METATARSUS ADDUCTUS NEO-NATAL MANAGEMENT

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There have been many early descriptions of infant foot deformities including one by Hypocrates in 250 B.C. The various deformities have always been present in the human population. Archeological evidence in Mexico showed that the Aztecs knew and treated clubfoot deformities (1). They used splints and also surgically sectioned the contracted tissues. There have been many descriptions and recommended treatments in the last century relative to clubfoot in which adduction of the forefoot is a component part.

Hiram Kite (2,3) in this century seems to have had the greatest influence on the description and conservative management of clubfeet and he preferred the term **metatarsus varus** since, at rest, he felt that the foot was supinated as well as adducted. He also preferred the term **one-third of a clubfoot** even while he agreed that this was not truly correct. The distinction, as he pointed out, being that the navicular was medial to the talar head in a clubfoot and in a metatarsus varus it was either directly in the front or lateral.

The term **metatarsus adductus** which enjoys most popular usage, concentrates on only one, although the most obvious, component of the abnormal anatomy. The best term is that which is most descriptive for most of the cases without being cumbersome. A title can never be all inclusive and although it is agreed that all three (3) segments of the foot may be involved in the deformity, metatarsus adductus comes closest to being most descriptive.

The senior author's first introduction to metatarsus varus deformity in depth was in 1957 while attending a seminar by H.J. Kite. At that time Kite was the recognized authority on talipes and he had noted over a period of some 25 years that the incidence of talipes equino varus was declining each decade while the number of recognized cases of metatarsus varus (as he called it) was increasing. This trend seems to have continued throughout the subsequent three decades. In fact, Berg (4) reported in 1986 that metatarsus adducto varus constituted 56% of all foot cases presented for treatment of the A.I. DuPont Institute in Wilmington, Delaware.

This trend may have resulted from the wider distribution of baby care manuals which encouraged belly sleeping (5). Babies often assume the knee chest position with the buttocks sitting on the feet effectively splinting them in a position of medial rotation of the limb and adductus deformity.

Without benefit of precise statistics the general impression gained during the period of 1957 through 1977 was that calcaneovalgus was the foot condition of greatest frequency in the infant population followed by tibial torsion and then metatarsus adductus. An associate, M. McDonough, D.P.M.(6), in a survey of 51 consecutive babies referred to our practice for foot care, found that metatarsus adductus was more common at 39% vs calcaneovalgus at 27%.

He further noted that metatarsus adductus was predominantly left-sided—17.6% vs 5.8%, and that calcaneovalgus was predominantly right-sided—19.6% vs 3.9%. He rationalized this as possibly due to the influence of the fetal environment of the later gestational stages. There is a predominance of left sided carry which results in the left side of the fetus being positioned against the stronger posterior uterine wall. Growth and increased compression probably forces the foot into a medial position relative to the leg. Poncetti and Becker (5) linked the etiology to uterine compression noting that a higher incidence in the first born child lent support to the theory. A review of the literature indicates that there are many probable factors such as this one but definitive etiology has not been established.

CLINICAL EVALUATION

A metatarsus adductus deformity is one in which there is an abnormal forefoot to rearfoot relationship with the metatarsals being adducted on the transverse plane. Occasionally there will also be a deformity on the frontal plane in which case the deformity would be referred to as **adducto-varus**. This problem is further complicated by the complex form of the deformity in which there is a valgus deformity of the rearfoot (3-8).

For clinical measurement it may be noted that a normal foot has a straight lateral border and that a metatarsus adductus has an angulated lateral border with the apex at the base of the fifth metatarsal. The severity of the deformity is determined by a flexibility test. A mild

case is manually correctable without force. A moderate case would be manually correctable only with force and a severe case is fixed and not manually correctable.

Other observations should be recorded such as a vertical skin crease medially, the status of the great toe and the status of the triceps muscle group. It is important to note the presence of an associated rigid equinus since this would represent a true clubfoot and not simply a metatarsus adductus deformity (2,9,10).

It is equally important to record the status of the rearfoot since a fixed varus without equinus would constitute a cavo-adducto varus deformity (11) and, of course, a rearfoot valgus would represent the complex form of deformity which has been referred to as skew-foot by some and complex metatarsus-adductus by others. One should further examine for associated deformities such as medial tibial torsion (2) which is commonly associated, and tarsal coalitions and ball-and-socket ankle (12) which are rarely associated.

