. If the occupation has to be changed, the rehabilitation services should select an occupation for the handicapped patient, in consultation with him and his family, and then train him for the new job. With proper education in the care of the hands and feet and appropriate training, these handicapped people can even be employed in industries where there is low risk of injury.

Fig. 197 Cloth-weaving

Fig. 198 Hand-loom weaving

Fig. 199 Tailoring

Vocational Training

Several vocational training programmes, like light engineering trades, tailoring, welding, printing, production of materials for engineering companies, agriculture, etc., should be started on a large scale.

Strenuous occupations involving a lot of standing and walking are to be avoided.

Sheltered Workshops

Some patients, even after proper training, are unable to compete with able-bodied persons in the open job market. These people should be employed in subsidized sheltered workshops.

Crippled Patients

For those leprosy sufferers with crippling deformities, who cannot be gainfully employed in any of the programmes described above, the only place will be in homes or institutions where they can be looked after. Occupational therapy programmes should be started to help these persons to spend their time gainfully and help the institution in some way. On the other hand, the old-age pensions provided by the government may help these patients to remain with their own families[104].

Conclusions

Rehabilitation comprises many different activities, including education of the public, social workers and the patients, early diagnosis, regular and complete treatment, prevention and correction of deformities, use of grip-aids, selection of the patients for appropriate jobs and training and placing them in selected jobs. All attempts should be made to integrate those handicapped for any reason into the community. Any initiative to deal with people handicapped by leprosy alone will be counter-productive, as it will help in perpetuating the negative image of leprosy as a special disease needing special people to take care of it. Governments and voluntary organizations should therefore come forward in a big way to help these people. In addition, physical, psychological, social and vocational rehabilitation should form an integral part of every development programme for the community.

Fig. 200 Shoe-making

Fig. 201 Three-wheeler transport (rickshaw)

Fig. 202 A leprosy patient painting with a brush to which a Modulan grip-aid has been applied

17 Prevention and Control of Leprosy

Even at a time when leprosy was considered incurable, the desire to contain and possibly prevent disease was quite strong among health leaders. But the methods available up until the middle of the last century were quite rudimentary, isolation of patients being the most common one.

Control through Isolation

For centuries, attempts have been made to contain leprosy through isolation of patients by various methods. Earlier, isolation was practised mainly for the purpose of social segregation of patients, reflecting strongly the fear and stigma against the disease. The methods employed then were often cruel and inhuman, relegating the leprosy sufferers to the fringes of society. In the later part of the nineteenth century and also in the twentieth century, the practice of isolation was rationalized more as a public health practice to prevent transmission of infection. This led to a more organized way of isolation through institutions often called sanatoria or leprosaria. Apart from institutional segregation, isolation was also practised through confining patients within certain settlements or villages. Isolation within homes was also a frequent practice.

While isolation of patients appeared to be rational in principle, in reality it was not able to produce the desired results for many reasons. Thus there were very few examples of successful disease control through isolation. Successful control of leprosy in Norway is claimed to be one such example[123]. Theer are several reasons as to why isolation failed. Firstly, unless all infectious patients in the community are identified and isolated, one cannot expect any significant impact on transmission. In practice, it is not possible to identify all patients unless there is an effective method of case detection. Even if identified, not all patients are likely to be willing to be isolated for various reasons such as separation from family, unwillingness to live in unfamiliar surroundings and further stigmatization. It was because of this that in certain countries isolation was made compulsory. However, compulsory isolation failed as it led to concealment of disease on a wide scale, resulting in more effective transmission of the disease. Thus experience showed that isolation produced more problems than it solved. However, the practice was continued in many situations for want of any other alternative. The emphasis on isolation changed with the advent of more successful methods such as effective treatment of patients.

