PAL perspectives IN PODIATRY

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How was the Root Functional Orthotic Developed?

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Without being the least bit facetious, the Root Functional Orthotic was developed from 1958 to 1959 by trial and error. Prior to 1959 I had developed a modified Levy Mold technique for making an orthosis over a non-weight bearing neutral position cast. The orthosis was made of oak wood flower and latex pressed onto leather that had been molded and shaped to the cast for the previous 24 hours. The leather was fixed to the cast, and the rubber butter compound was spatulated on the inferior side of the leather. The cast, leather, and rubber butter was pressed on a level table with the heel of the cast vertical. The cast was pressed down hard enough to squeeze out rubber butter beneath the leather at the deepest point of the heel cup and at the lowest point of the forefoot. In effect, the forefoot was supported in any inverted or everted deformed position that existed in the cast. After being dried and properly ground at the edges, the orthosis was dispensed and worn for two weeks. Subsequent visits were used to add triplane wedges under the medial side of the heel seat and along the lateral border of the heel. This orthosis very effectively prevented abnormal pronation of the foot and was very comfortable to wear. The orthosis also had disadvantages. It broke down from perspiration in a year or two, it became hygenically distasteful, it needed frequent reinforcement of the korex triplane pad which compressed, its strength was dependent to some degree on the rigidity of the shoe, and numerous adults noted low back pain developing after prolonged use. Today, we know that back pain resulted because the orthosis prevented normal pronation of the foot at heel strike. Normal pronation of the foot in the contact period is necessary to promote normal absorption of the shock of heel strike.

I devised the triplane pad on the basis of physical principals. If one wishes to prevent rotation of an elongated round body, a resistant force must be applied as close to perpendicular to the long axis of that body as possible. The long axis of the calcaneus sits in the shoe at an angle to all three body planes; hence the problem of heel control required a triplane shaped device directed against the sustenaculum tali. Thus, the triplane pad was conceived. It is still in use today in many offices in pad form, and was the precursor to the rearfoot post used on functional orthoses.

It will also be helpful to know that by 1958 I had discovered the concept of the neutral position of the subtalar joint. I had also measured hundreds of feet and had discovered the deformities of forefoot varus and valgus, rearfoot varus and valgus, and torsional abnormalities of the lower extremity. These revelations also made me aware that I needed a less flexible and compressable material to work with.

About 1958, I attended a seminar presented by Dr. John Connely on the use of plexiglas for the fabrication of arch supports made over a semi-weight bearing cast. The principal of semi-weight bearing casts is physically unsound for any orthosis that is being designed to control heel position. The rounded triplane shape of the non-weight bearing heel is necessary in any device that is going to apply a force perpendicular to the long axis of the heel. Therefore, I began to fabricate plexiglas orthoses over neutral position casts.

They would break in days or weeks because plexiglas is too brittle and lacks enough flexibility. In the search for a better plastic, I tried many. Most thermoplastics that can be moulded within a practical temperature range were too flexible and would not control the foot adequately. The foot would continue to pronate by bending the plastic and the materials would become deformed. I tested rohadur, a German imported plastic, and found it to be rigid enough and still somewhat flexible so that it was comfortable to wear.

About two years of experimentation was then required to develop a more exacting neutral position casting technique. I found experimentally that the best casting position was one in which the subtalar joint is maintained in a neutral position; the midtarsal joint is maintained in its full pronated position about both of its axes without too much force that tends to twist the metatarsus; the central three metatarsals must not be plantarflexed by dorsiflexing the toes; and the natural non-weight position of metatarsals 1 and 5 should not be altered.

Slight modifications of the positive cast were also found necessary. With some fleshy feet the lateral edge of the orthosis would cut into the foot uncomfortably. Plaster was added to the lateral side of the positive cast (lateral expansion) to bend out the lateral edge slightly. Too much plaster or plaster too close to the plantar surface of the heel caused a loss of heel control, and the patient's foot would slide laterally off the orthosis causing a loss of pronation control.

For patients with 5 or more degrees of forefoot adductus, the medial flange of the orthosis would gauge the foot. Plaster was added on the medial side of the positive where the medial edge of the orthosis contacts the positive. This bent the medial edge of the orthosis away from the foot and relieved the discomfort without adversely affecting function. Too much plaster in the medial arch, especially when it encroached upon the distal plantar medial aspect of the heel, seriously reduced functional control with the orthosis.

