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Review Article

Management of Leprosy Ulcers: A Review Article

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Leprosy ulcers primarily result from peripheral neuropathy and/or vascular impairment. *Mycobacterium leprae*, the causative agent of leprosy, can infect peripheral nerves, leading to neurological damage and subsequent ulcer formation, particularly in the hands and feet. Neuropathic ulcers are among the most common complications of leprosy and can lead to significant functional limitations, especially when compounded by deformities or amputations. This article reviews the current management strategies for leprosy ulcers. A literature review search was conducted, analyzing scholarly articles (including systematic reviews, clinical trials, randomized controlled trials, and case reports) published in English between 1982 and 2025. Databases such as PubMed, ResearchGate, Scopus, ProQuest, and Google Scholar were utilized, supplemented by manual searches. The keyword "leprosy ulcer treatment" guided the selection of relevant studies. Findings indicate that leprosy ulcer management requires a comprehensive approach, such as topical modalities, physical modalities, offloading modalities, and preventive modalities. The integration of these multidisciplinary strategies enhances therapeutic efficacy and improves patient outcomes.

Keywords: *Mycobacterium leprae*, Leprosy Ulcer Management, Leprosy Ulcer Treatment

Introduction

Leprosy ulcers primarily result from peripheral neuropathy and/or vascular impairment. The causative agent, *Mycobacterium leprae*, induces nerve damage that is present in approximately 60% of patients at diagnosis, develops in 30% during treatment, and occurs in 10% after treatment completion (Reinar et al 2019).

The fundamental therapeutic principles for management / treatment of leprosy ulcers include infection control through local wound care including sterile dressings, wound irrigation, debridement, and offloading and judicious use of systemic antibiotics when indicated (Han & Ceilley 2017). Chronic wounds significantly impact patients' socioeconomic status.

Various treatment modalities with differing efficacy have been employed for leprosy ulcers (Table 1).

Methodology

For analyzing the usefulness of different modalities a literature review search was conducted, identifying scholarly articles (including systematic reviews, clinical trials, randomized controlled trials, and case reports) published in English between 1982 and 2025. Databases such as PubMed, ResearchGate, Scopus, ProQuest, and Google Scholar were

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Table 1 : Therapeutic modalities for leprosy ulcers.

Topical Modalities	Physical Modalities	Off-loading Modalities	Preventive Modalities
Saline dressings (NaCl 0.9)	Ozone therapy	Below-knee plaster of Paris (BK POP) casting/ Total contact casting (TCC) and molded double-rocker plaster (MD POP) shoes	Wax therapy
Ketanserin	Low-level laser therapy (LLLT)	Microcellular rubber (MCR) footwear	Toilet soap
Clioquinol cream	Pulsed electromagnetic field (PEMF) therapy	Canvas shoes, and polyvinyl chloride (PVC) boots	
	Light emitting diode (LED)		
Zinc preparations	Surgical reconstruction		
Intralesional pentoxifylline (PTX)			
Phenytoin			
Polyhexanide 2% (PHMB)			
Topical insulin			
Collagen dressings			
Platelet-rich plasma (PRP)			
Leukocyte- and platelet-rich fibrin (L-PRF)			
Human amniotic membrane stem cells (hAMSC)			
Adipose-derived mesenchymal stem cell-conditioned medium (ADMSC- CM)			

utilized, supplemented by manual searches. The keyword “leprosy ulcer treatment” guided the selection of relevant studies.

Key Observations:

Various treatment approaches summarized in Table 1 can be systematically categorized into four principal therapeutic domains:

1. Topical therapeutic modalities
2. Physical treatment modalities
3. Off-loading modalities
4. Preventive modalities

Each category encompasses distinct interventions with specific mechanisms of action and clinical applications, as detailed in the following sections. This classification framework facilitates comprehensive understanding and implementation of evidence-based management protocols for leprosy ulcers.

