CHAPTER 37

NONOPERATIVE MANAGEMENT OF PES CAVUS

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The pes cavus foot type is a challenging multi-planal foot deformity that is generally described as a sagittal plane plantarflexion of the forefoot on the rearfoot. The pes cavus foot deformity can result in a multitude of effects on foot function and gait that each requires careful consideration for management whether operative or non-operative. The choice of management options between operative or non-operative approaches may be too simplistic for such a complex condition as pes cavus. The associated super-structural and neuromuscular concerns of the entire lower extremity from hip to toe further impact management option selection. An understanding, not only of the phases of gait, but how non-operative management measures such as foot orthoses, shoes with modifications, and leg bracing can aid and control each phase of gait both individually and in combination is important. Careful attention in any treatment plan to the chief complaint of the patient is of the utmost priority. When the clinician combines understanding of the function of the pes cavus foot with clinical examination, radiographs, and gait evaluation, a logical course of treatment becomes evident. Non-operative management options in the treatment of the pes cavus foot type will be emphasized here and reviewed. Illustrative cases will be utilized to highlight application of non-operative management and the logic of treatment approaches. It is hoped a greater understanding of the role of non-operative management options, as either the primary approach or when utilized as an adjunct to operative measures, will be greater understood and appreciated.

THE PES CAVUS GAIT

Heel Strike Phase of Gait

The gait cycle is generally broken down into two broad phases, the stance phase and the swing phase of gait. The stance phase begins with heel strike while the contralateral extremity is still on the weight-bearing surface near the toe-off phase of gait. The normal position of the calcaneus at heel strike is slightly inverted. The calcaneus, through subtalar joint pronation, everts into the mid-stance phase of gait to absorb shock and accommodate ground surface contour needs. In the pes cavus foot type, two broad scenarios are generally considered a possibility during the heel strike phase of gait in the frontal plane. The sagittal plane component of pes cavus should not be overlooked and will be reviewed subsequently. In the first scenario, the heel strike in the pes cavus foot is relatively normal in terms of position and alignment in the frontal plane. No rigid or uncompensated rearfoot varus is present as a component of the pes cavus foot type in this scenario. The Coleman block test would not be necessary in rearfoot clinical assessment because no rearfoot varus is present in stance. Standard weight-bearing foot radiographs do not demonstrate the frontal plane position of the calcaneus in stance. The lateral weight-bearing foot radiograph would be expected to show a relatively pronated alignment of the rearfoot joints attesting to the possibility of a rectus heel in the frontal plane in this scenario. Because the heel strike position of the calcaneus is relatively normal, no heel strike patient complaints such as ankle or tarsal instability would be expected. Shoe wear along the lateral heel or varus breakdown of the counter of the shoe would not be expected. Tarsal joint pain may not be a patient complaint due to the pronatory potential of the rearfoot and some degree of shock absorption occurring. The chief complaint may include, among other things, a forefoot plantar pressure keratosis lesion pattern beneath the first and fifth metatarsal heads or a diffuse tyloma type keratosis beneath the central metatarsal heads. If either a forefoot valgus or a plantarflexed first ray is present, the first metatarsal will contact the ground supporting surface early and first resulting in pressure and keratosis formation beneath the first metatarsal head. Supination instead of pronation will occur through the mid-stance phase of gait with rolling over to the lateral forefoot and potential pressure keratosis formation beneath the fifth metatarsal head area. A plantarflexed first ray or a forefoot valgus would show rearfoot varus in stance in this scenario that would not be present at heel strike and would reduce with the Coleman block test. If no frontal plane forefoot valgus is present but primarily a sagittal plane plantarflexion of the entire forefoot on the rearfoot, a diffuse tyloma of the plantar forefoot develops with capsular pain of the lesser metatarsophalangeal joints due to increased pressures of weight-bearing through this area in late mid-stance through the toe-off phases of gait.