Cast balancing in the developmental stages was quite simple. There were only two forefoot deformities to be concerned with. The forefoot was either normal, inverted (varus) or everted (valgus). It wasn't until the late sixties and early seventies that I found elevatus and congenital plantarflexed metatarsals and the plantarflexed cuboid with the 4th and 5th ray. These deformities have since complicated forefoot cast corrections by adding the need to sometimes balance a foot from metatarsals 2 to 5, 1 to 4, and 2 to 4. In the early developmental stages, for a forefoot varus, a plaster platform was added under the 1st metatarsal head until it reached the level of the 5th metatarsal head. For a forefoot valgus, a plaster platform was built under the 5th head until it reached the level of the 1st metatarsal head. In subsequent years further investigation of the forefoot revealed more specific deformities. We can now relieve forefoot symptoms in some cases that previously failed to respond with the use of orthoses.

Plaster platforms used for cast balancing may be made either too small or too large. When made too small or placed too far forward, the orthosis is too long and its distal edge will pinch the skin on the ball of the foot. When platforms are too large or are placed too far back, the orthosis is too short. Its distal edge may ride up on the shank of the shoe, and the orthosis is tilted causing malfunction. When forefoot varus is present in a foot, a short orthosis can irritate the plantar fascia and cause plantar fibromatosis that is irreversible when the orthosis is removed.

Today, a functional orthosis almost always functions better when it has a rearfoot post. During the initial stages of development, the functional orthosis did not have a rearfoot post. To control pronation better, I used a korex triplane wedge glued in the shoe under the medial side of the heel seat. By 1961 I began to use orthodontic resin that was mixed and poured into the heel of the shoe. While the resin was malleable, I would insert the orthosis into the shoe, tilt it to achieve the lateral post position, and tilt it back until the distal aspect of the orthosis was flat in the shoe. That provided the desirable orthotic motion to allow normal subtalar joint pronation.

In 1965, when I went into practice with Doctors Weed and Sgarlato, we tried to glue or otherwise adhere the rearfoot post to the orthosis. When no chemical bond could be found between orthodontic resin and the orthosis, Dr. Sgarlato talked with a dentist who suggested using a dental drill to make holes in the heel and make a mechanical bond. It worked, and over the years a technique was devised that permanently fixes the post to the orthosis. Motion is provided for the orthosis by grinding the plantar aspect of the post obliquely on its medial side. The post is originally put on the orthosis by inverting the orthosis while applying the post. The posting position, therefore determines how much motion will be present in the post because the post is ground medially until the distal aspect of the orthosis lies flat on the insole of the shoe.

Extrinsic forces from the leg that concentrate on the medial side of the calcaneus to cause excessive pronation or on the lateral side of the calcaneus to cause lateral postural instability initially caused control problems. Those control problems were eventually solved by altering the height of the sides of the heel cup and by flaring the rearfoot post.

Medial distribution of extrinsic forces necessitates shifting the rearfoot post medialward to better resist those forces. The medial side of the heel cup of the orthosis was increased in height while the lateral side of the heel cup was proportionately reduced in height. This heel cup height variation in conjunction with a medial flare of the post was quite effective in improving control of pronation in such cases.

Lateral postural instability caused by a lateral concentration of forces in the heel was controlled by the opposite heel cup variations: Higher lateral, lower medial heel cup with a lateral post flare.

When posting was applied directly to the heel of the orthosis, it necessitated elevating the heel of the orthosis on a platform while the post was applied. This allowed the plantar surface of the post to more closely parallel the plane of the insole in the heel of the shoe. This alteration eliminated the excessive indentation of the post in the heel of the shoe that tended to immobilize the post. A measurement technique was developed to determine the height of the posting elevator necessary for the foot gear in which the orthosis is to be worn.

The earliest functional orthoses also tended to bind in the shoe in the area of the medial flange. I began to reduce the height of the medial flange, quite apprehensively at first, until it suddenly dawned on me that a functional orthosis is not an arch support, and I eliminated the medial flange completely in the early sixties.

