The Modification and Enhancement of Foot Orthoses

The concepts of Richard O Schuster, DPM stand a world apart from Rootian Theory.

BY PAUL D. COFFIN, DPM

There is a distinct difference between orthotic modifications needed when utilizing Root theory versus Schuster theory of biomechanics. The Root theory can be summarized by these excerpts from *Abnormal Function of the Foot.*

"Abnormal pronation of the foot causes joint instability (hypermobility). Therefore, abnormal pronation of the subtalar joint always produces subluxation of other joints within the foot to some extent." (Page 326)

"Adaption of bone continues as long as active subluxation continues in the foot. The joints are eventually remodeled so that forces are transmitted evenly throughout the entire functional articulating surface of the remodeled foot. When this change is complete, the joint will no longer sub lux and no further adaptive changes will occur. Under these circumstances the joint often reaches a state in which it can be stabilized during stance despite abnormal function and bone alignment." (Page 338) (Figure 1)

Figure 1: Stabilized Foot

Root-style orthotics are designed to match the foot in this subluxed stable position. They do not re-align the foot with the orthotic but rather try to resolve the problem with posting the orthotic to control the subtalar joint. The Root approach builds orthotics which allow the foot to pronate until stable against the ground, and then accommodate the subluxation rather than treat it. This allows internal rotation of the lower extremity and the talar head.

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History

To understand Dr. Schuster's perspective on orthotics, you need a little history. He learned to make orthotics working with his uncle Otto F. Schuster making stainless steel plates. Stainless steel plates were designed to stop all the motion within the foot and hold it in place. (Figure 2) In the mid-1930s, Dr. Schuster was influenced by Dr. Dudley J. Morton who felt that the joints of the feet were there to allow movement and should not be held solidly in place. Dr. Schuster started working with Dr. Ben Levy to develop what became known as Levy molds. The orthotics were made by mixing a combination of latex, cork, and sawdust (rubber butter) to produce a non-compressible but flexible material which was then covered with leather. (Figure 3) This material would allow the foot to go through a normal range of motion while stopping it from over-pronating and subluxing.

Schuster was always interested in looking for the underlying cause of the biomechanical problems in the lower extremity rather than treating the symptoms. His examination of the lower extremity included measurements of the range of motions of all of the joints from the femoral acetabular joint to the metatarsal phalangeal joints. He also included measurements of the malleolar position (an estimate of tibial torsion) and femoral torsion as well as measurements of varus deformity of the foot and leg.

The measurements he looked at were based on evolutionary and developmental tendencies in the lower extremity. Once he had the data, he was able to build an orthotic to resolve what he felt was the underlying cause of the patient's symptoms. He always said if you did an adequate biomechanical evaluation, you

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should be able to predict the patient's gait. He would identify the underlying biomechanical cause of the gait abnormalities and develop a plan to resolve those problems. (Figure 4)

Schuster always believed that one needed a high medial flange to be able to control excessive subtalar joint pronation by controlling internal rotation of the talus. This came out of the use of stainless steel as a method of controlling foot function. To control STJ pronation, it is necessary to control internal rotation of the talus. As podiatrists, we focus on the function of the subtalar joint and its effect on the foot, but we should be focusing on internal rotation of the lower extremity because to control pronation, we have to control internal rotation of the talar head. To do this, while allowing the joints to go through a normal range of motion and yet prevent subluxations, the orthotic needs to be non-compressible but flexible through its long axis. This flexibility through the long axis allows motion of the mid-tarsal and Lisfranc joint while non-compressibility prevents subluxation.

When the talar head internally rotates secondary to excessive pronation, so does the knee and femoral acetabular joint. (Figure 5) The hinge joints at the knee, ankle, and metatarsal joints need to be kept perpendicular to the plane of progression for normal gait. If the knee is internally rotated, the femoral acetabular joint will externally rotate as compensation to keep the axis of motion of the knee perpendicular to the plane of progression. (Figure 6) This external rotation of the hip leaves the foot in an abducted position (out toe) on an internally rotated talar head, putting tension on the plantar fascia, the posterior tibial tendon, the flexor digitorum longus tendon, and flexor halluces longus tendon. The mid-tarsal and Lisfrancs joints are spread, allowing the ground reaction force to dorsiflex the metatarsals. This metatarsal dorsiflexion tightens the long flexors, creating flexor substitution and hammering of the lesser digits and jamming of the 1st MTPJ, resulting in hallux limitus/rigidus. (Figures 7, 8) The inability to dorsiflex the hallux on the head of the first metatarsal requires an increase in out-toe gait and forces the individual to push off the medial aspect of the 1st metatarsal head and the hallux IPJ. Pushing off of the medial side of the abducted forefoot creates torque, stretching out the ligaments and tendons on the plantar aspect of the foot, causing posterior tibial dysfunction, plantar fasciitis, hallux valgus, and an increase in subluxation of the joints.

