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*EDITORIAL*

# Appropriate footwear and orthoses are essential components in the management of the foot at risk of ulceration in leprosy

Karthikeyan Govindasamy[a,b] & Sathish Kumar Paul[c]

[a]*PhD Scholar, Warwick Centre for Global Health, Warwick Medical School, University of Warwick, Coventry CV4 7AL, UK*
[b]*Research Coordinator, The Leprosy Mission Trust India, New Delhi, India*
[c]*Head-Research, Schieffelin Institute of Health Research & Leprosy Centre, Karigiri, Vellore, India*

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*Summary* Ulcers are a serious complication and a common cause of morbidity in leprosy. The exact roles of impairments and distorted mechanics of the foot are not fully understood in the development of ulcers in patients with anaesthetic feet. A simple biomechanical evaluation of the foot along with the routine neurological assessment helps to identify feet at risk for developing an ulcer and also to prescribe appropriate orthoses, which are inserts designed to improve biomechanical function, encourage proper joint alignment and protect the foot. The orthotic intervention along with protective footwear offloads the peak plantar pressure sites of the foot, preventing ulceration. The provision and use of foot orthoses have generally been limited to tertiary leprosy referral centres. Advances in technology have made the fabrication of orthoses more rapid and precise, enhancing user acceptance and adherence. Effort should be made to provide simple orthoses that are easy to fabricate and effective in preventing plantar ulcers in leprosy, in the community health setting.

*Keywords*: Anesthetic foot, footwear, ulcer, foot impairment, leprosy

## Introduction

The posterior tibial nerve is frequently affected in leprosy[1,2] leading to loss of sensation and sweating, and intrinsic muscle paralysis in the foot, predisposing to ulcer formation.[3] Recurrent ulcers can lead to shortening and amputation of the affected limb[4] and delayed or non-healing ulcers can transform into squamous cell carcinoma.[5] Therefore, prevention of ulcers is critical to preventing disability. The actual burden of disability, including foot ulcers, due to leprosy is not known.[6] Over 42% (3088/7359) of admissions and over 55% (97561/174559) of bed-days utilized were for ulcer care at tertiary hospitals of The Leprosy Mission Trust India (TLMTI)

Correspondence to: Karthikeyan Govindasamy (e-mail: karthikot@hotmail.com)

 

and Schieffelin Institute of Health Research & Leprosy Centre (SIHRLC), Karigiri during the year 2019 alone.[7,8]

Although protective footwear can reduce the prevalence of ulcers,[9–11] the role of orthoses in protective footwear in preventing ulcers has not been satisfactorily studied.[12] The consensus statement on prevention of disability in leprosy emphasises the accessibility of footwear with soft insoles and orthoses to all those with anaesthetic feet.[13] An orthosis is a device designed to improve biomechanical function, encourage proper joint alignment or to protect an existing limb.

**Importance of podiatry assessment**

There is a wide variation in the alignment and flexibility of the foot in the general population.[14] This variation in general is not a concern but for those with loss of sensation and intrinsic muscle paralysis in the foot such as in leprosy, it can increase the risk of ulceration even with normal walking, by increasing the peak plantar pressure at vulnerable sites for ulcers such as the metatarsal heads.[15,16] This natural variation is perhaps a reason why not all patients with loss of sensation in the foot develop ulcers,[17,18] and we do not have clinical tools that can predict the feet at the risk of ulcer development.[15] Podiatry assessment is necessary to understand foot function and to plan foot orthoses to off-load the at risk sites for ulceration. While footwear with a micro-cellular rubber (MCR) insole with a shore value of 15–20, can increase the contact surface of the foot and reduce plantar pressure,[19,20] its ability to reduce peak pressures at the risk sites for ulcers is not known. Studies on commonly used insole materials have shown that optimizing the stiffness of materials promotes the distribution of externally applied forces evenly, thereby reducing the peak pressures at the risk sites.[21] Paul *et al.* demonstrated that materials such as Ethylene Vinyl Acetate (EVA) which is more rigid than MCR could provide greater stability and be a good alternative for MCR insoles and orthoses.[22]

**Foot orthoses to off-load pressure on at risk sites for ulcers**

The evidence from diabetic foot care has shown that therapeutic footwear and/or orthoses are effective in reducing peak plantar pressure, thus reducing the risk of first and recurrent ulcers.[23–25] Foot orthoses are custom-made and fall into two broad categories, accommodative and functional. Accommodative orthoses are made of soft materials to provide cushioning to the foot and shock absorption during the gait. Functional orthoses are made of more rigid materials and aim to re-align the foot to achieve the normal weight bearing position.[26] For example, Figure 1 shows a simple accommodative orthosis for the left foot that can be provided to patients with 'low-arch'. The common orthoses provided in leprosy for a specific foot problem are shown in Table 1 and Figures 2 to 5. They can either be provided as an individual orthosis or in combination depending on the foot problem. In one study, foot orthoses were inserted over the MCR insole to accommodate (off-load) the ulcer area, to promote ulcer healing; over a period of 7-month, 57% of ulcers in the experimental group healed, as compared to 12.5% of ulcers in the control group who received only MCR footwear.[27] It is important to note that just as an ill-fitting shoe can have a lasting impact on the biomechanics of the foot,[28] an imprecise orthosis can also worsen foot mechanics.

