# SKEWFOOT

**Alfred J. Phillips, D.P.M.**
**E. Dalton McGlamry, D.P.M.**

## INTRODUCTION

*Skewfoot* describes a metatarsus adductus foot-type with a pathologic rearfoot valgus component. The metatarsals are in an adductus position; the midfoot is abducted; and the rearfoot is in a pronated position. This forms a *Z* configuration (Fig. 1) which can be readily observed radiologically and appreciated clinically.

The term skewfoot was first coined in 1949 by Blount and McCormick who described three cases (1). The literature has described the deformity as Z foot, *Serpentine* foot, *S-shaped* foot, metatarsus adducto varus, contracture of the metatarsals, and congenital metatarsus varus (2). The etiology of the skewfoot deformity is varied. A few cases in the literature have been described as congenital in origin. This describes a metatarsus adductus foot-type with a congenital calcaneovalgus (3).

A good percentage of the cases reported have occurred after serial casting of the metatarsus adductus deformity in which the rearfoot was in a pronated position (2,4). This only emphasizes the need to keep the rearfoot in a neutral or a slightly supinated and equinus position during serial casting.

Another etiology is the untreated metatarsus adductus which has compensated by excessive subtalar joint pronation. These patients usually present with the chief complaints of deformities stemming from a collapsing pes valgo planus deformity. However, with careful examination or occasionally after surgical intervention to correct pes valgus the metatarsus adductus deformity is unmasked.

Literature describes successful treatment of this deformity (5) It has not been complete in addressing surgical intervention of the skewfoot deformity. Correction can be a very challenging and rewarding surgery and deserves discussion. The surgeon must be able to recognize the components of this deformity and apply the appropriate surgical procedures. This will be discussed along with case history presentations to illustrate preoperative and intraoperative decision making.

## CLINICAL EVALUATION

Clinically, the skewfoot deformity has components of metatarsus adductus and collapsing pes valgo planus. The metatarsals will be medially angulated. The base of the fifth metatarsal is prominent. An abnormally large space between the hallux and the second digit is commonly observed. A metatarsus varus deformity is frequently noted. The digits are in an abducted position in stance.

The pes valgo planus components observed are as follows: talar bulging or ptosis, low medial arch, abducted midfoot position, internal rotation of the malleoli, and a variety of forefoot biomechanical pathologies. These clinical observations can be appreciated in Figures 2 A & B.

Biomechanical evaluation of the foot must be performed on the skewfoot deformity to obtain a better understanding of the etiology. The metatarsus adductus component is most commonly congenital in origin. The pes valgus component can also be congenital in origin as in calcaneal valgus, however, it can also be secondary to the metatarsus adductus or compensation for another deforming force.

Rearfoot equinus can cause a severe deforming force. Root reports that 10 degrees of ankle dorsiflexion is needed in normal ambulation (6). If 10 degrees is not available the subtalar joint will pronate excessively in order to obtain the needed motion. This will result in a strong subluxatory force to the midtarsal joint which will in turn render the foot unstable.

The etiology of rearfoot equinus needs to be determined. A stress ankle dorsiflexion x-ray can rule out an osseous ankle block. Gastrocnemius equinus and a gastrosoleus equinus is determined by dorsiflexing the foot on the ankle with knee extended and knee flexed respectively. If less than 10 degrees of dorsiflexion is observed equinus is a significant component of the deformity and needs to be addressed when considering surgical correction.

**Fig. 1.** X-ray denoting typical *Z* configuration of skewfoot deformity.

The surgeon must also be aware of other deforming forces such as internal tibial torsion, internal malleolar torsion, internal and external femoral position, medial hamstring tightness and ligamentous laxity. Any deforming force which causes medial shift during weightbearing can influence the surgical treatment.

## RADIOGRAPHIC EVALUATION

The skewfoot deformity can be readily evaluated radiologically. Berg's classification of metatarsus adductus deformities was performed solely by radiographic evaluation. He described four types of metatarsus adductus; simple metatarsus adductus, complex metatarsus adductus, simple skewfoot, and complex skewfoot (7).

Berg described simple skewfoot as an adducted forefoot with an abnormally pronated rearfoot. The complex skewfoot deformity includes the addition of an abducted midfoot (7).

Metatarsus adductus is best evaluated in the dorsoplantar view and diagnosed when the metatarsus adductus angle is greater than 21 degrees. The metadductus angle is the angle made by the intersection of two lines, one bisecting the second metatarsal and the other a perpendicular to the bisection of the midfoot (Fig. 3 A). Or one can use a bisection of the second cuneiform for the second line. If using the bisection of the cuneiform any angle greater than 24 degrees is considered pathologic (8). Berg identifies radiologic evidence of metatarsus adductus if the bisection of the first metatarsal lies medial to the bisection of the talus as seen in Figure 3B.

