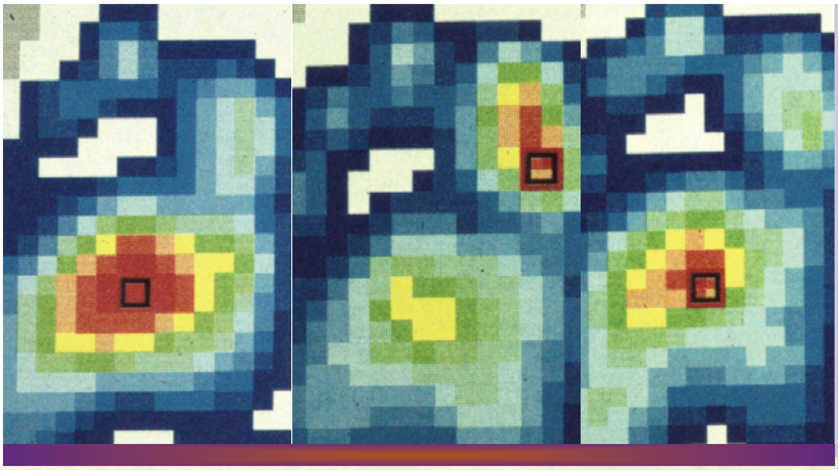

Orthoses, Materials, and Foot Function

Different uses require the unique properties inherent in the various types of devices available.

Goals and Objectives

After reading this article the podiatric physician should be able to:

1) Know the definition of the term orthosis and be familiar with the different types used in the treatment of foot pathology.

2) Know what are considered to be natural orthotic materials, their properties and proper use in fabricating foot orthoses.

3) Know what are considered to be synthetic orthotic materials, their composition, properties, and advantages and disadvantages when used in the fabrication of foot orthoses and insoles.

4) Understand a method of evaluating plantar pedal pressure using a computerized in-shoe sensor system.

5) Recognize various pedal pathologies that can result from excessive forefoot pressure during ambulation.

6) Evaluate the effects of different types of foot orthoses and insoles on plantar pedal pressure by interpreting computer-generated pedal pressure displays.

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*Following this article, an answer sheet and full set of instructions are provided (p. 140).—**Editor***

By Mark A Caselli, DPM

Orthoses and insoles are the mainstay of mechanical foot therapy as it has developed over the last century. Over the past two decades, tremendous advances have been made in the diagnosis and treatment of mechanical problems pertaining to gait, and thus the design and use of foot orthoses and insoles. Computer technology, new materials, and advances from orthotic laboratories have played a significant role in patient care.

Foot Orthoses and Insoles

By definition, an orthosis is a device that is used to protect, support, or improve function of parts

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of the body that move.[10] In the field of podiatric orthopedics, the terms orthoses and orthotics are used to describe a wide range of devices that are placed inside the shoe. Other terms used for orthoses include inserts, insoles, inlays, supports, and cushions.

The three basic types of foot orthoses are pre-fabricated, customized, and custom-molded. A pre-fabricated orthosis is one that is mass-produced and is intended to be dispensed to the user without modification. Pre-fabricated orthoses are usually designed to provide either increased support or shock absorption for a specific area of the foot, such as an arch support or heel cushion. They may also provide cushioning to the entire foot, as is the case with the use of a full insole.

A customized orthosis usually consists of a pre-fabricated base component that is modified in some way, such as adding a metatarsal pad or heel lift. A custom-molded orthosis is one made from a model of the patient's foot made from some form of three-dimensional impression-taking procedure. These devices are used for patients with more severe or complicated foot problems. They are commonly composed of a shell, the layer of material next to the foot and in total contact with the foot, and posting material, filling the space between the shell and the shoe. Custom orthoses can be further modified by adding materials to the top of the shell to either redistribute pressure or provide cushioning.

Foot orthoses are often described as being either accommodative or functional.

Foot orthoses are often described as being either accommodative or functional. An accommodative orthosis is designed primarily to accommodate a rigid foot or foot deformity, or one that is a risk, while a functional orthosis is designed to realign a more flexible foot by providing joint stability and support. In reality, most orthoses offer some degree of both accommodative and functional properties. In general, foot orthoses are designed to accomplish one or more of the following:

1) reduce shock,
2) reduce shear,
3) relieve areas of excessive plantar pressure,
4) stabilize and support the joints of the foot,
5) limit motion of joints.[5]

Orthotic Materials

Many different materials are used in the fabrication of foot orthoses. These materials are commonly divided into three basic types; soft, semi-flexible, and rigid. Examples of soft materials include polyethylene foams such as Plastazote® (Bakalite Xylonite LTD, {BXL} UK), closed-cell neoprene impregnated with nitrogen bubbles such as Spenco (Spenco Medical Corporation, Waco, TX), open cell foams such as Poron (Rogers Corporation, Rogers, CT), and gel-like viscoelastic polymers such as silicone. Leather and cork materials are usually considered to be semiflexible. Semiflexible materials are somewhat accommodative but provide more functional support than the soft type and do not bottom out as quickly.