When the patient is ambulatory it is important to record the dynamic muscular effect (7, 13-15). If the great toe varus becomes worse on standing, or if the entire forefoot adduction seems to increase, this would represent the dynamic component involving the adductor hallucis or secondary insertion of the posterior tibial tendon, or both.

Clinical Assessment

Objective

Status of lateral border of foot
Flexibility test: Mild
Moderate
Severe

Status of rearfoot: Neutral
Valgus
Varus

Vertical skin crease
Tibial torsion
Tarsal coalitions
Ball & socket ankle
Dynamic muscular effect: Abductor hallucis
Tibialis Posterior

Subjective

Untreated cases will develop subjective symptoms such as, difficult shoe fitting, abnormal shoe wear, metatarsal imbalances, a high percentage develop hallux valgus, and severe flatfoot deformity.

RADIOGRAPHIC ASSESSMENT OF METATARSUS ADDUCTUS

There have been a number of classifications and measurements of this deformity (16-20), but each of these seems to have its own shortcomings. The traditional podiatric method has been to establish a lesser tarsus axis as the basis of measurement (16). The inherent deficiency of this technique is that this can only be done in the older child or adult while this is, in fact, an infant deformity. Unless an earlier dependable measurement is used, one cannot measure progress of the therapy. Unfortunately, the lesser tarsus is radiographically silent in the first years of life (17).

The ground surface cannot be used as a reference point since the deformity also predates the stance position.

Engle et al (18) recommended a simple and convenient measurement using the longitudinal axis of the second cuneiform to represent the alignment of the lesser tarsus. This, too, is only useful in the more mature foot.

Lepow (19) uses a clever method of measuring the adductus by combining the arcs of a circle centered about the base of the first and fifth metatarsals. The junction of the arcs form a central line against which the long axis of the second metatarsal is measured. The deficiency in this instance is that the measurement records the interrelationship of the metatarsals to each other. It is, in effect, measuring a deformity against itself. It does not relate to the more proximal normal parts.

The difficulty in recording measurements of metatarsus adductus is that there are so many variables. The dilemma is threefold:

A. The metatarsals are the most obvious component involved and show varying degrees of deformity.
B. The lesser tarsal bones in the neonate are not measurable since they are radiographically silent.
C. In many cases there is an abnormal talocalcaneal relationship.

It is axiomatic that a variable is best measured against a fixed reference point. The best measure of time and distance as well as that which is deformed is against a known reference. Typical examples are: the equator, the international dateline, and the meridian of Greenwich.

In the clinical examination of the infant, the preferred method is to use the more proximal anatomy as the fixed point against which distal parts are measured relative to

attitude and range of motion (20). In order to be consistent, the examiner should carry this process into the radiographic study. The tibia is ideal for recording foot malpositions when viewed laterally since the foot and leg are on the same plane. In the anteroposterior view, however, the leg is at right angles to the x-ray plate and the tibia becomes less than an ideal reference point.

The talus is the foot bone having the most constant and normal relationship to the leg. This is especially true in metatarsus adductus deformity since equinus and dorsiflexion do not enter into the problem. The talus moves on the sagittal plane but is relatively fixed on the other two planes in the ankle mortise. No one has ever suggested that there is an abnormal talotibial position in this deformity. It is possible that a severe adduction deformity could influence the talar head to body angle, but for the most part, the central axis of the talus is aligned with the ankle and leg. The central axis of the talus, therefore, which generally represents an extension of the leg is the best starting point to measure for metatarsus adductus deformity.

The talocalcaneal angle of divergence (Kite angle)(2,3) is the first recommended measurement to determine the presence of rearfoot pathology. This is normally 20 degrees plus or minus five.

If the talocalcaneal angle is within normal limits, then the first metatarsal talar angle is useful. Simon's study (21) showed that in the infant this is normally 0 to minus 20 degrees. When there is pronatory rearfoot pathology the first metatarsal-tarsal angle is no longer valid; since both the talus and the metatarsals are positioned medially relative to the calcaneus.

After first determining whether the calcaneus is displaced on or beneath the talus one should next measure the metatarsals relative to the calcaneus. The central axis of the calcaneus is parallel to its lateral border. Ponsetti and Becker (5) have established the calcaneal fifth metatarsal angle as normally zero degrees. Gamble (17) wrote that the central axis of the calcaneus bisects the fourth metatarsal, not the fifth.

The calcaneal second metatarsal angle is probably the best measure of forefoot adduction, but normal parameters for this have not been established. A study to establish the normal calcaneal second metatarsal angle in infants and adults is now in progress.

