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Soft Molded Sandals for Insensitive Foot Care

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In the United States, the most common cause of sensory loss on the foot is diabetes. Fifty to seventy percent of all non-traumatic amputations in this country are performed on diabetics.[10] In Atlanta, Georgia, the amputation rate was lower by half after a program of foot inspection, footcare, and shoe-fitting was instituted.

A person with loss of sense of touch and pain in the feet should never walk barefoot. A single step on a sharp object or hot surface with bare feet often results in permanent loss of foot function or eventual amputation of the foot.

A comprehensive program of medically-prescribed, therapeutic footware should address the patient's need for appropriate shoes at all times. Once the need for prescribed footwear has been identified, there is a period between the time the prescription is written and time when the definitive shoes are dispensed to the patient. During that period, the feet still need protection. A form of protective, temporary footwear, needs to be worn by the patient until those shoes are ready. There are a wide variety of devices used for this purpose around the country. The form of these devices is largely dependent on the available facilities and footwear expertise.

A person with a plantar ulcer on an insensitive foot should never walk in shoes or sandals. The most important therapeutic consideration for a person with no sense of pain is to control the mechanical stresses during the healing of these wounds.[9] Shoes and sandals do not provide enough control over these forces.

After a wound has been covered completely by skin, the healing and repair of the injury is not complete. A person with sensory loss needs very careful monitoring during this period immediately after closure, because they are at very high risk of reulcerating the area. [7] Temporary footwear, which provides a high level of protection, should be worn during this time.

Usually, unmodified Plastazote®† shoes or postoperative wooden soled shoes are used as the temporary protection. Once they have served this temporary function, the shoes are discarded and only the definitive shoes are worn from then on. There are many other times, however, when protection of the insensitive foot is needed and custom molded footwear would be the best form of protection.

Other times when protective footwear is needed are listed here.

1. Many people do not want to wear their street shoes around the house until bedtime. Since a person with insensitive feet should never walk barefoot, protective footwear, for use in the house, should be worn. Most commercial house slippers have thin soles which are not intended for walking on rough surfaces and do not provide any significant protection from

† Plastazote® is a trademark of BXL Plastics Limited, 675 Mitcham Road, Croydon CR9 3AL England.

sharp objects on the floor.
2. Plantar foot deformity is often present when prescribed footwear is a necessity. With bony prominences or loss of plantar fat-pads, a person should never walk or stand barefoot on hard surfaces. This is a problem, particularly when this person showers and they stand on porcelain, concrete, or tile.
3. A person who needs prescribed footwear should always have at least two pairs. Most people, who need them, do not. This is important during periods of time when these shoes are being repaired or the prescription is changed.

Plastazote® was first used for orthopedic purposes by William Tuck, in England, in 1967.[11] He notified Dr. Paul Brand in Carville, Louisiana and the first Plastazote® sandals were constructed soon after. Plastazote® provided a material which was easily molded directly on the foot so protective, interim footware could be quickly constructed.

Prior to the introduction of Plastazote®, sandals at Carville were constructed of ⅝″ thick microcellular rubber. Microcellular rubber is not a moldable material and foot conformity had to be accommodated by constructing microcellular pads and wedges.[4] This was imprecise and time consuming.

Over the years, several people have contributed modifications to the design and construction techniques of the ''Carville'' sandal.[8] It has become an integral part of the total foot program.

Materials and Equipment Used to Construct the Sandal

The following is a list of the materials used to build the sandal.

Materials for the Plastazote® Foot Bed

2 pieces of ½″ × 6″ × 12″ Plastazote® #1 (medium)‡
2 pieces of ½″ × 6″ × 12″ Plastazote® #2 (firm)‡
2 pieces of ¼″ × 5″ × 12″ Plastazote® #3 (rigid)‡
2 pieces of Plastazote® #2, 5″ × 10″ × ½″ thick to provide heel lift
2 pieces of ¼″ × 3″ × 33″ Plastazote® #3 for wrapping the sides of the sandals

Additional Materials

Neoprene crepe soling (12 iron = ¼″) (24 iron = ½″) (1″ × 9″) Spring steel cut to the full length of the sandal's length.

