The Incidence and Significance of Forefoot Varus

Research affirms the principles of Richard O. Schuster, DPM.

BY JOSEPH C. D'AMICO, DPM

An article by this author in 1977 stated, "Equinus is one of if not the most destructive force in the foot".[1] While this may still be true, especially in reference to the pure pathological sagittal plane forces that accompany it, experience over the years has demonstrated that forefoot varus is a much more prevalent and, considering all aspects of its manifestation, an equally destructive pathology. This article will focus on its widespread prevalence, pathomechanics, and management.

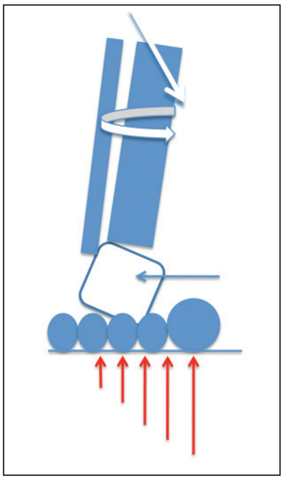

Figure 1A: Varus Begets Varus—Subtalar and midtarsal joint pronation as compensation for forefoot varus deformity occurring beyond midstance and into propulsion requiring maximum calcaneal eversion.

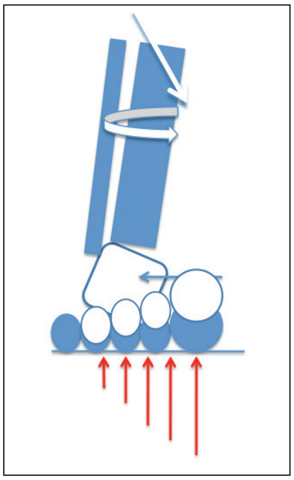

Figure 1B: Varus Begets Varus—Secondary supination of the longitudinal axis of the midtarsal joint in response to ground reactive forces (GRFs) creating additional varus deformity.

Introduction

Herman R. Tax, DPM once stated, "The excessively pronated foot is part of a structural malposition. This inherent biomechanical defect is present in the arch of a great majority of children and is the basic cause for most postural pathology of the lower extremity."[2] Carrying this one step further, the most significant inherent biomechanical defect present in the arch of the vast majority of children and the basic underlying cause for most postural pathology of the lower extremity involves a retained frontal plane medial structural deviation of the forefoot on the rearfoot at the midtarsal joint referred to as forefoot varus.

In a lecture entitled, "Developmental Flatfoot: The Primary Etiology in Adult Foot Pathology" presented at the 2018 Richard O. Schuster, DPM Biomechanics Seminar, the etiologic factors responsible for producing an excessively pronated developmental flatfoot in the pediatric population were discussed. Forefoot varus was ascribed as the number one most influential, commonly retained structural imperfection leading to adult foot and super-structural pathology.[3-6] This concept was inspired by Drs. Herman Tax, Justin Wernick, and Richard O. Schuster, DPM.[7-9]

Forefoot varus has been ascribed as the number one most influential, commonly retained structural imperfection leading to adult foot and super-structural pathology.

Incidence

Although a study by Cornwall, et al. indicated that the incidence of forefoot varus is between 9%-15%, most other studies have shown a much higher incidence in patient and non-patient populations.[10] Michaud/G/A Garbalosa, et al. in a study of 240 adult normal feet observed an 87% incidence of forefoot varus with 8.7 degrees as the mean.[11] In another study by Astrom and Arvidsen of 120 adult feet, it was noted that the "majority" had forefoot varus with an average of 6 degrees.[12] Richard O. Schuster DPM once stated, "It is noteworthy that almost every runner that we have had the opportunity to treat on a mechanical basis has had a moderate to severe forefoot varus."[13]

In a recent retrospective study of 100 randomly selected adult and 100 pediatric patients, the incidence of forefoot varus was found to be 92% in the pediatric group and 78% in the adult group.[3] The average was 16.9

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degrees left and 14.6 degrees right in the pediatric cohort and increased to 22.4 degrees left and 15.9 degrees right in the adults. Not one child was found to have a normal forefoot to rearfoot relationship, whereas in the adult patient population group 3% exhibited a normal forefoot to rearfoot relationship. It is interesting to note that no child was observed to have less than 10 degrees of available ankle dorsiflexion.

The incidence of true forefoot valgus in the pediatric group was 0% and the incidence of flexible forefoot valgus, (i.e., plantarflexed first ray creating 1-5 valgus relationship), was 8% with an average deformity of 6.2 left and 5.8 degrees right. This incidence increased to 19% in the adult group with the left average increasing to 8.2 and the right to 9.5 degrees. This result may be due, in some measure, to plantarflexion of the first ray as compensation for the retained underlying forefoot varus deformity.