The second scenario of heel strike in pes cavus is for the calcaneus to be inverted on the frontal plane. Rigid or an uncompensated rearfoot varus is considered to be present as part of the pes cavus deformity in this scenario. Tibial varum, either as a congenital deformity or as a result of malunion of leg bone fractures, may likewise result in a varus or inverted position of the calcaneus at heel strike. The varus heel strike may be very short lived and quickly pronate even during within the heel strike phase of gait prior to the mid-stance phase of gait. This phenomena can be seen in neuromuscular imbalance where the dorsiflexing and inverting muscles are dominant. Generally, the inverted position of the calcaneus at heel strike is more rigid and will persist into the mid-stance phase of gait with little if any subtalar joint pronation occurring. The Coleman block test would show minimal or no change in the varus or inverted frontal plane position of the calcaneus in stance. Standard weight-bearing foot radiographs do not reflect directly the frontal plane position of the calcaneus. The rearfoot joints might be expected to show a relatively supinated position due to lack of compensatory pronation for either frontal plane rearfoot varus or forefoot valgus positions of deformity. The chief complaint of patients with this more rigid rearfoot varus heel-strike includes tarsal and ankle instability to inversion, tarsal joint pain due to jamming and end range of motion function in supination, and plantar forefoot pressure keratoses beneath the first and fifth metatarsal heads. As mid-stance progresses, insufficient pronation occurs through the rearfoot joints and the lateral column of the foot remains in contact with the weight-bearing surface and the fifth metatarsal head contacts the ground early and first resulting in pressure keratosis in this area. Once the heel-lift occurs, the foot will roll over to the first metatarsal for stability and a pressure keratosis may occur here as well.

Mid-Stance Phase of Gait

The mid-stance phase of gait in the pes cavus foot type reflects the progression of frontal plane rearfoot positioning, generally of varus, through forefoot frontal plane positioning, generally of valgus, as described above either as flexible or rigid deformities. The mid-stance phase of gait also reflects the sagittal plane plantarflexion of the forefoot on the rearfoot that is the heart of the pes cavus deformity by definition. As the heel-strike phase of gait progresses through the midstance phase of gait, if the forefoot is plantarflexed on the rearfoot in the sagittal plane two possible mechanisms of compensation are possible. If the midfoot joints are flexible, the plantarflexion of the forefoot on the rearfoot is absorbed and compensated at that level and in actuality no sagittal plane pes cavus deformity may be appreciated in mid-stance. The midfoot joints are functioning at near maximal dorsiflexion and early weight-bearingf pressures are experienced through the plantar forefoot. Patient complaints may include midfoot joint pain and arthrosis, midfoot dorsal exostosis and prominence, and plantar central metatarsal keratosis formation and capsular joint pain. If the midfoot joints are rigid, no absorption or compensation for the sagittal plane plantarflexion of the forefoot on the rearfoot will occur at the midfoot level and a more proximal compensation through dorsiflexion of the ankle joint will occur. The foot during the mid-stance phase of gait maintains a high arch appearance on the sagittal plane. The foot functions as an ankle equinus deformity as ankle joint dorsiflexion is utilized to compensate for forefoot plantarflexion and place thefoot flat on the weight-bearing surface. Patient complaints may include anterior ankle pain, foot instability, plantar forefoot keratoses, and hammertoes.

Swing Phase of Gait

The swing phase of gait is important in the pes cavus deformity as neuromuscular concerns often involve a degree of anterior leg muscle group weakness and dropfoot difficulties. Swing phase hammertoe or clawtoe deformities may result in painful problems for patients that are otherwise flexible and reduce on stance as digital extensors compensate for a weakened tibialis anterior. Muscle imbalance may result in an inverted positioning of the calcaneus at heel strike if inverters of the anterior muscle group are dominant either through their spasticity and strength or weakness of their antagonists.

MANAGEMENT OPTIONS

Foot orthotic, shoe, and leg bracing of the pes cavus foot in an evolutionary process of design and modification specific for each patient. The best first try devices are ordered based on clinical diagnosis and patient needs assessment. Modifications, both planned and improvised, are typically the rule. Once a final prototype device is found to be functional and is meeting patient needs, a more permanent system can be constructed. It is wise to ask the patient to avoid obtaining new shoes prior to dispensing foot orthoses or application of leg bracing to shoes for pes cavus especially if considerable rigid or uncompensated rearfoot varus is present at heel strike. A new shoe should be obtained. The counter of a well worn shoe in a patient with rearfoot varus may be well broken into a varus attitude and the heel surface worn laterally. The softer shock absorbing heel constructions utilized in the pes cavus foot orthodic will adapt and be molded into further varus by the broken shoe and deform in such a way as to be counterproductive not aiding but possibly exaggerating subtalar joint instability. The higher the shoe counter or the deeper the depth of the shoe, not only accommodates the foot orthodic better, but can further lend support to subtalar instability. Ongoing monitoring of shoes for signs of varus and lateral wear with replacement or repair when noted, should be instructed to the patient with dispensing the foot orthodics. The phases of gait provide a functional outline for the discussion of the various non-operative treatment options for the management of pes cavus from functional foot orthoses to leg bracing and will be utilized to discuss the clinical applications of these types of treatment approaches.

