CHAPTER 2

PES CAVUS: An Update of Classification and Management

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Pes cavus is a deformity that can be overwhelming in its complexity. The surgical and conservative management of pes cavus has undergone a marked evolution over time. The evolution has been aided by a retrospective analysis of results, and by advances in diagnostic and surgical techniques. Currently, a practical scheme of classification has emerged to aid in surgical management decisions. The classification scheme is based on realistic surgical options as they correlate to the degree of pes cavus deformity. A review of pes cavus and the classification scheme is presented here as a practical working guide for the clinician.

DEFINITION

To understand pes cavus is to attempt to define the deformity. A pes cavus deformity is easily recognized, but to formulate a workable definition is a challenge. A brief overview of pes cavus is provided.

Pes cavus is considered to be primarily a sagittal plane deformity. Pes cavus is either a plantarflexion of the forefoot on the rearfoot, or dorsiflexion of the rearfoot on the forefoot. The choice of definition is only a matter of perspective. The forefoot perspective is primarily utilized in defining pes cavus due to the dominance of the forefoot as the more rigid deforming influence of the deformity. The sagittal plane "high arch" may be noted on stance examination, or may be evident only in the non-weight-bearing situation. The presence of pes cavus in stance reflects a more rigid type of deformity. The presence of pes cavus only in the non-weight-bearing situation reflects a more flexible type of pes cavus deformity. The definition of pes cavus must include consideration of both the potential flexible and rigid possibilities of the deformity. The clinical appearance of heel varus, high arch, and clawtoes may not necessarily be present in all pes cavus presentations. The pes cavus foot deformity is generally made up of combinations of forefoot and rearfoot, and rigid and flexible components in all three body planes, with a high longitudinal arch dominating in the sagittal plane.

A second consideration in the definition of pes cavus is the multiple planar possibilities of associated deformities, coupled with the major sagittal plane deformity. The transverse plane includes the components of metatarsus adductus. Transverse plane tarsal supinatory or pronatory malalignment possibilities may be associated with pes cavus as well. The frontal plane components of pes cavus are most commonly addressed during surgical correction. Surgical procedures, such as dorsiflexory osteotomies of the first metatarsal, or Dwyer-type calcaneal osteotomies, are primarily frontal plane corrections that only secondarily affect the sagittal plane component of pes cavus.

Finally, the neuromuscular contribution to the deformity should not be overlooked. The need to identify muscle imbalance and its compensation is important. Joint fusions or tendon transfers may be needed to aid in stability, and balance the foot for gait, regardless of the severity of the presenting deformity.

The definition of pes cavus is as complex as the deformity. Pes cavus is primarily a sagittal plane deformity of plantarflexion of the forefoot on the rearfoot, with secondary multi-planar forefoot and rearfoot rigid and flexible possibilities, coupled with neuromuscular concerns.

The pes cavus classification scheme to be presented subdivides the deformity into three basic types based on three possible surgical approaches. No specific evolution from one type to another is necessarily implied. It is possible to have more than one type as combinations. The classification scheme builds on the multi-planar and neuromuscular evaluation of a primarily sagittal plane deformity.

CLASSIFICATION SCHEME

No one classification system can include all of the clinical possibilities of pes cavus. Each foot and patient is unique in presentation, and in need. The first breakdown of the classification broadly divides the deformity into Type I, Type II, and Type III categories. These three types are grouped and defined based primarily on the complexity of the three broad surgical options available for correction of the deformity: digital procedures, isolated osteotomies, and major tarsal osteotomies and fusions. Type I, or mild pes cavus deformity, is primarily digital in nature and can be defined as the flexible cavovarus foot type. It is primarily a forefoot deformity and is surgically addressed, when indicated, by digital releases and fusions coupled with tendon transfers.

Type II pes cavus, or moderate pes cavus deformity, is more rigid in presentation and has not only sagittal, but also multi-planar components. It is surgically addressed by metatarsal and calcaneal osteotomies, coupled with Type I digital procedures and tendon transfers, when combination deformities exist. This is the most common pes cavus type.

