The Magical 4-Degree Rearfoot Post

Ray Anthony

When I hear an "expert" in foot orthotic therapy scoff at the "magical" (as they ironically tend to call it) 4-degree rearfoot post, I shake my head in despair because it's almost certainly the case that most have little to no idea how Dr. Merton Root, DPM developed the rigid rearfoot post prescription protocol back in the 1950s and 1960s, nor the thought processes—right or wrong-- behind how it was designed to function when applied to his very specific design of custom-made foot orthotic device, i.e., incorporating a rigid methyl methacrylate (MMA) rearfoot post adhered to an acrylic (Rohadur® during Root's time) shell with very little, if any, frontal plane torsion under load. "Every orthotic has a 4-degree rearfoot post. . ." the experts say ". . .where did that nonsense come from?" Well. . .

First and foremost, the original Root 4-degree MMA rearfoot post with an incorporated 4-degree pronation post motion applied to a Root Functional Foot Orthosis (RFFO) with a rigid acrylic shell does not conceptually or functionally equate in any way to a "soft"-- let's say ethyl vinyl acetate (EVA), rearfoot post with no post motion adhered to a "flexible"-- let's say polyethylene, shell that allows frontal plane torsion— the prescription paradigm for each device is completely different.

Root FFO Rearfoot Post Prescription Protocol

Dr. Root described how he developed the rearfoot post in a Podiatry Arts Laboratory (PAL) newsletter published in the Fall of 1981, and in Chapter 4, pages 91-96 of my book *The*

Manufacture and Use of the Functional Foot Orthosis (*M&U of the FFO)* published by Karger AG (back in Dark Ages) I explained Dr. Root's paradigm and fabrication technique as interpreted and employed by RX Laboratories in the early 90s to apply MMA rearfoot varus posts to acrylic or graphite shells. I described how the medial-plantar plane of a 4-degree rearfoot varus post is fabricated to parallel the distal edge of the orthosis shell, and that when the orthosis is tipped to place the rearfoot post onto its lateral-plantar plane, the distal front edge of the shell inverts 4 degrees from the supporting surface. In the PAL newsletter, Root describes it thus:

"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".

When one understands how a MMA post is applied to a rigid shell as described in the Root rearfoot post protocol, one must conclude that the post itself cannot be the primary prescription item that attempts to effect a positional change in the alignment of the rearfoot to leg, or rearfoot to supporting surface during static stance or gait. If a 4-degree MMA rearfoot varus post inverts the heel cup of a rigid orthosis shell by 4 degrees, and the pronation "grind off" allows the post to rock back onto its medial plantar plane, thereby returning the heel cup to its original position, how can the post effect a kinematic change in the static or dynamic position of the rearfoot? *[Note: Root's is solely a kinematic paradigm]* It should also be clear from Root's described protocol that, conceptually, the degree of varus post and the degree of post

motion must be the same on a rigid FFO with a MMA rearfoot post. Imagine if an 8-degree rearfoot post incorporated just 4 degrees of pronation grind off-- as body weight loaded the plate during weight-bearing, the rigid orthosis shell would tip beyond the medial-plantar plane of the rearfoot post until the distal-medial edge of the shell was in full contact with the sockliner of the shoe. As described by Root, the primary aim of a 4-degree MMA rearfoot varus post on a rigid shell was not to invert the heel by 4-degrees, but to allow 4-degrees of calcaneal eversion from heel contact to midstance, during the contact phase of gait. But why 4-degrees? And 4-degrees from what position?

It was Dr. Root's opinion that, <u>on average</u> the foot required 4-degrees of heel eversion from initial heel contact to foot flat to allow for an appropriate degree of internal tibial rotation, knee flexion, and therefore shock attenuation during the contact phase of gait. Dr. Root described how, during the development of his FFO, trial devices without post motion caused postural symptoms, in particular low back pain. The introduction of a post with motion appeared to reduce postural side-effects. Whether the choice of 4-degrees as the amount of heel eversion for a patient demonstrating an average sagittal plane inclination angle of the subtalar joint was right or wrong is irrelevant; this was the thought process behind the 4-degree rearfoot post. But what if the sagittal plane inclination angle of the subtalar joint axis was clinically determined to be higher or lower than average?

<u>Philips Modified Rearfoot Post Prescription Protocol</u>

In 1985, Phillips, Christeck, and Phillips published *Clinical Measurement of the of the Axis of the Subtalar* Joint, JAPMA 56: No.4. When considering the Rootian rearfoot varus post, one may interpret from the data, and in particular the discussion section of the Phillips paper that

the motion in a rigid rearfoot post should be prescribed based solely on the clinical estimation of the sagittal plane inclination angle of the subtalar joint (STJ) as high, average, or low. As discussed in *The M&U of the FO*, Chapter 5, pp 142-144, due to planal dominance, patients with a high sagittal plane inclination of the STJ axis (transverse plane dominance) conceptually require less calcaneal eversion during the contact phase of gait to allow for "normal" internal rotation of the lower-limb and therefore require less than the assumed average 4-degrees of motion in the rearfoot post, i.e., a 2-degree post with 2 degrees of motion. Patients determined to have a low axis (frontal plane dominance) require a greater degree of calcaneal eversion during the contact phase and should be prescribed a 6-degree post with 6-degrees of pronation motion. This change to the classic Root "4 with 4" rearfoot posting protocol became known at RX Laboratories as the Phillips Modified Root Rearfoot Post Protocol. To be reminded of how the sagittal plane inclination angle of the STJ axis affects the relationship between the frontal and transverse plane motions that occurs at the STJ and hos this affected transverse plane rotations of the shank, read the Phillips paper-- especially the discussion, and *Green D.R. and Carol A.: Planal Dominance. JAPA 74: No 2, (1984).* For prescription examples of how RX Laboratories used 2-, 4-, and 6-degree rearfoot posts along with the appropriate positive cast balancing to achieve various inverted orthotic heelcup positions in the Phillips Modified Root prescription protocol read Chapter 5, pp 117-125 of *The M&U of the FFO.*