Heel Strike Phase of Gait

A varus positioning of the calcaneus at the heel strike phase of gait that does not evert by subtalar joint pronation into the midstance phase of gait is challenging to manage by non-operative treatment options. If the rearfoot varus results in substantial subtalar joint and ankle instability with daily walking needs, a double-upright ankle-foot-othosis (AFO) with a lateral well padded T-strap is recommended. This clinical situation can be noted in patients following cerebral vascular accidents. The double-upright bars of the AFO provide the anchor for securing the padded lateral T-strap from the shoe. Lesser degrees of subtalar joint and ankle instability may be aided by a deep seated heel cup in a custom molded foot orthosis that is soft and will mold in time with wear to the heel of the patient. These devices are usually constructed of leather and rubber laminates or non-rigid plastic foot orthodic designs. An added advantage to this approach is the shock absorbing quality of this type of heel construction for this rigid pes cavus foot type. Out-sole flaring of the lateral heel of the shoe can be an adjunctive consideration, but generally does not in itself provide enough stability to the rearfoot. Lateral out-sole wedging, lateral build-ups on the foot orthodics, or valgus heel posting typically are poorly tolerated in patients with a rigid or uncompensated rearfoot varus that does not evert on the Coleman block test. If the calcaneus will not evert with the Coleman block test, it can not be expected to evert with foot orthoses and leg bracing.

A calcaneus that strikes the ground supporting surface in varus, that either very quickly in the heel strike phase of gait or through the mid-stance phase of gait pronates, should be permitted as well as encouraged to evert by the foot orthosis or shoe construction. The foot orthodic can be considered to function as a Coleman block test within the shoe. If pronatory motion is available through the subtalar joint, a lateral build-up of material can be added to the underside of a leather or softer type of foot orthodic from the heel to the forefoot to pronate the rearfoot and evert the calcaneus. The foot orthodic cannot be constructed of firm material that actually contacts the medial arch. Any firm contact of the medial arch may prevent pronation that is the purpose of the device. Out-sole lateral wedging of the shoe is not noted clinically to have a similar affect on the rearfoot to encourage pronation. The foot orthodic is dispensed to the patient and worn for a period of break-in. Successive layers of material such as Korex can be added to the plantar lateral aspect of the foot orthosis as would be performed in the Coleman block test until optimum patient comfort or maximal eversion of the calcaneus is achieved.

Pseudoequinus, the sagittal plane ankle dorsiflexory compensation of the plantarflexed forefoot on the rearfoot, can be reduced with a heel-lift built into the rearfoot portion of the foot orthodic or a higher heel on the shoe. The heel-lift will aid plantarflexion of the talus within the ankle mortise to reduce anterior ankle impingement symptoms that can occur with ankle dorsiflexion type compensation for rigid sagittal plane pes cavus. This effect can be increased with higher heel thicknesses to the ouside of the shoe as heel lifts within the shoe are limited by patient comfort as the foot at the heel is lifted out of the shoe.

Mid-Stance Phase of Gait

As the heel strike phase of gait progresses to the mid-stance phase of gait, the forefoot portion of the foot orthosis, combined with any extension beneath the metatarsal head region, begins to have its affect on foot function. Valgus posting of the forefoot of the functional foot orthosis can have two potential effects. Actual mid-stance phase of gait pronation is promoted if the forefoot valgus post is angled greater than the forefoot valgus deformity. Only a reduction in mid-stance phase of gait supination results if the forefoot valgus post is angled more exact to the forefoot valgus deformity present. A pronatory effect on the foot is likewise possible by the addition of a lateral build-up on a flexible foot orthosis that extends from the rearfoot to the forefoot. A forefoot extension of the foot orthosis to the sulcus area of the digits with a cut-out for the first ray can further encourage eversion of the forefoot as the mid-stance phase of gait progresses to the toe-off phase of gait. The forefoot extension, much like the heel area of the foot orthodic, can be constructed of softer shock absorbing materials to aid plantar metatarsophalangeal joint capsular type symptoms. Pocketing or cut-out accommodation for painful fifth metatarsal head pressure keratoses can likewise be incorporated into the forefoot extension of the pes cavus foot orthodic in the presence of rigid or uncompensated rearfoot varus. Lateral plantar build-ups are stopped well proximal to the fifth metatarsal head area and the fifth ray cut-out aids reduced pressures to the fifth metatarsal head region through the late mid-stance through the toe-off phase of the gait cycle. Out-sole wedging of the shoe from the heel to the forefoot is a reasonable adjunctive measure to aid pronatory forces to the foot but is not considered as a primary means of correction. Out-sole additions to shoes are more typically considered to aid frontal plane foot and leg positioning by abduction of the hip and a broader base of gait which further can add stability to the extremity.