Webbing for Straps

2 pieces of cotton webbing 1″ × 9″
2 pieces of cotton webbing 1″ × 8½″
2 pieces of cotton webbing 1½″ × 9″
2 pieces of cotton webbing 1½″ × 8½″
2 pieces of cotton webbing 1″ × 12″

Velcro® to be sewn to webbing

2 pieces of 1″ × 2½″ Velcro® hook
2 pieces of 1½″ × 2½″ Velcro® hook
2 pieces of 1″ × 2½″ Velcro® pile
2 pieces of 1½″ × 2½″ Velcro® pile

Glue

Contact Cement or other adhesive

Tools

- Skiving knife
- Ruler
- Scissors
- Polyfoam block (size 8″ high × 12″ wide × 18″ long) cut at approximately 45° from the top to the base at the front of the block.

Equipment

- Sewing machine or Patcher machine
- Finishing sander or grinding wheel
- Oven

Pieces of the Sandal Prepared in Advance

Most of the materials used in the construction of a sandal are pre-cut and pre-sewn in the

‡The numerical identifications of the different densities of Plastazote® correspond with the designations assigned for these densities by Alimed Inc., 297 High Street, Dedham, Massachusetts 02026.

shop to speed the construction process.

All pieces of Plastazote® are cut from large sheets into the rectangular sizes listed above. The cotton webbing and Velcro® are purchased on large rolls and cut to the sizes above in advance.

A 1½″ × 2½″ patch of hook Velcro® is sewn to one end of a 1½″ × 9″ piece of webbing. Approximately ½″ of cotton webbing is left exposed on the very end so the end can be grasped by the patient to release the strap. A 1½″ × 2½″ piece of pile Velcro® is sewn to the end of a 1½″ × 8½″ piece of webbing. This procedure is repeated on the 1″ × 8½″ and 1″ × 9″ pieces of cotton webbing.

The oven should be preheated to a temperature of 140° Celsius (285° Fahrenheit). This is the temperature at which all polyethylene materials should be heated.

Plastazote® is a closed-cell polyethylene foam material. If polyethylene foam materials are overheated, the cell structure is weakened and the material shrinks in all directions. To determine the amount of time a polyethylene foam should be heated, measure the thickness of the material in millimeters and multiply the thickness by twelve (10 mm × 12 = 120 seconds). The answer will be the time of heating in seconds.

To mold the Plastazote® directly on the foot, the heated Plastazote® is placed between the foot and a thick foam rubber block. The foot is pressed into the foam and Plastazote®. The foam presses the polyethylene foam up around the sides of the foot and into every plantar hollow and the material cools and remains in this shape.

The top/front of the foam a block is cut at a 45° angle to prevent obtaining a deep mold of the toes (Figure 1). A deep mold would create a ridge distal to the ends of the toes. During gait, the medial foot enlongates with pronation. This elongation could result in distal toe damage on an insensitive foot if this ridge were present.

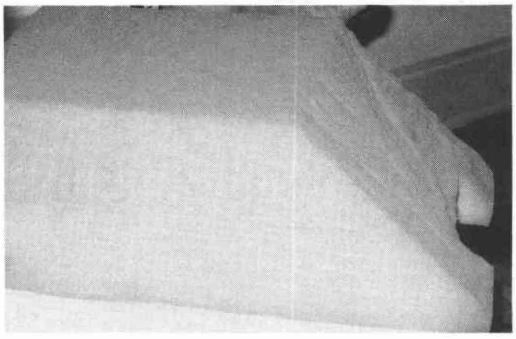

Figure 1. The open-celled foam block used to mold the Plastazote® footbed is cut on the top/front to prevent deep-molding the toes into the Plastazote®.

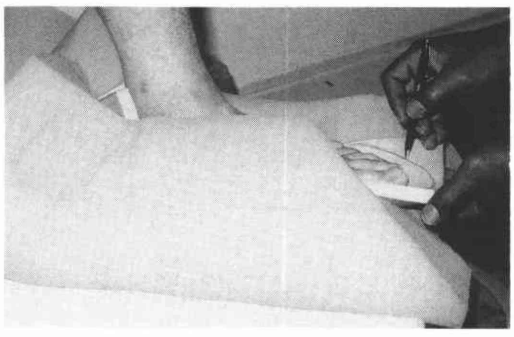

Figure 2. As the first Plastazote® layer is cooling, a line is drawn to mark the outer edge of the sandal.