Rigid materials include acrylic plastics and thermoplastic polymers. They are moldable at high temperatures and are primarily functional in nature. These are the most durable and supportive of the three types. This method of classifying materials provides a good general guideline for selecting materials either alone or in combination for the fabrication of a foot orthosis.

The problem with this classification system is that it could be misleading without a thorough knowledge of the properties of each of the materials. Many of the materials can range from being soft to rigid, depending on the thickness, number of layers, or form of the material used. A good example of this is an orthotic made from Plastazote, which can range from soft (a single layer of medium grade) to rigid (laminated layers of rigid grade). A better method is categorizing the materials as either being natural or synthetic with specific properties assigned to each material.

The benefits of leather as an orthotic material are a direct result of its intrinsic natural characteristics.

Natural Materials

Natural materials used for the fabrication of orthoses are those found in nature and include leather, cork, and rubber butter.

Leather

Leather orthoses can be either functional or accommodative depending on material combinations and casting techniques. The basic shell of a leather orthosis consists of adding layers of leather to one another to form a lamination that can be shaped to a positive cast of the patient's foot or molded to the foot or to the inside of a shoe directly.

The benefits of leather as an orthotic material are a direct result of its intrinsic natural characteristics. The collagen fibers that make up leather are woven in a three-dimensional pattern. Collagen's chemical properties give leather its distinctive porosity or breathability. As a result, leather can absorb up to 30 percent of its weight in water vapor without feeling wet. Tanning also gives leather the ability to retain its shape and resist the aging process. The refinement of high performance leather has resulted in features that include improved water repellency, low water absorption, fast and soft drying, and durability.

Other advantages of leather orthoses include the fact that leather conforms to foot contours and bony

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prominences and is well-tolerated by patients of all ages. Leather devices can be readily reshaped, remodeled, and adjusted in the office. The disadvantages of leather orthoses are that they tend to be more bulky than those made from thermoplastics for a given degree of motion control. They also tend to break down when worn by very active or obese individuals. While they can withstand a limited amount of moisture, they do not hold up well under repetitive soaking.[11]

Rubber Butter

Rubber butter is a generic substance formulated by mixing liquid latex with either cork, wood, or leather shavings, each producing a slightly different material. Rubber butter-like materials are manufactured by several companies and are available under various trade names. Cushion Cork (JMS Plastics, Neptune, NJ) is a latex and cork combination available in sheets that are supplied in thicknesses measuring 1/6 to 1/2 inch, and commonly used for fabricating wedges and lifts. Korex is a cork latex mixture manufactured by Armstrong. Thermocork (Apex Foot Health Industries, Teaneck, NJ) is the only heat molded product in this group and is available in thicknesses measuring 1/8 to 3/8 inch. Rubber butter which is composed of latex and leather grindings has more shock attenuating properties than the latex and cork mixtures; however, because of its leather content, it is susceptible to a greater degree of breakdown over time[8] These materials are also effective when used specifically as accommodations, either in conjunction with a standard-length foot orthosis or alone.

Figure 1a. F-Scan insole sensor being placed in an athletic shoe with the manufacturer's supplied shoe sock liner.

Figure 1b. F-Scan recording using the shoe alone, demonstrating high pressure areas under metatarsal heads

Synthetic Materials

The synthetic materials used in the fabrication of foot orthoses were developed to possess desired properties not found in naturally occurring materials.

Polyethylene and Polypropylene Thermoplastics

Polyethylene is a polyolephin which is synthesized from the monomer ethylene oxide. Polyethylene thermoplastics possess the properties of toughness and flexibility with good dimensional stability, are heat moldable, lightweight, and possess favorable weight/strength ratios. They are generally classified as being low, medium, high, or ultra-high density. They are available for orthosis fabrication primarily as Ortholen and Sub-Ortholen (Teufel, Stuttgart, Germany).

Carbon graphite orthotic devices are fabricated by laminating very thin sheets of carbon graphite fiber cloths using a liquid resin.

Ortholen is an extremely high density thermoforming polyethylene with a molecular weight of one million. It is a very tough material which is resistant to chemical erosion and is non-brittle at low temperatures. Ortholen is available in thicknesses of 3 to 6 mm., and is heat molded by heating to 350 degrees F. for 10 to 15 minutes. Orthoses fabricated from Ortholen are indicated when a functional or semi-functional device is desired as it provides efficient pronation control in situations where a moderately flexible orthosis is required. Sub-Ortholen is an ultra-high density thermoforming polyethylene with a molecular weight of 500,000. Although related to Ortholen, it has less toughness and strength but is easier to mold by heating to 300 degrees F. Sub-Ortholen is available in thicknesses of 1 to 6 mm..[8]

Polypropylene is also a polyolephin synthesized from the monomer ethylene oxide. As with polyethylene, polypropylene is a thermoplastic that is heat-formable and heat-adjustable at approximately 360 to 390 degrees F. Polypropylene differs from polyethylene in that it is a polymer of greater density and molecular weight, causing it to have a higher stiffness-to-thickness ratio. This results in polypropylene having generally less rapid and less severe plas-