1. Topical Therapeutic Modalities

a. Sodium Chloride 0.9% (NaCl 0.9%)

Saline therapy, or the use of normal saline solution (0.9% sodium chloride) as a cleansing agent, is considered a basic component of standard wound care for leprosy ulcers (Bansal & Mukul 1993).

b. Ketanserin

A study 2% ketanserin ointment (an S2-serotonergic blocker) significantly improved wound healing in various ulcers compared to placebo (35 vs. 37 patients), particularly in granulation tissue formation and epithelialization (Janssen et al 1989). Other study showed superior efficacy of 2% ketanserin gel versus 3% clioquinol cream. A higher cure rate was obtained with ketanserin treatment compared with clioquinol and/or Lassar paste treatment. However. Both are different category and ketanserin is considered useful as a co-adjuvant therapy in ulcer healing in leprosy patients (Salazar et al 2001).

c. Clioquinol cream

Clioquinol cream is not considered a standard therapy for leprosy ulcers. Its use is based on its antimicrobial properties, but there is very little high-quality evidence to support its effectiveness in promoting wound healing for this specific condition (Reinar et al 2019).

d. Zinc

Evidence supports the efficacy of zinc-based treatments for leprosy ulcers, with occlusive zinc dressings demonstrating reduced infection risk (Soderberg et al 1989).

e. Intralesional pentoxifylline (PTX)

The study reported accelerated granulation tissue formation and reduced time to epithelialization, establishing PTX as a valuable adjunct in leprosy ulcer management (Mikhael & El-Esawy 2015).

f. Phenytoin

Phenytoin (PHT), while primarily an anticonvulsant and antiarrhythmic medication, has demonstrated significant wound healing properties in the treatment of leprosy ulcers. Topical phenytoin accelerates granulation tissue formation and reduces wound exudate more effectively than standard saline dressings (Bansal & Mukul 1993).

g. Polyhexanide 2% (PHMB)

A study demonstrated leprosy ulcer therapy with polyhexanide 0.2% once daily experienced complete healing and no recurrence at 1 year follow-up (Zanchin et al 2018).

h. Topical insulin

A study demonstrated superior healing outcomes with topical insulin compared to conventional saline dressings, with insulin-treated leprosy ulcers showing faster rates of epithelialization and complete closure (Singh & Pawar 2020).

i. Collagen dressings

The use of collagen sheets has demonstrated efficacy in accelerating wound healing, particularly for plantar ulcers in leprosy patients. The foundational studies evaluating collagen sheets as a therapeutic intervention, reporting significant improvements in ulcer healing rates (Rao et al 1987).

j. Platelet-rich plasma (PRP)

Platelet-rich plasma (PRP) has emerged as an effective treatment modality for leprosy ulcers, demonstrating significant improvements in wound healing outcomes. PRP application, attributed to its ability to stimulate granulation tissue formation and accelerate wound closure, thereby reducing hospital stays and associated morbidity (Anandan et al 2016). A study revealed improvements in wound size reduction, macrophage activity, neovascularization, and granulation tissue development following PRP gel application (Sari et al 2016).

k. Leukocyte- and platelet-rich fibrin (L-PRF)

Leukocyte- and platelet-rich fibrin (L-PRF) have shown insufficient therapeutic benefits to warrant routine clinical application for treating leprosy ulcers (Napit et al 2021). However, other studies report more favorable outcomes such as autologous platelet-rich fibrin matrix (PRFM) significantly promoted ulcer healing (Nagaraju et al 2017), while subsequent investigations validated the clinical efficacy of PRF therapy (Dorjay et al 2022, Ghatge et al 2021).

l. Human amniotic membrane stem cells (hAMSC)

The treatment of leprosy ulcers with hAMSC secretome gel resulted in good healing and no wounds getting worse. The use of hAMSC secretome can accelerate wound healing (Natallya et al 2019, Alinda et al 2021).

m. Adipose-derived mesenchymal stem cell-conditioned medium (ADMSC-CM)

Leprosy ulcers can be treated with ADMSC-CM or AMSC-CM where ADMSC-CM was superior to AMSC-CM and FGD (Alinda et al 2021). Treatment of leprosy ulcers with topical ADMSC-CM ointment resulted in better clinical improvement and changes in the characteristics of the histological examination compared to controls (Alinda 2022, Alinda et al 2023).