Midfoot abduction is evident primarily on the dorsoplanter view. An increased cuboid abduction angle (greater than 5 degrees) (Fig. 3C) and lateral deviation of

**Fig. 2. A.** Plantar view of skewfoot. Note medial angulation of metatarsals.

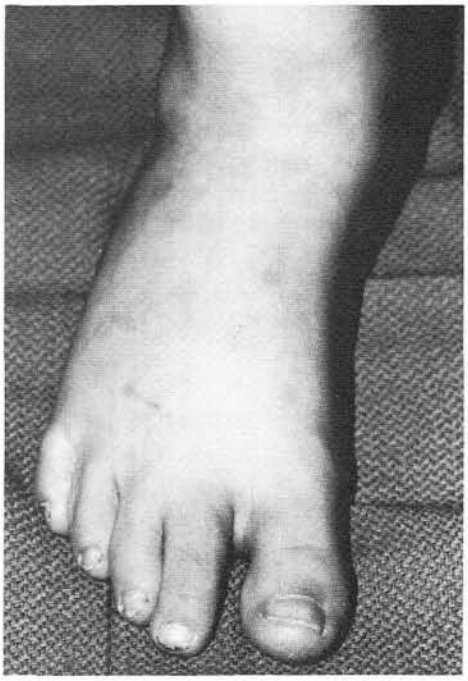

**Fig. 2. B.** Dorsal view of skewfoot. Note talar bulging and internal rotation of malleoli.

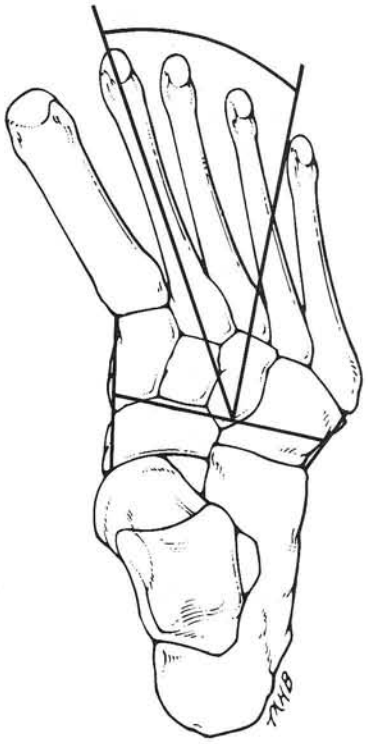

**Fig. 3. A.** Metatarsus adductus angle, angle formed by intersection of two lines, one bisecting second metatarsal and other representing line perpendicular to bisection of lesser tarsus.

the navicular on the talar head are noted. According to Berg the midfoot is abducted if the calcaneal parallel line lies in the medial one third of the cuboid or the base of the fourth metatarsal.

A valgus rearfoot is a triplane relationship and must be evaluated by a lateral and dorsoplantar view. A talocalcaneal angle greater than 35 degrees on the dorsoplantar view and 45 degrees on the lateral indicates a pronated rearfoot complex (Fig. 3 D, E). An anterior break of the Cyma Line, an increased cuboid abduction angle, less overlap of the lesser tarsus in the dorsoplantar view and increased overlap in the lateral view all are present in the pes valgus foot.

## INDICATIONS FOR SURGERY

Indications for surgery fall into one or more of the following categories:

-too old for correction by conservative means
-deformity is increasing despite conservative treatment
-deformity is obviously not manageable by conservative means
-deformity is beginning to cause secondary deformities

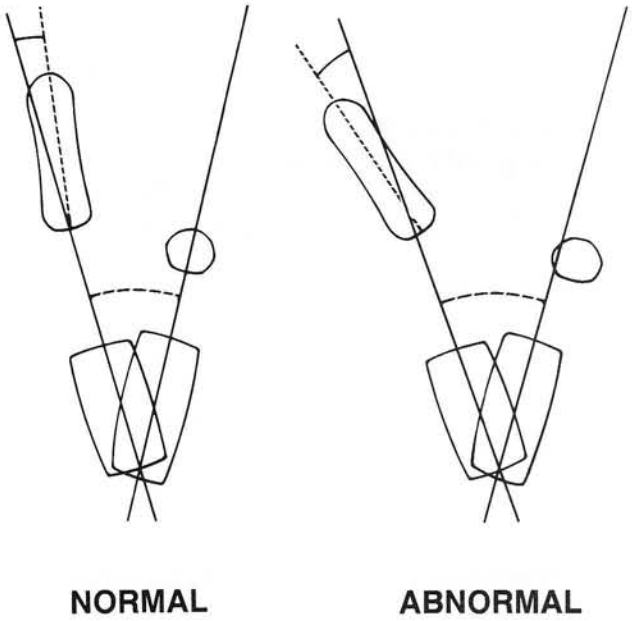


**Fig. 3. B.** Berg (8) identifies metatarsus adductus when bisection of first metatarsal lies medial to bisection of talus.