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tic, or shape, deformation than the polyethylenes.[9]

Rohadur

Rohadur nylon acrylic is a copolymer consisting of methylmethacrylate and acrylonitrile. It was first developed for orthopedic use by the Rohm Haas Company of Germany in 1951 as Thermolast-1. Sheets of this material were marketed by various companies under such trade names as Plexidur, Nyloplex, Sadur, and Cyrodur (all JMS Plastics, Neptune, NJ). In 1976, Thermoplast-1 was found to be possibly carcinogenic in its manufacturing process and was therefore reformulated and a new Rohadur resin was introduced as Thermolast-II. Rohadur thermoplastic is heat moldable and indicated for orthotic devices in which functional control is desired.

In addition to its use in fabricating orthoses to control pronation, Rohadur is commonly used in the fabrication of gait plates, which are used in the treatment of in-toe gait. Rohadur is available in sheets measuring 2, 2.5, 3, 3.5, 4, 5, and 6 mm. in thickness, with the 3 to 4 mm. thickness most frequently used.[8]

Poron retains its form stability and always returns to its original position, even after permanent load, while polyethylene foams such as Plastazote tend to permanently compress or "bottom out."

Carbon Graphite

Carbon graphite orthotic devices are fabricated by laminating very thin sheets of carbon graphite fiber cloths using a liquid resin. The number of laminations varies depending on the strength desired, but for most foot orthosis applications, the shell is approximately 2 mm. in thickness. This produces a thin rigid shell that is appreciably thinner than other thermoplastic orthoses.

TL-2100 (Performance Materials Corp., Camarillo, CA) is manufactured with an acrylic-based thermoplastic resin system reinforced with carbon fiber and combined in a sandwich configuration. This allows thermoformability and heat adjustability similar to that of polypropylene. The graphite reinforcement provides stiffness for support and strength for durability. There are four versions of TL-2100 available: Ultrastrength, so named because it is manufactured with approximately 50% more graphite than the other versions, Rigid, Semi-Rigid, and Semi-Flexible. Thicknesses range from 1.8 to 2.8 mm..[9]

Figure 2a. Functional foot orthosis made with a polyethylene shell, neoprene rearfoot posting, 1/16" Poron top cover, and 1/8" Poron forefoot extension to toes

Polyethylene Foams

Polyethylene foams are synthetic materials also classified as polyolefins. These are closed-cell foams that are nontoxic, resistant to chemicals and fluids, light, and when heated to suitable temperatures, are moldable. They are readily washable and discourage bacteria growth. Orthotic shells may be fabricated using one type of polyethylene foam or by laminating different foams together. A variety of polyethylene foams are available in assorted durometers or hardnesses. Polyethylene foams are manufactured under different trade names, with each company implementing its own system to name the materials various durometers. Some of the more commonly encountered trade names of polyethylene foams are Plastazote, Evazote, Pelite (all Bakalite Xylonite LTD,{BXL}, UK), and Aliplast (Alimed, Nedham, MA).[6]

Plastazote was first used as an orthotic material by American podiatrists in 1969 after Dr. Paul Brand found it to be successful for limb preservation in leprosy patients. Plastazote is heat-moldable at 140 degrees F. and is self-accommodating to lesions and bony prominences as well as being very lightweight. Plastazote is available in thicknesses of 1/16 to one inch. It is also available in three durometers: medium, firm, and

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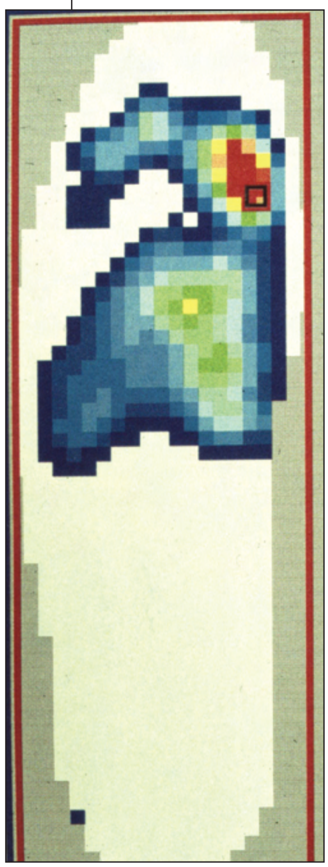

Figure 2b. F-Scan recording with functional orthosis in athletic shoe. Note the significant decrease in submetatarsal pressure, but increase in pressure plantar hallux, probably due to improved foot biomechanics with propulsion through center of hallux.

