

THE ORTHOTIC CARE OF THE DENERVATED FOOT IN HANSEN'S DISEASE

Carl D. Enna, M.D., F.A.C.S.¹,
Paul W. Brand, C.B.E., F.R.C.S.²,
Joseph K. Reed, Jr.³, and
David Welch⁴

Problems of the denervated foot in Hansen's disease (Leprosy) are due to both sensory loss and motor impairment with deformity resulting from peripheral nerve paralysis. Neither feature need be harmful providing prophylactic measures of orthotic care are instituted. It is still another factor, namely trauma or infection, or both, imposed upon insensitive and deformed areas that is responsible for destruction of the foot. The control of these problems therefore is based upon avoiding extrinsic trauma and particularly upon elimination of intrinsic trauma resulting from the repetitive stresses of walking and standing in unsuitable footwear. The latter feature is the basic principle of the orthotic care that is indicated (1).

The total management of the denervated foot of Hansen's Disease is carried out in three phases. All wounds, particularly those affecting the plantar surface, must be healed. This is accomplished by eliminating weight-bearing through bed rest or by applying a walking cast. When healing has been obtained, gross deformities are corrected surgically with restoration of the form and action of the foot to as nearly normal as possible. In the last phase, because of persisting residual anatomical and functional impairments, orthotic care is provided by altering the footwear to compensate for these changes (5).

When patients possess gross deformity which cannot be corrected because surgery is contraindicated, these deformities are more difficult to manage because modified footwear may not

relieve completely the high pressure points on the plantar surface. Such patients may remain confined to a wheelchair a greater part of the time; however, some degree of benefit is obtained by bearing weight intermittently for short distances during which time trauma is of short duration and relatively less intense, with recovery more likely to occur within the periods of rest obtained with use of the wheelchair.

The U.S. Public Health Service Hospital at Carville, Louisiana, is devoted to the care of patients with Hansen's Disease. The foot care program here includes a preliminary study of clinical, radiographic, and footprint examinations. The findings are correlated to determine if the problems are static or dynamic or both, in origin, if there are indications for surgical correction of pathologic deficits, and to determine the appropriate prophylactic measures to preserve the foot by preventing the recurrence of complications.

Manifestations of paralysis of the peripheral nerves vary from minimal isolated changes of sensory loss to patterns conforming to the distribution of the affected peripheral nerves, or the more extensive pattern of "stocking" distribution, and the deformities of claw toes and drop foot. These changes may exist alone or be associated with secondary changes of absorption and contractures. Also, even after surgery, varying degrees of deformity that require orthotic care may exist.

In Hansen's Disease, the foot may be classified arbitrarily into four categories: (The same classification applies to the denervated foot from peripheral nerve paralysis from any cause.)

Category I - the foot is grossly normal but possesses loss of plantar sensation.

Category II - the grossly normal foot possesses loss of plantar sensation and plantar scarring, commonly affecting the ball of the foot.

¹Chief of Surgical Department, U.S. Public Health Service Hospital, Carville, La.

²Chief of Rehabilitation Branch, U.S. Public Health Service Hospital, Carville, La.

³Formerly Chief of Orthotic-Prosthetic Department, U.S. Public Health Service Hospital, Carville, La., Reassigned to National Institutes of Health Clinical Center, Bethesda, Md.

⁴Orthotist, Orthotic-Prosthetic Department, U.S. Public Health Service Hospital, Carville, La.

Category III – the foot is deformed with loss of plantar sensation and plantar scarring; however, the length and width of the foot is not affected appreciably.

Category IV – the pathologic short and/or narrowed foot is due to metatarsal phalangeal or lateral ray absorption or to amputation.

TYPES OF FOOTWEAR FOR THE DENERVATED FOOT

Four general types of footwear have been developed for the denervated foot at this hospital. These include the sandal, a "healing shoe", the modification of a regular shoe including the extra-depth shoe, and a custom fabricated shoe.

SANDALS

Sandals are prescribed to be worn immediately following the healing of plantar ulcers or post-operative wounds while the patient is waiting for shoes being fabricated or for the delivery of purchased shoes. Some patients like these sandals and choose to wear them most of the time even when definitive shoes have been provided. Two types of sandals have been made; a simple "quickie" and a modified "clog".

The "quickie" sandal is simple in construction, and is made available to the patient in a matter of 20 to 30 minutes. It consists of a soft, flat insole of expanded polyethylene foam backed with a 6 mm-thick microcellular rubber, which is attached directly to an outer sole of neoprene crepe rubber (Fig. 1-A). The patient stands on the heated foam before it is attached to allow the foam to conform to the contour of the foot.