2. Physical Modalities

a. Ozone therapy

Administration of ozone to leprosy ulcers improves wound healing (Reis et al 2015).

b. Low-level laser therapy (LLLT)/ Light emitting diode (LED)

Leprosy ulcers treated with LLLT did not improve wound healing (Barreto & Salgado 2010). On the other hand, leprosy ulcer therapy with light emitting diode (LED) along with standard treatment was effective in healing wounds (Lee et al 2012).

c. Pulsed electromagnetic field (PEMF) therapy

The treatment of leprosy ulcers with standard therapy plus exposure to a PEMF resulted in faster healing (Sarma et al 1997).

d. Surgical reconstruction

Leprosy ulcers performed surgery using a fascio-cutaneous island flap from the instep, achieving excellent therapeutic results (Gravem 1991).

3. Off Loading Modalities

a. Below-knee plaster of Paris (BK POP) casting/Total contact casting (TCC) and molded double-rocker plaster (MD POP) shoes

Table 2 : Level of recommendation/evidence for different therapies for leprosy ulcers.

No.	Therapies	Level of Evidence	Level of Recommendation
1.	Sodium chloride 0.9% (NaCl 0.9%)	Very low	Weak
2.	Ketanserin	Low to very low	Weak
3.	Clioquinol	Very low	Weak
4.	Zinc	Very low	Weak
5.	Intralesional pentoxifylline (PTX)	Very low	Weak
6.	Phenytoin	Moderate to high	Strong
7.	Polyhexanide 2% (PHMB)	Low	Weak
8.	Topical insulin	Moderate to high	Moderate
9.	Collagen		Moderate
10.	Platelet Rich Plasma (PRP)	Low	Weak
11.	Leukocyte- and platelet rich rich fibrin (L-PRF)	Low	Weak
12.	Human amniotic membrane stem cells (hAMSC)	Low	Weak
13.	Adipose-derived mesenchymal stem cell-conditioned medium (ADMSC-CM)	Low to moderate	Weak
14.	Ozone therapy	Moderate	Moderate
15.	Low-level laser therapy (LLLT)/ Light emitting diode (LED)	Low	Weak
16.	Pulsed electromagnetic field (PEMF) therapy	Low to very low	Weak
17.	Surgical reconstruction	High	Strong
18.	Below-knee plaster of Paris (BK POP) casting/total contact casting (TCC)	High	Strong
19.	Molded double-rocker plaster (MD POP) shoes	Moderate to high	Strong
20.	Microcellular rubber (MCR) footwear	High	Moderate to strong
21.	Canvas shoes	Very low	Weak
22.	Polyvinyl chloride (PVC) boots	Moderate to high	Strong
23.	Wax therapy	Very low	Weak
24.	Toilet Soap	Very low	Weak

Wearing MD POP shoes for leprosy ulcer patients is felt to be more comfortable and is an alternative compared to BK POP/TCC (Pring & Casiebanca 1982). Leprosy ulcer therapy with PRP combined with total contact casting shows a faster healing time than total contact casting alone (Saha et al 2020).

Table 3 : General relationship between quality of evidence and strength of recommendation.

Quality of Evidence	Strength of Recommendation	Explanation
High	Strong	The benefits clearly outweigh the harms. This recommendation should be followed by most patients.
Moderate	Moderate	If the benefits are clear despite imperfect evidence, the recommendation can be strong. Otherwise, it is weak.
Low	Weak	The benefits and harms are uncertain. The decision should be made in collaboration with the patient.
Very Low	Weak	Can only be given as advice due to high uncertainty.

b. Microcellular rubber (MCR) footwear

Micro cellular rubber footwear is a standard and highly recommended intervention for off-loading pressure from leprosy foot ulcers. It is considered a cornerstone of ulcer management and prevention in leprosy care programs worldwide (Lal et al 2015).

c. Canvas shoes, and polyvinyl chloride (PVC) boots

Leprosy ulcers or healed ulcer scars treated with PVC boots have been observed to be more suitable for agricultural work environments, offered greater durability, and provided the same protective effect on less sensitive feet compared to canvas shoes (Seboka et al 1998).