Construction of the Sandal

Patients are seated in an adjustable chair to insure the knee and ankle can be maintained at right angles as the Plastazote® is molded to their foot. Patients with insensitive feet are asked to wear socks for heat insulation from the warm polyethylene foam.

To begin the sandal, a piece of 6″ × 12″ × ½″ thick, medium, Plastazote® #1 is heated according to the above formula. After the Plastazote® has been heated, it is placed on the foam block with the toe region hanging over the 45° cut of the foam block. The foot is aligned over the Plastazote® with the metatarsal heads positioned over the top edge of the cut-off section of the foam block. The patient's foot is then pressed into the Plastazote®.

After the Plastazote® foot bed has cooled, but before the patient is asked to lift their foot, an outline is drawn to mark a reference for what will become the outer sides of the sandal

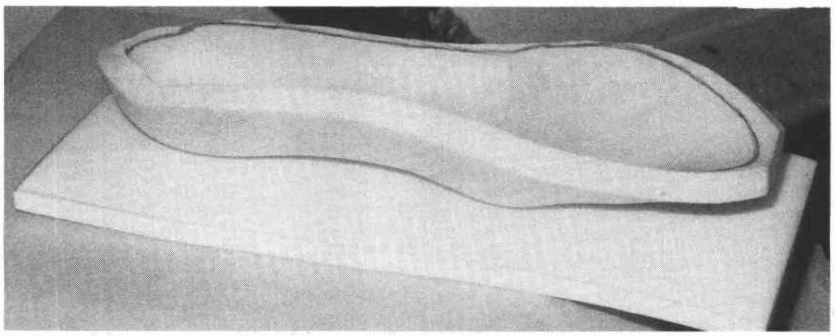

Figure 3. The molded #1 Plastazote® is set on the glued surface of the heated #2 prior to molding the two together.

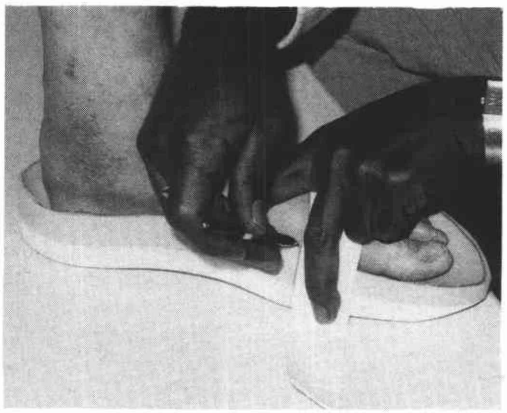

Figure 4. The cotton-webbing straps are held in place while the sandal and straps are marked for later gluing.

(Figure 2). Hold the pen marking this line in a vertical position. Purposely draw the toe area distal to the foot further distal to the toes than needed. Mark the toe of the sandal about 1″ distal than the toes of the foot. Material used to wrap the sides of the sandal will pull the distal end of the sandal back.

Cut the molded piece of Plastazote® around the outside of the molded portion to remove excess material. Make this cut approximately ½″ outside the drawn line. This will allow for better control of shaping the sandal during a later grinding process.

Apply adhesive to the bottom (convex side) of the molded material and to one side of a 6″ × 12″ × ½″ firm, #2 Plastazote® piece. Then heat the #2 Plastazote®. Set the heated #2 piece on the foam block and the molded #1 Plastazote® piece on top of it (Figure 3). Place the foot back into the molded #1 piece and then press down to mold the #2 Plastazote® piece to the bottom of the #1 piece. Plastazote® #1 and #2 are autoadhesive, but this