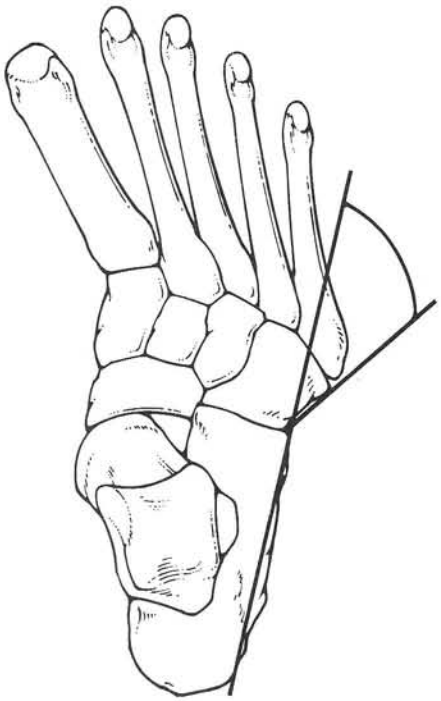

**Fig. 3. C.** Dorsoplantar view. Cuboid abduction angle, angle formed by bisection of lateral border of cuboid and lateral border of calcaneus.

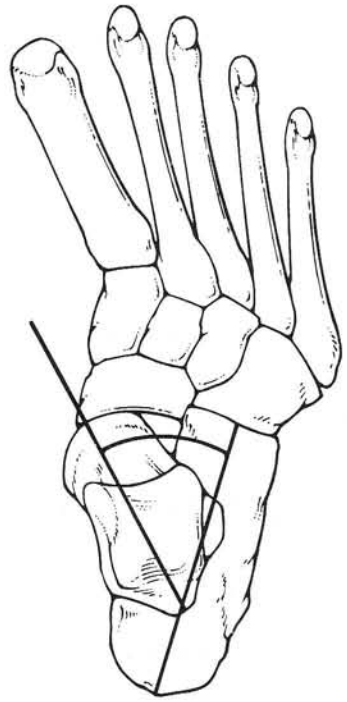

**Fig. 3. D.** Dorsoplantar view, talocalcaneal angle. Angle is formed by intersection of two lines, one representing bisection of head and neck of talus and other a line parallel to lateral border of calcaneus.

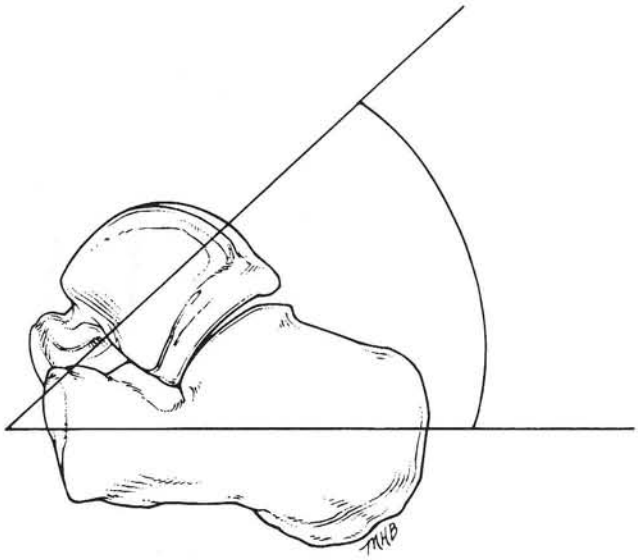

**Fig. 3. E.** Lateral view, talocalcaneal angle. Angle is formed by intersection of two lines, one representing bisection of head and neck of talus and second line representing calcaneal inclination axis.

-patient is experiencing painful compensation symptoms
-patient is accommodating life style because of related symptoms
-increasing difficulty with standard foot gear.