4. Prevention Modalities

a. Wax Therapy

Regarding therapeutic approaches for anesthetic feet with fissures and/or calluses, the patients receiving wax therapy have been reported to have greater subjective improvement than those using conventional foot soak treatments. This suggests that wax therapy may offer enhanced patient satisfaction and perceived benefits for these common leprosy-related foot complications (Sharma et al 2005).

b. Toilet Soap

Toilet soap, as a hypotonic keratolytic solution, provided superior keratin-softening effects compared to plain water when treating dry, anesthetic soles with multiple fissures and calluses in leprosy patients. Their study established the clinical benefits of this simple intervention for foot care management (Premkumar et al 1990).

Discussion

Normal saline dressing is not standard therapy for leprosy ulcers, but rather than a fundamental component of basic wound (Reinar et al 2019). Two studies used normal saline as a control group compared with topical phenytoin. Administration of normal saline dressing as a control showed that healthy granulation tissue appeared more slowly, and the average percentage reduction in ulcer volume was smaller (Bansal & Mukul 1993). Administration of normal saline dressing as a control compared with topical phenytoin suspension study, revealed that administration of physiological saline solution resulted in slower formation of healthy granulation tissue and

slower cessation of fluid discharge from the ulcer (Bhatia & Prakash 2004).

The level of evidence for saline therapy in leprosy ulcers is generally considered very low certainty (Reinar et al 2019). This conclusion is based on systematic reviews that have analysed existing studies (Table 2). The main reasons for this low level of evidence include:

a. Limited high-quality studies (Reinar et al 2019, Thatoju et al 2025).
b. Saline is used as a control group (Reinar et al 2019).

The level of recommendation for saline therapy is not explicitly detailed in standard guidelines, but its use is widespread due to its low cost, safety, and role in basic wound hygiene. It is considered a fundamental step in preparing the wound bed, which is a prerequisite for any further treatment. However, it is not recommended as a standalone, definitive treatment for healing leprosy ulcers (International Wound Infection Institute 2025).

Topical ketanserin has been studied as a treatment for leprosy ulcers, but it is not considered a part of the widely accepted standard therapy (Salazar et al 2001). The evidence supporting its use is limited, and a conclusive recommendation cannot be made based on the available research. The level of evidence for using ketanserin on leprosy ulcers is considered low. This is due to a lack of high-quality, large-scale studies (Table 2). A 2019 Cochrane review that examined various treatments for leprosy ulcers found only one small study that suggested topical ketanserin was more effective than clioquinol cream or zinc paste (Reinar et al 2019). The level of recommendation is considered weak (World Health Organization 2024).

The level of evidence for clioquinol is low to very low. This is primarily because it has been used in very few studies, and those studies often have methodological limitations (Table 2). For instance, a small comparative study found that topical ketanserin gel was significantly more effective in reducing ulcer size than clioquinol cream or zinc paste (Salazar et al 2001). The level of recommendation for its use is weak. (Reinar et al 2019, World Health Organization 2024).

Comparative studies show zinc oxide plaster achieves comparable efficacy to 10% povidone-iodine in ulcer management (Overbeek & Tham 1991). Zinc adhesive tape (impregnated with zinc oxide) has proven particularly advantageous, demonstrating equivalent effectiveness to conventional magnesium sulfate and glycerin paste (MGSA) dressings containing proflavine - an acridine derivative with bacteriostatic properties - and benzalkonium chloride (Walton et al 1986). Overall, the level of evidence for zinc therapy, whether topical (such as zinc oxide paste or zinc tape) or oral, is very low. A 2019 Cochrane systematic review found that there were only a few studies evaluating the effectiveness of zinc therapy, and most had methodological limitations, such as small sample sizes and a high risk of bias (Table 2). Although some small studies found that zinc tape may speed healing time, these findings were not strong enough to justify broad recommendations (Reinar et al 2019). Zinc therapy for leprosy ulcers does not have a high recommendation rate and is supported by weak scientific evidence. Although zinc is an essential nutrient for wound healing, its use specifically for leprosy ulcers requires further research (Reinar et al 2019, Thatoju et al 2025).