Type III pes cavus, or severe pes cavus deformity, is an advanced multi-planar deformity of the forefoot and rearfoot, and generally includes neuromuscular imbalance. Along with Type I and Type II surgical procedure possibilities, the primary surgical approach includes major midtarsal and tarsal fusions and osteotomies.

This broad categorization is easily applied and appreciated. Gray zones of distinction will be reviewed more fully. The overlap from one type to the next should not be forgotten. The planar possibilities, neuromuscular imbalances, and patient complaints help define the sub-typing and gray zones between the major types of pes cavus deformity.

Type I, Mild Pes Cavus Deformity

Type I, or mild pes cavus, can be a component of all three types of pes cavus, or present as a unique type of pes cavus. Common patient complaints include plantar forefoot tyloma(s), metatarsalgia, and hammertoes with associated clavi. Clinically, the patient presents with a flexible forefoot plantarflexion on the rearfoot in the non-weight bearing examination, with associated rigid or flexible hammertoe deformities. The foot may be normal in appearance if only weight-bearing radiographs are performed.

The only objective signs of deformity may be in the swing phase of gait examination, or in the non-weight-bearing appearance of the foot. The cavus attitude that is apparent when non-weight bearing disappears in stance through compensatory mechanisms such as midtarsal and tarsal sagittal plane flexibility. Force plate gait analysis will show abnormal pressures in the forefoot during the stance phase of gait that are not clinically visible.

Surgical approaches include metatarsophalangeal joint releases, proximal interphalangeal joint fusions of the digits, and rarely Hibbs-type extensor tendon transfers. The only measure of surgical results may be the absence of postoperative clinical symptoms. Few radiographic or weight-bearing realignments are appreciated postoperatively. Force plate analysis of gait shows reduced pressure peaks through the forefoot when comparing preoperative and postoperative plantar pressure analysis.

Type II, Moderate Pes Cavus

Type II, or moderate pes cavus, can have components of Type I pes cavus. Type II pes cavus has a more rigid nature and is more clinically evident on weight-bearing examination. Type II pes cavus is primarily sagittal plane in presentation, but generally possesses a pronounced frontal plane component as well. The frontal plane components of Type II pes cavus include both forefoot and rearfoot possibilities. The frontal plane forefoot pathology may include plantarflexion of the first ray as an isolated problem, or valgus deviation of the entire forefoot. The rearfoot frontal plane pathology includes varus deviation of the calcaneus as either compensation for forefoot first ray plantarflexion, or as a fixed deformity in itself.

Patient complaints in Type II pes cavus include painful forefoot lesion patterns of the first and fifth metatarsal. Digital deformities may be flexible or rigid, and are generally painful. Some degree of instability of the foot and ankle may be present. Neuromuscular concerns are generally minimal, but can include weakness and unsteadiness. Clinically, the foot may have a sagittal plane high arch, coupled with a varus attitude of the calcaneus. Radiographic changes include increased first metatarsal declination and calcaneal inclination angles. The rearfoot may appear either supinated or pronated.

The surgical approaches for Type II pes cavus include dorsiflexory osteotomy of the first

metatarsal, and Dwyer-type calcaneal osteotomies. Digital procedures and tendon transfers for any Type I pes cavus combination are considered. More aggressive tarsal tendon transfers to release contracture or to aid weakness are considered as needed.

Type III, Severe Pes Cavus

Type III, or severe pes cavus, is a marked deformity in the classic presentation, with little doubt of the severity. At times the distinction between Type II and Type III pes cavus can be difficult. The surgical approach considerations for Type III pes cavus are major tarsal fusions or osteotomies, coupled with procedures included in Type I and II pes cavus, if combination deformities exist.

Assigning a classification to a foot in the gray zone of Type II or Type III pes cavus requires identifying those factors that may warrant a major tarsal fusion or osteotomy procedure. The basic decision is whether osteotomies of the metatarsals and/or calcaneus or major midtarsal or tarsal fusions or osteotomies (Cole type) would be best to correct the deformity and meet patient needs. The decision to classify a gray zone deformity as Type II, not Type III pes cavus, is often made if patient complaints are centered more on painful lesion concerns, not instability, even in the face of borderline severity of clinical deformity. A decision to classify a deformity as a Type III pes cavus, instead of a Type II pes cavus, is made when patient complaints are more of instability and balance and not lesions or digital concerns. Therefore, recognizing the patient needs and concerns is important in the classification process, especially in borderline cases.

