Problems in Family Practice

Common Foot Deformities in Infancy and Childhood

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The evaluation and management of common foot disorders are presented. In addition to the routine history and physical examination, analysis of x-rays of the foot in the weight-bearing position is vital. A method of interpreting these x-rays is presented. The emphasis of the paper is upon distinguishing conditions requiring surgical management from those readily treated in the office. The office management of the latter deformities is presented in detail.

The family physician daily sees infants and youngsters with foot disorders. Whereas some conditions need prolonged or involved orthopedic management, many require simple therapeutic measures readily initiated in the office. The practitioner who appreciates the basic rudiments of foot disorders – for instance, whether in-toeing is due to intrinsic deformities of the foot or to torsional malalignment of the lower extremities – is able to reassure the patient's family and see that appropriate management is initiated promptly.

This paper will attempt to assist the physician in undertaking the evaluation of common foot disorders. An important diagnostic aid in evaluation of the foot is the interpretation of weight-bearing x-rays of the foot. This radiographic analysis will be presented initially, followed by a review of the more common foot disorders. The paper is not meant to be an exhaustive treatise of orthopedic foot disorders; my purpose is to cover the more common conditions seen in the busy practitioner's office.

Clinical Examination

Prior to examining the patient a detailed history is obtained. It is necessary to know how long the foot deformity has been present, whether it is progressive or resolving, and if any associated sensory or motor deficit has been noted. If the youngster is old enough to walk, then the child's or the parent's impression of the effect of weight-bearing on the foot deformity is important. Also of interest is the presence of this or similar deformities in other members of the family.

Having obtained this information one proceeds to the physical examination. Examination of the feet must include an examination of the entire lower extremities and the spine. Ideally, the person should be examined in diapers or shorts so that the extremities and spine can be observed. See whether he stands normally with the spine straight and the pelvis level. One should palpate the spine for any defects of the spinous processes and then observe spine motion to see that it is free and supple. The examiner should place his hands upon the iliac crests to determine that the pelvis is level and that the legs are equal in length. Next, examine the hips and knees to determine that full motion and strength are present. Following this, the patient, assuming he is a walker, is then asked to walk in his normal manner. In this way the examiner can determine the effect of the foot deformity upon his gait.

The examiner then proceeds to a specific evaluation of the feet. They are first examined in the weight-bearing position. At that time, one can determine whether the longitudinal arch is present, whether the heel is in proper alignment, and what the effect of weight-bearing is on the alignment of the forefoot to the hindfoot. Additionally, one notes the alignment of the entire foot to the midline axis of the body. The foot is then examined in the nonweight-bearing position. Note whether any deformities are fixed or supple. For instance, fixed flatfoot deformities of the foot will persist in the nonweight-bearing position, whereas flexible flatfoot conditions will disappear in the nonweight-bearing position and an arch will be noted. Motion at the ankle (the tibial-talar joint), subtalar (the talo-calcaneal joint), and the midtarsal (the combined talonavicular and calcaneal-cuboid joint) and forefoot joints is then evaluated. This must include both passive and active motion. Any fixed deformities – that is, limitation of passive motion – should be noted. Active motion is essential in determining that all muscle groups are present. In neuromuscular disorders producing foot deformities, the examiner must perform a complete muscle examination of all muscle groups in the foot. Each muscle being tested must actively contract, initially moving the bone or joint against gravity and then moving the bone or joint against increasing resistance. Thus, the muscle's presence and its strength are assessed. A thorough sensory examination likewise is necessary. Lastly, the examiner should observe the plantar surface of the foot for callosities or other signs of abnormal pressure; the toes and dorsal surfaces of the feet likewise may show corns and other signs of pressure from overlying shoewear.

Radiographic Evaluation

In addition to a careful clinical examination, accurate radiographic studies of the feet are an essential requirement in delineating foot disorders.[1] For this, x-rays with the child in the weight-bearing position in both the A-P and lateral position are essential. The necessary films are easily secured in those subjects old enough to stand, and consist of A-P and lateral views of both feet and ankles taken in the weight-bearing position.

