METATARSUS ADDUCTUS

Bradley D. Castellano, D.P.M. Thomas F. Smith, D.P.M.

INTRODUCTION

Metatarsus adductus is one of the most common congenital foot deformities. Its actual incidence is not well documented and is probably underestimated at one in every 1000 live births (1).

Confusion continues to exist over the significance of this disorder. Since many different designations have been used to describe metatarsus adductus and similar disorders the literature is somewhat difficult to interpret. Description of the pathologic anatomical relationships and classification systems used to describe metatarsus adductus will be presented.

Metatarsus adductus, the name most commonly accepted at present, has also been called metatarsus varus (2, 3), metatarsus adductovarus (4), pes adductus (5), metatarsus supinatus (6), forefoot adductus (7), and hooked forefoot (8) to name a few. While all of the names are descriptive of a foot deformity they are either less exact or combine frontal plane or rearfoot deformities with the pure transverse plane deformity at LisFranc's joint known as metatarsus adductus (Fig.1).

Theories of Etiology

There have been numerous investigations and speculations on the cause(s) of metatarsus adductus. As with any congenital deformity efforts to discover the true etiology are warranted for two reasons. First, if a causal relationship can be determined for any malformation, prevention may be possible by alleviating the deforming force. Secondly, if the etiology is known, treatment can be better directed at the cause of the deformity. The success or failure of the treatment plan hinges on many factors not the least of which is practicality.

One of the most widely accepted theories of the etiology of metatarsus adductus is that of abnormal intrauterine position (1,9). This is supported by studies which show a disproportionate number of affected infants in prima gravida mothers (10).

Heredity has been shown to account for only two to four percent of all cases of metatarsus adductus (3).

However, a slight male preponderance does exist with an approximately 1.3:1 ratio reported by most authors. Kite felt that muscle imbalance was the cause of metatarsus varus with tibialis anterior and tibialis posterior overpowering the weaker peroneal muscles (3). This theory was disputed by Reimann and Werner who showed that metatarsus varus could only be reproduced in the normal infant foot by extensive capsulotomy even with extreme tension placed on the tibialis anterior tendon (11). They concluded that metatarsus varus was the result of primary subluxation of LisFranc's joint with soft tissue adaptation occurring secondarily.

Other theories of causal relationship which have been proposed include abnormal tendon insertion of tibialis anterior (5,12), tibialis posterior (13), and abductor hallucis muscles (14). Osseous malformations include absence of the medial cuneiform (5), and arrest of the natural ontogeny (15). Combinations of the above factors have also been suggested (16).

Definition

Since confusion continues to exist in contemporary literature on the definition of the terms which are used to describe deformities of the forefoot and rearfoot interpretation is in order. The definitions used by Eugene Berg in his appraisal of metatarsus adductus and skewfoot are among the more precise and anatomically correct and will be used for clarity's sake throughout this paper (10).

The deformity of pure metatarsus adductus is by definition located at the tarsometatarsal joints. Transverse plane deviation at this joint without other abnormalities of the foot is called metatarsus adductus. Variants of metatarsus adductus exist. When found in combination with frontal plane inversion of the forefoot it is known as metatarsus varus. Metatarsus varus in combination with rearfoot valgus is considered skewfoot. Lateral deviation of the midfoot associated with metatarsus adductus and skewfoot was described by preceding the term with the word *complex* added to each of the disorders (10).



Fig. 1. Typical appearance of metatarsus adductus deformity. Bilateral expression of disorder is quite common.

Anatomic Considerations

The tarsometatarsal joint (LisFranc's joint) is a complex structure consisting of metatarsocunieform, metatarsocuboid, and intermetatarsal joints. The transverse arch of the foot is made up of these articulations. The apex of the arch is located at the recessed second metatarsocunieform joint. As the metatarsals extend distally they angle plantarly to form the longitudinal arch of the foot. The medial metatarsals are more flexed than the lateral which results in diminishing arch formation along the lateral border of the foot and loss of the transverse arch at the metatarsophalangeal joint level.

The articular surfaces at LisFranc's joint are for the most part flat. The close approximation and keystone effect of the joint allows only slight degrees of motion primarily in the sagittal plane. Ligamentous attachments between the tarsus and the metatarsus are quite substantial and are stronger plantarly than dorsally. There are seven dorsal ligaments: the first metatarsocuneiform ligament is the most substantial and is located dorsomedially; the second metatarsal is secured to all three cuneiforms dorsally; the third metatarsal is attached to the third cuneiform by a dorsal ligament; finally the fourth and fifth metatarsals are bound to the cuboid by a dorsal ligament each.