The "clog" sandal (Fig. 2) requires a twenty-four hour period to make. It has a thick base consisting of a polyethylene insole fully molded in its entire extent, and is supported by a neoprene crepe sole with a mixture of wood flour and latex placed between the soles to maintain the molding of the insole (Fig. 1-B). The "clog" sandal possesses significant practical advantages over the simple "quickie" type, and is therefore preferred whenever possible. The sandals are held to the foot with straps made of cotton webbing and Velcro tape.

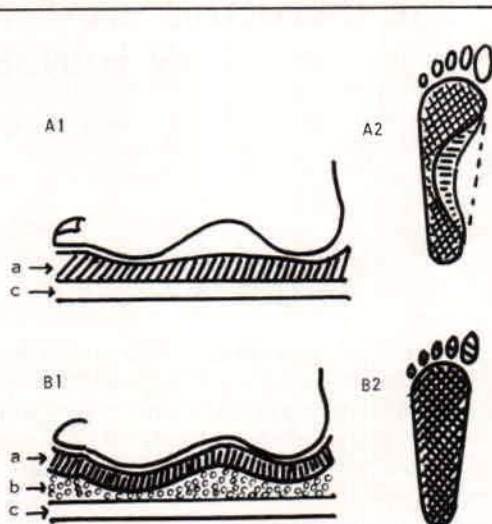


Fig. 1A. The soft non-molded insole (a) which does not distribute the weight bearing pressures evenly and completely to the plantar surface (A2).

Fig. 1B. A molded insole (a) fitting against the plantar surface to distribute the weight bearing pressures evenly to the plantar surface.

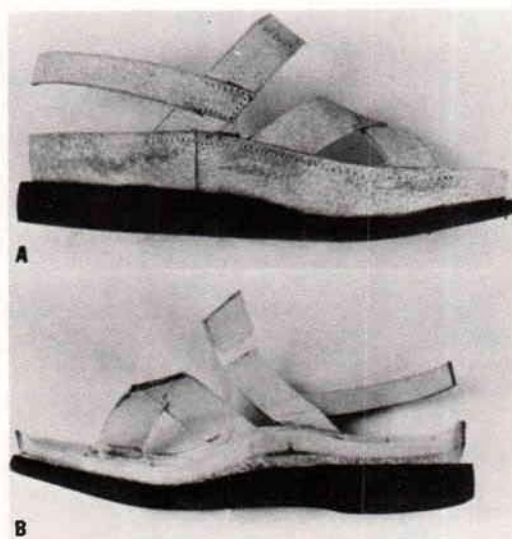


Fig. 2A. Lateral and, B, sagittal views of the molded clog sandal.

THE HEALING SHOE

The "healing shoe" was developed as a compromise when the patient refuses absolute bed rest or will not tolerate a plaster cast. It is made over a recently made plaster model of the foot and ankle. A molded insole of polyethylene is then made and fastened to the model by tape. The entire model and insole are then covered with polyethylene, from the heel forward to include the quarter and vamp of the shoe. It is made in a manner so that the insole can be removed for adjustment or replacement. This is reinforced by lamination with polyester resin, nylon stockinette, and a layer of fiberglass upon which a crepe rubber sole is applied (3). The shoe is taped to the foot so that it can not be removed except by a staff member. Since the introduction of Lite Cast II⁵, it is now possible to use this material instead of the polyester resin, with a considerable savings of time.

THE MODIFIED REGULAR SHOE

A third type of footwear is the modified regular shoe. The shoe is available for purchase with regular or extra depth. Alterations are made mainly of the insole and outer sole, for the purpose of relieving high pressure points by distributing weight-bearing forces evenly to the plantar surface of the foot while standing and during propulsion. The extra depth shoe is designed so that the insole, which may vary from 6 to 12 mm. in thickness, can be removed and a custom-made insole of polyethylene can be substituted.

Soft insoles are inexpensive but require frequent replacement. They may be molded or not. To be effective, the non-molded insole must be of sufficient thickness so that the foot can sink completely into the material yet leave some resilient padding under the prominent parts of the foot. This type of insole is used only in open sandals because the movements of the foot in a shoe with such an insole makes it prone to damage from friction. The effectiveness of a thin, soft, non-molded insole is questionable, and thus it is used only for feet without deformities which do not need relief for high pressure points. Per-

haps the best insole of this type is the Spenco insole, a microcellular rubber material covered with nylon to reduce friction and shear.