Functional orthoses aim to re-align the subtalar joint in the neutral position during walking, to facilitate a normal weight bearing pattern.[29] Cast measurement in a functional weight bearing position with the subtalar joint in the neutral position is ideal for prescribing a

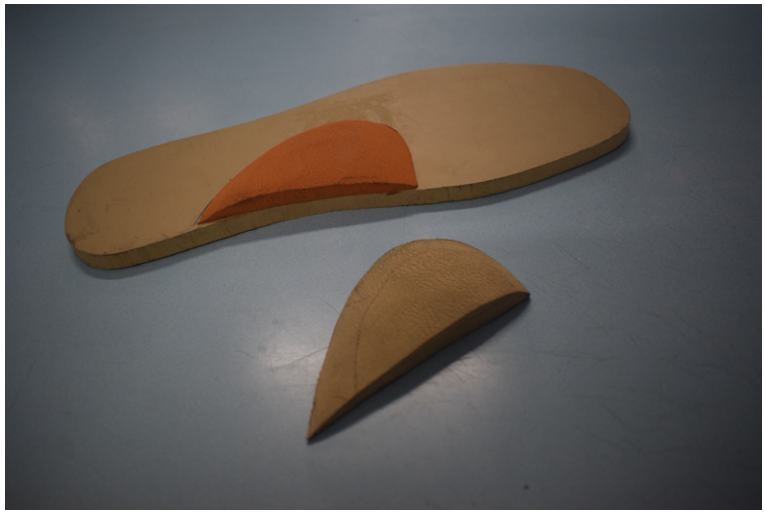

**Figure 1.** Accommodative orthosis, which fits under and supports the medial arch of the foot; the illustration is for the left foot.

**Table 1.** Foot problems and common accommodative orthoses used in leprosy

| Foot problem | Accommodative orthosis |
|---|---|
| Pronated foot | Hathi Pad or Cobra Pad (Figure 2) |
| Supinated foot | Tarsal Platform (Figure 3) |
| Ulcer/Callous in 1st MTH | 'Wing' Plantar Metatarsal Pad (Figure 4) |
| Ulcer/Callous in the 3rd MTH | 'U' Plantar Metatarsal Pad (Figure 5) |

functional orthosis.[30] Technicians require high precision and accuracy to fabricate functional orthoses. Although the subtalar neutral position is the reference point for casting, the reliability of maintaining the foot in the subtalar neutral position while casting has been questioned.[31,32] With recent advances in technology it is possible to modify the subtalar joint position virtually. Figure 6 shows the evaluation of the subtalar joint position in a patient through a laser scanner. The custom-made insoles with integral orthoses using such techniques have helped prevent ulcer recurrence compared to the conventional MCR insoles in leprosy patients.[33] Figure 7 shows a functional orthosis made by a computerized fabrication method.

The most common method adopted by technicians to measure foot alignment in patients before providing footwear is to get the foot dimensions in static stance.[34] This method has been useful to prescribe footwear to a patient with intact foot contours.[35] It has been challenging, however, for footwear technicians and health staff to assess and provide protective footwear with the required orthoses to anaesthetic feet with abnormal mechanics.[36]

The rationale for prescribing footwear with orthoses in anaesthetic feet with varied foot alignment has often been unclear to health care workers and patients. Ignorance about appropriate footwear and orthoses is a common reason for non-compliance.[37] Studies have demonstrated that evaluating the foot in both static and kinetic stance have facilitated in assessing the abnormal variations and asymmetries of the foot. Assessing the subtalar joint range of movement, the rearfoot and forefoot alignments, first ray position and the

**Figure 2.** Hathi or Cobra pad, which fits under and supports the medial arch and heel of the foot; the illustration is for the right foot.

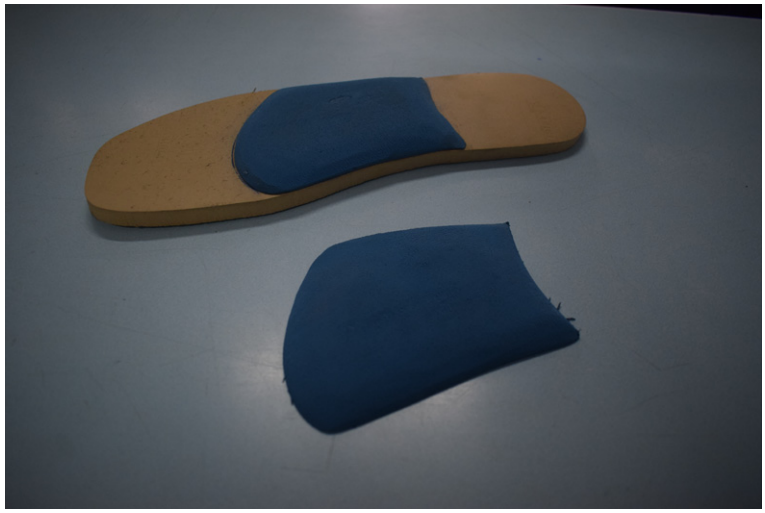

**Figure 3.** Tarsal platform which fits under and supports the mid-foot (tarsal bones); the illustration is for the right foot.