While one child may have fairly substantial postural strain symptoms, a second child may voice no complaints. In the one case the child may be very active and complain of leg and foot related strain after activities, while the second child may simply avoid activities. In still other instances the complaints may stem more from the parents who observe a very awkward gait or who are concerned that they cannot motivate the child to participate in physical activities. Often the real symptoms are only uncovered with knowledgeable questioning by the examiner.

## SURGICAL PROCEDURES

At the Podiatry Institute different surgical procedures have been used to correct the Skewfoot deformity. They have been used solely or in combination with other procedures. Often times the complexity of the deformity mandates that multiple procedures be employed.

*Equinus Correction*, as discussed previously in the clinical evaluation, equinus can be a tremendously deforming force. In order to prevent the recurrence of the pes valgus component of the deformity, equinus must be corrected if present.

*Gastrocnemius recession* is performed to correct gastrocnemius equinus. A distal tongue and groove recession is most commonly performed as described by Fulp and McGlamry (Fig. 4A, 4B) (9). A frontal plane *Z* lengthening at the level of the combined tendon is the most frequently performed tendo Achillis lengthening (5A. 5B). This is obviously performed for those deformities with gastrosoleus equinus. Figures 4A and 4B demonstrate these procedures.

*Collapsing pes valgo planus correction*. The most popular and effective procedures performed at the Podiatry Institute are the Evans calcaneal osteotomy and the medial arch tendosuspension.

*Evans opening calcaneal osteotomy* effectively lengthens the lateral column of the foot by the placement of bone graft into the lateral anterior aspect of the calcaneus just proximal to the calcaneocuboid joint. This indirectly realigns the midtarsal joint and in turn creates a more stable subtalar joint. This procedure is primarily performed in those patients in which there is principally a transverse plane deformity. This procedure will unmask a previously unappreciated metatarsus adductus

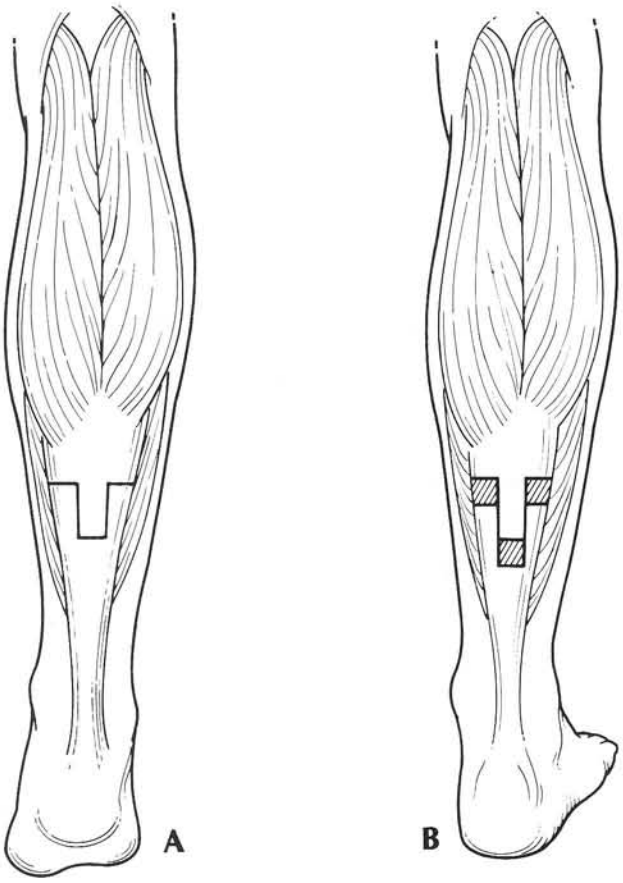


**Fig. 4. A, B.** Gastrocnemius recession.

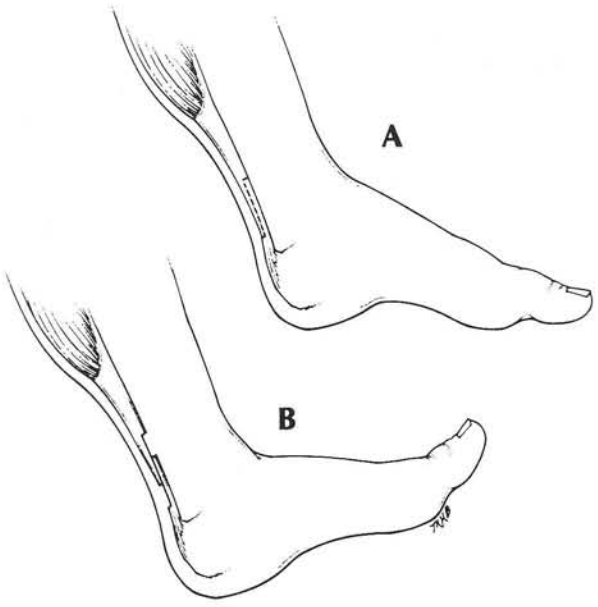


**Fig. 5. A, B.** Tendo Achillis frontal plane lengthening.

deformity. At times this may necessitate surgical correction of a metatarsus adductus that was not previously fully anticipated. The Evans procedure is demonstrated in Figures 6 A & B.