Control through Treatment of Patients

Trying to control leprosy through treatment of patients is essentially a method of secondary prevention as it aims to prevent transmission indirectly through elimination of the source of infection. For this approach to be successful, it is essential (a) that all, or at least a very large majority of, patients, particularly the infectious ones, i.e. the multi-bacillary patients, are detected, (b) that they are detected in time with no delay as otherwise they would already have transmitted infection in the community, (c) that the patients are promptly put on treatment and ensured that they complete their treatment in time, (d) that the chemotherapy employed is highly effective and capable of making the patients non-infectious within a short period of time, and (e) that the treatment does not lead to any significant relapse of the disease or drug resistance.

Dapsone treatment: Control of leprosy in the community through treatment of patients became possible with the advent of the first effective drug, Dapsone.

Large-scale use of this drug started in the 1950s with great promise. However, over the next 30 years the limitations of Dapsone treatment were exposed both for treating individual patients and for using it as a public-health tool to eliminate the reservoir of infection and consequent transmission of the disease. The first problem was that Dapsone was a slow-acting bacteriostatic drug which did not inspire great confidence in the patient or health worker. Secondly, compliance with treatment during Dapsone monotherapy was a major problem. Patients could not see an immediate clinical improvement, and the prolonged treatment was not conducive to maintenance of regular treatment. The perception of many health workers that Dapsone was not really a highly effective drug, together with the fear of relapse, resulted in the patients continuing Dapsone treatment indefinitely. The negative social attitudes towards leprosy and leprosy patients changed little in spite of the limited control that was possible through Dapsone treatment. This resulted in poor case-detection and case-holding of patients, and highlighted the need for the technology not only to be effective but also to be perceived as effective.

In the early days of Dapsone, it was considered that mass treatment of patients would reduce the reservoir of infection sufficiently to bring about major reductions in the transmission of infection and thus the incidence of the disease. While reductions in prevalence were possible in well-organized programmes, reductions in incidence were seen only in a very few situations.

However the most important negative effect of Dapsone treatment was the development of resistance of **M. leprae** to Dapsone resulting in substantial treatment failures[124]. Over the years, secondary Dapsone resistance was reported with increasing frequency. Wherever Dapsone resistance was sought among treated and relapsed patients with multibacillary leprosy, it was found to exist, and its prevalence was steadily increasing in many countries. The situation with regard to the occurrence of primary Dapsone resistance was even more disturbing, and the rate of its incidence appeared to be increasing at a faster pace than that of secondary resistance. While studies on secondary Dapsone resistance showed that it was in the range of 30 to 200 per thousand patients, primary Dapsone resistance among untreated patients was found to be between 320 and 500 per thousand patients. This alarming situation called for urgent action.

Multidrug Therapy (MDT): By the early 1980s, it was clear that Dapsone was steadily losing its usefulness, due to resistance. Although more potent anti-leprosy drugs such as Rifampicin and Clofazimine were available then, the information and guidelines available on how to apply them in a practical way in the field were insufficient. It was under these circumstances that WHO constituted the Study Group on Chemotherapy of Leprosy for Control Programmes in 1981, which came up with a recommendation for the standard multidrug therapy (MDT) for treatment of leprosy, particularly for the field programmes[125].

The rationale behind MDT is the prevention of selection of drug-resistant mutants and the killing of all drug-sensitive organisms so that treatment failure and relapse could be prevented. It is estimated that a fully developed lepromatous leprosy patient harbours between 10^{11} and 10^{12} AFB with a viable population of about 10^{9}. This viable population consists of several sub-populations of drug-sensitive and naturally drug-resistant strains. It is estimated that in any wild population of **M. leprae**, the number of naturally occurring Rifampicin-resistant mutants is about

one in 10^7, and the number of naturally occurring Dapsone- and Clofazimine-resistant mutants is about one in 10^6 in each case. In any monotherapy, the relevant drug-sensitive organisms are killed progressively depending upon the anti-bacterial activity of the drug, leaving behind the naturally occurring mutants resistant to the drug applied in the monotherapy. It is these unaffected drug-resistant mutants which later multiply and result in late relapses. In multiple drug therapy, this problem is prevented as the second drug will effectively kill the mutants resistant to the first drug, and vice versa. However, it is important to ensure that the drugs selected are bactericidal to the maximum extent possible. In leprosy, while we have one highly bactericidal drug in Rifampicin, the other drugs available such as Dapsone and Clofazimine are essentially bacteriostatic.