By the mid sixties I developed a more complete appreciation of the 1st ray function. The 1st ray must be able to plantarflex during propulsion before the hallux can dorsiflex sufficiently for toeoff. An arch support or any orthosis that supports the shaft of the 1st metatarsal will restrict hallux dorsiflexion and can cause hallux limitus. Patients had on occasion reported pain at the 1st metatarsophalangeal joint after prolonged use of the orthosis. The pain could be alleviated by not wearing the orthosis. On observing function of the 1st ray in freshly amputated specimens of the foot while engaged in a research problem, I became aware of the restriction offered to 1st ray plantarflexion by the functional orthosis. Consequently, the width of the orthosis was reduced so the medial edge ended between the 1st and 2nd metatarsals. Narrowing the orthosis to this extent did not interfere with functional control of the foot. It did allow the orthosis to move better in the shoe and facilitate wearing functional orthoses in types of women's shows that previously would not accommodate an orthosis.

As late as 1980, a variation in the functional orthosis was made. In feet with a congenital plantarflexed cuboid, patients would tend to fracture their orthoses transversely beneath the calcaneocuboid joint. Sometimes, patients with this problem would complain of a sensation of pressure in this area that might become uncomfortable at times. For this type of case, a 1/16" thickness of plaster is applied to the positive cast directly beneath the calcaneocuboid joint. In the ten or so cases treated in this manner to date, it has alleviated the pressure sensation and the breakage, and no loss of functional control has been evidenced. This variation is not yet being recommended for general use since it is still in the experimental stage.

The Root Functional Orthotic has not yet been fully developed. It is still developing as more specific variations of the human foot are identified.

AT PODIATRY ARTS LAB, THE MOST CRITICAL PROCESS IN THE FABRICATION OF THE ROOT FUNCTIONAL ORTHOTIC IS THE EXTENSIVE, HANDCRAFTED CASTWORK THAT PRECEEDS THE MOLDING OF THE ROHADUR. BECAUSE WE USE NO MACHINES OR EQUIPMENT, OUR DETAILED CASTWORK COMPRISES MORE THAN 50% OF THE TIME SPENT IN FABRICATING YOUR ORTHOTICS. WE FEEL THE RESULTS ARE WELL WORTH THE TIME.

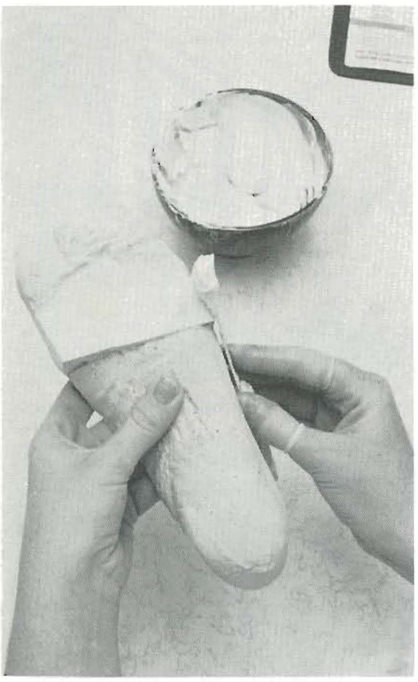

FIGURE I

During the first step, your positive cast is balanced for either inverted or everted forefoot deformity via balancing platforms. Care must be taken to guarantee exact placement of these platforms, as this ensures proper orthotic length.

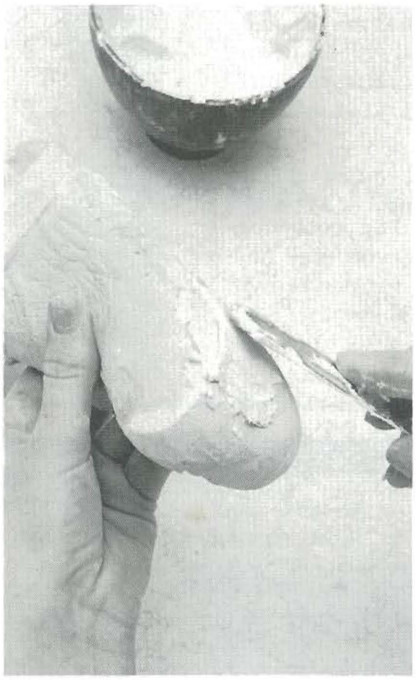

FIGURE 2

Because the weightbearing foot at stance also tends to be slightly wider than the non-weightbearing foot captured during casting, a thin lateral expansion must be added.