The plantar ligaments of the tarsometatarsal joints are more variable on the lateral side, however, the cuneometatarsal ligaments are always present. The first metatarsal is attached on its inferior surface to medial cuneiform by a rectangular ligament. The most substantial ligament on the plantar aspect of LisFranc's joint courses distally from the medial cuneiform dividing into two bands which insert in the second and third metatarsals. No ligamentous attachments originate from the plantar second cuneiform. The third cuneiform ligament also splits into two bands which are applied to the plantar aspects of the third and fourth metatarsals. Metatarsocuboid ligaments are often absent on the plantar aspect and are small when present.

At birth the bases of the metatarsals and the cuneiforms are cartilaginous and radiolucent. As the child ages, the osseous and fibrous tissues become more rigidly fixed in the position of rest. Therefore, treatment regimens have been age related with conservative methods being attempted in the infant, soft tissue procedures performed in young children, and osseous correction in the older child.

Clinical Evaluation

The diagnosis of metatarsus adductus can usually be made based on clinical presentation. The deformity may be diagnosed at birth, however, many investigators state that the deformity is often unrecognized until the child is a few months old. The deformity may be bilateral with asymmetric or symmetrical involvement. Unilateral cases occur with slightly less frequency (3).

Examination of the newborn foot with metatarsus adductus deformity reveals a forefoot which is adducted in the transverse plane with the apex of the deformity at LisFranc's joint. The fifth metatarsal base will be prominent and the lateral border of the foot convex in shape (Fig. 2). The medial foot border is concave with a deep vertical skin crease located at the first metatarsocuneiform joint level (Fig. 3). The hallux may be widely separated from the second digit and the lesser digits will usually be adducted at their bases. In some cases the abductor hallucis tendon may be palpably taut just proximal to its insertion into the inferomedial aspect of the proximal phalanx.

Grading and classification systems have been proposed by some investigators in an attempt to determine which patients will spontaneously correct or require only conservative therapy. However, efforts to use clinical criteria to determine which cases will be recalcitrant have proven unsuccessful. Bleck described one such grading system and found that recurrence of the metatarsus adductus following conservative therapy could not be predicted on the basis of the severity of the deformity or on the degree of flexibility (17). His classification system remains useful, however, in describing the clinical presentation of metatarsus adductus (Fig. 4).

Metatarsus varus presents somewhat differently in that the forefoot is inverted in relation to the rearfoot. Adduction at LisFranc's joint is present and often is quite a severe component of this deformity. Contracture of the tibialis anterior may also be present (18). The rearfoot is typically in a valgus position completing the presentation of a skewfoot. Often rearfoot valgus is considered



Fig. 2. Prominence of fifth metatarsal base and convex lateral foot border is considered diagnostic of metatarsus adductus.



Fig. 3. Concavity of medial foot border with marked skin fold is seen in this two year old with metatarsus adductus.



Fig. 4. Bleck's classification of metatarsus adductus based on severity. A. Represents normal forefoot to rearfoot alignment. B. Shown to contrast forefoot adduction with forefoot abduction seen in this illustration. C. Mild metatarsus adductus. Note rearfoot bisection passes

compensatory for metatarsus varus; however, in newborns this is not the case since weightbearing and the need for compensation has not yet occurred.

Occasionally, metatarsus adductus or its variants are confused with congenital clubfoot. Differentiation is, however, simple since the rearfoot is usually in neutral to valgus alignment in patients with metatarsus adductus, whereas infants with clubfoot exhibit significant varus and equinus of the rearfoot. Also, the adductus through third digit. D. Moderate metatarsus adductus deformity with rearfoot bisector passing between third and fourth digits. E. Severe metatarsus adductus with bisector passing lateral to fourth digit.

component of talipes equinovarus is located primarily at the midtarsal joint with medial subluxation of the navicular on the talar head.

Radiographic Evaluation

The radiographic evaluation of metatarsus adductus in the child and adult patient has received a fair degree of attention in podiatric literature. The method of quantifying the degree of forefoot adduction was first proposed



Fig. 5. Pediatric metatarsus adductus angle as described by Lepow et al, 1987. Angle is formed by line drawn through the intersection points of two arcs. Axes of arcs are located on medial and lateral borders of first and fifth metatarsal bases respectively. Longitudinal axis of second metatarsal completes arms of pediatric metatarsus adductus angle.

by Sgarlato in 1971 (19). This angle was determined by drawing a line through the second metatarsal and a line perpendicular to the axis of the midfoot. An angle greater than 20 degrees was felt to represent pathologic metatarsal adduction. Engel et al proposed a simplified method of determining metatarsal adduction (20). Their method used the bisection of the second metatarsal and the second cuneiform. A normal angle using this method was determined to be less than 24 degrees. A method of determining the degree of metatarsus adductus in the unossified pediatric foot was presented by Lepow et al (Fig 5) (21).