The *medial arch tendosuspension procedure* is performed when there is severe instability in the medial column. This procedure, a modification of the Young tendosuspension, involves the relocation of the tibialis anterior tendon through a notch in the navicular to help elevate the medial arch and plantarflex the first ray. The tibialis posterior tendon is advanced on itself and the spring ligament tightened. This corrects the deformity in the sagittal plane and creates stability in the medial column (Fig. 7A, 7B).

*Metatarsus adductus repair.* There are two common procedures performed at the Podiatry Institute: a modified Berman-Gartland procedure and the Lepird procedure. Both procedures are reviewed extensively elsewhere in this text. Both correct for metatarsus adductus by lesser metatarsal osteotomies which allow the metatarsals to be shifted in a lateral direction.

It should be emphasized that rearfoot pronation may also be secondary to metatarsus adductus. In cases where the rearfoot pronation is purely secondary to the forefoot problem, one may only need to correct the metatarsus adductus and to temporarily support the rearfoot. This, however, is only appropriate where there are no additional pronatory forces present. The difficulty is often in determining when rearfoot pronation is truly secondary to metatarsus adductus.

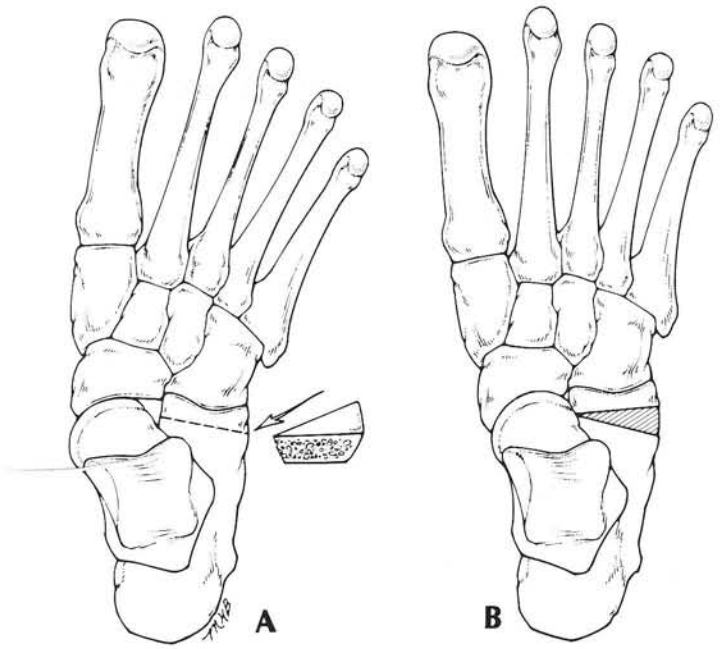


**Fig. 6. A.** Evans calcaneal osteotomy, preoperative plan.

**Fig. 6. B.** Evans calcaneal osteotomy, postoperative.

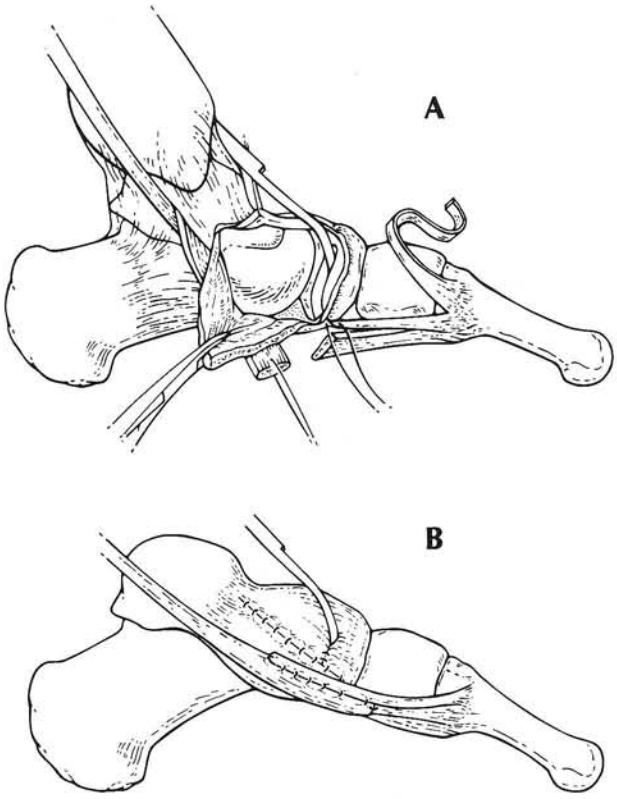


**Fig. 7. A, B.** Medial arch tendo-suspension procedure.

## CASE HISTORIES

The following case histories will illustrate the decision making process at Doctors Hospital when deciding on the correct surgical procedure. There are two common types of clinical scenarios. The first is a severe metatarsus adductus deformity with a mild pes valgus component and with no external pronatory forces acting on the rearfoot. The pes valgus deformity in this case is compensation for the metatarsus adductus deformity. In this situation the metatarsus adductus is corrected and the rearfoot valgus is controlled by conservative means (orthotic control).

The second scenario occurs when there is a mild metadductus deformity with a severe pes valgus deformity. The pes valgus deformity is usually compensation for a deforming force other than metatarsus adductus. This may be an equinus deformity or an uncorrected congenital calcaneovalgus deformity. It is often this type case that masks the presence of the forefoot deformity, simply because of the amount of abduction which is present at the midtarsal joint. It is these cases in the middle that make decision-making difficult. Depending on the severity of the deformity, the rearfoot deformity may be addressed with an Evans calcaneal osteotomy, a medial arch tendosuspension, and an Achilles lengthening procedure when appropriate.