Swing Phase of Gait

The swing phase of gait can be characterized in the pes cavus foot type with weakness and dropfoot. A double-upright type AFO can be constructed with a spring assist at the ankle joint level to aid dorsiflexion. The AFO could also be designed with a fixed ankle that limits ankle joint motion in general if greater stability is required. To aid positioning of the foot in rigid sagittal plane plantarflexion of the forefoot on the rearfoot, a thicker heel is added to the shoe as the AFO is attached. The double-upright type AFO has the advantage of the option for adding a padded lateral T-strap to aid eversion and valgus positionig of the foot. A molded plastic AFO with similar ankle construction options to limit ankle plantarflexion or assist with ankle dorsiflexion. can likewise be considered. The advantage to this particular devise is the foot-plate portion of the molded plastic AFO can be adjusted and modified like a custom molded foot orthosis to aid accommodation of lesions and encourage pronatory effects in the pes cavus foot.

ILLUSTRATIVE CASES

Case 1: Leather Mold Foot Orthotic

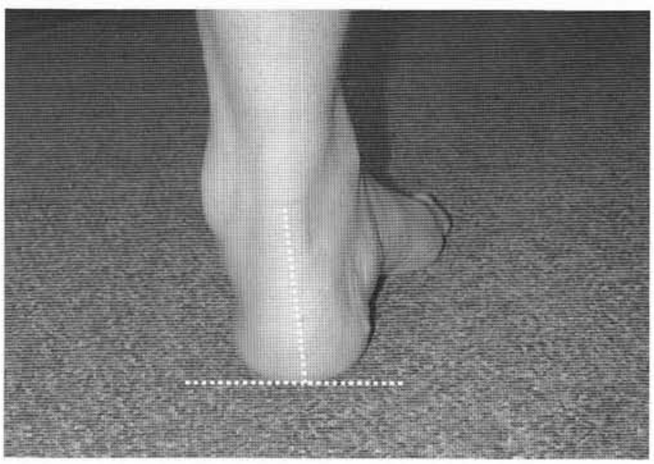

Figure 1A. Inverted position of calcaneus in stance demonstrating rearfoot varus in a case of rigidly plantarflexed first ray with flexible compensatory rear-foot varus.

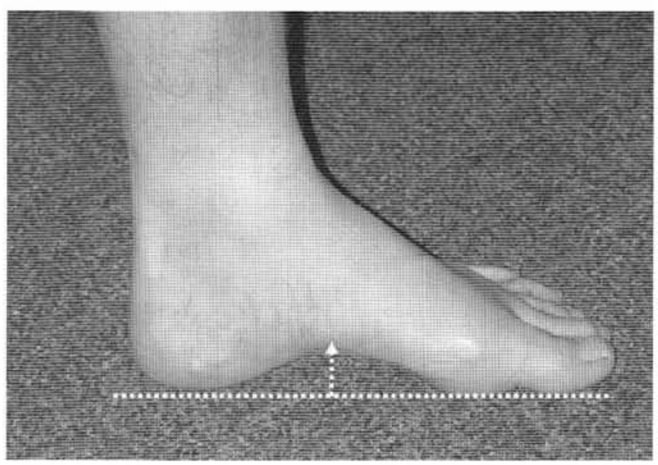

Figure 1B. Medial perspective view with typical sagittal plane deformity of plantarflexion of the forefoot on the rearfoot appreciated.

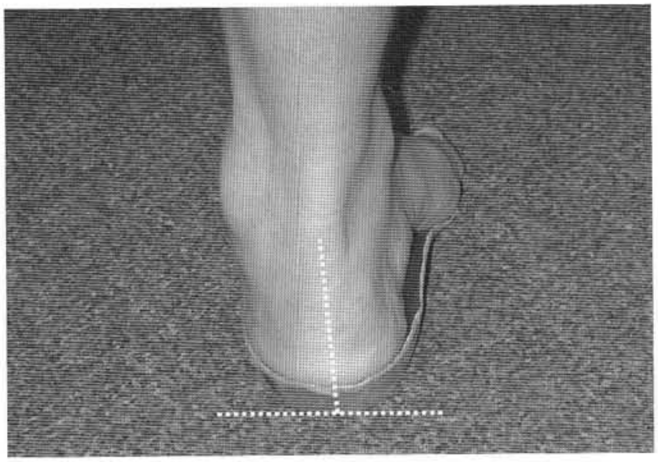

Figure 1C. Inverted position of the calcaneous in stance still noted standing in leather mold type foot orthosis with heel lift and cushioning.