Radiographs can be obtained even with very young infants by either taping the feet to the radiographic

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cassette, or by a parent or assistant holding the lower extremities in this simulated "weight-bearing" position. The radiologist can be helpful in positioning the child to obtain the necessary views.

Radiographs in the A-P projection (Figure 1) of the normal foot show that the midtalar line (a line drawn through the long axis of the talus) projects anteriorly through the longitudinal axis of the first metatarsal; the midcalcaneal line (a line drawn through the long axis of the calcaneus) projects anteriorly through the longitudinal axis of the fourth metatarsal. The angle formed by the midtalar and midcalcaneal line is referred to as the A-P talocalcaneal angle and varies between 15 to 35 degrees.

Similar axes should be determined with the lateral projection (Figure 2). The midtalar line (a line through the long axis of the talus) projects anteriorly through the midline of the first metatarsal to form a straight line. The angle formed by the midtalar line and the calcaneal line (a line through the long axis of the calcaneus) is the lateral talocalcaneal angle and varies between 15 to 35 degrees. Additionally, the angle formed by the midshaft axis of the tibia and the midcalcaneal line in the lateral projection is normally 20 degrees of dorsiflexion.

Let us apply this analysis to several of the basic foot deformities. Hindfoot varus deformities (inversion at the subtalar joint, which is an angular and rotational deformity along multiple axes at the subtalar joint) produce a very typical radiographic pattern. The A-P projection (Figure 3a) will show a reduced (less than ten degrees) talocalcaneal angle with the midtalar line projecting far lateral (in the region of the third or fourth metatarsal) to the first metatarsal. The lateral projection (Figure 3b) likewise shows a greatly reduced talocalcaneal angle, with the midtalar line projecting far superior to the metatarsals. Additionally, the forefoot is adducted and inverted, deformities readily visualized on the x-rays (Figure 4).

Hindfoot valgus (eversion at the subtalar joint, which is combined angular and rotational deformity along several axes of the subtalar joint) likewise produces very typical radiographs which contrast with the varus deformity. Here the A-P radiograph (Figure 5a) shows a greatly increased talocalcaneal angle in the weight-bearing position, with the midtalar line projecting far medial to the first metatarsal. Furthermore, there is a greatly increased talocalcaneal angle in the lateral radiograph (Figure 5b), with the anterior aspect of the talus medial to the os calcis. The anterior projection of the midtalar axis points to the floor, far below the first metatarsal; the midtalar and first metatarsal axes, rather than forming a straight line as in the normal foot, show a distinct break or sag, usually at the talonavicular joint. Additionally, the forefoot appears to be laterally angulated (abducted) and everted, features that can be appreciated on the x-rays.

Let us consider one additional deformity, metatarsus adductus. Here the hindfoot has normal talar-calcaneal relationships, but the forefoot is adducted (angulated toward the midline of the body) in relation to the longitudinal axis of the foot (Figure 6).

Congenital and Developmental Deformities of the Feet

Common foot deformities, of both congenital and developmental origin, will be reviewed on an individual basis. While some of these are present at birth,[2] others develop at later stages of growth.

First, a word on terminology. Talipes is derived from the Latin *talus* (ankle bone) and *pes* (foot) and is the generic term used for foot deformities of congenital origin. Terms designating acquired deformities of the foot are preceded by the word *pes*. The primary deformities of the foot and ankle can be described as follows (Table 1): *varus* – the heel is inverted (adduction and rotational deformities at the talocalcaneal joint) and the forefoot is inverted (adducted and supinated); *valgus* – the heel is everted (abduction and rotational deformity) and the forefoot is everted (abducted and pronated); *equinus* – the foot is plantarflexed at the ankle joint; *calcaneus* – the foot is dorsiflexed at the ankle joint, with the heel at a lower level than the toes. Many combinations of these deformities can exist. The forefoot can have both angular deformity in two planes as well as rotational deformity along its long axis. Supination is inward rotation and pronation is outward rotation along the long axis of the foot.