The typical complaints of patients with Type III pes cavus primarily concern gait abnormalities. Painful lesions and digital complaints generally co-exist. Pes cavus at this level is rigid and unforgiving. This fact, coupled with the possibility of neuromuscular disease, makes walking painful and difficult to execute.

Clinically, a very high-arched, sagittal plane deformity exists with multi-planar components of forefoot and rearfoot varus/valgus and adductus. Digital deformities, such as hammertoes or clawtoes, tend to be rigid, and contribute to further forefoot plantarflexion. Radiographs reinforce the severity of the clinical picture.

The corrective procedures employed for the sagittal plane component of Type III pes cavus include midtarsal and tarsal osteotomies and arthrodeses. Arthrodeses at the midtarsal or tarsal levels allow multi-planar correction and aid stability in the face of neuromuscular imbalance. Major midtarsal or tarsal osteotomies, such as the Cole type, are indicated in primarily sagittal plane deformities. Any frontal or transverse plane components of pes cavus may need to be addressed separately, even when major midtarsal or tarsal osteotomies or arthrodeses are performed. Type I and Type II pes cavus procedures are used as adjunctive techniques to address transverse plane, frontal plane, and digital components of combined deformity.

ILLUSTRATED PES CAVUS-TYPE II

Five subtypes of Type II pes cavus are possible (Fig. 1A). Evaluation of Type II pes cavus is based on three primary clinical tests. These three tests form the basis of Type II pes cavus evaluation. Further sub-testing and evaluation is performed based on the outcomes and presentation as noted. The three levels of testing on the diagram correlate with the three horizontal hashed lines. The tests proceed from proximal to distal in the Type II cavus foot. The testing levels include: 1. Coleman block test of the rearfoot, 2. Rigidity and flexibility of the metatarsophalangeal (MTP) joints, and 3. First ray position. The algorithm proceeds then, with a determination of rigidity vs. flexibility at each step. Those areas determined to be rigid are surgically released or corrected. Those areas determined to be flexible are allowed to move or reduce as the more rigid components of the pes cavus are corrected. Each of the five subtypes will be evaluated and a case presented to highlight clinical tests and procedure selection in each.

Subtype 1

This subtype of Type II pes cavus has rigidity requiring correction only at the MTP area and first ray. The rearfoot component is flexible. The forefoot controls the rearfoot. The Coleman block test shows the heel reduced from varus to vertical preoperatively, that was maintained for five years postoperatively without the need for rearfoot surgery. Sagittal plane clinical examination showed a preoperative heightened longitudinal arch, that was well-reduced postoperatively with metatarsal osteotomies and digital releases. Pre- and postoperative radiographs demonstrate the reduced

metatarsal declination angle with metatarsal osteotomies and the tarsal joint changes of pronation that account for the reduction in rearfoot varus. The preoperative varus calcaneal position, noted clinically, is only a compensation for the plantarflexed deformity of the first ray.

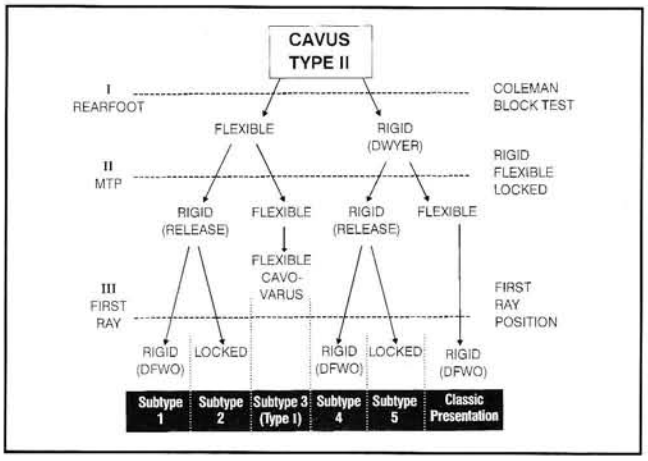

Figure 1A.