### Case History I

This case involves metatarsus adductus repair and Evans calcaneal osteotomy (Figs. 8 A-D). A 9 year old caucasian male presented to Doctors Hospital for surgical correction of a painful pes valgus deformity. The patient's pain was described as dull aching and occurred at the medial arch and medial ankle. The deformity had been present for several years. It had, however, increased in severity over the previous year. The patient's pain was aggravated by standing and walking. Conservative measures had been unsuccessful in relieving the patient's pain.

The patient's lower extremity physical examination was significant for the following:

-0 degrees ankle dorsiflexion with knee extended and flexed bilaterally,
-mild crepitus noted upon range of motion of the midtarsal and subtalar joints bilaterally,
-medial angulation of metatarsals in relation to the lesser tarsal bones,
-abduction of forefoot at midtarsal joint,

In stance the rearfoot was maximally pronated with a positive Helbings' sign bilaterally.

X-ray evaluation revealed moderate metatarsus adductus deformity of 25 degrees and a severe collapsing pes valgo planus deformity with a 35 degree talocalcaneal angle on the dorsoplantar view and 40 degrees on the lateral view. The cuboid abduction was 25 degrees bilaterally.

Diagnosis of gastrosoleus equinus, metatarsus adductus deformity, and collapsing pes plano valgus was reached, all present bilaterally. These findings confirm the presence of skewfoot.

Surgical procedures performed included a frontal plane tendo Achillis lengthening, an Evans calcaneal osteotomy with allogeneic bone graft, and a Lepird procedure.

The Achilles tendon lengthening was obviously needed to correct the moderately severe gastrosoleus equinus. The Evans calcaneal osteotomy was chosen to correct the severe abduction at the midtarsal joint. It was determined that a medial arch tendosuspension would not likely be needed. The medial column of the forefoot seemed adequately stable. If later it is determined that more stability of the medial column is needed, a medial arch tendosuspension could still be performed. The metatarsus adductus was corrected by a Lepird procedure. Essentially, the same procedures were performed on the opposite foot at a subsequent time.

**Fig. 8. A.** Case History I, dorsoplantar preoperative radiograph.

**Fig. 8. C.** Postoperative dorsoplantar radiograph.

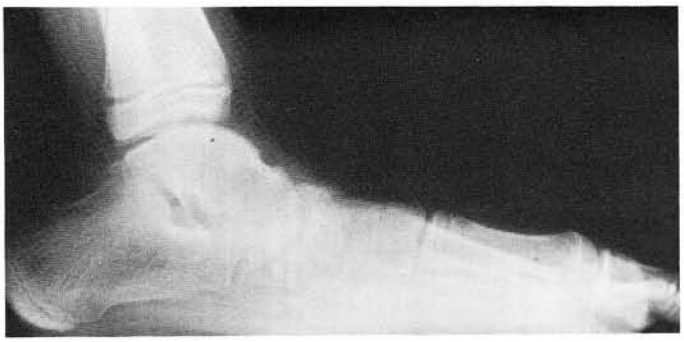

**Fig. 8. B.** Lateral preoperative radiograph.

**Fig. 8. D.** Postoperative lateral radiograph.

Six months follow up revealed: ankle joint range of motion 10 degrees dorsiflexion with the knee extended and knee flexed, rearfoot perpendicular to the weightbearing surface upon stance, Helbing's sign absent, and metatarsals in a rectus position.