Congenital Clubfoot (Talipes Equinovarus)

In talipes equinovarus, the forefoot is adducted and inverted (and also internally rotated on its long axis, or in supination), the hindfoot is likewise in varus, and the entire foot is plantarflexed. Although a strong familial tendency exists, its exact genetic pattern has yet to be established.[3] It is distinctly more common in males than females. It can be viewed as an in utero failure of the normal development of soft tissues and muscles of the legs and feet, with the feet never achieving their normal in utero movements. The result is a very severely contracted and deformed foot with deficient leg musculature.

Congenital clubfoot must be diagnosed at birth. Treatment will vary greatly depending upon the severity of the condition. This is one deformity that should be followed by an orthopedic surgeon. A series of plaster casts, reapplied at weekly or biweekly intervals, is usually the first step in correcting the various deformities of a clubfoot. The rationale of serial corrective plaster casts is that the soft tissues producing the deformity are gradually stretched so that the bones can assume their normal alignment. Bones grow in response to the stress applied to them; without proper alignment, their subsequent growth will be abnormal. This is the thesis behind the early correction of all foot deformities. Moreover, although the soft tissues are con-

Table 1: Major Foot Positions and Deformities

Joint	Motion	Deformity
Ankle	Plantarflexion	Equinus
	Dorsiflexion	Calcaneus
Subtalar (Talo-calcaneal joint)	Inversion (adduction and rotation)	Hindfoot varus
	Eversion (abduction and rotation)	Hindfoot valgus
Midtarsal (Talo-navicular and calcaneal-cuboid joints)	Plantarflexion	Cavus
	Dorsiflexion	Planus
	Lateral rotation	Supination
	Medial rotation	Pronation
	Abduction	Abductus
	Adduction	Adductus

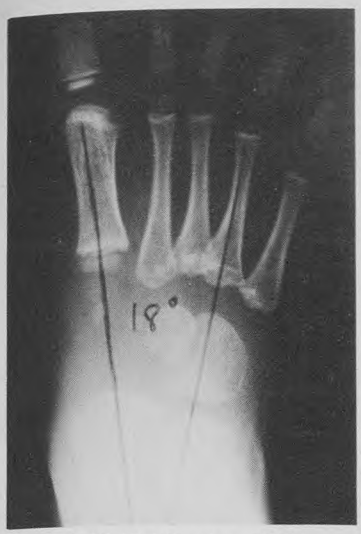

Figure 1. Weight-Bearing AP View of Normal Foot
The anterior projection of the midtalar line runs through the first metatarsal, and the anterior projection of the midcalcaneal line extends through the fourth metatarsal. The angle they form is normally 15-35 degrees (TC angle).

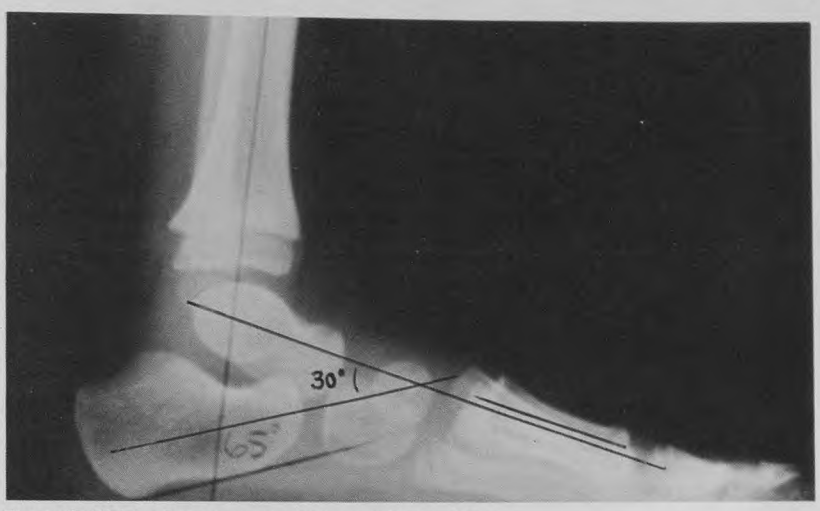

Figure 2. Weight-Bearing Lateral View of Normal Foot
Note how the anterior projection of the midtalar line extends through the first metatarsal, and that the midtalar and first metatarsal lines are colinear. Likewise, the midcalcaneal line bisects the midtalar line to form an angle of 15-35 degrees (the lateral TC angle).