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rigid. The medium and firm durometers are commonly used in the fabrication of accommodative and dynamic insoles, while the rigid durometer is used in the fabrication of semi-functional orthotic devices. Evazote is available in only one durometer which is very self-accommodating and lightweight. Pelite is available in four durometers and is commonly used as a liner for prosthetics. Aliplast is comparable to Plastazote and supplied in four durometers.[8]

Polyurethane Foams

Polyurethane foam is a thermosetting, non-heat-moldable foam that is manufactured either as an opened or closed-cell foam. The opened-cell type is the most commonly used. Poron, an open-cell polyurethane foam made from a combination of polyether and polyester resins, was developed by the Rogers Company of Connecticut utilizing a patented process. It is used wherever the reduction of pressure from static or dynamic forces is to be achieved, as in the production of foot orthoses or shoe inlays. This polyurethane foam is stable in form, elastic, shock-absorbing, odorless, and washable. As an opened-cell foam, medical grade Poron dissipates heat well, and by allowing water vapor transmission, enables perspiration to be transmitted away from the foot. This opened-cell nature also allows the air to circulate according to the weight lying on the material.

Poron retains its form stability and always returns to its original position, even after permanent load, while polyethylene foams such as Plastazote tend to permanently compress or "bottom out." When used as a shock-attenuating soft tissue supplement for the plantar aspect of the foot, it is available in thicknesses ranging from 1/16 to 1/2 inch in a single durometer. The material is manufactured both perforat-

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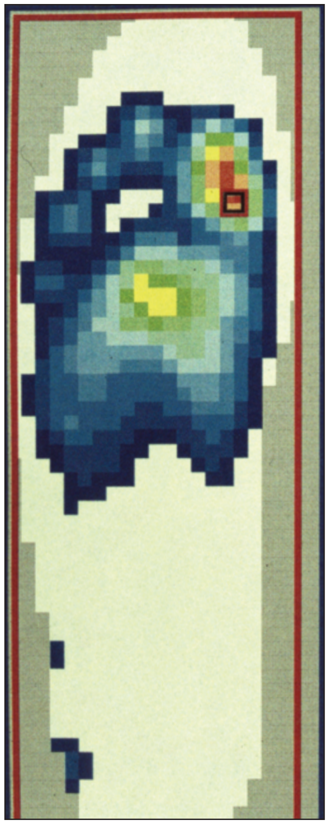

Figure 3b. F-Scan recording with semi-functional orthosis in athletic shoe. Note that there is slightly less decrease in submetatarsal pressure than with the functional orthosis, but the decrease in pressure plantar hallux is probably due to its less functional design.

Silicone rubber offers excellent viscoelastic properties capable of providing shock absorption.

Figure 3a. Semi-functional foot orthosis made with thinner polyethylene shell, Poron longitudinal arch reinforcement, lower durometer neoprene rearfoot posting, 1/16″ Poron top cover, and 1/8″ Poron forefoot extension to toes

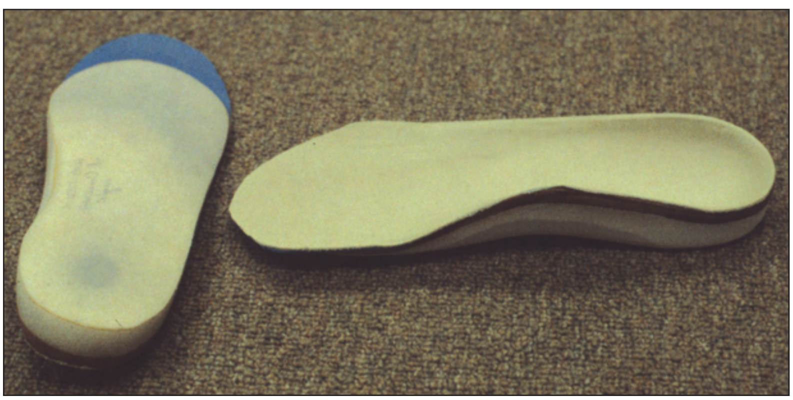

Figure 4a. Accommodative foot orthosis made with a 2-ply leather shell placed on firm Plastazote with a 1/8″ Poron forefoot extension.

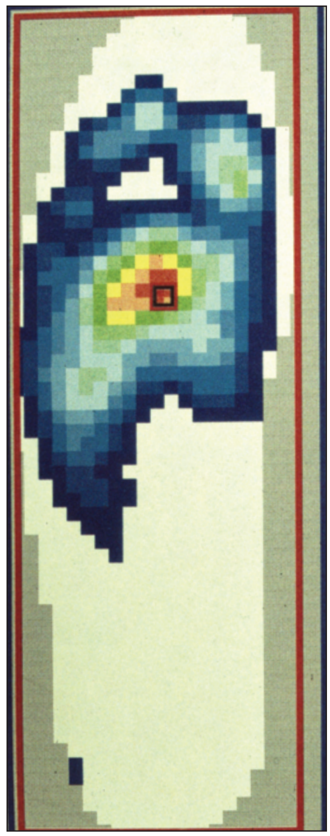

Figure 4b. F-Scan recording with accommodative orthosis in athletic shoe. Note decrease in submetatarsal pressure as compared to shoe alone, but not as great a decrease as with the functional or semi-functional devices. Note also the decrease in pressure on the plantar hallux.