The level of evidence for pentoxifylline in treating leprosy ulcers is very low due to the lack of specific, high-quality clinical trials on its use for leprosy ulcers (Table 2) (World Health Organization 2024).

Phenytoin has been studied as a promising alternative or adjunct treatment. Its use is

primarily topical and is based on its positive effects on wound healing, rather than its anticonvulsant properties. Topical phenytoin has several benefits that contribute to wound healing such as enhanced granulation and healing, antimicrobial and anti-inflammatory properties, analgesic effect (Reinar et al 2019), stimulates fibroblast proliferation (Bhatia et al 2004).

Cost-effectiveness studies have shown that topical phenytoin is an inexpensive and widely available therapeutic agent (Prasad et al 2017). The use of topical phenytoin for treating leprosy ulcers has a moderate to high level of evidence, but it is not a first-line or highly recommended therapy in major international guidelines. Level of recommendation is moderate. There is significant evidence from a number of clinical trials supporting its effectiveness *(*Table 2) (Thangaraju et al 2015). Polyhexanide (PHMB) 0.2% was a promising treatment for trophic foot ulcers in leprosy, but this study was a preliminary, open, uncontrolled study, which means it had a small sample size and did not compare PHMB to another treatment (Table 2) (Zanchin et al. 2018).

The level of evidence for using PHMB in this context is low. A single, preliminary study, while encouraging, is not sufficient to establish a high level of evidence. Level of recommendation of PHMB is not a high-level recommendation in major clinical guidelines (Reinar et al 2019, World Health Organization 2024).

The evidence supporting the use of topical insulin for chronic ulcers, including those in leprosy patients, is growing. Several studies, including randomized controlled trials (RCTs), have shown positive results. A randomized interventional pilot study specifically on chronic trophic ulcers in leprosy patients found that topical insulin significantly accelerated wound healing and shortened the time to complete healing compared to a placebo (normal saline). Level of recommendation of using insulin for treating leprosy ulcers is moderate (Table 2). While major organizations like the World Health Organization (WHO) do not list topical insulin as a primary, high-level recommendation, the existing research suggests it is a viable treatment option. Its recommendation level is elevated by its low cost, widespread availability, and efficacy in settings with limited resources (Singh & Pawar 2020).

The level of evidence significantly influences the strength of a recommendation, but not automatically. High-quality evidence tends to lead to a strong recommendation, while low-quality evidence almost always leads to a weak recommendation. Table 3 shows the general relationship between the two (Guyatt et al 2009).

The level of evidence for collagen is moderate to high. The effectiveness comes from systematic reviews and meta-analyses, although most of these studies focus on chronic wounds in general (e.g., diabetic foot ulcers, venous ulcers) rather than specifically on leprosy ulcers (Shu et al 2022). Level of recommendation is moderate. Collagen dressings are not a first-line treatment for leprosy ulcers in major international guidelines like those from the World Health Organization (WHO), which prioritize off-loading and debridement. However, they are highly recommended as a part of advanced wound care for ulcers that are stalled or slow to heal despite standard care (World Health Organization 2024)

The level of evidence for PRP in treating leprosy ulcers is low (Table 2). The available evidence primarily comes from small-scale clinical studies and case reports, which are limited in scope and are subject to bias (Conde-Montero et al 2017, Suryawati et al 2020). Due to the limited evidence from small studies, PRP is not a high-level recommendation in major clinical guidelines from organizations (World Health Organization 2024).

The use of L-PRF for chronic wounds is a subject of growing interest. Based on current medical literature, there is a low level of evidence as dedicated high-quality research on leprosy ulcers is limited (Table 2). Several small-scale studies and case reports have shown encouraging results, with reports of accelerated healing, reduced pain, and improved tissue regeneration (Dorjay et al 2022, Ghatge et al 2021, Napit et al 2021, Priya et al 2023). A randomized controlled trial (The TABLE trial) comparing L-PRF with normal saline dressings for leprosy ulcers noted that while the treatment showed a favourable trend, the overall effect sizes were small and not consistently statistically significant (Napit et al 2024). Due to the limited, often preliminary nature of the studies, L-PRF does not have a high-level recommendation in major clinical guidelines from organizations (World Health Organization 2024).