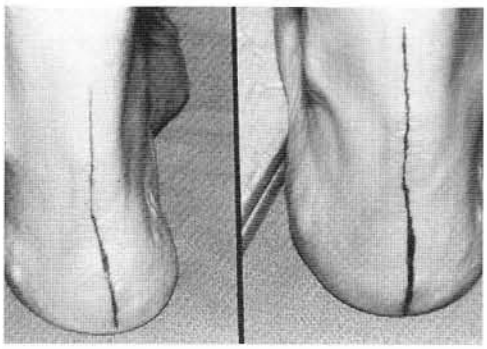

Figure 1B. Preoperative clinical comparison of varus stance position of the heel that is reduced with the Coleman block test.

Figure 1C. Rectus position of the heel maintained five years, postoperatively.

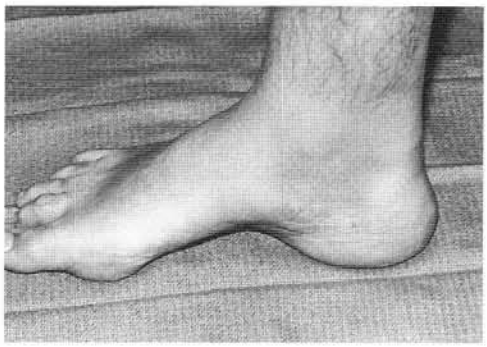

Figure 1D. Preoperative stance position, medial clinical presentation.

Figure 1E. Five year postoperative stance position, medial clinical presentation.

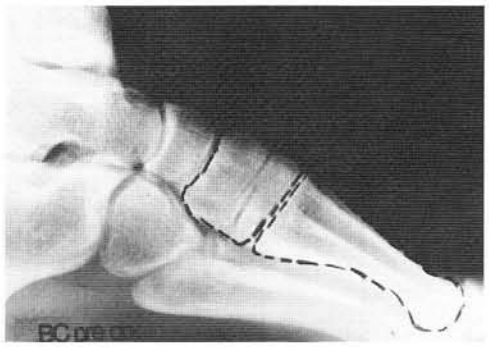

Figure 1F. Preoperative lateral radiograph.

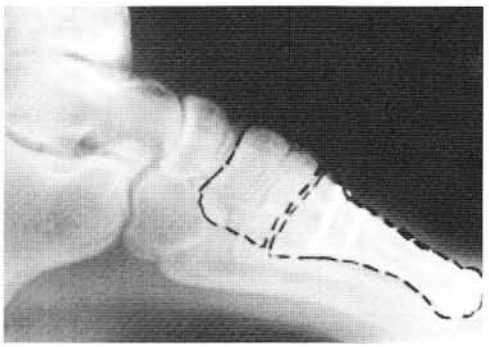

Figure 1G. Five year postoperative lateral radiograph.

Subtype 2

This sub-type is very interesting, in that the only rigid component of the deformity is at the metatarsophalangeal joint level. In essence, the digital deformities control the pes cavus mal-alignment. Generally, neuromuscular imbalance is present to weaken through paralysis, and strengthen through spasticity and create the deformity. An example of such an imbalance is presented here in a case following a closed-head injury many years prior. The preoperative clinical presentation is that of spasticity of the extensor hallucis longus tendon, with resultant plantarflexion of the first ray, and resultant rearfoot varus. Postoperatively, with lesser digital release and stabilization as well as Jones extensor tendon transfer and interphalangeal joint fusion of the great toe, adequate reduction of the deformity is noted. Little change is noted on the radiographs preoperatively or postoperatively, attesting to the positional and flexible nature of this Type II pes cavus presentation.

Figure 2A. Preoperative lateral stance position.