X-ray assessment:

A) Talo calcaneal (Kite) angle - simple
- complex

B) Talar first metatarsal angle - only if simple type metatarsus adductus

C) Calcaneo fifth metatarsal angle

D) Calcaneo second metatarsal angle

CONSERVATIVE TREATMENT

It is both surprising and disconcerting that papers (22,23) are still being published which postulate that spontaneous correction of metatarsus adductus occurs in most children thereby rationalizing a policy of non-treatment. This belief persists in spite of evidence to the contrary. There is no lack of uncorrected cases at every age level and while it is true that they are painless in early years the condition becomes increasingly difficult to correct with each passing month. When subjective symptoms finally develop the safe and noninvasive conservative treatments are no longer effective.

Corrective surgery has reached a dependable state of sophistication but it seems a shame that the patient must be subjected to such risks and inconvenience for a condition which could have been corrected before the patient even stood.

The physician or pediatrician serves the patient well when they advise early treatment. The earlier treatment takes less time and this reduces the overall cost. More importantly, the tissues are malleable permitting a more complete correction; and, secondary adaptive changes have not yet occurred. I am impressed that a short course of manual stretching exercises by the parents is justifiable although Kite (2,3) had no confidence in this. He was also critical of outflare shoes stating that "These attempts only delay treatment and do little to correct." Severe cases should be treated in the first weeks of life. Bleck (8) recommended that all cases be treated before the patient reaches four months of age and that after nine months prognosis for correction is poor. This may be viewed as a four month window of opportunity.

It is well established that an infant foot deformity will respond favorably to gentle and persistent mechanical correction using casts and splints (Fig. 1). One is encouraged, therefore, to understand the principles and master the manual skills needed to employ effective conservative care.

One of the traditional problems with cast therapy of metatarsus adductus has been the presence of a pes valgus foot deformity at follow-up. Of 18 feet with complex metatarsus adductus (skewfoot) treated conservatively, Berg (4) found at follow-up that every case had "flatfeet". Pes valgus (flatfoot) deformity also developed in 117 of the feet with simple metatarsus adductus. Evidently the same force which abducts the metatarsus also forces the calcaneus laterally from beneath the talus.

PLASTER CASTING

There are two simple but important moves that the operator can do to prevent the development of pes valgus. As noted by Drennan and Sharrad, the talus has

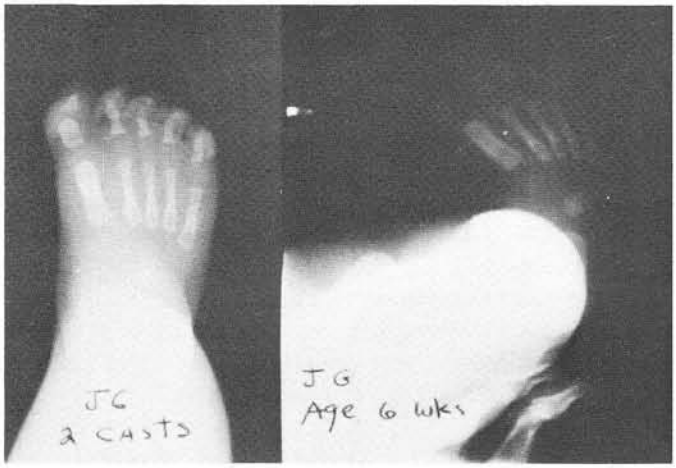

Fig. 1. This case shows benefit of early conservative casting. In the infant there are really no hard tissues and so there is little to resist corrective forces. There is a four month open window of opportunity. The physician who fails to offer this option performs a disservice because later surgery, at best, is still imperfect.

Fig. 2. Practice on naked foot before plaster is applied. Protect against developing pes valgus deformity by: A) Holding foot in equinus which reduces the talocalcaneal angle B) Compress medial to lateral to "fix" the rearfoot preventing calcaneus from abducting along with metatarsals C) Use opposite hand to abduct forefoot.

Fig. 3. With plaster applied beyond toes, stabilizing and corrective forces are manually applied.

no muscle attachments and its position is passively determined. It is only when the talus is dorsiflexed that eversion of the subtalar joint can occur." (24). Any movement of the foot into equinus, therefore, is attended by rearfoot varus with the os calsis rotating beneath the talus. This reduces the talocalcaneal angle of divergence which satisfies one of the goals of treatment.