Thus it is clear that for treatment to be effective and have an impact on transmission, it is important that: (i) all combinations should include Rifampicin, (ii) Rifampicin should be administered long enough to kill most of the Rifampicin-sensitive strains, and (iii) the other drugs should be administered for sufficiently long periods to kill all the naturally occurring Rifampicin-resistant mutants. Thus the three drugs selected for MDT were Rifampicin, Clofazimine and Dapsone.

The original 1981 recommendations on duration of treatment was (a) for multibacillary (MB) leprosy a minimum of two years or until smear negativity and (b) for paucibacillary (PB) leprosy a fixed period of 6 months. Subsequently, the VII Expert Committee on leprosy reduced the period of treatment of MB leprosy to a fixed period of one year[126], based on additional evidence available then. The details of drugs and dosage of MDT are given in Chapter 10.

Other Methods of Control or Prevention in Leprosy

As part of disease control, preventing the disease before it occurs is important for any disease. In leprosy, preventive interventions tried include chemoprophylaxis and immunoprophylaxis.

Chemoprophylaxis

Soon after the advent of Dapsone, the possibility of using it as a chemoprophylactic agent was considered by several workers as small-scale studies carried out in several countries had demonstrated that Dapsone was capable of providing significant but varying protection to contacts of leprosy patients. Subsequently, two large-scale studies were carried out in India, one of which was a double-blind, randomized controlled trial among contacts of MB leprosy. The other was a large study of the general population which showed Dapsone prophylaxis to be effective[127]. The double blind study showed Dapsone to be effective as a prophylactic with a level of protection of over 50%[128]. Acedapsone, a long-acting sulphone, was also tried through studies in Micronesia and India[129, 130]. These studies also demonstrated the prophylactic value of the drug. Rifampicin in a single dose has also been tried as a prophylactic in a number of studies. In general, the protection given by Rifampicin was not very different from that of Dapsone. A meta-analysis of 14 chemoprophylaxis trials showed that chemoprophylaxis gave about 60% protection against leprosy[131]. While chemoprophylaxis, with its complex operational problems and modest level of protection, may not hold much promise as a tool for control of leprosy in the community, it can be a very useful tool in special situations where there is a need to protect individuals at high risk of acquiring the disease.

Immunoprophylaxis

With regard to immunoprophylaxis, the use of the anti-tuberculosis vaccine, BCG, had been considered for leprosy for a long time, in view of the similarities between the two causative organisms. A number of small-scale studies, starting from the work of Fernandez in 1939, indicated that BCG was capable of converting the lepromin skin test reaction, and, possibly, of protecting against the disease. There was experimental evidence that BCG protected mice against infection in the footpad. All of this evidence led to the organization of large-scale controlled trials in Uganda, Papua New Guinea, Burma and India. In addition, limited information on the protective effect of BCG against leprosy became available from Venezuela and Malawi. In all of the large-scale studies, BCG was found to be effective in preventing leprosy, although the protective efficacy varied from about 20% in Burma to greater than 80% in Uganda[132, 133]. Overall, the protective efficacy of BCG against leprosy was quite small in Asia, particularly in India. The factors that contributed to the varying levels of protection in different studies are not fully understood. In any case, there is no need to apply BCG specifically against leprosy as it is already being widely used in the prevention of tuberculosis.