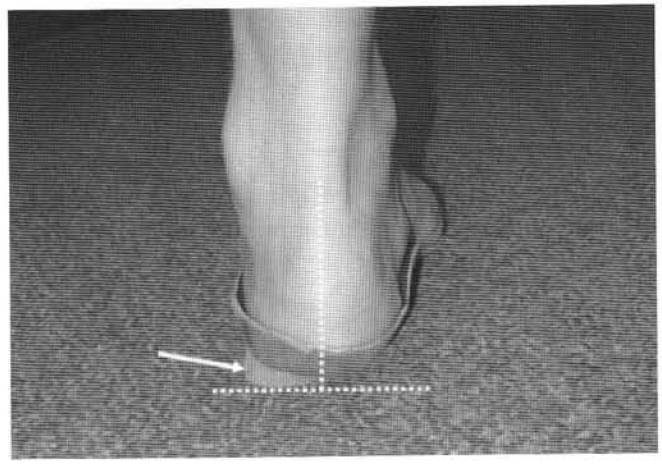

Figure1D. More rectus alignment of the posterior calcaneus with lateral wedging in place as a trial for assessment of correction. (Coleman block test)

Figure 1E. Medial perspective of stance with the foot orthosis in place before the lateral wedging is in place, arch well away from foot orthosis contact.

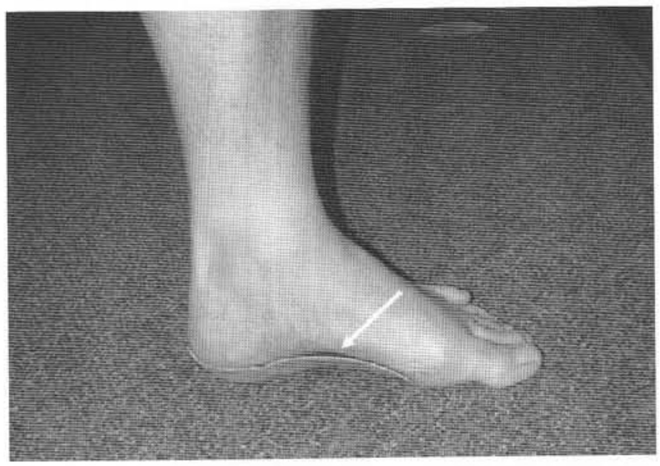

Figure 1F. Medial perspective of stance with the foot orthosis in place and the lateral wedging as a trial for assessment, arch nearly contacting the foot orthosis.

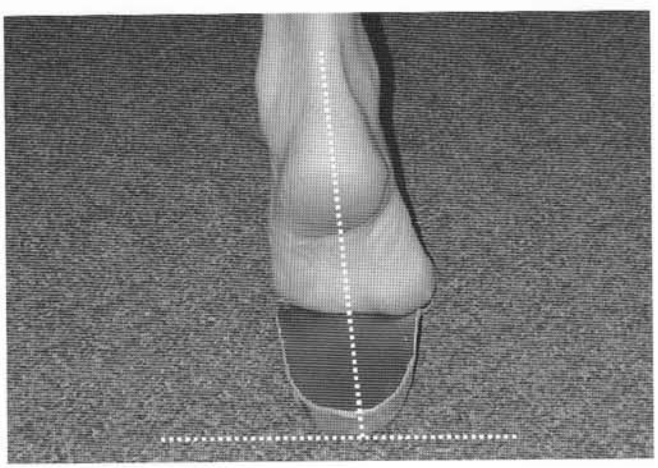

Figure1G. Toe-off positioning of the calcaneus with the foot orthosis in place with some reduction in the inverted position of the heel from the first ray pocketing.

Figure 1H. Toe-off positioning of the calcaneus with the foot orthosis in place and the lateral wedging added with a more inverted position of the heel.

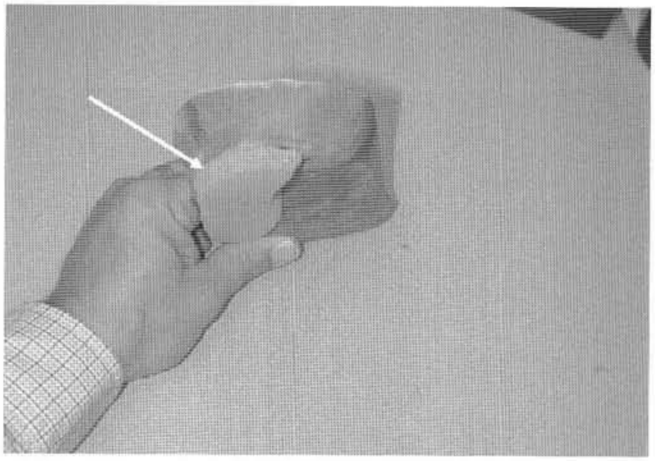

Figure1I. Posterior view of the foot orthosis with the lateral wedging added and before final contouring and grinding.