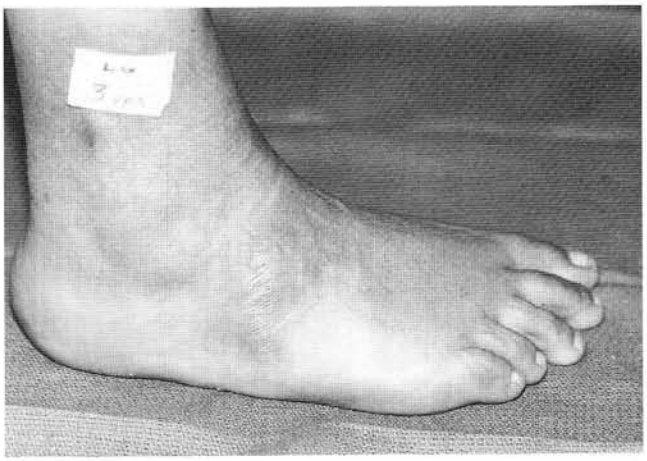

Figure 2B. Three year postoperative lateral stance position.

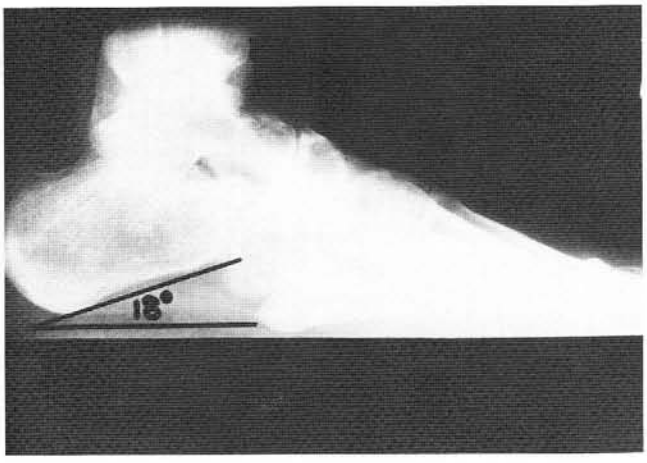

Figure 2C. Preoperative lateral radiograph.

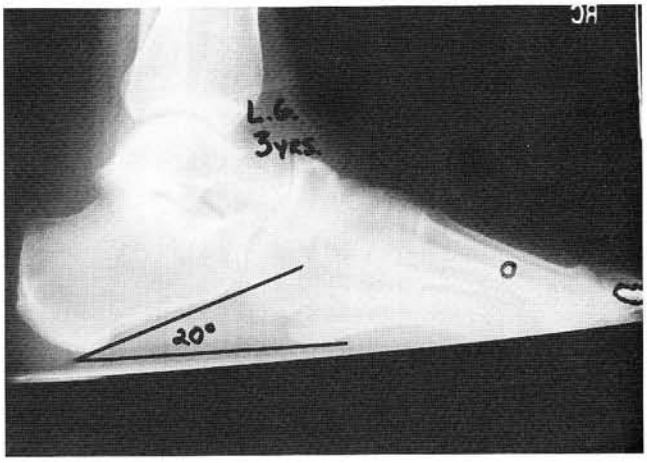

Figure 2D. Three year postoperative lateral radiograph.

Subtype 3 (Type I)

This presentation of Type II pes cavus is actually a Type I pes cavus deformity. The pes cavus deformity is flexible and reducible at all levels. It is included in this algorithm for completeness. Preoperative and postoperative non-weight-bearing clinical examination of Type I pes cavus showing evidence of change in appearance of the foot with less plantarflexion of the forefoot on the rearfoot after only digital release and stabilization. Preoperative and postoperative weight bearing clinical examination show little evidence of change, except a more rectus digital alignment in the same patient. Preoperative and postoperative swing phase shows loss of digital contractures at this point in the gait cycle following Hibbs type tendon suspension.

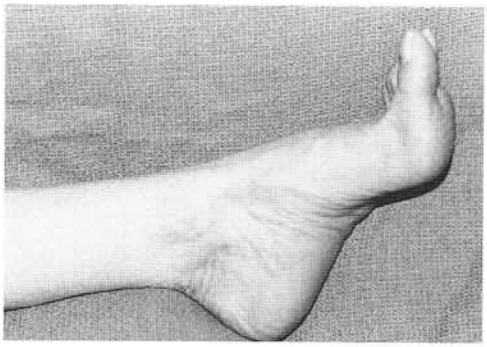

Figure 3A. Preoperative non-weight bearing lateral view.