tracted and tight, they become only more contracted with time. Assuming that the deformities of a clubfoot can be fully corrected by a series of plaster casts, the youngster's foot then requires special shoes with a bar interconnecting them (Denis-Browne bar) to hold the feet abducted, dorsiflexed and externally rotated. This device is used to maintain, not obtain, correction of the foot deformity. Once the youngster is standing, he is placed in special shoes with an outflare last, outer heel wedge, and a short leg brace with an equinus stop, a device preventing the ankle from drifting into plantarflexion.

Should serial plaster casts not attain full correction or should a recurrence of the deformity develop, then release of the contracted medial and posterior structures of the foot is necessary. This includes transection of the multiple joint capsules and ligaments and lengthening the contracted tendons, such as the tendo Achilles.[4] Limited bony resections can likewise be performed.[5] Tendon transfers to restore muscle balance about the foot are an adjunctive form of treatment and usually are not done until one is certain that bony deformities will not recur.

Late treatment, for deformity existing at 12 years of age or more, is directed more at realigning the foot by bony reconstructive procedures rather than by further soft tissue procedures. By this age the abnormal bone development has occurred, and one can hope to restore proper alignment of the foot only by resecting portions of the bones. Here one is really eliminating the multiple joints of the hindfoot by fusing the four major bones of the hindfoot into one mass which has a normal appearance. Tendon transfers at this time will improve the muscle balance of the foot. Observation until skeletal maturity is attained is necessary to see that the deformity does not recur.[6]

Metatarsus Adductus

In this deformity of the forefoot, all five metatarsals are adducted (medially angulated toward the midline of the body) in relation to the long axis of the hindfoot. The cause is probably environmental (ie, intrauterine positioning), although a familial incidence is observed. Metatarsus adductus can be readily diagnosed in the early neonatal period, usually without the necessity of radiographs.

Treatment will vary with the severity of the adduction deformity. Initially, abduction stretching exercises of the forefoot (stretching the forefoot lateral to the midaxis of the foot) will be sufficient. Occasionally, serial plaster castings to bring the forefoot out of adduction and into greater amounts of abduction are necessary, with the casts changed at weekly or biweekly intervals to gain greater correction at each cast change. Once full correction has been attained, the youngster is held in a straight last shoe for one to two years. It is important to perform repeat examinations at three to six-month intervals to see that recurrence does not take place.

Flat Feet (Pes Planus, Pes Planovalgus, or Pronated Feet)

This much less serious condition usually has a favorable outcome. Here we see essentially a laxity of all the soft tissues of the foot. On examination one notes a collapse of the longitudinal arch of the foot and rounding of the medial border of the foot, with the heel either in neutral position or in slight valgus. Additionally, the forefoot is usually abducted, everted, and pronated. Whereas the deformity is present in the weight-bearing position, there is no deformity in the non-weight-bearing position, and supple motion is present at the subtalar and midtarsal joints. This distinguishes a simple flatfoot from the more severe foot deformities, such as peroneal spastic flatfoot due to tarsal coalition or vertical talus. Radiographic evaluation of pes planus was presented earlier.

One additional word of caution. Infants normally have a plantar fat pad which fills and obliterates the longitudinal arch. This fat pad persists until age three, eliminated by the more forceful ambulation established by that age. Thus, it is difficult to distin-

Figure 3a. Weight-Bearing AP View of Varus Foot Deformity
Note how the TC angle is markedly reduced, that the anterior projection of the midtalar line is well to the lateral side of the foot, and that the forefoot is adducted in relation to the hindfoot.

Figure 3b. Weight-Bearing Lateral View of Varus Foot Deformity
Note how the lateral TC angle is markedly reduced in degree and that the anterior projection of the midtalar line passes superiorly to the metatarsals. Additionally, the forefoot is inwardly rotated or supinated.

guish the "physiologic" flatfoot from a true flatfoot due to a collapse of the longitudinal arch in a youngster under three years of age. Palpation of the bones of the hindfoot in the weight-bearing position may distinguish the two conditions; a valgus alignment of the heel certainly suggests true flatfoot or pes planovalgus deformity. Infants with a "physiologic" fat pad suggesting a pes planus need merely to be observed at yearly intervals.