The patient is presently one year status post surgery on the right side and six months status post surgery on the left side with adequate correction and excellent relief of symptoms.

## Case History II

This case involves a triple arthrodesis (Figs. 9 A-D). A 12 year old male presented to the Doctors Hospital with a chief complaint of a chronic aching pain in his right foot. The pain was primarily located in the plantar medial arch. It was described as severe upon prolonged standing and walking. The patient's parents indicated that the deformity had been present since birth and had progressively worsened since weightbearing. The left foot was clinically more severe than the right.

Physical examination was significant for the following:

-decreased ankle dorsiflexion with knee extended or flexed,
-marked abduction of the midfoot,
-everted calcaneal stance position,
-internally rotated tibia.

All the above findings were present bilaterally.

**Fig. 9. A.** Case History II, dorsoplantar preoperative radiograph.

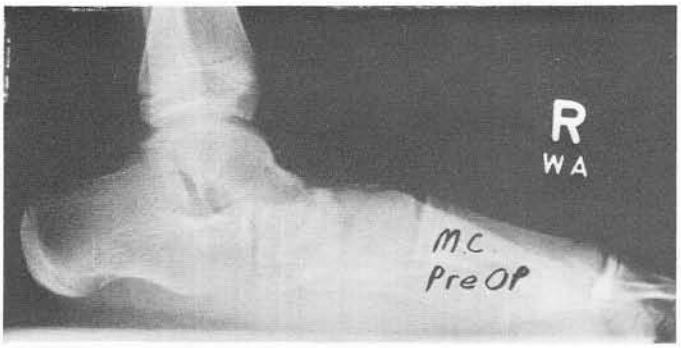


**Fig. 9. B.** Lateral preoperative radiograph.

**Fig. 9. C.** Dorsoplantar postoperative radiograph.

**Fig. 9. D.** Lateral postoperative radiograph.

Radiographic evaluation was significant for an elevated talocalcaneal angle of 40 degrees on a dorsoplantar view and 50 degrees on lateral view. The cuboid abduction angle was also grossly elevated at 25 degrees. The talar head was adducted with approximately 50 percent articulation with the navicular. The metatarsus adductus angle was 25 degrees.

Clinical impressions included metatarsus adductus, collapsing pes valgo planus, gastrosoleus equinus and severe bony adaptation to the deformed position.

Surgical procedures performed were gastrocnemius recession and triple arthrodesis. Triple arthrodesis was performed due to the inherent subtalar joint instability and severity of bony adaptation. In addition, it was felt that with a triple arthrodesis both the forefoot and the metatarsus adductus deformity could be adequately accommodated with one surgery.

The patient is now 2 years postoperative. The subtalar and midtarsal joint are fused and the patient is asymptomatic. Even though some true metatarsus adductus remains it appears adequately compensated by the alignment of the lesser tarsus. The overall alignment of the metatarsals in relation to the calcaneus appears very satisfactory.

## Case History III

Case III involves a medial arch tendosuspension and an Evans calcaneal osteotomy (Figs. 10 A-D).

A 10 year old female presented to Doctors Hospital with a chief complaint of painful flatfeet. The patient related a mild, diffuse cramping pain of both feet. She also complained of rolling over of her ankles. The patient's parents stated that she first complained of these symptoms 3 years earlier with a gradual increase in the severity of the condition.