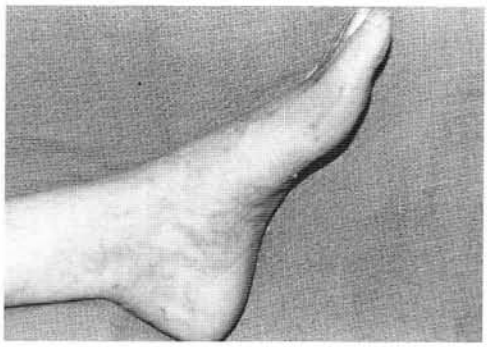

Figure 3B. Two year postoperative non-weight bearing lateral view.

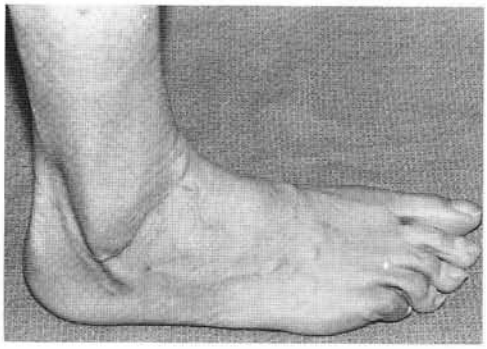

Figure 3C. Preoperative lateral stance position.

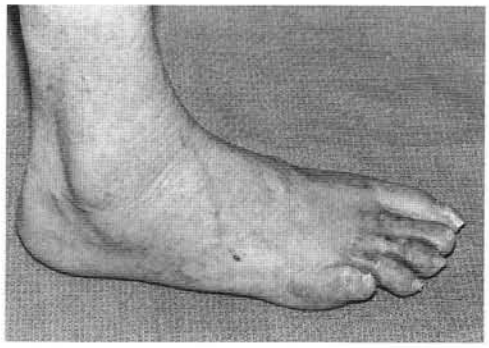

Figure 3D. Two year postoperative lateral stance view.

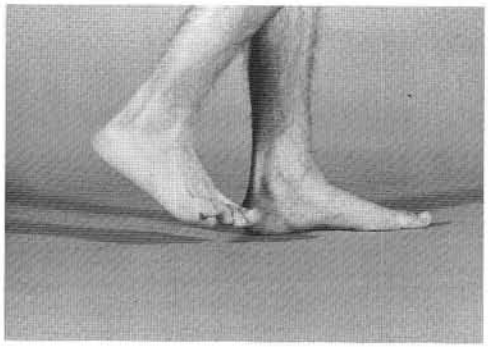

Figure 3E. Preoperative swing phase lateral clinical presentation. (supplemental case)

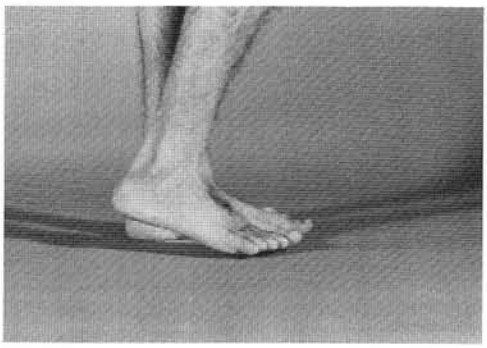

Figure 3F. Postoperative swing phase lateral clinical presentation. (supplemental case)

Subtype 4

This presentation of Type II pes cavus is the most challenging to surgically correct, as it is rigid in all three levels of preoperative testing. Preoperative calcaneal stance is in varus and does not reduce on the Coleman block test. Postoperatively, a rectus heel is only achieved following Dwyer calcaneal osteotomy. Preoperative and postoperative sagittal plane views show reduction of the longitudinal arch with first metatarsal dorsiflexory osteotomy and digital release and stabilization. Preoperative and one year postoperative radiographs demonstrate structural re-alignment through multi-level correction.