Apart from BCG, other vaccines based on cultivable mycobacteria, such as the ICRC bacillus and **"Mycobacterium w"**, have been tried as immunoprophylactic agents against leprosy. In a multi-arm trial in South India, the ICRC bacillus demonstrated a very good protective effect against leprosy, whereas **"Mycobacterium w"** did not[134].

A major initiative to develop an anti-leprosy vaccine derived from killed M. leprae came from the Immunology of Leprosy (IMMLEP) Scientific Working Group, set up by the WHO. After obtaining huge quantities of M. leprae from armadillos, large-scale field trials of a vaccine consisting of a mixture of killed M. leprae and BCG were set up in Venezuela, Malawi and India[134, 135, 136]. Whereas the trials in Venezuela and Malawi did not demonstrate protection by the mixture of killed M. leprae and live BCG, the trial in India showed considerable protection of about 64%.

In conclusion, it is clear that, with the current low levels of leprosy endemicity in most countries, and the limited risk of around one to two per 10,000 even in the endemic population, the cost effectiveness of any prophylactic procedure as a public-health practice is open to question as there will be a need to treat very large numbers of people prophylactically in order to prevent the very few cases that are expected to occur. Further, if prophylaxis is confined only to household contacts, an easily identifiable high-risk group, it is unlikely to have much impact from the public-health point of view and is unlikely to contribute significantly to eliminating or eradicating the disease. On the other hand, prophylactic procedures may offer individual benefits in exceptionally high-risk situations.

18 Elimination of Leprosy as a Public Health Problem

Elimination of leprosy as a public health problem was set as a goal by the World Health Assembly (WHA) in 1991. At that time, the WHA set the target of reducing the prevalence rate of leprosy to less than one case per 10,000 population by the year 2000, a major initiative against an age-old disease.

While for centuries leprosy was considered as a perennial problem with no solution in sight, the introduction of multidrug therapy (MDT) in the 1960s and 1970s has resulted in enormous progress towards a drastic reduction in the disease. Since 2000, Novartis has supplied MDT free of charge to patients worldwide which alone has helped to cure more than 4.5 million patients. The WHO initiative together with the strong commitment of leprosy-endemic countries and the support of NGOs and donor agencies have contributed to the steep reduction of the global burden of leprosy by 95% and the achievement of the WHA target in over 120 countries.

The information available on the leprosy situation as of the beginning of 2008 indicates that the bulk of the problem continues to be in (South-East-)Asia, which with about 170,000 new cases contributes to 67% of the global burden, while the contribution of Africa and the Americas is only 12% and 16% respectively.

In 2008, only three countries reported prevalence levels of leprosy of over one per 10,000 population. In the Americas, Brazil has a prevalence rate of 2.40 per 10,000. In Asia, Nepal has a prevalence rate of 1.18 and Timor Leste of 1.23 per 10,000 population.

India, due to its size still the country with the highest number of new cases in absolute terms, has made a tremendous progress towards the elimination of leprosy as a public health problem during the past 15 years, with a reduction in prevalence of 96%, i.e. from 24.2 per 10,000 in 1992 to 0.7 per 10,000 in 2007.

The goal set by the World Health Assembly is to achieve elimination of leprosy everywhere in the world. The idea was to reach the original target of less than one case per 10,000 population in the year 2000, which was later extended to 2005. Now it appears that it might take another few years before every country reaches this target. However, elimination of leprosy aims at reducing the disease burden to very low levels so that the disease is likely to disappear slowly over time. To maintain such a low level determined action will be needed in all endemic countries for quite some time.