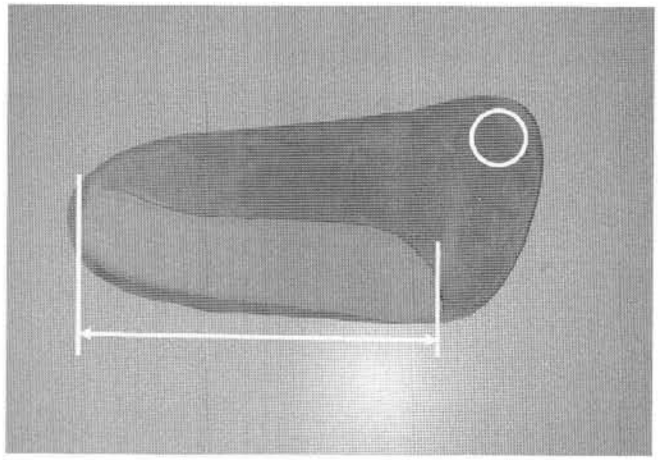

Figure1J. Underside of the finished foot orthosis with pocketing at the first ray area and lateral wedging from the heel to just proximal to the fifth metatarsal head.

Figure1K. Final stance evaluation with rectus alignment of the posterior calcaneus with lateral wedging fixed in place.

Figure1L. Final toe-off evaluation with maintenance of the rectus alignment of the posterior calcaneus in gait.

Case 2: Ankle-Foot-Orthosis

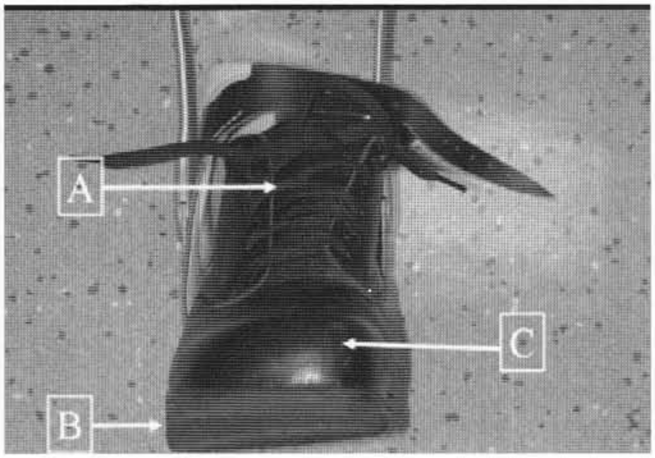

Figure 2(A). Anterior perspective close-up view of a high-top shoe affixed to a double-upright brace with a fixed ankle. Laced type construction with padded tongue. (B). Out-sole lateral wedge to the toe from the heel. (C). Extra-depth to accommodate thickness of foot orthosis with high toe-box to allow space for clawtoe deformities.

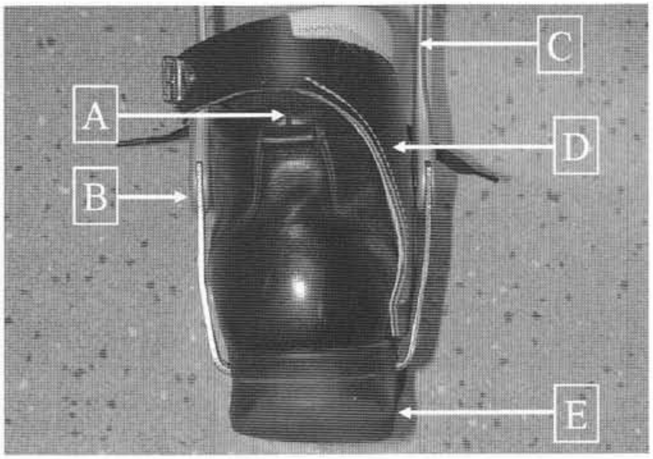

Figure 2B. Posterior perspective close-up view of a high-top shoe affixed to a double-upright brace with a fixed ankle. A. Padded collar about the counter of the shoe. B. Fixed ankle hinge on medial up-right. C. Lateral up-right. D. Lateral T-strap that buckels ann is secured over the medial up-right. E. Lateral out-sole flare at the heel that extends to the toe.