A molded insole has the advantage of distributing weight-bearing pressures over the entire plantar surface, but it occupies space which necessitates an extra-depth shoe to accommodate it. The need for this type of insole and shoe can be predetermined by using the thin "Harris" foot mat (4) or the microcellular slipper sock (2) placed within a shoe and tested while walking.

Materials used for the construction of insoles fall into two categories, a closed cell polyethylene foam material and microcellular rubber. The polyethylene foams can be molded in a heated condition directly on the foot or on a model of the foot. Three polyethylene materials have been employed; Plastizote⁶, Pelite⁷, and Ali Plast⁸. Plastizote is available in 3 mm., 6 mm., and 13 mm. thicknesses. We have employed the 6 mm. sheet as thin material and the 13 mm. as thick material. The 3 mm. thick Plastizote is too thin for therapeutic use. The 6 mm. ("thin") layer is generally used when the insole is supplemented with a supporting material, whereas the 13 mm. ("thick") layer is often used without additional support.

Pelite is available in medium and firm densities, and is available in 3/16-in., 3/8-in., and 1/2-in. thicknesses. The popular thickness used here is the 3/8-in. firm layer of Pelite which is usually combined with Plastizote to give it added support. It is used as an alternative to microcellular rubber because it can be bonded to Plastizote at the time of initial heating and then molded directly over the foot.

Ali Plast has been recommended as a substitute for Plastizote. It is available in two forms. Ali Plast 4E is similar in density to Plastizote. It is supplied in 24 in. x 36 in. sheets of 1/4 in. and 1/2-in. thicknesses. Ali Plast 6A is slightly more

⁶Patented by Bakelite Xylonite, Ltd. Available from Smith and Nephew, Ltd., Bessemer Road, Hertfordshire, England; or The Knit-Rite, Inc., Paramedical Distributors, 1121 Grand Avenue, Kansas City, Missouri 64106; or the Apex Foot Products Corp., 118 West 22nd Street, New York, New York 10011.

⁷Available from Fillauer Orthopedics, 936 E. Third Street, Chattanooga, Tennessee 37401; or the Apex Foot Products Corp., 118 West 22nd Street, New York, New York 10011.

⁸Available from Ali Med., 11 Concord Square, Boston, Massachusetts 02118.

⁵Available from the Orthopedic Co., Inc., Merck, Sharp & Dome, West Point, Pennsylvania 19486.

dense than Plastizote, and is recommended as a backing for Ali Plast 4E. It is supplied in 21 in. x 36 in. sheets of 1/8 in., 1/4 in., and 1/2 in. thicknesses. Its use here has been limited in deference to Plastizote.

Two kinds of microcellular rubber are employed, plain Neoprene⁹ and a nylon reinforced neoprene, the Spenco insole¹⁰. Plain neoprene is classified as R-425-N, and R-431-N. The R-431-N is slightly denser than R-425-N and both are available in the 3-mm. and 6-mm. thickness. The material is used mainly to support the molded Plastizote insole, provide additional softness, and can be bonded to the underside of the insole by contact cement. The 3-mm. sheet is used because there is minimal distortion and less difficulty attaching it to the edges of the insole. Several layers can be added to increase the softness of the insole. The Spenco insole is microcellular rubber covered with a thin layer of nylon which gives the rubber stability with a capability of stretching in all directions, yet upon release it resumes its original state. The addition of nylon makes this an expensive item but it preserves the microcellular rubber to give it longer wear as well as producing less friction. It is used alone for the grossly normal foot with an insensitive sole, or it may be used to complement the molded Plastizote insole when it is placed over it.

Plastizote has been used almost exclusively as the basic layer for soft molded insoles. It is molded by heating to 140°C for three minutes after which it is applied directly to the foot or to a plaster model of the foot. Other materials, Pelite and microcellular rubber, have been used to complement the molded Plastizote. A combination is used when weight-bearing forces are excessive and, although tests may suggest an even distribution of the plantar pressures, real-life activity demonstrates that the Plastizote alone does not provide adequate protection. Every model of the foot must be of recent origin, preferably being made immediately before it is used, as a model with a long "shelf life" may not represent the present deformity exactly, and molded insoles prepared from them should not be expected to protect adequately the plantar surface.

⁹Obtainable from Rubatex Corp., Bedford, Virginia 24532.

¹⁰Obtainable from Spenco Medical Corp., P.O. Box 8113, Waco, Texas 76710.