The priority given to the elimination of leprosy has been and even more will be questioned from time to time. Leprosy is not a disease that kills people. Nor does it occur in as large numbers as malaria, tuberculosis or many other tropical diseases. Still, leprosy elimination is seen as an important priority for the following reasons: (i) Leprosy is a communicable disease; that means that if nothing is done, it will perpetuate itself endlessly (ii) The disease causes huge suffering as a result of the permanent and progressive disability it produces (iii) The social stigma against leprosy patients results in discrimination and social suffering, and (iv) What makes leprosy elimination particularly attractive are the opportunities available to see an end to this age-old problem. The opportunities are firstly technological, mainly through the highly effective treatment in the form of MDT, and secondly epidemiological in the sense that leprosy is a disease already on the retreat in many areas. Other opportunities include availability of sizable resources from donor agencies, including free drug supply. Leprosy is a winnable war and if this is successful, it will result in one less problem in the area of communicable diseases.

The core strategy for leprosy elimination remains to identify all leprosy cases and cure them with MDT. Each endemic country faces its own problems in attaining and maintaining leprosy elimination and has to develop effective measures, in close cooperation with other countries, the WHO, and various partners.

With regard to case detection, it is important to recognize that, in order to achieve leprosy elimination, nearly every case of leprosy in the community should be identified. In practice, this does not happen in many situations. For too long, the responsibility for identifying cases of leprosy was held solely by health services, particularly specialized (vertical) leprosy services. While this approach had its advantages, the major disadvantage was the relatively poor health services coverage of population, resulting in large number of patients remaining undetected. The role of the individual, the family, and the community in suspecting leprosy and reporting to the health service was not given due importance. Thus the major need now is to increase the focus on creating community awareness about the disease, its curability, and the availability of MDT treatment services – in general: the inappropriateness of stigmatizing persons affected by leprosy.

In relation to treatment with MDT, the capacity of the general health services should be built up sufficiently and made to function effectively. Further, it should be ensured that they receive adequate support including an uninterrupted supply of MDT drugs. Thanks to the generous donations of MDT drugs by Nippon Foundation from 1995 to 2000 and Novartis since 2000, every patient in every leprosy-endemic country has been able to obtain MDT drugs free of charge. It is this "drug security" that has brought about a revolutionary change in the fight against leprosy.

One area that will need continued attention will be the physical and socio-economic rehabilitation of disabled persons affected by leprosy. Thus leprosy, albeit becoming a very small public-health problem, will need continued attention for several years to come.

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Recommendations for Further Reading

(in alphabetical order)

Books and Brochures

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Acta Leprologica (in French): Editorial Office, 3, place Claparède, Geneva, Switzerland.

China Leprosy Journal: published by China Leprosy Association, No. 2 Huifuxi Road, Guangzhou, People's Republic of China, in Chinese, with summary in English (started in 1985).

Indian Journal of Leprosy (formerly Leprosy in India, started in 1929).

Editorial Office: 12/1 First Seaward Road Valmiki Nagar, Madras 600 041, India.

International Journal of Leprosy. Editorial Office: P.O. Box. 25072, Louisiana State University, Baton Rouge, Louisiana 70894, USA.

Japanese Journal of Leprosy (in Japanese, with summary in English).

Le bulletin de l'ALLF (in French): Association de leprologues de Langue Francaise. 4, rue Jean Jacques Bel, 33 000 Bordeaux, France.

Leprosy Review: Editorial Office: Lepra, Fairfax House, Causton Road, Colchester CO1 1PU, England.

The Star: Gillis W. Long Hansen's Disease Centre, Box 325, Point Clair Br Carville, Louisiana 70721, USA.