The radiographic classification of metatarsus adductus and skewfoot deformities was presented by Berg in 1986 (10). He delineated four configurations of adduction of the foot based on varying forefoot, midfoot, and rearfoot relationships. Prognostic value was placed on these determinations stating that combined (complex) deformities tended to require increased periods of conservative therapy or even surgical intervention.

Pathomechanics of Metatarsus Adductus

As with many congenital foot deformities, the effects may not be seen until the child begins weightbearing. Unfortunately, at that time the deformity tends to be resistant to conservative therapy. Early diagnosis and treatment is urged by most authors (1,11,12). Intoe gait may be the original complaint described by some parents. This type of gait pattern tends to cause the child to trip frequently, especially while running. Intoe gait may be due to metatarsus adductus, however, other deformities such as internal tibial torsion and excessive femoral anteversion may be the cause of the internal foot position. Hip dysplasia and internal tibial torsion have both been associated with metatarsus adductus, therefore, these combination deformities should be carefully considered (22).

Ambulation will be affected by internal foot position regardless of the etiology. Unconsciously, the child tries to reduce the adducted gait by abduction of the forefoot at the midtarsal and subtalar joints. It then becomes important to differentiate the patients which have compensatory rearfoot abduction from those who have a congenital rearfoot valgus deformity. In the former condition treatment of the forefoot deformity with accommodation of the rearfoot valgus may be indicated. However, congenital rearfoot valgus deformity has been shown to be quite recalcitrant to conservative therapy (10,23).

References

- 1. Wynne-Davies R: Family studies and the cause of congenital clubfoot, talipes equinovarus, talipes calcaneovalgus, and metatarsus varus. *J Bone Joint Surg*, 46B:445, 1964.
- 2. Cramer, K: Metatarsus varus congenitus. Archiv fur Orthopadie, Mechanotherapie und Unfallchirurgie 2:5370-5374, 1921.
- 3. Kite, H: Congenital metatarsus varus. J Bone Joint Surg 49A:388-396, 1967.
- Lloyd-Roberts G, Clark G: Ball and socket ankle joint in metatarsus adductus varus. J Bone Joint Surg, 55B:193-196, 1973.
- 5. Bankart B: Metatarsus varus. Br J Med, 2:685-687, 1921.
- Rothbart, B: Metatarsus adductus and its clinical significance. J Am Podiatry Assoc, 62:187-191, 1972.
- Mittleman G: Transverse plane abnormalities of the lower extremities: intoe and outtoe gait. J Am Podiatry Assoc, 61:1-5, 1971.
- 8. Rushforth G: The natural history of hooked forefoot. J Bone Joint Surg, 60B:530-532, 1978.
- Chapple C, Davidson D: A study of the relationship between fetal position and certain congenital deformities. J Pediatr 181:483-493, 1941.
- 10. Berg E: A reappraisal of metatarsus adductus and skewfoot. J Bone Joint Surg 68A:1185-1196, 1986.
- 11. Reimann I, Werner H: Congenital metatarsus varus. *Clin Orthop* 110:223-226, 1975.
- 12. Peabody C, Muro F: Congenital Metatarsus Varus. J Bone Joint Surg 15:171-189, 1933.
- 13. Browne R, Paton D: Anomalous insertion of the tibialis posterior tendon in congenital metatarsus varus. J Bone Joint Surg 61B:74-76, 1979.
- 14. Lichtblau, S: Section of the abductor hallucis tendon for correction of metatarsus varus deformity. *Clin Orthop* 110:227-232, 1975.

- 15. Tax H, Albright T: Metatarsus adducto varus. J Am Podiatry Assoc, 68:331-338, 1978.
- Yu G, Wallace G: In McGlamry ED (ed): Comprehensive Textbook of Foot Surgery vol 1. Baltimore, Williams & Wilkins, 1987, p 334.
- 17. Bleck E: Metatarsus adductus: classification and relationship to outcomes of treatment. *J Pediatric Orthop* 3:2-9, 1983.
- Ghali N, Abberton M, Silk F: The management of metatarsus adductus et supinatus. J Bone Joint Surg 66B:376-380, 1984.
- 19. Sgarlato T: A Compendendium of Podiatric Bio-

mechanics. San Francisco, California College of Podiatric Medicine, 1971, p 176.

- 20. Engle E, Erlich N, Krems I: A simplified metatarsus adductus angle. J Am Podiatry Assoc 73:620-628, 1983.
- 21. Lepow G, Lepow R, Lepow R, Hillman L, and Neville R: Pediatric metatarsus adductus angle. *J Am Podiatric Med Assoc* 77:529-532, 1987.
- 22. Jacobs J: Metatarsus varus and hip dysplasia. *Clin Orthop* 16:203-212, 1960.
- 23. Ponseti I, Becker J: Congenital metatarsus adductus: the results of treatment. *J Bone Joint Surg* 48A:702-710, 1966.