This movement can be further enhanced by compressing the rearfoot. The operator gently squeezes the tarsus between the fingers and the thenar eminence of one hand while the opposite hand abducts the forefoot (Fig. 2). Even in a simple metatarsus adductus it is important to compress the tarsus in the equinus attitude to protect the rearfoot from iatrogenic damage. Remember that a normal foot would be inclined to eversion or pes valgus deformity when and if the metatarsals are forced into abduction if there is nothing to stabilize the hindfoot.

The soft and cartilaginous lesser tarsal bones which are not touched during this maneuver are, none the less, the principal beneficiaries of the treatment.

It is strongly recommended that the operator study the position of the hands on the infant foot to note the clinical effect before the plaster is applied. It is not enough to have good intentions. One must be certain that the foot will, in fact, be corrected by the manual pressures. To put it briefly, practice on the naked foot before it is obscured by plaster (Fig. 3).

The technical details of infant casting have been covered previously (25) and will not be repeated here. Several tips are:

A. Do not use excessive padding.
B. Hold the foot in neutral position while both the padding and plaster are applied.
C. Include a tongue of plaster to extend along the medial side of the great toe to place a stretching effect on the abductor hallucis muscle. Trim the plaster away from the remainder of the toes.
D. Cast weekly until complete correction is attained.
E. If medial tibial torsion is an associated finding, cast to mid-thigh derotating the limb.

THE GANLEY SPLINT

This device (26) has been used for over 25 years and, although not a substitute for plaster of paris in the child under six months of age, it duplicates the action of plaster and has distinct advantages over every other

device available. It is almost always used for retention subsequent to plaster cast correction. Once the foot becomes corrected it is tedious to apply casts on a weekly basis and it is more practical to have the parent apply the Ganley Splint for several months to prevent recurrence.

The second valuable application of the Splint is for those children aged one to three where the earlier treatment was not undertaken. Adjust the crossbar so as to invert the rearfoot. This will prevent the undesirable pes valgus deformity. The cut out shoe is bent at midfoot so as to abduct the metatarsus (Fig. 4). For increased spot pressures, the inside of the shoe may be padded with felt. Usually these are placed over the cuboid area and along the shaft of the first metatarsal. It is important to mount the splint and shoe on the child's foot while in the office to determine if, in fact, some correction has been attained.

Early aggressive treatment with plaster casts and splinting will obviate the need for surgery in most cases. Surgery in our hands has been reserved for those patients who have remained uncorrected by age seven and up.

SURGICAL PROCEDURES FOR METATARSUS ADDUCTUS

Soft tissue release for the forefoot adducto varus in the young child was employed as early as 1945 by Heyman (27). In 1958 Heyman, Herndon, and Strong (28) published the classic paper for soft tissue correction of metatarsus varus and claimed to achieve 25 excellent results in 29 feet. Although the procedure has been found to be effective by some it has also received its share of criticism. Stark et al (29) reported a 417 failure rate of the HHS on 56 feet. They noted that a painful dorsal prominence was a frequent occurrence following surgery on a nonpainful condition. They questioned whether the procedure dealt with the actual pathology. According to Cummings and Wood Lovell (30) the procedure was followed by stiffness and pain and stated "The HHS procedure is now done infrequently."

Release of the abductor hallucis either at its origin or tendinous insertion has been advocated. Poulos and Asher (31) recommended the more conservative tenotomy in contrast to Thompson (32) who performed radical avulsion of the entire muscle. This author has successfully lengthened the tendon of the abductor hallucis but experienced one unfortunate case which developed excess hallux valgus subsequent to a snap tenotomy performed as an adjunctive procedure to talipes correction.

Fig. 4. Ganley splint is only foot-leg orthosis which offers control of tarsal position, metatarsal correction, and derotation of tibial torsion simultaneously. Felt pad is placed over lateral cut within shoe to offer counterpoint pressure.

Browne and Paton (14) emphasized the dynamic contracture of the secondary insertion of the tibialis posterior tendon. Turco (7) agreed with this and added that there are also abnormal accessory attachments of the achilles, the tibialis anterior tendon, and the abductor hallucis sending attachments to the tibialis posterior tendon. He pointed out however that these may be secondary adaptations to an already existing deformity.

Ghali (13) recommended capsule and ligament release through the tarsometatarsal as well as the naviculocuneiform joints. Postoperatively the liberated joints were held open with plaster casts restoring tarsometatarsal alignment.

The most widely acclaimed procedure of the past eighteen years has been that of Berman Gartland (33). It is reserved for the patient over age six and consists of angulation osteotomies of the bases of all the metatarsals. There have been modifications of the osteotomy and fixation techniques, but this procedure has come to be the accepted standard. Base osteochondrotomies as reported by Johnson (34) represent a variation on the same theme.