Milestones in the Field of Leprosy

1847 A book on leprosy by two Norwegian dermatologists, DanielIssen and Boeck, was published.
1873 Hansen discovered Mycobacterium leprae at Bergen, in Norway.
1874 The Leprosy Mission founded by a dedicated Irishman, Mr. W.C. Bailey.
1879 Albert Neisser, a German dermatologist, was first to stain and demonstrate leprosy bacilli.
1897 The first International Leprosy Congress held in Berlin.
1898 Jadassohn, a Swiss-German dermatologist, first used the term "tuberculoid" to describe a form of leprosy.
1906 The American Leprosy Mission (ALM), founded in 1903 as the USA arm of "The Mission to the Lepers", became independent.
1908 Fromm and Wittmann synthesized dapsone at Freiburg, Germany.
1912 Murata first described erythema nodosum leprosum (ENL) in Japan.
1919 Mitsuda introduced the lepromin test.
1931 The International Leprosy Association founded in Manila, Philippines.
1941 Faget first used a disubstituted derivative of dapsone (Promin®) intravenously in treating leprosy at the National Leprosarium, Carville, USA.
1946 Cochrane first used dapsone in oily suspension intramuscularly for the treatment of leprosy in India.
1947 Lowe first used dapsone orally for the treatment of leprosy in Nigeria.
1950 First reference to leprosy at a World Health Assembly appeared in the Report of the Director General to the 3rd Assembly.
1951 The Gandhi Memorial Leprosy Foundation started at Wardha, in India.
1950s Brand ushered in the era of reconstructive surgery at the Christian Medical College at Vellore, and at the Schieffelin Leprosy Centre at Karigiri in India.
1954 Barry et al. synthesized clofazimine, the active ingredient of Lamprene®, in collaboration with J.R. Geigy Limited.
1954 The annual World Leprosy Day initiated by Raoul Follereau in Paris.
1958 The WHO Leprosy Secretariat established in Geneva.
1958 Ridley proposed the logarithmic scale for determining the Bacteriological Index (BI).
1960 Shepard first reported that leprosy bacillus may multiply to a limited extent in the mouse footpad.
1962 Browne and Hogerzeil first reported on the efficacy of Lamprene® in leprosy patients in Nigeria.
1963 Wade described the histoid variety of lepromatous leprosy.
1963 Pettit and Rees first reported on secondary dapsone resistance in Malaysia, proven by the mouse footpad method.
1965 Sheskin reported on the effect of thalidomide in erythema nodosum leprosum (ENL).
1966 Ridley and Jopling proposed a five-group classification of leprosy according to immunity.
1966 The International Federation of Anti-leprosy Associations (ILEP) founded in Berne, Switzerland.
1966 Rees reported an increase in the yield of leprosy bacilli per footpad by suppressing the immune mechanism of the mouse with thymectomy and whole-body X-ray irradiation (T/900r).
1968 Rimactane® (rifampicin) introduced by CIBA Limited, Basle, Switzerland.
1969 Lamprene® introduced by J. R. Geigy Limited, Basle, Switzerland.
1970 Leiker and Kamp, and Rees et al. reported on the treatment of leprosy patients with rifampicin.
1971 Kirchheimer and Storrs reported a disseminated experimental **M. leprae** infection in the nine-banded armadillo.
1972 Freerksen initiated a large-scale multidrug therapy programme in Malta, with Isoprodian (a combination of dapsone, prothionamide and isoniazid) and rifampicin, given daily.
1973 Convit et al. first used immunotherapy with a mixture of heat-killed **M. leprae** plus live BCG in patients with lepromatous and indeterminate leprosy.
1974 Waters et al. first reported that drug-sensitive **M. leprae** is capable of persisting in spite of continuous dapsone therapy.

1975 The Immunology of Leprosy (IMMLEP) Task Force, which later became a component of the UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases, established in Geneva, Switzerland.

1975 Walsh et al. reported on a leprosy-like disease (LLD) occurring in wild armadillos in Louisiana, USA.

1976 Jacobson and Hastings reported the first case of rifampicin-resistant leprosy confirmed by mouse footpad studies.

1976 Colston and Hilson, and Kohsaka et al. reported on the growth of **M. leprae** in the footpad of the nude (athymic and hairless) mouse.

1976 Leininger et al. first detected naturally acquired leprosy in a chimpanzee born in Sierra Leone.

1977 The Scientific Working Group on Chemotherapy of Leprosy (THELEP), a component of the UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases, set up in Geneva, Switzerland.