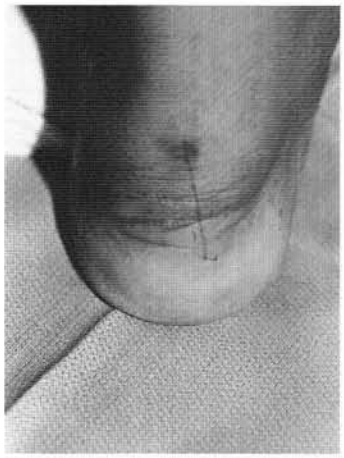

Figure 4A. Preoperative Coleman block test.

Figure 4B. One year postoperative rectus heel.

Figure 4C. Preoperative medial stance.

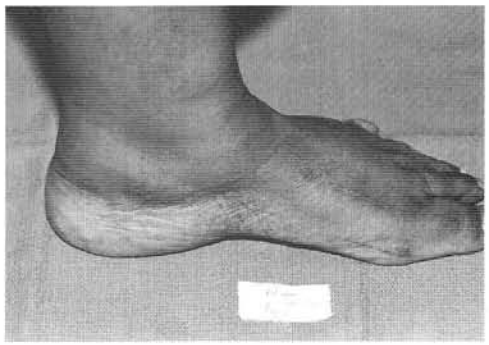

Figure 4D. One year postoperative medial stance position.

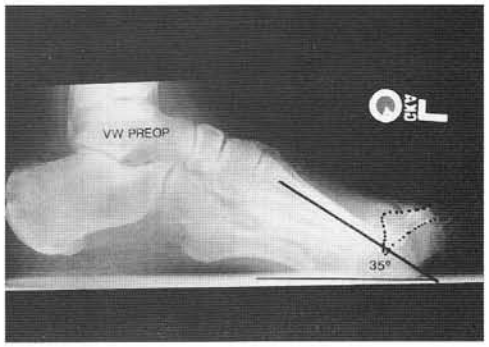

Figure 4E. Preoperative lateral radiograph.

Figure 4F. One year postoperative lateral radiograph.

Subtype 5

This presentation of Type II pes cavus shows flexibility in the first ray that is not appreciated until surgical release of the MTP contracture is performed. The metatarsal is not plantarflexed rigidly, but is "locked"in plantar flexion behind a clinically non-reducible hallux hammertoe deformity. Surgical correction is directed at the digital contractures and rearfoot varus, not the first ray position. Preoperative varus stance position of the calcaneus is evident. Postoperative reduction is noted following Dwyer calcaneal osteotomy in the frontal plane. Preoperative vs. postoperative sagittal plane reduction in longitudinal arch is apparent with only digital release and no first metatarsal osteotomy. The preoperative and postoperative radiographs show how the Dwyer calcaneal osteotomy is a frontal plane correction and little correlation to the sagittal plane radiographic calcaneal inclination angle is noted in this particular case.

Figure 5A. Preoperative heel varus position.

Figure 5B. One year postoperative rectus heel.

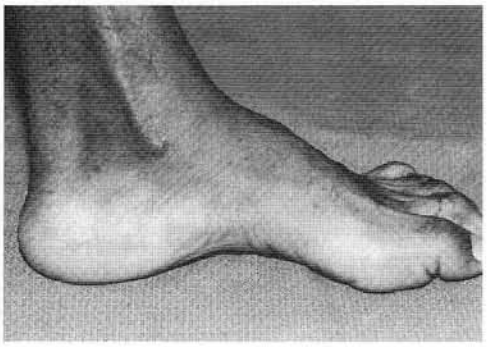

Figure 5C. Preoperative medial stance position.

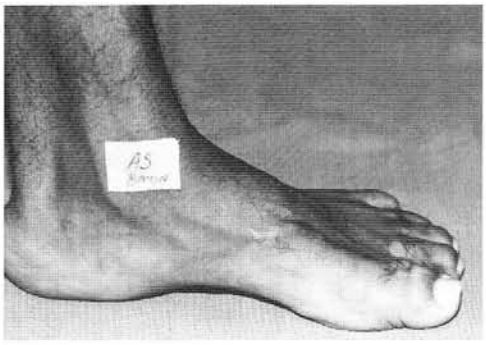

Figure 5D. One year postoperative medial stance position.