This condition is readily managed in the office. The less severe forms – those in which the hindfoot or heel is not in excessive valgus – can be treated with Oxford shoes containing a Thomas heel (a heel containing a medial heel wedge and a longitudinal extension of the medial half of the heel), a medial extension of the heel counter of the shoe, and a longitudinal arch support (scaphoid "cookie"). Milder forms respond well to simply an arch support in a regular Oxford shoe, much less costly for the family. Remembering that bones develop in response to the stress applied to them, the assumption is that by supporting them in the more normal position the bones of the foot will thus develop normally. It is doubtful, however, that the shoes overcome the basic ligamentous laxity of the foot.

More severe cases of flat feet, those in which the heel is in significant valgus, may need surgical procedures at about age five or six in order to restore and maintain the proper alignment of the talus and the os calcis so that they may subsequently develop in a more normal manner; the usual procedure for this is an extra-articular bone graft at the subtalar joint stabilizing the talus and os calcis in the normal position, a procedure which does not interfere with subsequent growth and development of either bone.

Vertical Talus (Congenital Convex Valgus, Congenital "Rocker-bottom" Foot)

This condition is initially confused with flat feet because of the rounded position of the medial border of the foot and the rounded position of the plantar surface of the foot. On closer inspection, however, one realizes that the problem is more complex. This is a very severe congenital deformity of the foot in which there is a primary dislocation of the talonavicular joint, with the navicular articulating with the dorsal aspect of the talus, locking it in a plantarflexed or vertical position. The forefoot is dislocated dorsally in relation to the hindfoot. Additionally, the os calcis is markedly plantarflexed. (Figure 7) Because of the plantarflexed position of the os calcis and the talus, with the forefoot dorsiflexed in relation to the two bones of the hindfoot, a very distinct "rocker-bottom" deformity of the arch of the foot results.

This very severe deformity should be diagnosed promptly. It requires the management of an orthopedic surgeon skilled in the care and treatment of this very rare deformity, for multiple staged surgical procedures are necessary.

Tarsal Coalition

Varying degrees of union are present between two or more tarsal bones in this congenital abnormality producing a rigid planovalgus foot. Whereas simple flatfoot deformity will appear normal in the nonweight-bearing position and will allow motion at the subtalar and midtarsal joints, in tarsal coalition there is no change in appearance from the weight-bearing to the nonweight-bearing position and there is no subtalar or midtarsal joint motion. The exact cause of tarsal coalition is unknown, but appears to represent a failure of differentiation and segmentation of the primary mesenchyme, with resultant incomplete bone and joint development. The coalition may be completely osseous, cartilaginous, or fibrous, with involvement including any of the bones of the hindfoot in varying degrees and combinations.

As occasionally there are no symptoms, it is only during a careful evaluation of a suspected flatfoot deformity that the true nature of the deformity is apparent. Usually, however, the child will give a history of

difficulty of running on rough ground because of the absence of any hindfoot motion which usually accommodates for the variation in the ground surface. Moreover, there will be a history of frequent "ankle sprains," which in actual fact are very mild strains of the ankle joints and are the result of the added stress placed on the ankle joint because of the absence of hindfoot motion. Radiographically, an oblique x-ray of the hindfoot in the nonweight-bearing position will usually demonstrate or suggest the tarsal coalition; laminography is occasionally necessary to delineate the deformity fully.[7]

Treatment varies with the severity of the symptoms. In the very mild cases no specific treatment will be necessary. Occasionally, where the coalition is rather limited, resection of the fibrous or bony bridge can be accomplished. In a significant number of cases triple arthrodesis of the hindfoot (fusion of the four bones of the hindfoot) will be required.