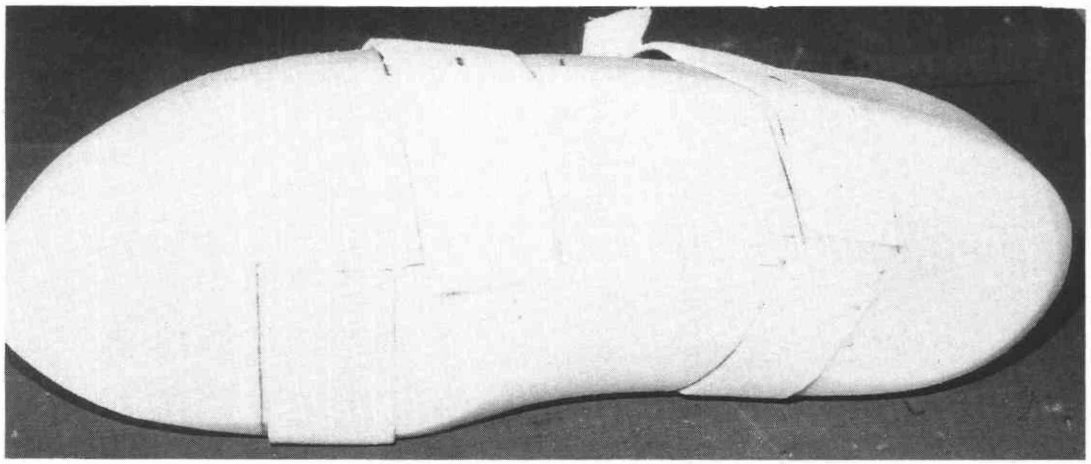

Figure 5. The straps are cut so they do not overlap under the footbed.

characteristic of the material has not proven to form a dependable bond in these sandals.

Then cut the #2 piece to the edge of the #1 piece and ground both pieces vertically to meet the line drawn earlier. At this time, ground flat some of the roundness on the plantar surface of the molded #2 piece and flatten by grinding the area under the metatarsal heads and toes.

Use the 1½″ wide webbing to build the strap which will cross over the midfoot region just in front of the ankle. Use the 1″ webbing for the strap which will cross over the top of the metatarsals just proximal to the metatarsal heads. Also use 1″ strapping behind the heel.

Place the patient's foot in the foot bed and "velcro'' the straps together and hold them in place over the foot. Align the straps over the foot and mark the Plastazote® and straps (Figure 4). Glue together the Plastazote® footbed and straps, using the marks as a reference. Cut the straps under the sandal so they don't overlap (Figure 5).

Coat with glue the 5″ × 10″ × ½″ scrap piece of #2 Plastazote® and the bottom of the molded footbed and heat the #2 piece. Glue the #2 piece under the heel arch and metatarsal heads. Ground down the bottom to form a ½″ high wedge heel which tapers down to the metatarsal heads (Figure 6). This heel lift also serves to fill any remaining arch and curvature under the sides of the molded footbed.

The sole of these sandals should be absolutely rigid. On smaller patients the rigid Plastazote®, which will be added later, will be sufficient to accomplish this. But in larger, heavier patients, it may be necessary to include a rigid steel shank from the heel to the toe. For those patients, glue a piece of leather to the bottom of the footbed to prevent penetration of the steel through the footbed. Bend up the steel from the metatarsal heads to the end of the toe of the sandal in the form of a rocker. Glue the steel shank to the bottom of the leather, and shape and grind flat a filler material around the shank so bumps will not form in the outer sole of the sandal.

If the steel shank is not used, coat with glue a piece of 5″ × 12″ × ¼″ rigid #3 Plastazote® and the bottom of the footbed. Heat the #3 piece and then attach it to the bottom of the footbed. This is done by adhering the heel of the sandal to the #3 piece first and then, in a rolling motion, elevate the heel of the sandal as the toe is pressed down onto the material piece (Figure 7). This creates a rocker sole with increased toe spring under the toes.

Skive back one end of a piece of rigid Plastazote® 3″ wide by 33″ long and ¼″ thick to a distance of 2″ and at a shallow angle. Then apply glue over the 2″ skived portion and the entire other side of the rigid Plastazote® piece. Coat the sides of the footbed with glue. Heat the rigid Plastazote® and glue it vertically around the perimeter of the sandal (Figure 8). Glue the skived end to the medial arch area of the footbed first. This leaves the glue coated skived area facing out from the sandal. Completely wrap the #3 strip around it, overlapping onto the skived area, and cut off the excess. Trim the bottom flat and round the upper edge

Figure 6. The bottom of the sandal is ground flat under heel, arch, and metatarsal heads after the heel wedge is glued on. The area under the toe is ground up to form the rocker.