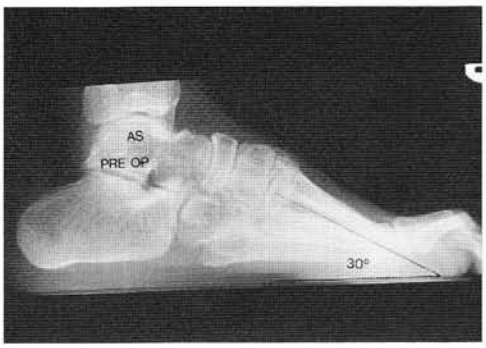

Figure 5E. Preoperative lateral radiograph.

Figure 5F. One year postoperative lateral radiograph.

Classic Presentation, Stage II

This clinical case is the classic biomechanical pes cavus with rigid plantarflexion of the first ray, varus of the calcaneus, and little digital deformity. Reduction in preoperative rearfoot deformity with no reduction in Coleman block testing, as well as rigid plantar flexion of the first ray, both requiring osteotomy, is noted. Postoperative radiographs show good reduction of the deformity. Frontal plane foot pathology of Type II pes cavus, as well as appreciation of painful lesions, is poorly noted on standard sagittal plane lateral weight-bearing foot radiographs.

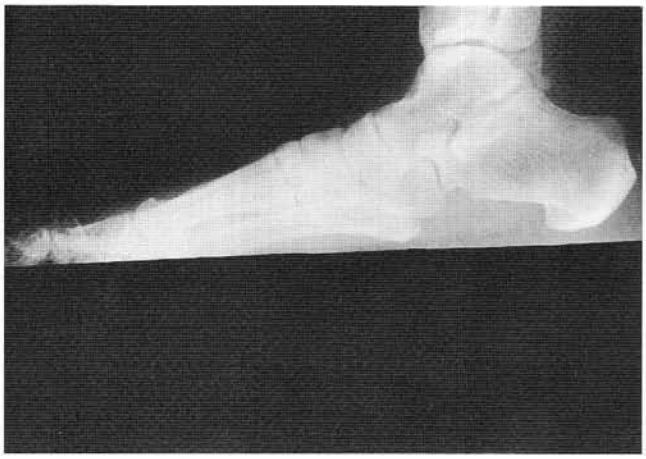

Figure 6A. Preoperative lateral radiograph.

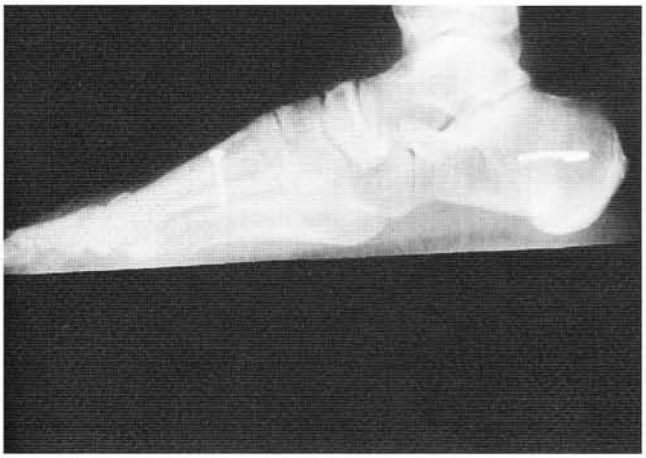

Figure 6C. Postoperative lateral radiograph.

Figure 6B. Preoperative anterior-posterior radiograph.

Figure 6D. Two year postoperative anterior-posterior radiograph.

CONCLUSION

Pes cavus is a complex deformity of the foot. Many varying clinical presentations are possible. Three basic surgical approach procedural combinations are possible. To define pes cavus and break it down into these three basic types based on correction options helps in the understanding of the surgical approach to pes cavus.

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