Though patients with normal plantar sensation may wear conventional shoes possessing leather insoles without problem, they are not recommended for the sensory denervated foot as they are potentially harmful. The addition of a Spenco insole is a simple measure that provides protection for the foot that has no deformity, but lacks sensation.

CUSTOM FABRICATED SHOES

The outer sole of footwear may be hard as reflected in the use of leather or it may possess a resiliency in the form of a neoprene crepe sole. When the outer sole is modified, it is altered to alleviate plantar pressure as the foot "rolls" or "rocks" forward during propulsion. Two modifications are made to provide a forward roll on the foot in gait. The metatarsal bar (Fig. 3) is placed under the metatarsal shafts to receive some of the weight ordinarily transmitted to the metatarsal heads which is now vulnerable to injury on account of plantar scarring and underlying bone deformity involving the metatarsal heads. The second modification is the 'rocker sole' which is used when the foot is short.

The short foot is most difficult to manage due to shortening of the toe lever which makes the



Fig. 3A. Lateral and, B, sagittal views of a regular shoe with a deep toe box and a metatarsal bar.

distal ends prone to damage during the push-off phase. This foot presents an even greater problem when a concealed drop foot with functioning plantar flexors exists. Grossly, the short foot is classified as having either one-third or two-thirds loss of the forefoot. Where there is loss up to one-third, the foot may be fitted with a regular or extra depth shoe but with specific modifications (Fig. 4). A molded soft insole and a rocker sole



Fig. 4A. Lateral and, B, sagittal views of a "rocker" mechanism applied to a shoe of regular length.

are basic, with a molded filler for the toe box. The part of the shoe beyond the end of the foot must be prevented from taking weight by keeping it turned upward and held by a steel shank (Fig. 5).

The markedly short foot requires a custom fabricated shoe to fit the foot (Fig. 6). It is made on a model of the foot. The soft insole is molded on the entire length of the plantar surface, and an outer rocker sole occupies the entire length of the shoe to receive the body weight with an even and wide distribution of its pressures to the plantar surface (Fig. 2). It is also necessary to turn the forepart of the shoe upward thirty degrees or more so that the foot "rocks" forward. The pres-

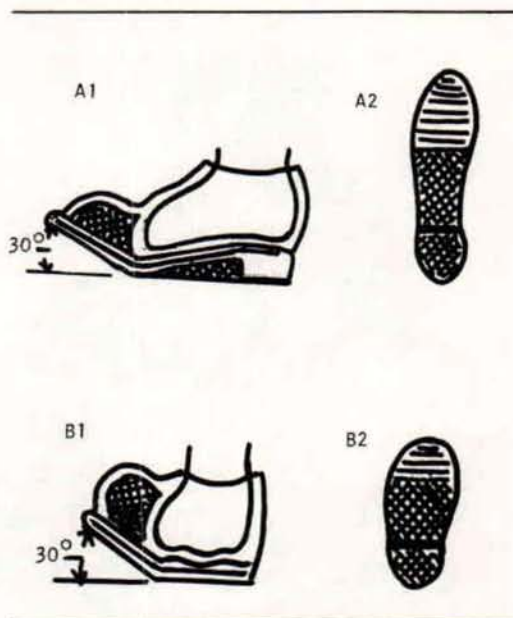


Fig. 5A-1&2. A rocker mechanism applied to a regular length shoe fitted to a foot with 1/3 loss of forefoot.

Fig. 5B-1&2. A short shoe fabricated with rocker mechanism to fit an extremely short foot.

sure is still taken on the proximal part of the shoe, but not distally since the long lever would multiply the thrust on the end of the foot. The upward turning of the forepart of the shoe also serves to help the foot to clear the ground as it is raised to enter the swing phase. The rocker shoe "rocks" forward when there is unilateral involvement. However, with both feet shortened, requiring custom fabricated rocker shoes, the patient's gait becomes modified with flat steps and short strides. The steel shank prevents collapse of the sole complex and provides an even transmission of body weight to the foot through the rocker mechanism.