Opening wedge cuneiform osteotomy was first advocated by Fowler (35) in 1959 for the correction of residual forefoot adduction of talipes equinovarus. In a series of 18 feet Hoffman et al (36) claimed that the average correction of adductus was 72% using the Fowler procedure and forefoot equinus was improved 47%. Coleman (9) felt that it is a rare case that requires this surgery and the indication is in the dynamic deformity which upon stance becomes decidedly adducted. All of these authors cited the importance of plantar soft tissue releases.

Grumbine (37) advocated a closing wedge cuboid osteotomy for metatarsus adductus. He recommends a bi-plane wedge to correct the varus component and on occasion will extend the wedge over to include the second or third cuneiform bones.

This author has had favorable experience using the cuneiform opening wedge osteotomy for metatarsus adducto varus or adducto valgus. If the deformity is mature and fixed one has the additional option of removing a wedge from the cuboid. This allows further mobilization of the forefoot assuring axial alignment of metatarsus to tarsus.

It is natural to question why one would choose procedures other than the Berman Gartland procedure with its proven track record.

THE BIOMECHANICAL CONCEPT

Identify the level of deformity
Operate on that which is deformed.

This principle is unassailable and most foot surgeons believe that the Berman Gartland procedure is an example of its application. The very name tells us that there is a deformity of the metatarsus. Grossly the foot is deformed and the angulated forefoot is the outstanding feature. Finally, the x-ray convinces the examiner that the axial alignment of the metatarsus to the hindfoot is abnormal.

The sum of these observations weighs heavily in faulting the metatarsus as the level of deformity. With this in mind the surgeon applies his/her skills in performing osteotomies of the metatarsal bases concluding that he is correcting that which is deformed.

There is an appealing logic to the above interpretation but there is also some deception.

If the metatarsals are truly deformed then one should be able to isolate an individual bone and compare it to a bone from a normal foot. If the x-ray tracings in figure 5 are studied, however, one finds it difficult to identify which bone is from the deformed foot. It is significant that the addition of the medial cuneiform tracing in Figure 6 allows the observer to identify which foot is deformed. Figure 7 shows the full x-ray of both feet and tracings. This simple exercise has been employed repeatedly with the same result.

It raises some intriguing questions:

Is it the metatarsus or the cuneiform bones which are deformed?

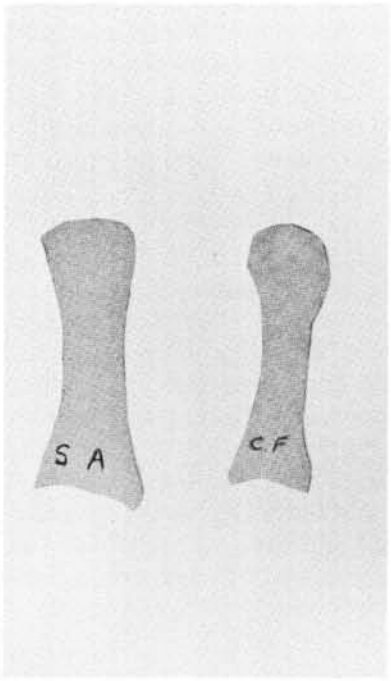

Fig. 5. Label which is assigned to this condition is "metatarsal deformity." It seems reasonable, therefore, that one should be able to measure or at least identify deformed bone. Tracings shown, however, are from normal and deformed foot but show no appreciable difference.

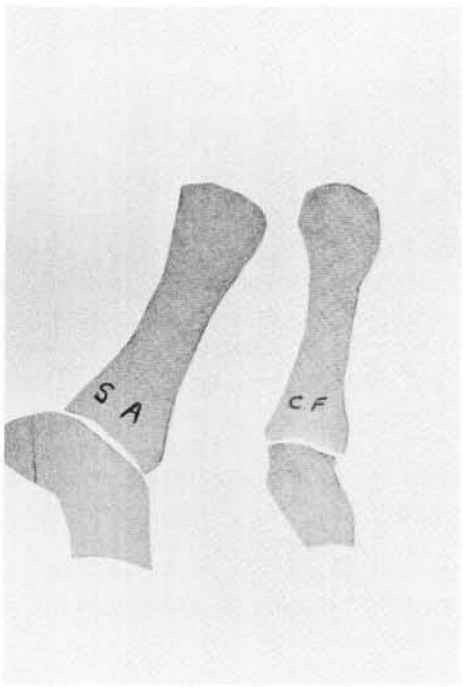

Fig. 6. When tracing of medial cuneiform bone is added it becomes easy to identify foot with metatarsus adductus.