1977 The THELEP controlled clinical trials in patients with lepromatous leprosy started at the Central Leprosy Teaching and Research Institute, Chingleput, South India, and at the Institute Marchoux, Bamako, Mali.

1977 Yawalkar first initiated a single-blind trial to compare therapeutic effects of adding Rimactane® 450 mg daily or 1200 mg once monthly to dapsone 50 mg daily in patients with lepromatous leprosy in Dakar, Senegal.

1977 Pearson et al. reported on primary dapsone-resistant leprosy proven by the mouse footpad method in Ethiopia.

1979 Languillon, Yawalkar and McDougall first reported on high efficacy and good tolerability of the once-monthly 1200 mg single-oral dose rifampicin schedule plus dapsone 50 mg daily in patients with lepromatous leprosy in Dakar, Senegal.

1981 Deo et al., of Bombay, India, reported on the anti-leprosy vaccine prepared from ICRC bacilli killed by gamma irradiation.

1981 Hunter and Brennan reported on the phenolic glycolipid antigen (PGL-I) from M. leprae.

1982 Warndorff-van Diepen reported the first case of possible clofazimine-resistant leprosy.

1982 CIBA-GEIGY's single-blind comparative trial carried out in Brazil, India and Senegal provided the first confirmation of the high efficacy, good tolerability and practicability of the supervised once-monthly 1200 mg single oral dose rifampicin schedule for the treatment of patients with lepromatous leprosy (Yawalkar, McDougall, Languillon et al. Lancet, 1982).

1982 Report of a WHO Study Group on multidrug therapy (MDT) regimens for leprosy patients was published. Once-monthly administration of 600 mg rifampicin is the most potent component of the recommended regimens.

1984 XII International Leprosy Congress held in New Delhi, India.

1984 The first IMMLEP field trial with a vaccine from heat-killed **M. leprae** derived from armadillos plus live BCG started in Venezuela.

1986 The CIBA-GEIGY Leprosy Fund established in Basle, Switzerland.

1988 XIII International Leprosy Congress held in The Hague, Netherlands.

1991 The 44th World Health Assembly passes a resolution to eliminate leprosy as a public health problem by the year 2000.

1992 The double-blind WHO trials with the combination of ofloxacin and rifampicin versus current MDT started in Brazil, Kenya, Mali, Myanmar, Pakistan, the Philippines and Vietnam.

1993 XIV International Leprosy Congress held in Orlando, Florida (USA)

1997 The WHO Expert Committee on Leprosy reduces the duration of treatment for multibacillary patients from 24 months to 12 months.

1998 XV International Leprosy Congress held in Beijing, Peoples Republic of China.

1998 In a controlled, double-blind prophylactic vaccine trial launched in 1991 by the Indian Council of Medical Research near Chennai, India, four leprosy vaccines were tested in 171,400 volunteers. ICRC vaccine, developed by the Indian Cancer Research Centre, Mumbai, provided 65.5% protection, BCG + Killed **M. leprae** 64%, BCG alone 34.1% and M. w 25.7% protection.

1999 WHO has set up a strategic plan entitled “The final push towards leprosy elimination 2000–2005”. Launch of the Global Alliance for the Elimination of Leprosy.

2000 From 2000 through 2005, the MDT needed worldwide will be donated by Novartis in line with its “Memorandum of Understanding” with WHO.

2001 Announcement at 54th World Health Assembly that the global prevalence of leprosy had fallen to below 1 case per 10,000 by the end of 2000.
XVI International Leprosy Congress held in Bahia, Brazil.

2005 Agreement of Novartis and the Novartis Foundation for Sustainable Development with the WHO for the extension of the MDT donation until at least the end of 2010.

2008 XVII International Leprosy Congress held in Hyderabad, India. Novartis and the Novartis Foundation for Sustainable Development announce the continuation of MDT donation until the eradication of leprosy.