Pes Cavus

Pes cavus is a fixed equinus (plantarflexion) deformity of the forefoot in relation to the hindfoot. If clawing of the toes is associated, the term claw foot is sometimes used to describe the condition. Cavus deformity is usually a manifestation of some underlying neuromuscular disease, although some cases of pes cavus are congenital and have no detectable neuromuscular deficit. The neuromuscular defect may lie anywhere from the cerebellum to the spinal column, to the anterior horn cells or peripheral nerves, or to the muscles. The result is a muscle imbalance between the forefoot dorsiflexors and plantarflexors, with the latter being relatively stronger than the dorsiflexors. Because of the continued imbalance, contractures of the soft tissue structures, such as the plantar fascia of the foot, ultimately develop to give a fixed deformity. Clinically, the youngster's foot presents with a high arch. The additional neuromuscular findings will depend on the particular etiology, with the claw toe deformity likewise a result of the muscle imbalance. Again, congenital pes cavus does not show a neuromuscular deficit.

Radiographically, a weight-bearing lateral view of the foot will demonstrate the exaggerated high arch position; one should realize that the bones of the hindfoot are in proper relationship to the tibia and that the forefoot bones, beginning at the midtarsal joint, are markedly plantarflexed in relation to the bones of the hindfoot.

Figure 4. Weight-Bearing AP Projection of a Varus (Left) and of a Normal (Right) Foot This x-ray graphically illustrates the reduced TC angle in the varus foot, with the midtalar axis projecting to the lateral aspect of the foot (or in reality, that the forefoot is adducted and supinated in relation to the hindfoot).

Once the initial diagnosis is made, further work-up is vital in order to fully delineate the cause of the cavus deformity. If there is any suggestion of a neuromuscular lesion, then the precise site of this deficit must be established by a careful neurologic work-up, which may require diagnostic studies such as electromyography, special x-rays of the spine including myelography, muscle biopsy, and serum enzyme studies of muscle function.

Ultimately, an orthopedic surgeon can restore the alignment of the forefoot by surgical resection of the contracted structures and by tendon transfers to restore forefoot dorsiflexors, but the critical issue is to establish the proper diagnosis. Prior to initiating orthopedic treatment, one must know whether the condition is static or whether it is a progressive neuromuscular disorder in which further muscle weakness and imbalance can be expected.

The usual complaint of the individual with congenital or idiopathic cavus deformity of the foot is that of increased pain along the metatarsal heads because of the excessive obliquity of the metatarsals, producing the symptoms of metatarsalgia. This can be treated with a metatarsal or Jones bar, which is applied by an orthopedic shoemaker, to relieve the pressure from the metatarsal heads. Occasionally arch supports or a metatarsal pad will likewise provide some symptomatic relief.

Hallux Valgus and Bunion Deformity

These terms are commonly used synonymously, although they refer to different elements of the same syndrome – lateral deviation of the great toe at the metatarsalphalangeal joint

Figure 5a. Weight-Bearing AP Projection of Valgus Foot Deformity
Note that the TC angle is markedly increased, that the anterior projection of the midtalar line extends medial to the forefoot, and that the forefoot is abducted in relation to the hindfoot.