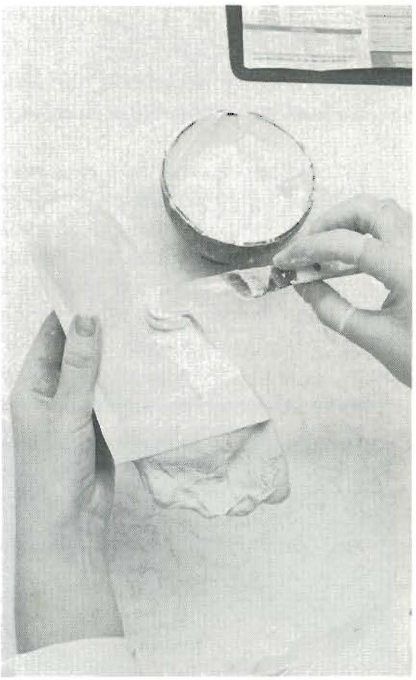

FIGURE 3

Medial expansion is also added. As a result of this extra process, most of the common irritation problems arising at the lateral aspect of the orthotic, the heel cup, or the medial longitudinal arch, are eliminated.

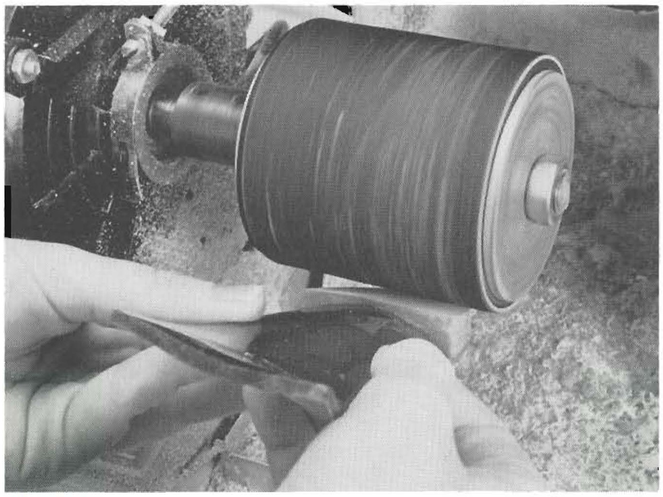

FIGURE 4

After the castwork has been completed, the rohadur is pressed and then ground to a specific width on the cast. You will note that the orthotic does not encompass the entire width of the foot, the herein lies another advantage of the PAL Root Functional Orthotic: Because conventional orthotics or arch supports wrap around the foot, an error in casting can cause the foot to be trapped "inside" and quickly deform. With the Root Functional Orthotic, the foot sits "on top" of the device and will slide off if a problem exists. Corrective action can then be taken. Another advantage is the case of examining proper biomechanical function in the shoe. A properly functioning Root Functional Orthotic should leave an even indentation at the distal aspect within the shoe. Excessive indentation medially or laterally indicates a functional problem, and the orthotic and the foot should be re-examined.

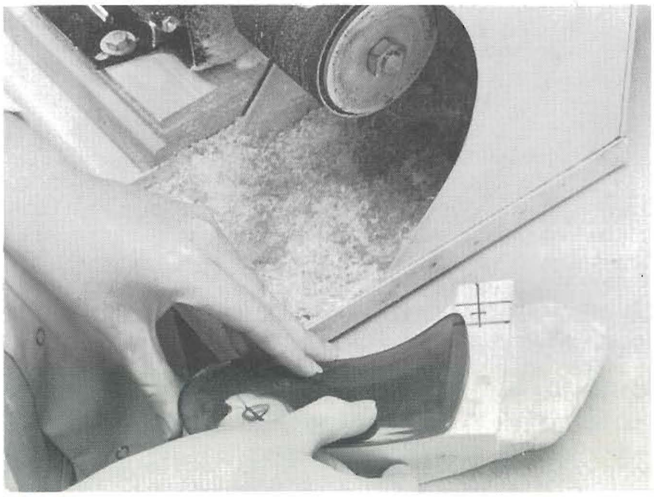

FIGURE 5

The last important step in fabricating the Root Functional Orthotic is to apply the inverted rearfoot post and grind in the appropriate manner. Basically, as the foot moves so does the orthotic The orthotic inverts at heel strike, and then is allowed to pronate via the motion ground into the post. Of all the orthotics made at our laboratory, the Root Functional Orthotic is by far the most demanding. But we derive the satisfaction of knowing that we are providing your patient with the very best Root Functional Orthotic that can be made.