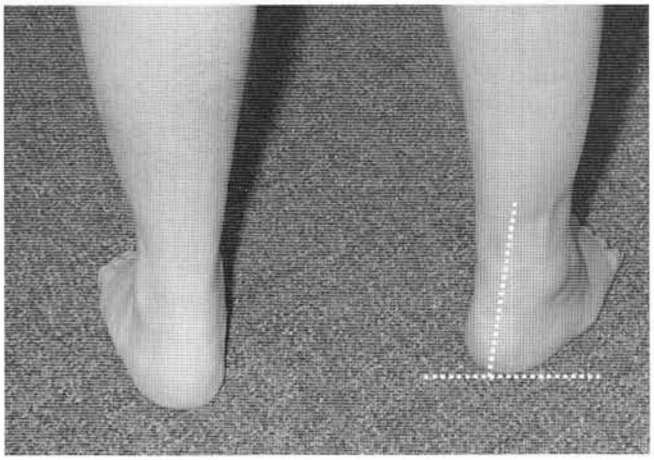

Figure 2C. Posterior view perspective of a spastic rearfoot varus that is flexible and the result of a closed head injury with left-sided hemi-paresis and dropfoot.

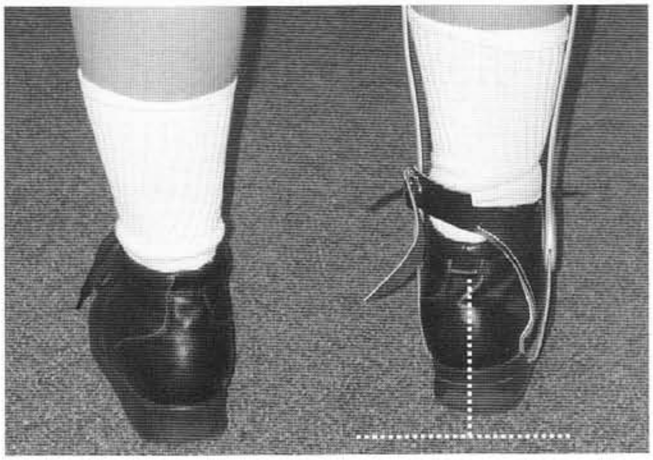

Figure 2D. Posterior view of the extremity in the ankle-foot -orthosis. Note the rectus alignment of the heel as compared to the unshod extremity in the previous figure.

Case 3: Functional Foot Orthosis

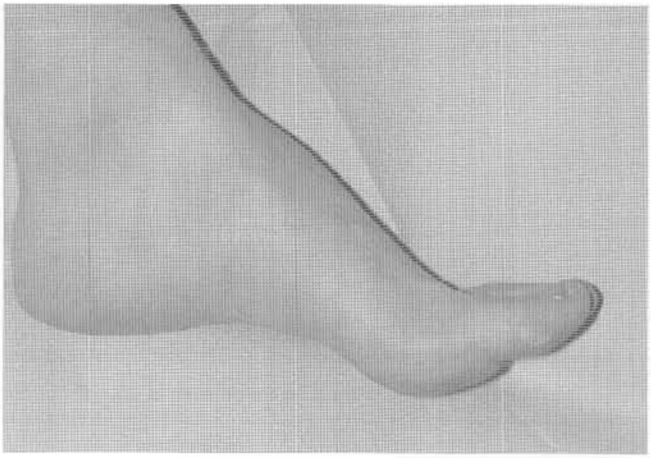

Figure 3A. Medial view perspective nonweight-bearing semi-flexible pes cavus with plantarflexed first ray and a flexible rearfoot varus.

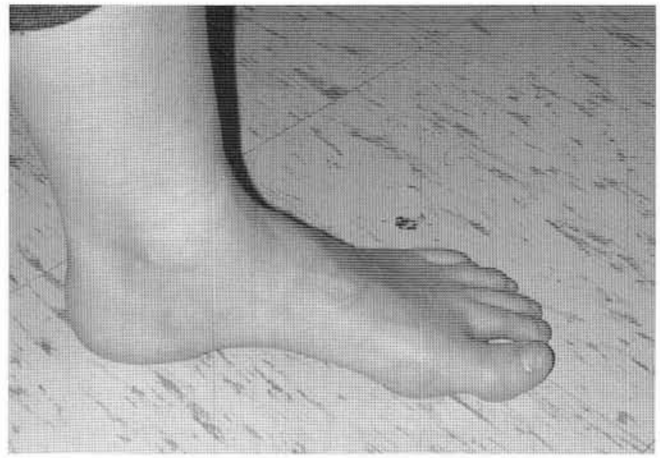

Figure 3B. Medial view perspective weight-bearing semi-flexible pes cavus with plantar flexed first ray and a flexible rearfoot varus with reduction in the deformity by primarily midtarsal sagittal plane hypermobility.