The use of embryonic stem cells is largely confined to research due to ethical and safety considerations. Therefore, there is no high-level recommendation for this therapy in a clinical setting (Lo & Parham 2009). Despite these promising findings, the evidence is still in its early stages. The studies are often small, lack long-term follow-up, and are not yet replicated on a large scale (Table 2). The safety and long-term efficacy of stem cell-based therapies for this condition are not fully established.

The use of stem cells for wound healing is a growing area of research, particularly for chronic, non-healing wounds like leprosy ulcers. The use of adipose-derived mesenchymal stem cell-conditioned medium (ADMSC-CM) for treating leprosy ulcers has a low to moderate level of evidence. While the research is promising, it is not yet strong enough to support a high-level recommendation for routine clinical practice. However, most of the studies focus on adult mesenchymal stem cells (MSCs) derived from sources like adipose tissue (fat), bone marrow, or the umbilical cord such as ADMSC-CM, not human embryonic stem cells (hESCs). These adult-derived MSCs are considered a promising therapeutic option because they can promote tissue repair, modulate the immune response, and secrete growth factors (Alinda 2022, Alinda et al. 2023). Despite these promising findings, ADMSC-CM is not yet a high-level recommendation in major clinical guidelines from organizations (Table 2) (World Health Organization 2024).

Level of evidence of using ozone for treating leprosy ulcers is moderate (Table 2). The evidence for ozone therapy's efficacy comes from a number of clinical trials and systematic reviews, although much of the research focuses on other types of chronic wounds, such as diabetic foot ulcers, which share a similar underlying issue of poor circulation and neuropathy (Wen et al 2022), Level of recommendation of using ozone for treating leprosy ulcers is moderate (Table 2). Ozone therapy is not currently included in the standard, high-level recommendations from major international organizations like the World Health Organization (WHO) for leprosy ulcer management. However, its use is growing in specialized wound care settings, particularly for chronic, non-healing ulcers (Bomfim et al 2021).

The use of LLLT and LED for treating leprosy ulcers has a low level of evidence (Table 2). The evidence for LLLT in leprosy ulcers comes primarily from a limited number of small-scale studies. A key randomized clinical trial on 51 patients with leprosy ulcers found no significant difference in healing outcomes between the LLLT group and the control group (Barreto & Salgado 2010). While LLLT has been shown to have positive effects on wound healing and pain management in general skin wounds (by promoting cell proliferation and collagen synthesis), its efficacy is highly

dependent on specific parameters (wavelength, energy density, etc.) (Taha et al 2024), which are not yet standardized for leprosy ulcers (World Health Organization 2024). LLLT and LED therapy are being researched for other types of chronic wounds, with some promising but inconsistent results. The proposed mechanism of action for these therapies is that they can promote cell proliferation and collagen synthesis, increase blood flow and reduce inflammation (Whelan et al 2001), accelerate the healing process in some contexts, such as diabetic foot ulcer (Baracho et al 2023). Level of recommendation of LLLT and LED is weak. The both modalities of therapy are not included in the primary treatment guidelines for leprosy ulcers by major international organizations (World Health Organization 2024).

Treatment of PEMF can be used in various healing processes including delayed fractures, anti-pain, multiple sclerosis and Parkinson's disease. It is used in off-label chronic wound healing applications (Markov 2007). The use of PEMF therapy for treating leprosy ulcers has a low to very low level of evidence. Research on leprosy ulcers themselves is very limited, and no dedicated, well-designed studies have been found to specifically test PEMF as a primary treatment (Table 2) (Reinar et al 2019). Given the lack of consistent and conclusive evidence, PEMF therapy is not a high-level recommendation in major clinical guidelines from important organizations (Table 2) (World Health Organization 2024).