The Author

S. J. Yawalkar

(date of birth: 22 June 1931)

Formerly dermatologist, Medical Department Ciba-Geigy Limited, Basle, Switzerland (1974–1994) and Head of the Skin Department, G.T. Hospital and Hon. Professor of Dermatology, Grant Medical College, Mumbai, India.

Medical training in Nagpur and Mumbai (India) and Munich (Germany).

He has been working on leprosy and dermatology since 1960 and has contributed to:

Plastic Surgery in the Tropics (1965) by Prof. R.J. Maneksha, F.R.C.S.

Spot Diagnosis Volumes 4 and 5 (1966 and 1970), Arlington Books, London.

Textbook of Medicine (1969 and 1973) by Prof. R.J. Vakil, M.D., F.R.C.P.

Practice of Dermatology (1972,1976, 1982) by Prof. P.N. Behl, F.R.C.P.

Surgical Rehabilitation in Leprosy (1974) by Prof. F. McDowell, M.D., DSc, and Prof. C.D. Enna, M.D.

Indian Year Book of Medical Sciences (1974) by R.J. Vakil, M.D., F.R.C.P.

Diabetes Mellitus for Practitioners (1974) by Prof. A.S. Godbole, M.D., M.R.C.P, and Prof. N.G. Talwalkar, M.R.C.P

Facts about Common Diseases (1976). Editor: Dr. A. Nair.

Geigy Scientific Tables Volume 6 (1992) by Dr. C. Lentner, Ph.D.

Topical Corticosteroids (1992) by Prof. H. Maibach, M.D. and Dr. Ch. Surber, Ph.D.

Leprosy (1993), Edited by Dr. B.R. Chatterjee

Textbook of Dermatology (1994). Edited by Prof. R.G. Valia for the Indian Association of Dermatologists, Venereologists and Leprologists.

Clinical Diagnosis by Prof. M.P. Misra, M.D., F.R.C.P. (under publication)

He is the author of:

Leprosy for Practitioners (1968 and 1974)

Learn German (1963 and 1972)

Five Reviews on Dermatology for Raptakos Brett and Co. (1963–1972)

Lamprene in Leprosy (1979, 1984, 1988 and 1993)

Eczema – Basic Information for Medical Practitioners (1989 and 1990)

He is the co-author of:

Leprosy – Basic Information and Management (1987, 1989, 1992, 1996)

Desferal in Dialysis Patients with Aluminium Overload (1993)

Modulan Grip-aids for Rehabilitation in Leprosy (1993)

Desferal for the Treatment of Chronic Iron Overload (1994)

Edited "Probe", a medical quarterly, from 1963 to 1974, and planned and edited the skin section of the first Indian Textbook of Medicine, published by the Association of Physicians of India in 1969.

He was Vice-President, Indian Association of Dermatologists and Venereologists in 1968–1969.

Participated in the first meeting of the THELEP Scientific Working Group, set up by the WHO, held in 1977 in Geneva, Switzerland.

Originated and established once-monthly rifampicin schedule for treating patients with leprosy, in 1977–1979. It is the most effective component of WHO/MDT.

He and his colleagues developed Miracorten® (Ultravate® in the USA), the most potent topical corticosteroid. He participated in a symposium on Miracorten held in Scottsdale/Phoenix, USA, in 1990.

An article on leprosy, based on the interviews that Mr. R. Tunley (USA) conducted with him, was published worldwide in the Reader's Digest, in 1991.

Organized and participated in the international conference on aluminium overload in dialysis patients, held in Paris in June 1992.

His books have been translated into Chinese, Vietnamese, Indonesian, Bengali, Urdu, French, German and Spanish.

MDT has brought smile to the faces of millions of leprosy patients.

The dictum "once a leprosy sufferer always a leprosy sufferer" has become a saying of the past. Curing a leprosy patient is the most gratifying experience in clinical, especially in dermatological, practice.

S. J. Yawalkar

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