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ed and non-perforated with a variety of surfaces and topcovers, including smooth, abraded, felt, and multi-stretch nylon. Poron was once marketed by Langer Inc. of Deer Park, NY under the name PPT. Today, however, PPT is no longer made of Poron, though it has similar properties.[6]

Rubber Foams

The term rubber refers to a group of compounds (both natural and synthetic) with elastic properties. The chemical industry classifies this group as elastomers. In the mid-1930's, Dupont invented the synthetic rubber neoprene, a polychloroprene. Once a Dupont trademark, neoprene is now used extensively industry-wide in the manufacture of foot orthoses, usually on the undersurface of a rigid or semi-rigid plastic shell. It is used as a balancing or posting material and is also used for providing some degree of cushioning and shock absorption.

In an attempt to produce an insole that would better absorb lateral and oblique forces and decrease the problem of blisters, Wayman Spence, MD and Marlin Shields, PT, in 1966, developed Spenco (Spenco Medical Corp., Waco, TX). Spenco is neoprene closed-cell foam with entrapped nitrogen bubbles and a nylon (polyamide) topcover. Spenco insoles are currently available in 3/32, 1/8, and 1/4 inch thicknesses. They are indicated for absorbing vertical forces, torque, and fore, aft, and lateral sheer, thus preventing blisters in athletes. Spenco insoles are also used to help prevent neuropathic and rheumatoid ulcerations by reducing the increased plantar foot pressure responsible for skin breakdown. Spenco does, however, retain heat and moisture due to its closed-cell nature.[6]

Lynco (Apex Foot Health Industries, Teaneck, NJ), an open cell neoprene foam insole with a nylon topcover, better dissipates heat than Spenco, but due to its open-cell nature, it is felt not to be as good a shock attenuator.

Silicone

Silicones are entirely synthetic polymers containing repeating silicon and oxygen atoms with organic groups directly attached to the silicon atom. Depending on the length of its polymer

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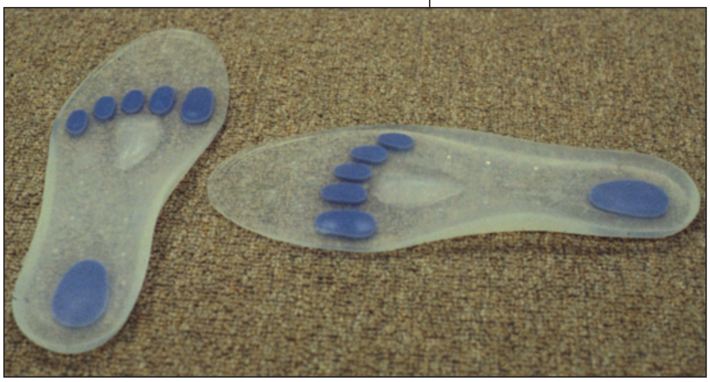

Figure 5a. Silicone full-length insole with heel and arch support contouring, metatarsal pad, and softer padding at the metatarsal and heel areas.

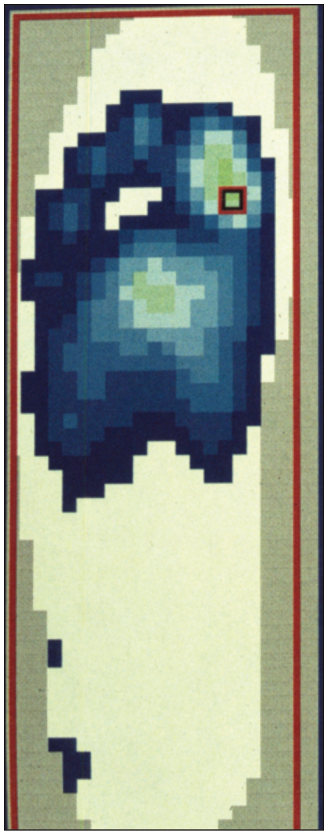

Figure 5b. F-Scan recording with silicone insole in athletic shoe.

A variety of both heel and full foot orthoses fabricated from silicone are currently available on the market.

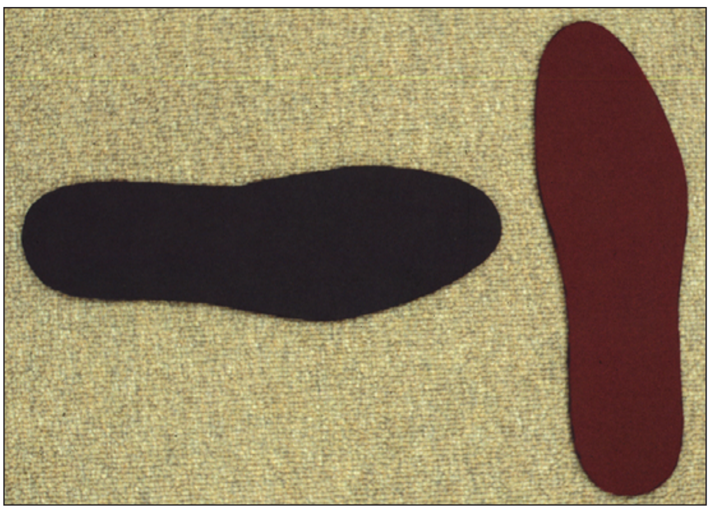

Figure 6a. Spenco (neoprene closed-cell foam) 1/8 inch full-foot insole.