If the cuneiforms are deformed, how did it happen?

Have we been operating on the wrong bones?

Is there a better way?

Careful consideration leads one to the belief that in the early stages the foot is angulated and deformed but

Fig. 7. X-rays of abnormal and normal foot from which tracings were made. This simple exercise shows that what begins as a positional metatarsal problem ends as structural cuneiform deformity. Surgery should be directed toward deformed cuneiform not normal metatarsal.

Fig. 8. Foot corrected by multiple metatarsal osteotomy will produce a rectus foot clinically. Price of correction is that patient now has deformed metatarsals as well as deformed medial cuneiform.

the metatarsals of themselves are not. They are simply malpositioned relative to the rearfoot. As noted above, the first metatarsal shows normal anatomy even in the mature foot with fixed metatarsus adductus. At this stage it is the medial cuneiform bone which is grossly abnormal with the most apparent alteration being a deviated articular facet at its distal margin. The essential deformity, therefore, is an abnormal LisFranc Articular Set Angle (LASA).

Fig. 9. An open wedge osteotomy is performed at mid cuneiform, and size of opening measured. If corrective effect is adequate, bone grafts are inserted to maintain new position.

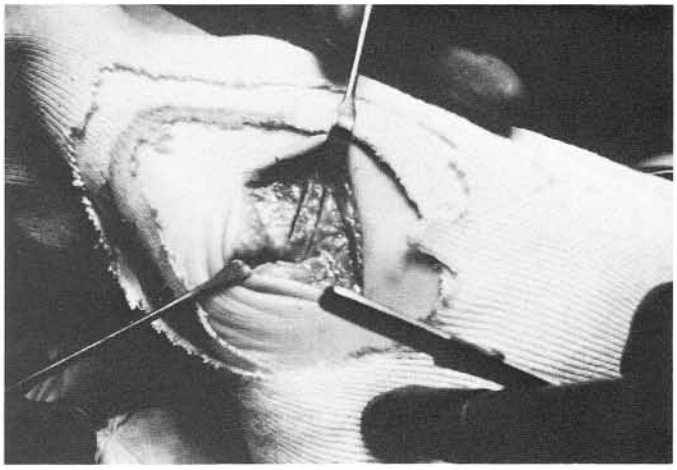

Fig. 10. If cuneiform osteotomy proves inadequate in correcting forefoot adductus then closing wedge osteotomy is performed through cuboid. This combination lengthens medial column and shortens lateral column of foot.

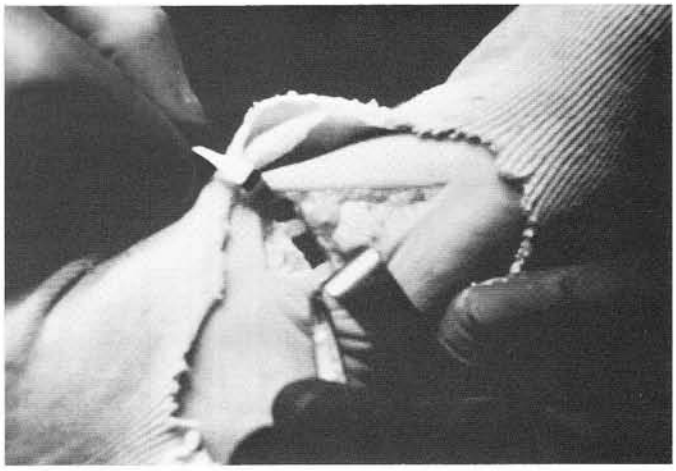

Fig. 11. Considerable dorsoplantar dimension of cut cuneiform bone lends itself to additional correction of sagittal plane deformities. Larger wedge of bank bone is inserted dorsally to control forefoot varus component. To correct plantarflexed medial column in an adducto-cavus foot larger wedge is placed plantarly.