Approximately 10-15% of cases of plantar ulcers require reconstructive surgery. If there is deeper tissue infection or bone involvement, one of three procedures may be performed including subtotal metatarsectomy, and transmetatarsal amputation. In addition to split-skin grafting in cases with large exposed areas, flaps are necessary for chronic heel ulcers and metatarsal head ulcers because these are weight-bearing areas (Kadam 2016). Reconstructive surgery for plantar ulcers in leprosy patients must be accompanied by reduction of the high-pressure zone on the plantar and transpositional flaps, so as to provide a good short-term and long-term therapeutic effect (Jin et al 2009).

The evidence is high and comes from decades of clinical practice and a variety of studies, including retrospective reviews and case series. Level of recommendation of reconstructive surgery is strong (Table 2). It is considered a standard and often necessary intervention for leprosy-related deformities and chronic ulcers. It associated with significant underlying deformity, a key component of disability prevention and rehabilitation in leprosy care (Almast 1971). In contrast to emerging therapies with limited evidence (like some advanced dressings or energy-based treatments), reconstructive surgery has a long history of use and proven efficacy in leprosy management, particularly for grade 2 deformities as per WHO classification (World Health Organization 2024).

Below-knee plaster of Paris (BK POP) cast, more commonly known as a total contact cast (TCC), is a highly effective and well-established method for off-loading pressure in patients with leprosy foot ulcers. Some considerations for using MD POP shoes are more comfort to patients, cheaper, the risk of causing osteoporosis is smaller compared to BK POP so it can reduce the risk of bone fractures (Pring & Casiebanca 1982).

Relieving excessive pressure can be achieved by using such as total contact cast, canvas shoes, or PVC boot. In the early phase after ulcer healing (6-8 weeks) the tissue will be more susceptible to damage, therefore the use of an off-loading device must be continued. Stress reduction can be achieved by consistent use of total contact casts, cast walkers and modified shoes.

A total contact cast (TCC) is a special cast that goes around the lower leg and redistributes pressure throughout the foot (Mueller et al 1989). Nonremovable casts are more useful than removable casts with a faster ulcer healing time (Armstrong et al 2001). Three types of TCC namely nonremovable TCC, removable TCC (RCC) and shoe-model cast (SMC) show that the use of an off-loading device in non-infected neuropathic ulcer patients will accelerate wound healing time with a median time wound healing in 34 days (Nabuurs-Franssen et al 2005). Patients with peripheral arterial disease (PAD), infections, and heel ulcers had a lower healing rate. The use of soft soles in footwear is useful because cushioning reduces forces. If the force decreases, the pressure will also decrease. Microcellular rubber (MCR) footwear is considered the best for supporting body weight and preventing external injuries with hard soles (Cross & Brandsma 2012).

Level of evidence is moderate to high (Table 2). The evidence supporting TCC is substantial and has been accumulating for decades. The concept of using TCC for leprosy ulcers was pioneered by Paul Brand in India in the 1940s, and its efficacy has been demonstrated in multiple studies, case series, and is now the gold standard for off-loading diabetic foot ulcers, a condition with similar pathophysiology (Armstrong et al 2001). Level of recommendation is strong. The use of TCC for off-loading neuropathic ulcers is strongly recommended by clinical guidelines and professional organizations. This is based on its proven ability to facilitate rapid healing by immobilizing the foot and significantly reducing plantar pressure (Li et al 2023).

The use of moulded double-rocker plaster (MD POP) shoes for off-loading in leprosy ulcer patients is a valid and effective technique. The level of evidence is moderate to high, and the level of recommendation is strong, particularly in the context of leprosy care programs (Table 2) (World Health Organization 2024). It widely recommended as a simple, effective, and relatively low-cost method for managing and preventing ulcers in insensitive feet (World Health Organization 2024).

Microcellular rubber (MCR) footwear provides a soft, cushioned insole that conforms to the shape of the foot, effectively distributing pressure over a larger area and reducing the concentration of force on vulnerable points like the heel and metatarsal heads (Lal et al 2015). Level of evidence of MCR footwear is moderate to high (Table 2). The evidence supporting the use of MCR footwear is based on decades of clinical experience and numerous studies that have demonstrated its effectiveness in reducing plantar pressure. While the studies may not be large-scale randomized controlled trials, their findings are consistent and have led to the widespread adoption of MCR footwear (Govindharaj et al 2017). Level of recommendation MCR footwear is strong (Table 2). It is widely recognized by international organizations (World Health Organization 2024).