1st metatarsophalangeal joint position is essential in understanding the foot biomechanics and in prescribing appropriate orthoses.[38] Cross and Lehman proposed a Simple Semantic Classification (SSC) to identify the foot at risk for ulcer, which is reliable and valid, and could be effectively used by health care workers in peripheral health centres in a resource limited setting with minimal training.[39] The use of this simple algorithm for prescribing footwear and orthoses for patients in resource limited settings could help in effective management of the foot with loss of sensation.[29,40,41]

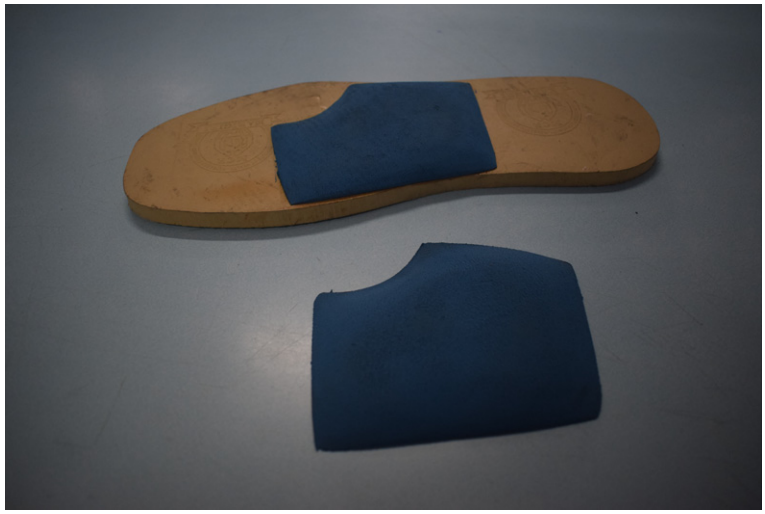

**Figure 4.** Wing Plantar Metatarsal Pad (PMP) which fits under the mid foot with cut-out to off-load the ulcer area; the illustration is for the right foot with an ulcer over the fifth meta-tarsal head.

**Figure 5.** U Plantar Metatarsal Pad (PMP) which fits under mid foot with cut-out to off-load the ulcer area; the illustration is for the right foot with an ulcer over third meta-tarsal head.

Leprosy patients are also looking for newer footwear designs.[42] Gupta *et al.* suggested that acceptability would improve when footwear is provided with newer designs, varied colour and is of a good fit.[43]

## Recent advances in footwear and orthosis fabrication

With the recent advances in technology, the peak plantar pressures at risk sites can be effectively identified using tactile sensors.[40,44] Based on the joint alignment of the foot identified

**Figure 6.** Evaluation of the subtalar joint position in a patient through a laser scanner.

**Figure 7.** Functional orthosis made by a computerized fabrication method.

through computerized scanning, orthoses can be either manufactured through computerized 3D printing or milling technology.[33] While the newer technologies are attractive, providing simple and effective orthoses at the peripheral level is needed and effort should be made to include the provision of basic accommodative orthoses such as the tarsal platform, plantar metatarsal pads and medial arch support in leprosy programs to improve the effectiveness of the footwear provided. Bulk production of ready to fit orthoses could help reduce the burden on the health care worker in peripheral settings. Availability of cost effective rigid and semi rigid, ready to fit anti-pronatory and supinatory orthoses for different foot sizes could help patients in remote locations.[45]

## Conclusion

Limited evidence shows that appropriate footwear and orthoses are effective in reducing peak plantar pressures and thereby ulcers in anaesthetic feet. However, the use of these interventions has been restricted to referral centres due to a lack of personnel for fabrication at the field level. Advances in technology will help in customizing the fabrication of orthoses and make it cost effective. Viable and cost-effective options could be made available for the health staff in a virtual medium to customize and visualize the orthosis before fabrication. The computerized fabrication of orthoses could become an ideal method in the future. Meanwhile, the bulk production of ready to fit orthoses can meet the immediate needs at peripheral health centres.

## Ethics approval

Not required.

## Competing interests

The authors have no competing interests.

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## Authors' contributions

KG and SKP: contributed to the development and editing of the manuscript.

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