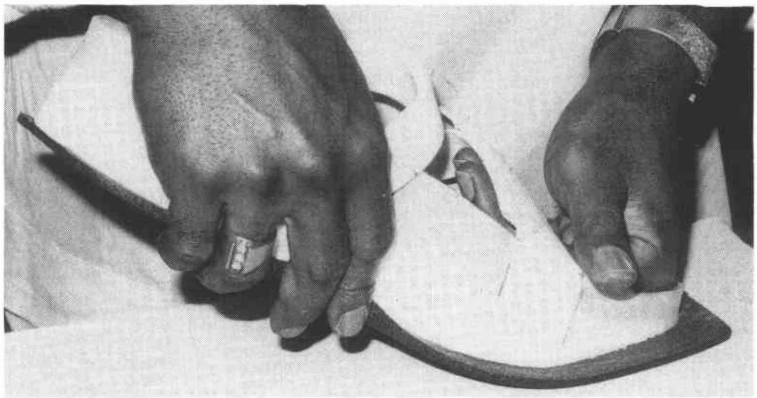

Figure 7. The heel of the sandal is lifted before the front of the heated #3 Plastazote® is glued to the footbed to help form the rocker sole.

Figure 8. The sandal is made more rigid by gluing ¼″ #3 Plastazote® vertically around the footbed.

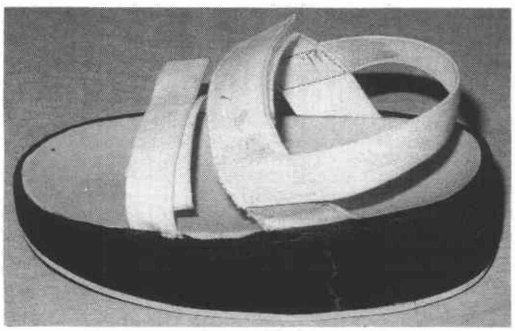

Figure 9. The completed sandal with neoprene crepe soling and heel strap attached.

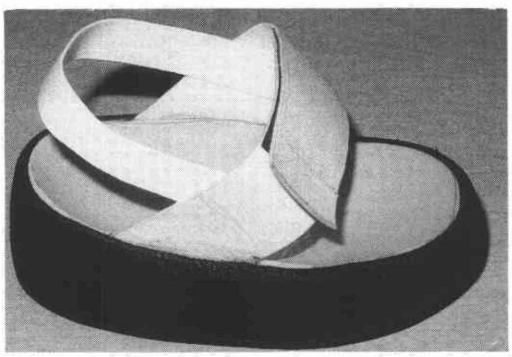

Figure 10. For shortened feet a single, broad strap can be used across the instep.

level with the top of the footbed by grinding. Then glue neoprene crepe soling to the bottom.

Place the patient's foot into the sandal to fit a heel strap. The strap is 1″ cotton webbing. Mark the location of the strap. Remove the sandal and sew the strap into place (Figure 9). Rivets can also be used to attach the strap.

For shortened feet, use only a single vertical, instep strap of 1½″ to 2″ width and attach the heel strap to this single strap (Figure 10). For more long-term use, construct the straps and sides of leather (Figure 11). If the patient's skin

Figure 11. Leather can be used for sandals intended for long-term or outdoor wear.

is thin and atrophied, softer materials such as beta-pile can be used as straps.

Considerations for Insensitive Feet

In a series of 41 diabetic patients with sensory neuropathy in their feet, when measured with pedobarograph, 51% had abnormally high pressure under their metatarsal heads.[2] This is compared to only 7% of non-diabetic patients displaying higher pressures. The skin under the metatarsal heads has been shown in many studies to be the most frequently ulcerated part of the insensitive foot.[3,6] The forefoot region of insensitive feet needs a higher level of protection than the rest of the foot. This can be accomplished in the Plastazote® sandal by making the sole rigid and creating a rocker effect in the sole design.[7] A rigid sole minimizes shear between the sandal and skin. It also eliminates flexion and extension at the metatarsal-phalangeal joints.[7] If the toes of the foot are rigid, a flexible soled shoe will press up into the toes during gait.

Rocker soles have been shown to greatly reduce foot pressure during gait. The point on the sole where rocking begins should always be posterior to the metatarsal heads, but ideally would be placed near the middle of the sandal. These rocker styles of sole are also helpful in the rehabilitation of patients with fused ankles.[5]

Conclusion

For 20 years at the Gillis W. Long Hansen's Disease Center in Carville, Louisiana, Plastazote® sandals have proven to be an effective form of interim footwear for insensitive patients. The technique is simple and highly adaptable to many types of foot therapy.

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