CORRELATING THE SHOE TO FOOT DEFICITS

The Category I denervated foot presents the problem of only one deficit, the loss of sensory perception on the plantar surface. This type of foot requires a soft insole within a proper fitting shoe, with the addition of a Spenco insole worn on a prophylactic basis. If the footprints or the

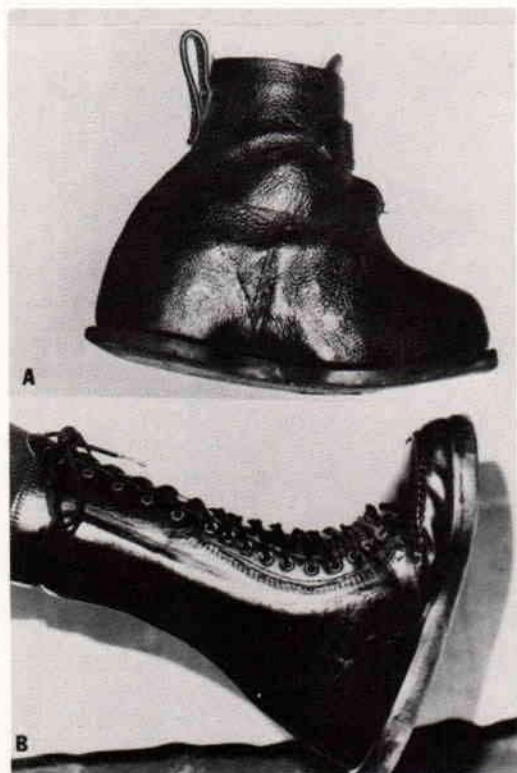


Fig. 6A. Custom fabricated shoe for a short foot.

Fig. 6B. Short boot required to stabilize the ankle to maintain balance.

microcapsule sock demonstrates an uneven distribution of the plantar pressures, a molded Plastizote insole is indicated. These insoles are used instead of the insole of a factory-made extra depth shoe, and because they are removable replacement when indicated because of wear is facilitated.

The Category II denervated foot possesses two deficits, loss of plantar sensation and loss of subcutaneous tissue with scarring. This foot requires a molded insole, which is preferably made of Plastizote. Should Plastizote alone be inadequate to relieve the plantar high pressure points, the Plastizote insole is complemented by the addition of either Pelite or microcellular rubber. These insoles require an extra depth shoe to accommodate them.

In the Category III denervated foot, there is in addition to loss of plantar sensation and scarring, the presence of deformity. Gross deformi-

ties such as claw toes and drop foot are remediable by surgery unless contraindicated for general health reasons. Absorptive bone changes, particularly at the metatarsal phalangeal joint level, which may result in abnormal bony prominences on the plantar surface can usually be managed with orthotic measures. The basic provision is the molded Plastizote insole alone or supplemented by a layer of microcellular rubber. In the case of rigid claw toes, an extra depth shoe with a deep toe box usually provides adequate space. In advanced cases of metatarsal phalangeal damage with scarring, a metatarsal bar placed proximal to the joint level transfers part of the body weight to the metatarsal shafts to alleviate the metatarsal heads from compression and shear forces (Fig. 5A-1&2). When ulceration recurs in spite of adapted footwear, surgery may be advised to remove a bony prominence or to move the whole line of metatarsal thrust to a more proximal and less scarred level by metatarsal head excision. This will be of permanent benefit only if the patient continues to wear specially modified footwear.

In Category IV, the denervated foot is short, because of either a complete transverse metatarsal phalangeal absorption or amputation. A regular shoe, usually requiring extra depth, can be modified to fit a foot with loss of less than one-third of the forefoot. This will result in only little change in the gait pattern. However, an extremely short foot is best managed with a shoe fabricated to fit the foot exactly. Here the custom fabricated shoe with a molded Plastizote insole and a "rocker" mechanism is employed (Fig. 5B-1&2).

METHODS FOR ASSESSING PLANTAR PRESSURES

The "Harris" footprint mat is used for assessment in diagnosis and treatment. It is a simple practical method that is inexpensive and provides a permanent record. The thick mat is used with bare feet for routine study, whereas the thin mat is used within the shoe (4). Its main limitation is that it does not record pressures on the sides and dorsum of the foot. When measurement of pressures are desired of the lateral and/or dorsal aspects of the foot, these can be determined by use of the microcapsule sock (2).

SUMMARY

The use of modified types of footwear have been effective in preserving the denervated foot of Hansen's Disease. Their prophylactic value is especially significant when they are employed for the insensitive and deformed foot. Of equal importance is use of them following corrective surgery to obviate further damage to the foot.

Corrective orthotic measures are never employed for the purpose of overcoming deformity because abnormal forces may be created that are potentially dangerous to the denervated foot. The objective of orthotic care for the denervated foot is to provide a soft molded insole to fill spaces that are void, thereby increasing the surface area receiving pressure yet provide relief of points of high pressure. Once this is accomplished, it can be maintained through recheck examinations at regular intervals when worn parts of the footwear are replaced. This type of patient is never discharged, but instead remains under the constant surveillance of the physician and orthotist.

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