These findings coincide with prior studies noted above and reveal that although the incidence of forefoot varus diminishes by a little over 10% (i.e., 9 out of 10 children possess forefoot varus and approximately 8 out of 10 adults), the severity of the deformity increased by almost 30% on the left foot and 10% on the right. This increase may be due to the development of additional positional varus as a result of compensation for the original structural imperfection. Since the forefoot is unstable during late midstance and into propulsion, the medial displacement of body weight along with abduction of the forefoot increases ground reactive forces through the 1st, 2nd, 3rd and to a lesser degree 4th metatarsal segments, in essence twisting or supinating the forefoot on an everted rearfoot complex and promoting a repetitive positional deformation referred to as forefoot supinatus. The adage "pronation begets pronation" can be construed here as varus begetting more varus. (Figure 1A and B)

The ascribed etiology for congenital osseous forefoot varus deformity is a lack of valgus rotation of the head and neck of the talus.

Etiology

The ascribed etiology for congenital osseous forefoot varus deformity is a lack of valgus rotation of the head and neck of the talus. This results in the medial segment of the forefoot being inverted when the subtalar joint is in its neutral position and the posterior calcaneus is perpendicular to the floor.[14] Forefoot supinatus is a positional, acquired, soft tissue abnormality that accentuates existing structural varus and may be caused by any condition producing calcaneal eversion past the vertical. Both the os-

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seous and soft tissue variety of forefoot varus compensate in the same manner and may result in maximally pronated feet.

Everyone is born with forefoot varus. It is one of several atavistic, hand-like characteristics in the human foot that has not been outgrown. It was originally designed and intended by nature to allow the foot to function in the jungle: to grip, to grasp tree limbs, to conform to uneven terrain and to climb. Since we no longer live in the jungle, these characteristics are no longer necessary. The hard, flat, unyielding, two-dimensional surface on which our three-dimensional foot must function requires compensatory adjustments in order to allow it to meet the ground. Shoes almost always improve the ability of the foot to utilize its weight-bearing architecture more effectively and efficiently than it would if it were functioning barefoot. (Figure 2)

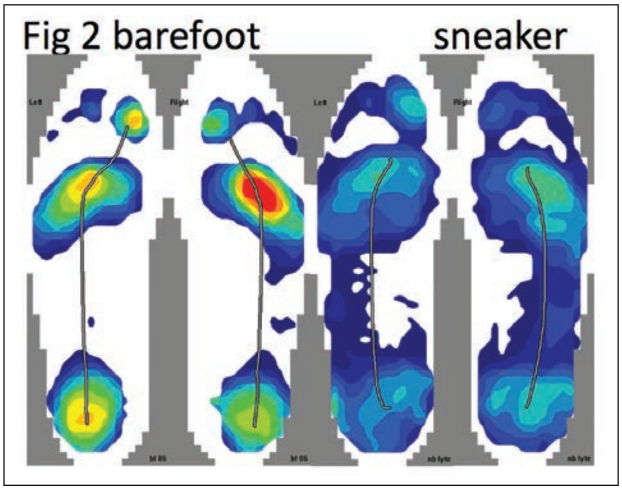

Figure 2: Barefoot Sneaker—F Scan* averaged stance excluding the first and last steps of a typical patient's gait analysis performed barefoot and in sneakers. Note the predominance of weight on the heel and forefoot regions in the barefoot testing even though this was a patient with a severely collapsing foot and the uniform distribution of weight-bearing surface contact area as well as marked reduction in pressure in the sneaker. Observe the proper connection from the heel to the ball of the foot as well as improvements in digital participation as well as Center of Force pathways in the sneaker testing.
* *Tekscan Boston, MA

Ontogenetically, the foot, lower limb, and ankle are all subject to varus influences during the third trimester. The left limb is crossed over the right in the majority of instances and pressed against the vertebral column of the mother.[6] Due to the pliable, plastic nature of the lower extremity, the osseous segments take on the shape of the forces imposed upon it. This result in the newborn is the retention of a number of significant sagittal, transverse,

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and frontal plane twists and bends that must be outgrown against the deforming effects of gravity as the child develops. Dr. Schuster developed a list of 'scars' present in the human foot at birth that, if retained, create pathology in the individual.[8] On the frontal plane, these include: genu varum, tibial varum, forefoot varus, metatarsus varus, metatarsus primus varus.

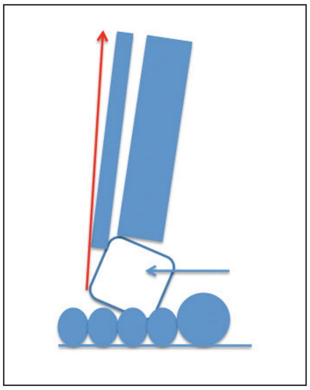

Figure 3: calcaneal eversion as compensation for forefoot varus shortens the distance between origin and insertion of the gastroc/soleus complex resulting in secondary adaptive contracture and introduction of a pathologic sagittal plane influence into the foot.