Figure 2: Stainless Steel Plate

Figure 3: Rubber Butter Orthotic

Schuster's modifications put into his orthotics were based on his biomechanical exam and his definition of neutral position. Schuster defined neutral position as the point where the joints are in their mid-range of motion. Schuster took most of his impressions in a semi-weight-bearing technique in which he would hold the subtalar joint in neutral by palpating the STJ just distal to the medial and lateral malleoli and moving the STJ to a point where it was felt evenly on the medial and lateral sides. (Figure 9) This allowed him to capture the total amount of varus (tibial, rear foot, and forefoot) against the horizontal surface and align the knee, ankle, and 1st MTPJ. This made the posting of the orthotic quite simple. (Figure 10) Forefoot posts were only used in cases where there was not enough pronation of the Lis Franc's and mid-tarsal joints to bring the forefoot and the first metatarsal head to the ground. The original Levy molds had toe crests placed in them. The concept was to raise the distal toes by lifting them on the plantar aspect of the PIPJ, decreasing pressure on the distal aspect of the toes. Metatarsal pads or U pads for plantar-flexed metatarsals or intractable plantar keratoma were used, but these were made as modifications to the plaster cast and not the orthotic.

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Modifications

Metatarsal Pads

Metatarsal pads are used to raise the metatarsal heads. They are useful as a teardrop pad to separate the metatarsal heads as a treatment for a neuroma. The downside is the pad can increase the tension on the flexor tendons going to the 2nd and 3rd and 4th phalanges. These increases may create hammertoes and increase flexor substitution, which will eventually cause more plantar-flexion of the metatarsal heads.

Toe Crests

Toe crests were put into orthotics—part of the reason was to take pressure off the tips of the toes where

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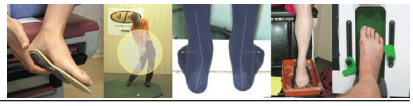

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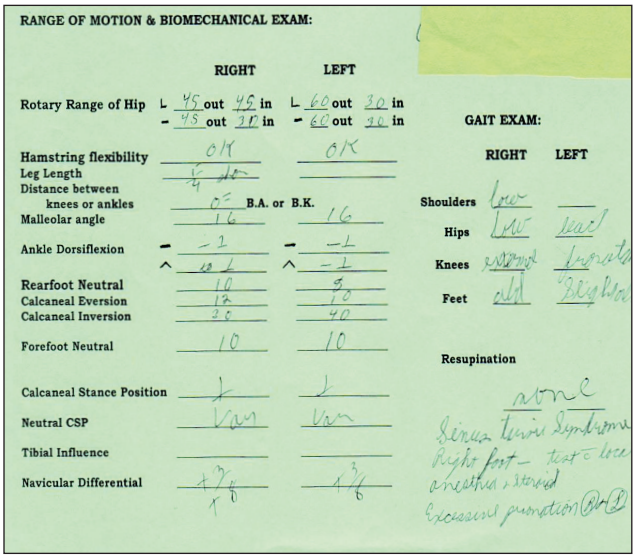
they were developing hyperkeratotic lesions. On leather orthotics you could see the pressure points of the toes. This is a problem of too much tension on the flexor tendons created by medial rotation of the talar head and may be better with a varus heel wedge to remove the tension on the FHL tendons.

Valgus Rear Foot Posts

These are often used to keep people from spraining their ankles, but they do so at the risk of over-pronating the foot, creating hallux limitus/rigidus. A better way to resolve this is with a long lateral flange which is slightly beveled to the outside rather than inside, allowing the individual to sense the lateral border of the foot and stabilize it.

Forefoot Valgus Posts

These are useful only if there is enough range of motion at the Lisfrancs and midtarsal joints to allow for pronation of the forefoot on a stabilized rear foot. If there isn't enough range of motion at the Lisfrancs joint or midtarsal joint, then a forefoot post should be used with a long lateral flange. They are helpful in some patients with plantar fasciitis.


RANGE OF MOTION & BIOMECHANICAL EXAM:

	RIGHT	LEFT
Rotary Range of Hip	L 45 out 45 in / - 45 out 20 in	L 60 out 30 in / - 60 out 30 in
Hamstring flexibility	OK	OK
Leg Length		
Distance between knees or ankles	0 B.A. or B.K.	
Malleolar angle	16	16
Ankle Dorsiflexion	- 2 / ^ 10	- 1 / ^ 1
Rearfoot Neutral	10	9
Calcaneal Eversion	12	10
Calcaneal Inversion	30	40
Forefoot Neutral	10	10
Calcaneal Stance Position		
Neutral CSP	Var	Var
Tibial Influence		
Navicular Differential	4	4