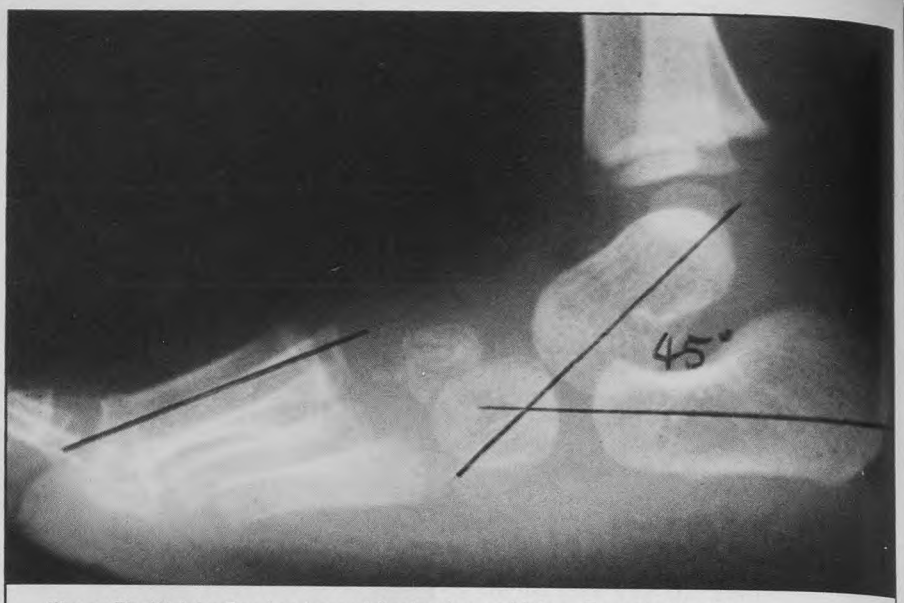

Figure 5b. Weight-Bearing Lateral Projection of Valgus Foot Deformity
Note that the lateral TC angle is greatly increased and that the anterior projection of the midtalar line extends plantarward to the first metatarsal with these two lines no longer colinear, causing a sag in the longitudinal axis.

and medial prominence of the first metatarsal head with its overlying acquired bursa. Frequently, particularly in the pediatric age group, secondary deformities are a progressively increasing problem. Frequently the bunion and hallux valgus are secondary or acquired deformities due to a medially (toward midline of the body) directed first metatarsal (called metatarsus primus varus).

Examination reveals a widened forefoot with a suggestion that the first metatarsal is more medially directed than normal, unusual prominence of the medial aspect of the first metatarsal head with or without an overlying acquired bursa, and the great toe in valgus (directed toward the lateral aspect of the foot). Ultimately the great toe can be in such increased valgus that it is overlapped by the second toe (which can then develop a hammertoe deformity). The skin overlying the bursa may be reddened and inflamed depending on the pressure from the overlying footwear. The secondary deformities progressively increase with time.

Treatment will vary with the severity of the condition and the severity of the symptoms. Initially, just the use of adequately wide shoes will suffice, something readily available with the current practical shoe styles. Most shoe repair shops have a device called a bunion stretcher, with which they can literally stretch out the leather overlying the metatarsal head to provide greater relief from the shoe.

If there is significant deformity, and particularly if the first metatarsal is in varus, then surgical correction of this deformity is necessary. Not only does this eliminate the progressive secondary deformities, thereby relieving the symptoms, but the treatment is directed to the cause of the deformity – the first metatarsal. Here one restores the normal alignment of the first metatarsal, as well as eliminating the bunion and realigning the great toe.

Hammertoe Deformity

Hammertoe is a deformity characterized by contractures of the proximal interphalangeal joint. The distal interphalangeal joint may be in

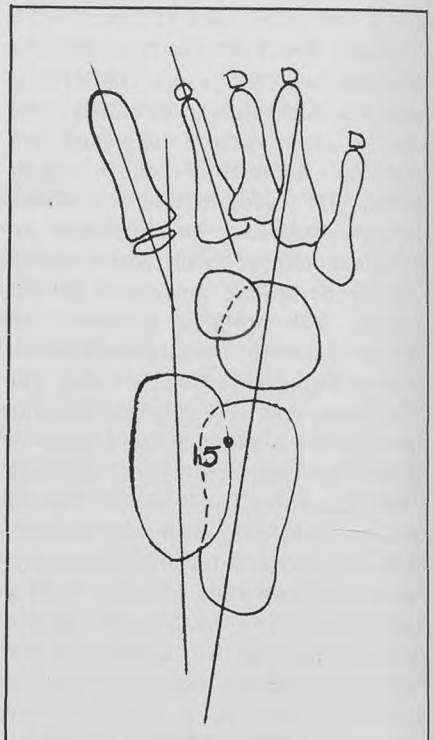

Figure 6. Diagram of AP Projection of Metatarsus Adductus
Note the adduction of the forefoot (metatarsals) in relation to the hindfoot, which has a normal TC angle.