Level of evidence of canvas shoe is very low (Table 2). There is a lack of clinical evidence supporting the use of canvas shoes for off-loading leprosy ulcers. Instead, evidence from clinical practice and studies on related conditions (like diabetic foot ulcers) indicates that soft, unsupportive footwear can be a cause of ulcer formation rather than a solution. Canvas shoes can easily trap moisture, which softens the skin and makes it more vulnerable to breakdown. The thin, unpadded sole and lack of a structured upper can lead to excessive pressure points and shear forces, which are the primary causes of ulcers in an insensitive foot. Canvas shoes are not a recommended or effective method for

off-loading leprosy ulcers. Their use has a very low level of evidence for this purpose (Table 2) (World Health Organization 2024).

The use of polyvinyl chloride (PVC) footwear for off-loading in leprosy ulcer patients is a common and recommended practice. Level of evidence of PVC footwear moderate to high (Table 2). The evidence for using PVC footwear comes from long-standing clinical practice, observational studies, and its consistent effectiveness in a variety of settings. While large-scale randomized controlled trials may be limited, the clinical consensus and the widespread success of PVC footwear in leprosy care programs provide a strong basis for its recommendation (Table 2). PVC footwear is a widely used and recommended intervention for the management and prevention of foot ulcers in individuals with leprosy neuropathy. It is considered a durable, cost-effective, and practical solution that is accessible in many low-resource settings (World Health Organization 2024). The primary goal in managing leprosy foot ulcers is to protect the insensitive foot from trauma. PVC footwear achieves this by providing a protective barrier, distributing pressure, supporting the foot (World Health Organization 2024).

Paraffin wax therapy has demonstrated benefits in wound management through its thermal and occlusive properties, which may theoretically improve cutaneous microcirculation and skin integrity. Wax therapy is primarily used as an adjunct treatment for existing leprosy ulcers, limited direct evidence supports its role in preventing ulcers in leprosy patients (Kumar et al 2014). The use of paraffin wax as a prevention modality for leprosy ulcer patients is a practice with a very low level of evidence for a prevention purpose (Table 2). There is no scientific evidence or clinical trial data to support the use of wax for ulcer prevention in leprosy patients. The evidence is instead cautionary, based on decades of clinical experience and expert opinion that highlight the significant risks involved. The primary problem is the patient's sensory loss, which removes their ability to feel pain or an unsafe temperature. In fact, it carries significant risks. Level of recommendation of the use of wax for the prevention of ulcers in leprosy is weak (Table 2) (World Health Organization 2024).

Level of evidence of toilet soap for prevention of leprosy ulcers is very low (Table 2), There is no scientific evidence or clinical trials that support the use of toilet soap for ulcer prevention in leprosy. The evidence, based on clinical experience, points to the potential for harm rather than benefit. Skin irritation and dryness, caused by soaps, particularly bar soaps, can be alkaline and contain harsh chemicals that strip the natural oils from the skin, leading to dryness, cracks, and fissures. This can make the skin more susceptible to breakdown and ulcer formation, especially in feet that have a compromised natural barrier due to neuropathy (Ebenezer & Scollard 2021). Level of recommendation of toilet soap for prevention of ulcers due to leprosy is weak (Table 2) (World Health Organization 2024).

Conclusion

Multiple therapeutic approaches for leprosy ulcers have been described in the literature, yet systematic reviews indicate the existing evidence remains of very low certainty. This limitation underscores the critical need for comprehensive meta-analyses to compare outcome parameters across studies, which would enable identification of optimal treatments for clinical application. Current understanding suggests that leprosy ulcer management requires a comprehensive, multimodal approach to maximize therapeutic effectiveness. The combination of various evidence-based interventions appears most

promising for improving treatment outcomes, though higher-quality research is urgently needed to establish standardized protocols.

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