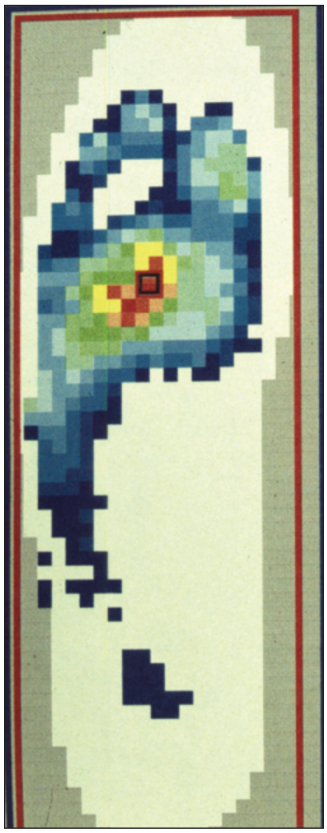

Figure 6b. F-Scan recording with Spenco insole in athletic shoe.

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chain and the degree of cross-linking, silicone can be present in many different types of commercial products ranging from fluids to rubbers. Silicone rubbers are compositions containing a high-molecular-weight dimethyl silicone linear polymer and are commonly used in the fabrication of foot orthoses. Products containing silicon polymers tend to be relatively expensive. In the case of orthotic devices, those made of true silicone tend to be more costly than similar products made from other materials such as polyurethane foams. Silicone, however, has many properties that make it highly desirable for use in the manufacture of orthoses.

Silicone rubber offers excellent viscoelastic properties capable of providing shock absorption by dissipating the energy evading the body during ambulation. It accomplishes this task without bottoming out as quickly as other materials used for the same purpose, thus making it an excellent substitute for the natural viscoelastic body tissues. Silicone rubber has the ability of remaining flexible at very low temperatures and is not distorted by heat up to 400 degrees C. (752 degrees F). Orthoses made from silicone can be heated and cooled without drying or cracking. Other important characteristics include a high degree of chemical inertness which allows the silicone devices to be soaked in many types of solutions for both cleaning and disinfecting without loss of any function. This chemical inertness also reduces the chance of allergies upon contact with the skin and does not support bacterial growth or odor. They do tend to have the disadvantage that they retain heat and cannot be ground for adjusting.[2]

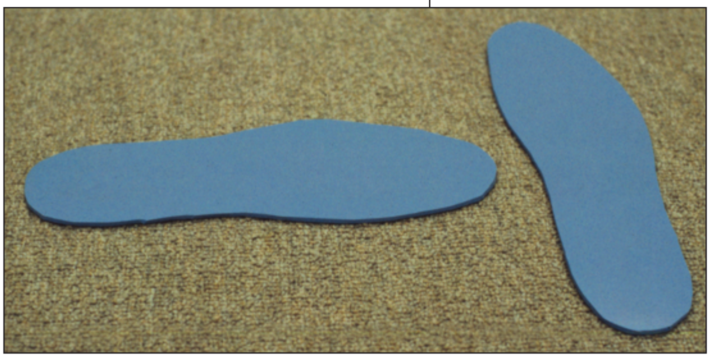

Figure 7a. Poron (opened-cell polyurethane foam) 1/8 inch full-foot insole.

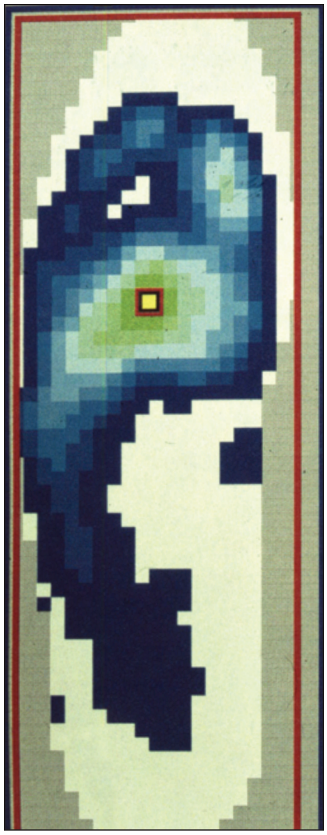

Figure 7b. F-Scan recording with Poron 1/8 inch insole in athletic shoe.

Many studies also linked excessive sub-metatarsal pressure associated with the peripheral neuropathy seen in diabetes as a cause of plantar pedal ulceration.

A variety of both heel and full foot orthoses fabricated from silicone are currently available on the market. Although they differ somewhat in appearance, they are all designed primarily for both shock attenuation and weight dispersion. Several of the silicone orthoses incorporate precisely positioned softer padding, targeting the metatarsal and heel regions of the foot where shock load is highest. Some full-length insoles also include contouring that provides both heel and arch support, as well as shock absorption.