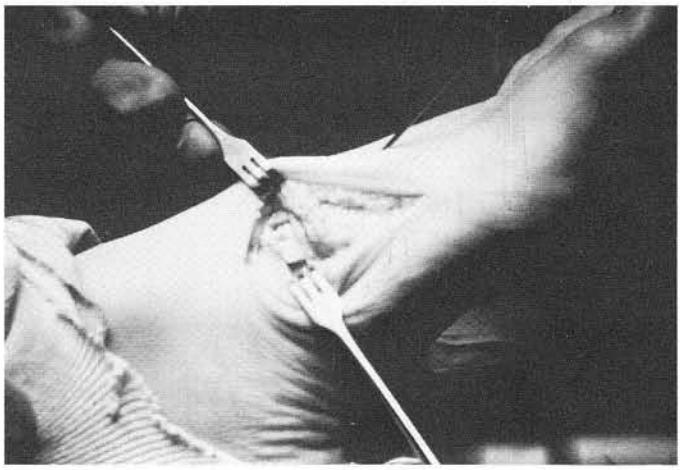

Fig. 12. Autogenous bone taken either from cuboid (or calcaneus) fills void between cortical wedges. K-wire and cast is used for six weeks to maintain correction.

Fig. 13. Postoperative x-ray with transparent tracing of preoperative bone outline. Note that abnormal LisFranc Articular Set Angle (LASA) has been corrected. Closing cuboid osteotomy was included, although it is not apparent on this x-ray.

The cuneiform bones in the infant foot are soft amorphus cartilage which is radiographically silent until about eighteen months of age. The metatarsal diaphysis, on the other hand, is ossified at birth indicating that as a cubic mass the metatarsals are more solid, with rigid internal architecture already in place. Although all bones are growing rapidly, the metatarsals are less likely to be subject to deformation than are the more malleable cuneiforms. These immature lesser tarsal bones are sandwiched between the more ossified talus and calcaneus of the rearfoot and the metatarsals distally. This is an application of Pajot's Law* which states, "A solid body contained within another (more rigid) body having smooth walls will tend to conform to the shape of those walls" (* Dorland's Medical Dictionary).

The term metatarsus adductus is factual and useful for identifying the transverse plane condition. It is unfortunately misleading when one wishes to gain an understanding of the developmental progress of the deformity. The first metatarsal which is predominantly affected is adducted and out of position, but it is not deformed. Because it is preformed as bone it then proceeds to deform the first cuneiform whose strength and ossification occurs only later.

The examiner must determine whether the angulation involves LisFranc's joint. If it does, then the foot is best served if the LisFranc Articular Set Angle (LASA) is corrected. It is difficult to justify a difficult, traumatic, and time consuming exercise of cutting through multiple cortical bone sites which, in fact, are not deformed in the first place. If the LASA is deviated, then the deformity involves a joint complex and the goal of normal physiology demands correction at the abnormal cuneiform level.

THE SURGICAL TECHNIQUE

This is reserved for the older child, i.e. a mature age seven to adulthood.

The sequence of procedures is:

Step 1. Opening wedge cuneiform osteotomy

Step 2. Soft tissue release as individually needed. This may include: the plantar fascia, the abductor hallucis, the tibialis anterior tendon and/or secondary insertion of the tibialis posterior tendon.

Step 3. Closing wedge cuboid osteotomy for the mature rigid foot.

A curvilinear incision is centered dorsomedially over the first cuneiform bone. The medial marginal vein is identified and reflected dorsally. The tibialis anterior tendon transverses the operative field and must be mobilized and reflected. One half of its insertion may be detached to assist exposure. If the tendon is a deforming factor it may be open lengthened or its insertion released from the first metatarsal.

The medial cuneiform bone is then exposed subperiosteally and an osteotomy performed at its midpoint. The cut may be in the distal third if the operator is certain that only the first cuneiform is to be opened, (as for correction of metatarsus primus varus). If the cut is to be deepened for increased correction, however, the midpoint is preferred to avoid harm to the joint at the base of the second metatarsal. The osteotomy is held

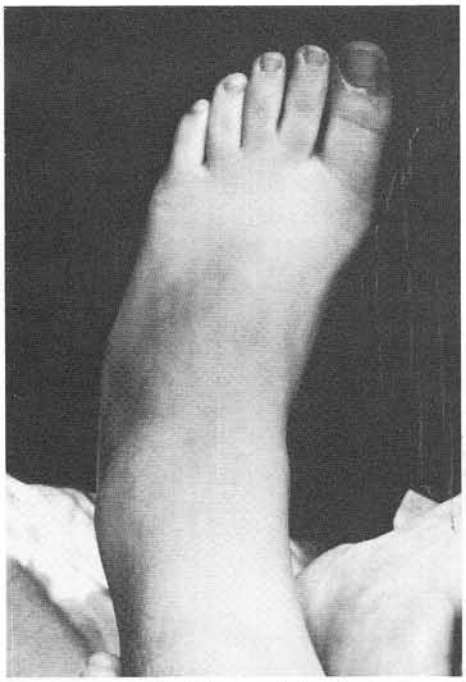

Fig. 14. Fixed metatarsus adductus deformity is shown in twelve year old female. Parents were advised early that treatment was unnecessary.