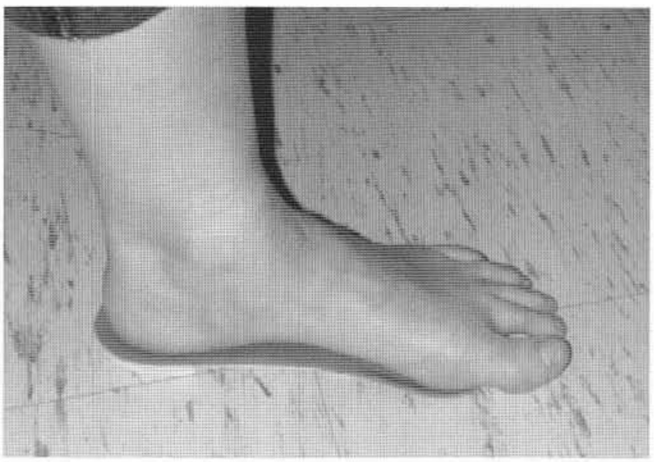

Figure 3C. Posterior view perspective of the calcaneus in weight-bearing with rearfoot varus evident.

Figure 3D. Posterior view perspective of the calcaneus in weight-bearing on a functional foot orthosis with a neutral heel post, padded heel cup, valgus forefoot post, and first ray pocket in padded forefoot extension. The heel is now perpendicular to the floor.

Figure 3E. Medial view perspective of semi-flexible pes cavus with plantarflexed first ray and a flexible rearfoot varus with no foot orthosis in place.

Figure 3F. Medial view perspective of semi-flexible pes cavus with plantarflexed first ray and a flexible rearfoot varus with the foot orthosis in place and reduction in the longitudinal arch.

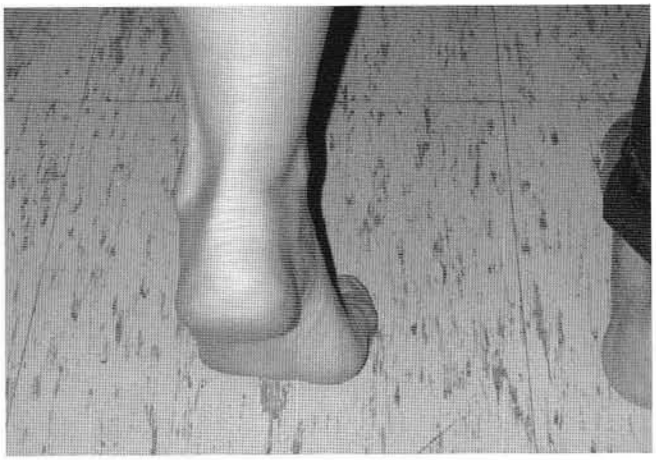

Figure 3G. Posterior view perspective of toe-off phase of gait with the foot orthosis not in place.

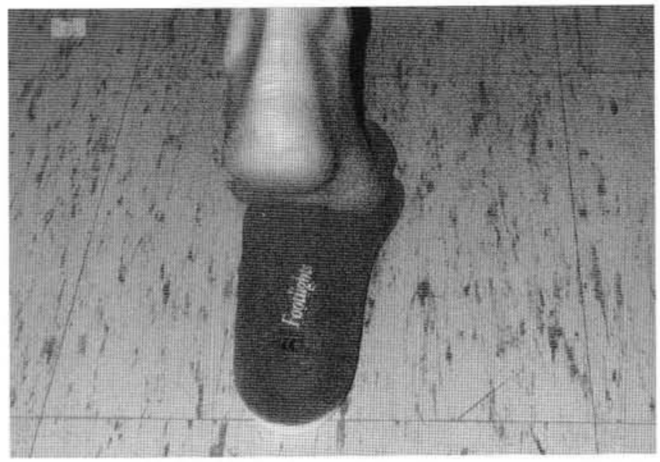

Figure 3H. Posterior view perspective of the toe-off phase of gait with the foot orthosis in place with less varus positioning of the foot as the forefoot extention with the first ray accommodation portion of the device becomes functional.

SUMMARY

The pes cavus foot deformity presents challenges in management whether operative or non-operative approaches are considered. Foot orthoses, shoe accommodations, and the AFO all have a place in non-operative management of the pes cavus foot. An understanding of pes cavus foot function, as well as the non-operative treatment modalities and how their affects impact each phase of the gait cycle, aids the overall understanding and logic of this management approach. Imagination and ingenuity aid both the podiatric physician and the patient through the development process for a system that best meets the need of the patient. The reward of a device or combination of devices that meet these goals can be great and have a significant impact on quality of life for patients affected by pes cavus.