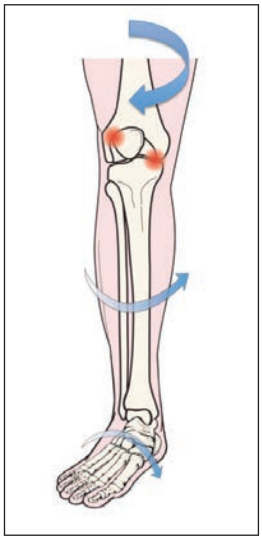

Figure 4: Pronatory compensation for forefoot varus extending into the midstance phase of gait. The foot is collapsing, the tibia along with the leg is internally rotating while the opposite limb is swinging forward creating a dynamically applied counter rotational torsion to the extremity. This creates pathological forces that may result in low back, hip, limb, knee, leg, ankle or foot symptomatology.

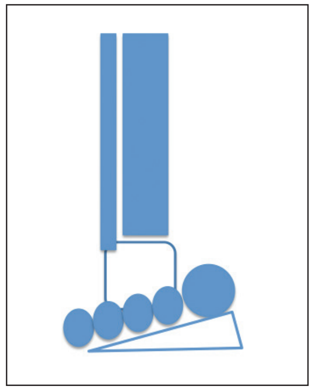

Figure 6: Bringing the Ground Up to the Foot—Design a device to uncompensate the foot by supporting the deformity with a complimentary forefoot varus post thereby reducing or eliminating the need for rearfoot compensation.

Compensatory Pathomechanics

In discussing the importance of frontal plane imbalances, Dr. Schuster stated, "Clinical evidence suggests that the most troublesome imbalances of the leg and foot are those that occur on the frontal plane."[7] He went on to state that the reason for this is that deformities on the sagittal and transverse planes have a much greater available range of motion to compensate, whereas the total amount of lateral to medial motion in the adult rearfoot complex is only 30 degrees.

Since the plane of the forefoot is not parallel to the supporting surface, a compensatory adjustment must be made in order to bring the foot in contact with it. Compensation for a forefoot varus deformity, whether osseous or soft tissue (forefoot supinatus), will vary from patient to patient and is primarily dependent upon subtalar joint mobility. The degree of clinical dysplasia of the foot is directly proportional to the degree of forefoot varus present and the amount of subtalar joint pronation available. Accompanying first and fifth ray hypermobility further accentuates and increases forefoot dysplasia.

The physiologic age of the patient also plays a role in how well the foot can adapt to this common structural imperfection. In the younger individual with a greater range of motion along with strong intrinsic and extrinsic musculature, the foot will attempt to resupinate during the late heel off phase of gait; however, with advancing age, range of motion decreases and muscles become weaker, thus less capable of resupinating the foot. In some cases, the foot lifts off in a maximally pronated position and never recovers during swing phase, causing it to be placed down in this same position.[14]

It is true that a pathologic, compensatory sagittal plane force with the entire weight of the body attempting to pass over it can exert extreme stresses through the subtalar and oblique axis of the midtarsal joint, in essence breaking the foot in half. However, the rotary frontal plane compensatory forces seen in forefoot varus with accompanying calcaneal eversion past the vertical shorten the distance from origin to insertion of the Achilles

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FIGURE 5:

Conditions Precipitated, Perpetuated or Aggravated by Forefoot Varus Compensation

- Patellofemoral Pain Syndrome
- Chondromalacia Patella
- Low Back Pain
- Iliotibial Band Syndrome
- Medial Tibial Stress Syndrome (Shin Splints)
- Metatarsal Stress Fractures
- Functional Hallux Limitus
- Hallux Extensis
- Hallux Abducto Valgus
- Posterior Tibial Tendinitis (Posterior Tibial Tendon Dysfunction, Adult Acquired Flatfoot)
- Navicular Enthesopathy
- Lateral Talocrural Compression Syndrome (Sinus Tarsitis)
- Morton's Neuroma
- Metatarsalgia
- Hammertoes
- Tibial Sesamoiditis

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tendon, creating a similar sagittal plane deformity by adaptive contracture. (Figure 3) So, although forefoot varus is primarily a frontal plane deformity, it also results in a secondary acquired sagittal plane deformity.

Another aspect to consider is the fact that since the foot is excessively pronating, at least until late midstance and usually into propulsion, the opposite limb on the transverse plane is swinging forward and producing external rotation of the weightbearing limb to provide propulsive stability. However, when the weight-bearing limb is internally rotating due to pathologic forefoot varus compensation in an attempt to get the foot in contact with the supporting surface, this results in a dynamic, counter-rotational tensional torsion that is applied with each step, aggravating and perpetuating low back, hip, knee, leg, foot and ankle pathology (Figures 4, 5).