**Fig. 10. A.** Case History III, dorsoplantar preoperative radiograph.


**Fig. 10. C.** Dorsoplantar 2 1/2 year postoperative radiograph.

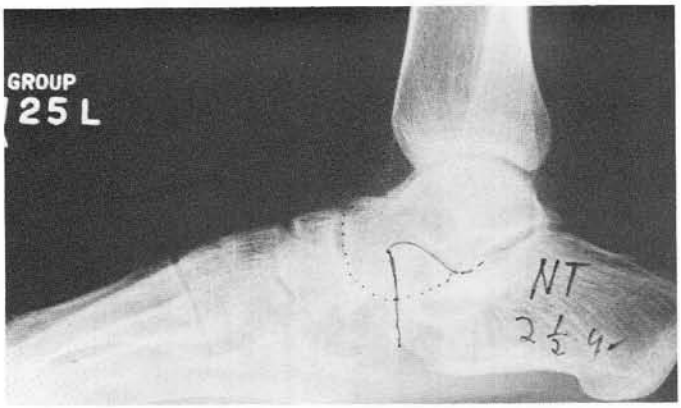


**Fig. 10. B.** Lateral preoperative radiograph.

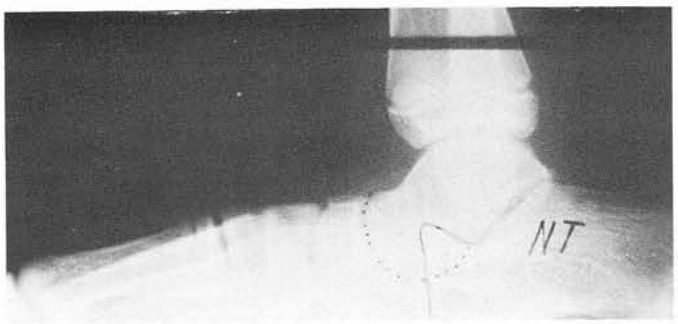


**Fig. 10. D.** Lateral 2 1/2 year postoperative radiograph.

Physical examination was significant for the following:

-ankle dorsiflexion (minus) 10 degrees with knee extended and (plus) 5 degrees knee flexed,
-severe medial talar head bulging,
-mild medially angulated metatarsals,
-hypermobile medial column,
-all findings were present bilaterally.

Radiologic evaluation was significant for an elevated talocalcaneal angle of 30 degrees on a dorsoplantar view and 50 degrees on a lateral view. Cuboid abduction angle was 25 degrees. The metatarsus adductus angle was elevated at 20 degrees.

Clinical impressions included gastrocnemius equinus, severe pes valgus deformity, and mild metatarsus adductus deformity.

Surgical correction consisted of gastrocnemius recession, medial arch tendosuspension, and an Evans calcaneal osteotomy. Instability of the talonavicular joint in attempted ankle dorsoflexion made it apparent that the pes valgus deformity was providing compensation for the equinus.

The patient is now 2 years postoperative and clinically much improved. The feet are still excessively hyper-

mobile and will continue indefinitely to require orthotic control. There is now no difficulty in maintaining orthotic control. Both feet appear to be improving with growth, and no new deformities are noted.

## Case History IV

A 9 year old male presented to the Podiatry Institute with the chief complaint of flatfoot (Fig. 11A & B). The patient's parents also related that the patient runs stiff legged and regularly tripped over his own feet. He had been treated from birth with casts and night splints and later with twister cables to turn the feet out. He had worn orthotic devices for the past 3 years with no noticeable improvement.

Physical examination was significant for the following:

-medially angulated metatarsals
-space between the first and second toes
-15 degrees of ankle dorsiflexion knees extended
-mild talar bulge in stance
-reasonable stability of midtarsal and subtalar joints.

Radiological examination was significant for:

-metadductus angle of 25 degrees bilaterally
-talocalcaneal angle was mildly elevated to 30 degrees in the dorsoplantar view
-cuboid abduction angle was 8 degrees bilaterally.

Diagnoses included metatarsus adductus and compensatory pes plano valgus. Metatarsus adductus was determined to be the primary deforming force. It was felt that if the metadductus was corrected, the mild pes valgus deformity would be controlled with orthoses and would likely be self resolving.

Surgical recommendations included abductory wedge osteotomies first through fifth metatarsals bilaterally.

The procedure chosen is currently the author's favorite for metatarsus adductus correction. The abductory osteotomy of the first metatarsal was fixated with a 4.0 mm screw. The osteotomies of the second, third, fourth, and fifth metatarsals were fixated by cerclage wiring.

In metatarsus adductus (or metatarsus varus) the metatarsals are somewhat superimposed over each other. This makes the lateral aspect of each metatarsal more accessible. Insertion of screws or monofilament wire is thus performed more easily from lateral to medial.

The patient is presently 6 months postoperative on the left and one month postoperative on the right. The patient's symptoms have essentially disappeared on the left side.

**Fig. 11. A.** Case History IV, dorsoplantar preoperative radiographs, bilateral.


**Fig. 11. B.** Dorsoplantar postoperative radiographs, left foot.

## CONCLUSION

Evaluation of the skewfoot deformity is essential in determining the correct surgical procedure. Clinical and radiological evaluation as well as intraoperative and postoperative experience with patients with skewfoot deformities dictate the chosen procedure.

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