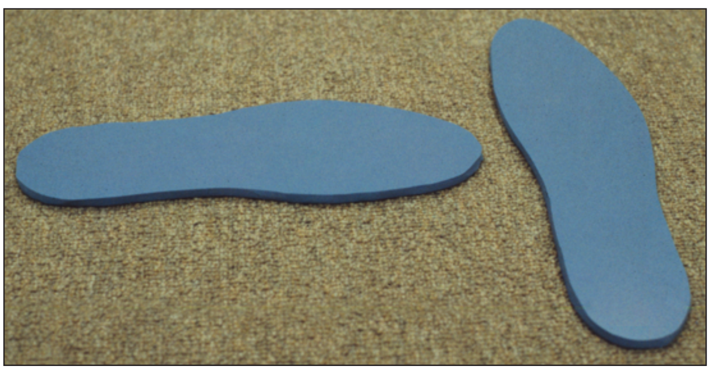

Figure 8a. Poron (opened-cell polyurethane foam) 1/4 inch full-foot insole.

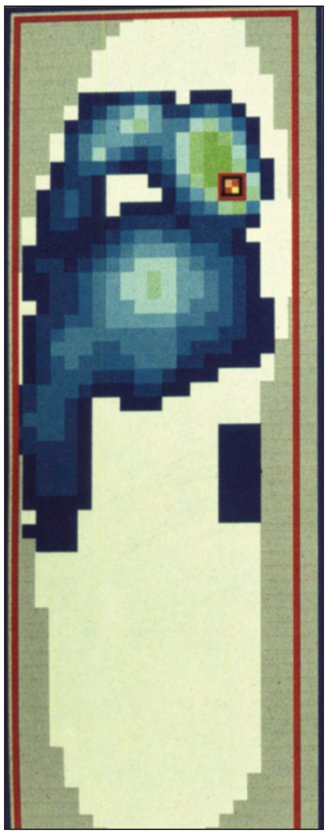

Figure 8b. F-Scan recording with Poron 1/4 inch insole in athletic shoe.

Evaluating the Effects of Orthoses and Insoles on Foot Function

Recent technological advancements have provided objective methods of

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accurately determining the effects of orthoses and insoles on specific features of foot function, specifically pedal plantar pressure. In order for a device to be of value in assessing pedal plantar pressure, it must be capable of measuring the pressure at the shoe-foot interface or the orthotic/insole-foot interface during ambulation. There are currently a number of systems on the market that are capable of accomplishing this task.

One of the commonly used systems is the F-Scan In-Shoe System (Tekscan, Inc., Boston, MA). This system utilizes an ultra thin (7/1000 in.) pressure sensitive insole sensor containing 960 individual pressure sensing points. The F-Scan software records and calculates stance times and pressures at the shoe-foot interface. Increasing pressure is depicted by color changes ranging from violet (lowest pressure) to red (highest pressure) along the standard color spectrum. In-shoe plantar pressure can thus be a valuable tool in detecting both areas of increased plantar pressure and the ability of shoegear, insoles, and orthoses to off-load these high-pressure areas.[1]

One of the most common areas of the foot that is associated with pathology due to excessive pressure, especially during the push-off phase of gait, is the plantar surface of the lesser metatarsals. Conditions such as metatarsalgia, hyperkeratosis, ulcerations, and stress fractures have been attributed to excessive pressure in this area.

Metatarsalgia is described as a localized or generalized pain in the region of the distal aspect of one or more of the metatarsals during weight bearing. Pain may be the result of either positional or functional malalignment of the metatarsals. The most common type of metatarsalgia involves a long lesser metatarsal bone (typically second or third) that projects past the theoretically perfect curve. The increased pressure and friction from this long metatarsal occur during the push-off phase of gait, when the foot is fully loaded. Metatarsalgia may also be caused by a plantar-flexed lesser metatarsal that results from a contracted hammertoe condition. The plantar weight-bearing area under the metatarsal often begins to form a protective callus, and eventually a deep, painful plantar keratoma may develop.[3,4] Many studies have also linked excessive sub-metatarsal pressure associated with the peripheral neuropathy seen in diabetes as a cause of plantar pedal ulceration. With loss of normal sensation, the diabetic fails to be aware of excessive plantar pressure.[1]

Metatarsal stress fractures are also the result of increased repetitive pressure on the sub-metatarsal area of the foot. These were initially the most commonly diagnosed stress fractures when they were thought to occur only in military recruits. Although these fractures remain relatively common in the military, they also involve a significant number of athletes.[7] The presence of diabetes appears to result in the increased prevalence of metatarsal stress fractures in the athlete. The most frequently fractured of the metatarsal bones are the second and third.[1]

Metatarsal stress fractures are also the result of increased repetitive pressure on the sub-metatarsal area of the foot.