A study of 385 adults with an average age of 63 years with an average forefoot varus of 9.9 degrees demonstrated a direct correlation with ipsilateral hip pain or tenderness and total hip replacement.[15] Those with the higher degrees of varus had 1.8-1.9 times the likelihood of hip pain on either side and 5.1 times the chance of undergoing total hip replacement. The authors concluded that this risk factor is potentially modifiable with foot orthoses.

The relationship between knee pain such as chondromalacia patella (CMP), patellofemoral pain syndrome

Schuster used to say that about one-half the measured amount of forefoot varus was necessary to neutralize all visible pronation.

(PFPS), medial genicular strain, etc., and the excessive pronation accompanying compensated forefoot varus have been documented (Figure 4).[16-19] In a 1972 article entitled "Podiatry and the Foot of the Athlete", Schuster postulated a mechanism between pedal pronation and CMP.[13] The pathology was treated with prescription foot orthoses with forefoot varus posting extended to the sulcus.

Dr. Schuster was the first to advocate and employ forefoot posts extended to the sulcus especially for use in runners.[9] A study by Drs. Saxena and Haddad confirmed Schuster's earlier assessment on the widespread incidence of forefoot varus in runners with knee pain, finding forefoot varus present in 91% of patients with PFPS.[20]

Compensation for forefoot varus via subtalar and midtarsal joint pronation results in a diminished ability for the first ray to provide stability for propulsion as evidenced by a dorsally deviated first met head position on weightbearing. The resultant functional hallux limitus creates an impediment to forward passage of the body over the supporting foot, in essence "jamming" the joint and causing stresses to be displaced to the next most stable segment (i.e., distally to the interphalangeal articulation, creating hallux extensis, and laterally to the more stable second or third metatarsophalangeal articulations.)[21]

Management

The osseous deformity of forefoot varus can be very effectively and most commonly managed conservatively through the prescription of custom foot orthoses, although a medial cuneiform opening wedge osteotomy may be considered as a surgical option.[22]

In a forward that Dr. Schuster wrote entitled, "About the Evolution of the Foot", he stated "Fortunately foot characteristics that were so useful to our tree-dwelling ancestors and such a problem to modern man can be recognized as imbalances and properly dealt with."[23] Therefore, the first step and key to the successful management of these inherent structural imperfections is their accurate identification. If one phrase could capture Schuster's philosophy in managing these conditions, it would be "bring the ground up to the foot" (Figure 6). Therefore, the goal of most mechanical therapy for the foot and leg would be to create a situation where the imperfection in structure is met by a complementary, mirror-image structural imperfection, and thus no compensatory adjustment in function would be required.

Schuster used to say that about one-half the measured amount of forefoot varus was necessary to neutralize all visible pronation. Herman R. Tax, DPM used to say, "If you can see it it's excessive."[24] More simply stated: if your foot is moving downward you are not moving forward. Although he never utilized force

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Schuster Seminar Set for Nov 9-10, '19

The Richard O. Schuster, DPM Memorial Biomechanics Seminar will be held Nov 9 and 10, 2019 at NYCPM. Joseph C. D'Amico, DPM is the Scientific Chair; featured lecturers include Stanley Beekman, DPM, Richard Blake, DPM, Mark A. Caselli, DPM, Paul Coffin, DPM, Jeffrey Cusack, DPM, Howard Dananberg, DPM, Robert Eckles, DPM, Justin K. Greisberg, MD, James Losito, DPM, John McNerney, DPM, R. Daryl Phillips, DPM, J.David Skliar, DPM, Jinsup Song, DPM, PhD, and Russell L. Volpe, DPM. This activity has been approved by NYCPM for a maximum of 15.75 CME contact hours.

Register at www.nycpm.edu/cmelist.asp. Contact Audrey Negron with any questions: anegron@nycpm.edu/212-410-8068. •

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plate technology, Schuster pioneered the use of time-lapse photography to analyze gait.[25] In patients who could not be sufficiently controlled with the prescribed forefoot orthotic correction, he added additional extrinsic posting to the shoe by splitting the sole. This process was repeated until all visible pronation was neutralized.

Since the contact phase during running was so short, Schuster was never an advocate of rearfoot posting. He did, however, employ it because he felt the rearfoot post stabilized the orthotic in the shoe, thereby assisting the forefoot post in maintaining alignment during late mid-stance and propulsion. He was also the first to recognize the importance of utilizing forefoot posting extended to the sulcus to further enhance control and effectiveness. This was especially significant in stress situations such as occur during sports activities requiring running.[9]

Summary

Forefoot varus is one of the most common structural imperfections in the human foot. Failure on the part of the clinician to identify and neutralize this progressive, atavistic deformity lessens the likelihood of successful outcomes and diminishes the ability to create optimum alignment and function during stance and ambulation. **PM**

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