Fig. 15. Foot is rectus at eight weeks postoperative. Note improvement in lateral border of foot.

open with a baby lamina spreader and the degree of correction assessed. If the correction is adequate the osteotomy is filled with a bone graft. The author usually combines bank bone with autogenous bone.

If additional correction is required the osteotomy may be deepened through the middle cuneiform bone, or one may choose to proceed to steps two and three as listed above.

The cuboid osteotomy, when needed, is performed through a curvilinear incision extending from the calcaneous to the fourth metatarsal shaft. Using a hemostat the superficial fascia should be raised in a tent fashion to identify and then reflect the lateral dorsal cutaneous nerve. A wedge is removed with the apex directed toward the medial cut in the cuneiform bone. It is not necessary nor advisable to cut completely across the foot. One is also cautioned against removing too large of a wedge from the cuboid as a firm approximation of the cut surfaces may become a problem. The bone removed from the cuboid is grafted into the cuneiform medially and supplemented with bank bone as needed.

With the lateral column of the foot shortened and the medial column lengthened the contour of the foot is greatly improved. Internal fixation is not always necessary since the graft is often quite stable. When needed the author's preference is threaded Kirschner wires (K-wires) since they can be removed easily at four to six weeks. If the cuboid closure is unstable then a staple is used.

ADVANTAGES OF CUNEIFORM VS. METATARSAL OSTEOTOMY

1. It avoids the growth plate of the base of the first metatarsal.

2. There is a greater contact surface area which enhances both stability and bone healing.

3. Of the surface area available, the cuneiform offers proportionately more cancellous bone and complete healing will occur in a shorter time span through cortical bone (38,39). Charnley and Baker (40) attribute greater healing speed to the endosteal surface and blood supply, both being proportionately greater in cancellous bone.

4. The cuneiform is greatest in its dorsal to plantar dimension and this architecturally will tend to resist dorsal collapse of the medial column of the foot. This dorsal collapse is a recognized risk in base wedge osteotomy.

5. A more proximal osteotomy has a longer radius arm and thus requires a smaller wedge to gain the same degree of correction.

6. Two plane correction is more easily accomplished. For example to correct a varus component as well as adduction a bone graft which is wider dorsally may be used.

7. Any tendency for recurrence of the adduction deformity would compact the osteotomy site which enhances healing. By contrast, recurrence of adduction would tend to distract a metatarsal osteotomy and delay healing.

8. Because the osteotomy is stable and under compression, internal fixation is often not necessary in cuneiform osteotomy. Internal fixation is always necessary for first metatarsal osteotomy and frequently screws are used. Screws require a large drill hole and this removes that much of medullary bone which would otherwise contribute to osteogenesis. The first metatarsal has less bone per square unit area available for healing and the screw hole further removes some of this important medullary bone. The cuneiform, on the other hand, requires only Kirschner wire fixation.

9. The most significant advantage may be that a cuneiform osteotomy corrects the abnormal LisFranc articular set angle. The metatarsal correction is a Cheater osteotomy since it ignores the abnormal LASA.

DISADVANTAGES OF CUNEIFORM OSTEOTOMY

1. The procedure is made difficult by the presence of the tibialis anterior tendon which traverses the operative field.

2. The procedure requires bone grafting which introduces a separate set of potential complications.

3. That part of the osteotomy bridged by the grafted bone will heal slower.

4. Soft or medullary bone is more inclined to collapse with loss of correction. This event is conceivable but it has not been observed to happen in the author's experience. A threaded K-wire maintains the open osteotomy position and helps to prevent collapse.

SUMMARY

The goal of management of infant foot deformities is to have the child take the first steps on a perfectly normal foot. With few exceptions this goal can and should be accomplished by early conservative treatment which is both safe and painless. Discussion of this therapy using manipulation, casting, and splinting is reviewed herein.

Unfortunately it is fashionable to delay treatment either through ignorance or by intent so that the older patient with uncorrected metatarsus adductus is presented as a surgical challenge.

It is not always possible to convert the worst feet into the very best by any surgical procedure. The operative approach as described in this paper is felt to be superior to the more traditional operations for metatarsus adductus deformity. It is physiologically responsive to the needs of the foot since the surgical focus is at the level of greatest deformity.

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