Having said all this, in Chapter 4, page 91 of *The M&U of the FFO,* I proposed that a rigid rearfoot post has three main functions: Firstly, it stabilizes the orthosis shell against "rolling around" on the convex surface of the inferior heel cup. Secondly, even a zero-degree (flat) rearfoot post can increase GRF against the medial aspect of the heel in the region of the sustentaculum tali and therefore beneath the head of the talus. In the PAL newsletter, Root

proposes a high medial heel cup height as a primary prescription variance to effect a change in the position of the rearfoot during gait thus:

"Medial distribution of extrinsic forces necessitates shifting the rearfoot post medialward to better resist those forces. The medial side of the heel cup. . .was increased in height [and] this . . . variation was quite effective in improving control of pronation".

And thirdly, as discussed, the MMA rearfoot post on a Root FFO was designed to allow a quantified amount of calcaneal eversion to occur beyond Root's defined STJ neutral position during the contact phase of the gait cycle.

A further question must be answered: If a rigid MMA 4 degree post with 4 degrees of motion on a rigid orthosis shell made from a cast with the heel "balanced" to heel vertical does not change the position of the rearfoot to a less inverted position at midstance-- assume a heel that does not evert in quite-standing or during gait-- where does the rearfoot varus "correction" come from in the Root FFO prescription protocol, i.e., how does the Root FFO attempt to turn a fully-compensated rearfoot varus into a partially-compensated rearfoot varus, which, of course, was the one common kinematic objective in the Root paradigm? The answer is balancing the positive cast to position the heel and therefore the heel cup of the orthosis shell into an inverted position. Dr. Richard Blake, DPM took this cast correction to an extreme with the Blake Inverted positive cast modification; and Dr. Lundeed, DPM achieved the same effect by cutting off the heel of the positive cast, inverting it to the supporting surface, and screwing it back into position. In *Positive Cast Sectioning: An essential prescription writing protocol - JBPM, 1, pp11-14 (1995),* I offered a modified cast sectioning method.

Therefore, when one understands the development and evolution of the Root FFO, it is clear a 4-degree rearfoot varus post with 4 degrees of post motion was prescribed for a STJ joint with a clinically determined average sagittal plane inclination angle of the axis, and that this prescription protocol belongs only inside the Root FFO paradigm, i.e., only when manufacturing a rigid orthotic shell with a rigid MMA rearfoot post.

And here are some other things to consider:

Due to shearing forces at the rearfoot post-orthotic shell interface, a rigid post will quickly avulse from a polypropylene or other "soft" shell material. Most orthotics laboratories stopped using MMA in the late 1980s following publication of animal studies that warned of the possibility of carcinogenic changes in the respiratory and olfactory epithelium in those processing the material. It was not until 2011 that MMA monomer was found to be potentially carcinogenic in humans. As soon as most orthotic laboratories replaced MMA with high-density (usually 70 Shore A) EVA as their preferred rearfoot post material, Root's 4-degree post with 4-degrees of motion became a prescription protocol of the past; because despite the high level of chemical cross-linking between the blended polymers of ethylene and vinyl acetate, the closed cell, semi-rigid EVA foam rapidly "bottoms-out", thereby negating any degree of incorporated post motion. And, even if a MMA rearfoot varus post could be securely applied to a flexible shell material such as polypropylene, the post motion would be immediately negated if the shell allowed even the smallest degree of frontal plane twisting under load.

Do I personally prescribe foot orthoses with rigid shells? No. Do I ever use MMA as the posting material? Never. Do I use EVA posts? Yes, but I have become convinced that using an EVA rearfoot post on any foot orthosis with a heel cup is not the most effective way to increase

or decrease vGRF across the plantar surface the heel. Do my EVA posts have post motion/ Of course, not. Therefore, by concept, I never manufacture Root FFOs, and neither does any other foot health care practitioner or commercial laboratory using “flexible” polypropylene shells with EVA posts. Do I believe, 31-years after the publication of *The M&U of the FFO* that the rearfoot post on a Root FFO functioned in the way Root imagined it to function? No. Do I believe the small kinematic changes caused by a foot orthosis are responsible for the symptom relief experienced by the patient? In most cases, no. However, I do understand and appreciate the thought processes behind the choice of a 4-degree rearfoot post with 4 degrees of post motion for a foot demonstrating an average sagittal plane inclination angle of the STJ axis within the Root FFO prescription paradigm designed in the pre evidence-based medicine era

In conclusion, despite my current foot orthotic prescription habits, i.e., I haven’t prescribed a Root FFO for at least the last 15-years, it stills grates my gears when I hear in a podcast or read in an article an expert in clinical biomechanics and foot orthotic therapy mock the magical 4-degree rearfoot post in a discussion about orthotic devices, other than Root FFOs.

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