GAIT EXAM:

	RIGHT	LEFT
Shoulders	lower	
Hips	low	med
Knees		
Feet		

Resupination: none

Sinus Tarsi Syndrome
Right foot – tx: loc anesthesia + steroid
Excessive pronation

Figure 4: Biomechanical Exam

Accommodations

Accommodations for plantar-flexed metatarsals such as "U" pads and dancer pads are helpful to control hyperkeratotic lesions; however, we are treating the symptoms and not the underlying cause of the symptoms. Surgical intervention to dorsiflex a metatarsal head frequently results in a secondary lesion under

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another metatarsal head. The underlying cause of these problems, in many cases, is retrograde pressure secondary to uncontrolled subtalar joint pronation.

Heel Lifts

Heel lifts are often useful for unequal leg lengths. Most people have adjusted to unequal leg lengths of less than a 1/4 inch. Heel lifts sometimes create more problems in the long run. In the case of anterior cavus feet, they are a must, but anything over 3/8 inch cannot be put into the shoe. A lift of more than 3/8 inch should be added to the shoe.

Dancer Pads

Plantar-flexed first metatarsals are usually helped by dancer pads. They are also helpful for sesamoiditis.

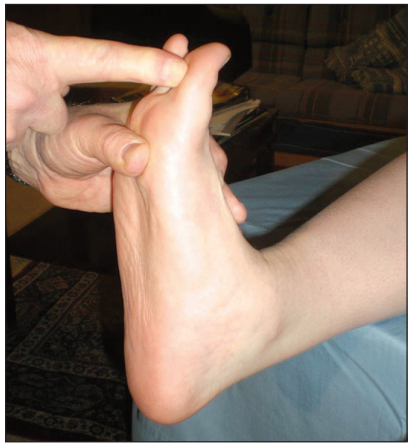

Figure 7: Hallux Limitus/Rigidus

Figure 8: STJ in Neutral Position

Figure 5: Excessive STJ Pronation

Figure 6: External Hip Rotation

Figure 9: STJ Neutral Position

Kinetic Wedge

These are useful if using hard plastic orthotics and in cases of hallux limitus. They are not helpful if there is hallux rigidus. Kinetic wedges allow the first metatarsal head to plantar-flex, taking the tension off the flexor halluces longus tendon and allowing dorsiflexion of the head of the1st metatarsal on the base of the proximal phalanx at toe-off.

Morton's Extensions (L-pads):

These extensions were originally used by Morton to balance the tripod of a foot with a short 1st metatarsal. They are useful to help decrease pressure on the 2nd metatarsal head. They can also be used to create a rocker effect in hallux rigidus.

Rear Foot Varus Wedges

Rear foot varus wedges are more functional when intrinsically posted at the time of manufacturing the orthotics. Rear foot varus wedges are practically useless unless the wedging is brought up underneath the head of the talus with a high enough medial flange to prevent internal rotation of the talar head and a lateral flange to keep the foot centered on the orthotic. Dr. Schuster was fond of a picture of a golf ball with a wedge underneath it.

Figure 10: Schuster Neutral Impression

Forefoot Varus Wedges

When the subtalar joint is held in neutral position and there is not enough range of motion in the mid-tarsal or Lisfrancs joints to bring a varus forefoot and the first metatarsal head to the ground surface, then a forefoot varus wedge should be considered. The only way to get the forefoot to bear weight is to sublux the STJ and medial column to get the first metatarsal head to the ground, resulting in irreversible stretching of the ligamentous and tendinous structure on the plantar of the foot.

Podiatry has focused on the foot and missed the fact that all orthotics work by changing muscle recruitment patterns. As long as patients function differently, their pain will probably improve. A thumbtack under the 1st metatarsal head would cause a person to supinate the foot, and under the 5th metatarsal head would cause pronation. The goal with orthotics and modifications should be to keep the knee, ankle, and MTPJs aligned and keep the joints of the foot in their mid-range of motion to prevent subluxation and the development of osteoarthritis. **PM**

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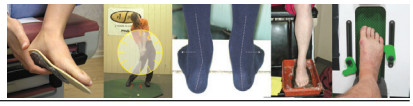

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Dr. Coffin has been in private practice in Sioux City, Iowa, for over 37 years, specializing in biomechanics and custom orthotics. A graduate of the New York College of Podiatric Medicine, he is a diplomate of the American Academy of Podiatric Sports Medicine. Dr. Coffin studied under and apprenticed in the orthotics laboratory of his uncle, the late Dr. R.O. Schuster, who was among the first foot specialists to design orthotics specifically for athletes, especially runners. Dr. Coffin frequently lectures to medical professionals and coaches. He is the CEO and Founder of CJS Laboratories, manufacturer of flexible, non-compressible custom orthotics.