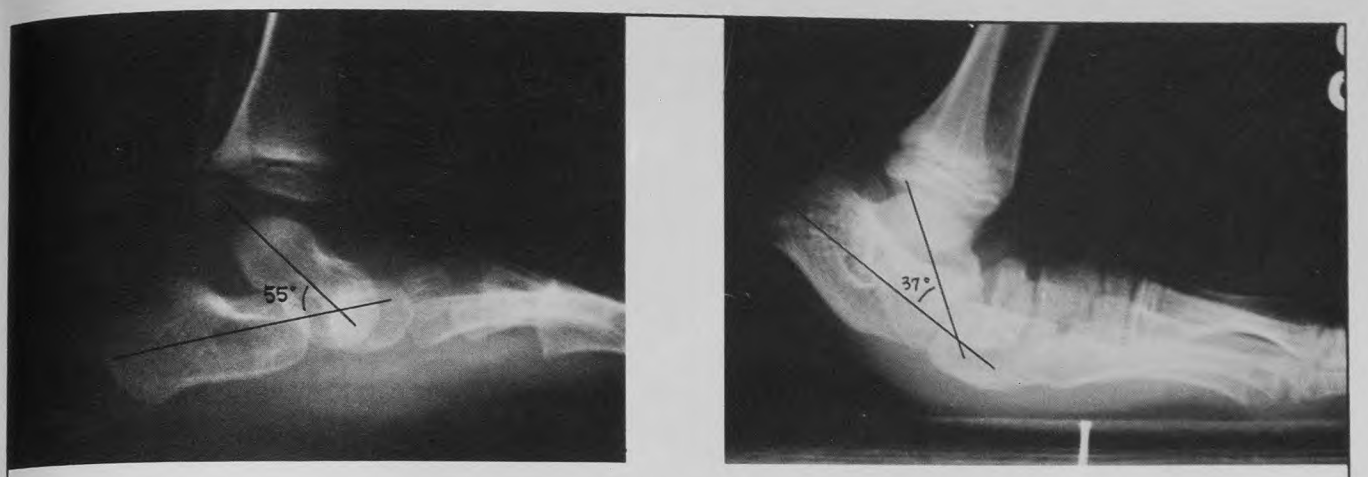

Figure 7. Weight-Bearing Lateral Projections of Two Examples of a Vertical Talus Foot Deformity
Note the vertical incline of the talus with the marked increase in the TC angle and complete disruption of the line formed by the midtalar and the first metatarsal axes. The film on the right further shows that the heel, as illustrated by the os calcis, is in marked equinus (plantarflexion).

flexion, neutral, or slight hyperextension. Ultimately, the metatarsalphalangeal joint becomes hyperextended. Hammertoe is often bilateral and symmetrical, with the second toe most frequently affected and much less frequently the third and fourth toes. The deformity is usually congenital, and there is a very high familial incidence.

Symptoms are produced at two sites, the PIP joint and the metatarsal heads. Painful callosities develop under the metatarsal heads due to the distortion of the toe with its loss of assistance in toe push-off to relieve pressure from the metatarsal heads. Additionally, a painful corn develops over the dorsal aspect of the PIP joint as a result of pressure from overlying footwear.

Infants and children with hammertoe can be treated conservatively by passive stretching exercises or perhaps with adhesive tape strapping, fastened to the neighboring two toes, to hold the proximal interphalangeal joint in the extended position. In the adolescent, if the deformity is severe and disabling, surgical correction is indicated. A very satisfactory method of treatment is resection of and fusion of the proximal interphalangeal joint in neutral position.

Claw Toes

In contrast to hammertoe deformity, clawing of the toes is characterized by hyperextension of the metatarsalphalangeal joint and flexion of both the proximal and distal interphalangeal joints. Additionally, rather than being an idiopathic condition, the deformity usually is secondary to pes cavus or to a neuromuscular deficit. Thus, it is important to distinguish it from hammertoe deformity, for clawing is a much more serious condition. Consequently, a more extensive workup to rule out a neuromuscular disorder is required. Treatment, naturally, will vary with the particular cause of the clawing.

Closing Comment

The deformities described above are the more common ones seen in the busy practitioner's office. The family physician appreciating these conditions can more effectively initiate their prompt and appropriate treatment.

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