The Use of Orthoses and Insoles in the Management of Excessive Lesser Metatarsal Plantar Pressure

The following figures demonstrate the effects of various foot orthoses and insoles on the plantar pedal pressure of a patient exhibiting excessive sub-lesser metatarsal plantar pressure. F-Scan readings were taken at the push-off phase of gait when the sub-lesser metatarsal pressure was at its peak. The measurements were recorded using the F-Scan In-Shoe sensor with the patient wearing an all-purpose type athletic shoe. The readings were taken first with the shoe alone containing the manufacturer-supplied shoe sockliner, then with various types of foot orthoses and insoles replacing the sockliner. The orthoses were custom made from an impression cast of the patient's feet and fabricated from a variety of both natural and synthetic materials as described. They represent what would be considered either functional, semi-functional, or accommodative devices. The insoles are made of some of the various types of biomaterials described in this paper.

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EXAMINATION

See answer sheet on page 141.

1) A pre-fabricated orthotic device that is modified to meet a specific patient's needs is considered:
A) A pre-fabricated orthosis
B) A customized orthosis
C) A custom orthosis
D) An insole

2) Which one of the following cannot be accomplished with the use of foot orthoses?
A) Reduce shock
B) Limit motion of joints
C) Mobilize rigid joints
D) Stabilize and support joints

3) Which one of the following represents an example of a soft material that might be used in the fabrication of a foot orthosis?
A) Opened cell polyurethane foam
B) Polyethylene thermoplastic
C) Rohadur
D) Sub-Ortholen

4) One of the advantages of using leather in the fabrication of foot orthoses is its breathability. This property is due to:
A) Special tanning process used in preparing leather
B) Thinness of leather
C) The lamination method of fabricating leather orthoses
D) The three-dimensional pattern of leather's collagen fibers

5) The primary disadvantage of leather foot orthoses is that:
A) They conform to foot contours and bony prominences
B) They can be easily adjusted and reshaped
C) They tend to be more bulky than those made from thermoplastics
D) They are poorly tolerated by patients

6) Rubber butter is a generic substance formulated by mixing liquid latex with all but which one of the following?
A) Cork
B) Plastic shavings
C) Leather shavings
D) Wood

7) Which one of the following is not a property of the polyethylene thermoplastics?
A) Good shock absorber
B) Dimensional stability
C) Light weight
D) Durable

8) Ortholen and Sub-Ortholen are polyethylene thermoplastics that are heat moldable at what temperatures?
A) 100 to 150 degrees F.
B) 200 to 250 degrees F.
C) 300 to 350 degrees F.
D) 450 to 500 degrees F.

9) Foot orthoses made from polypropylene thermoplastic can be made thinner than those made from polyethylene because of polypropylene's:
A) Higher heat moldable temperature
B) Greater density and molecular weight
C) Lighter color
D) Rougher surface

10) The material most commonly used for the fabrication of gait plate orthoses is:
A) Rigid Plastazote
B) Sub-Ortholen
C) Polypropylene thermoplastic
D) Nylon acrylic

11) Polyethylene foams are commonly used to fabricate orthoses and insoles for neuropathic diabetic patients due to which one of the following properties?
A) Availability in varying thicknesses
B) Heat-moldability
C) Self-accommodating nature
D) Lightweight

12) Which one of the following is not a property of polyurethane foams?
A) Heat-moldable
B) Good shock absorbers
C) Do not permanently deform
D) Dissipate heat

13) Poron polyurethane foam allows perspiration to be transmitted away from the foot due to its:
A) Good shock-attenuating properties
B) Opened-cell nature
C) Multistretch cover
D) Elasticity

14) The synthetic rubber neoprene is primarily used in the manufacture of foot orthoses as a:
A) Topcover
B) Forefoot extension
C) Posting material
D) Shell

15) Spenco, a neoprene foam,

Continued on page 140

Continuing Medical Education

EXAMINATION

(cont'd)

was initially invented for what purpose?

A) Prevention of blisters in athletes
B) Improved arch support
C) Prevention of foot ulcers in diabetics
D) As a liner for ski boots

16) Spenco insoles tend to retain heat and moisture due to their:

a) Neoprene component
B) Nylon topcover
C) Closed-cell nature
D) Thickness

17) What property of a silicone polymer determines whether it will exist as a liquid or rubber?

A) The temperature at which it exists
B) The length of its polymer chain
C) The atmospheric pressure at which it exists
D) The degree of moisture it contains

18) Silicone rubbers tend to be hypoallergic, can be easily cleaned and disinfected, and resist bacterial growth due to what property?

A) Viscoelasticity
B) Flexibility
C) Special topcovers
D) Chemical inertness

19) In order for a device to be of value in assessing the effect of foot orthoses on pedal pressure it must be able to:

A) Produce a "hard copy" of pedal pressures
B) Assess pressure on at least 500 different points of the foot
C) Measure pressure at the orthotic-foot interface
D) Display pressure readings in different colors

20) Abnormally high sub-metatarsal pressure is associated with all but which one of the following foot pathologies?

A) Metatarsal stress fracture
B) Plantar ulceration
C) Plantar keratoma
D) Interdigital neuroma

See answer sheet on page 141.

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