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The Role of Surgery in Management of Primary Metatarsus Adductus

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ABSTRACT

Background: Metatarsus adductus is the most common congenital foot deformity in children. Different bone surgical procedures were portrayed to treat severe cases of fixed metatarsus adduction.

Objective: To establish a protocol for diagnosis and treatment of forefoot adduction deformity in metatarsus adductus, and to evaluate the results of double column osteotomy (closing wedge cuboid osteotomy and opening wedge medial cuneiform osteotomy) (i.e. lateral column shortening with medial column lengthening) in correction of the foot deformity. **Patients and Methods**: In this prospective study 16 patients with 17 feet with fixed metatarsus adductus were operated upon for forefoot adduction deformity in Zagazig University Hospitals since 2018. 10 boys and 6 girls from 4-12 years old. The right foot was operated upon in 7 patients and the left foot in 10 patients. All cases underwent double column osteotomy; closing wedge cuboid osteotomy and opening wedge medial cuneiform osteotomy.

Results: According to the grading system applied in this study, there were twelve cases with excellent results (nearly 70%). There was no pain throughout the foot. The forefoot adduction deformity was completely corrected. There was no supination in all cases. All cases manifested no complaints of the footwear or braces. All cases were satisfied and their parents revealed gratification of the foot shape and gait. There were 3 good results (18%), 2 fair results (12%), and no poor result. **Conclusion:** Double column osteotomy (combined cuboid/cuneiform osteotomy) is a safe operation, which allows satisfying correction of forefoot adduction deformity in severe rigid metatarsus adductus.

Keywords: Metatarsus Adductus, Surgery, Double Column Osteotomy.

INTRODUCTION

Metatarsus adductus (MA) was first portrayed by Henke in 1863, however until 1940 it was inconsistently reported in the literature [(1)]. Metatarsus adductus is a relatively common congenital foot deformity, which reportedly happens in 1:1000 alive childbirths and there is an expanded incidence with subsequent siblings of 1:10 [(2)]. In patients with MA, there is a disorder of the arrangement of the forefoot, with shifting degrees of supination and adduction (Figure 1).

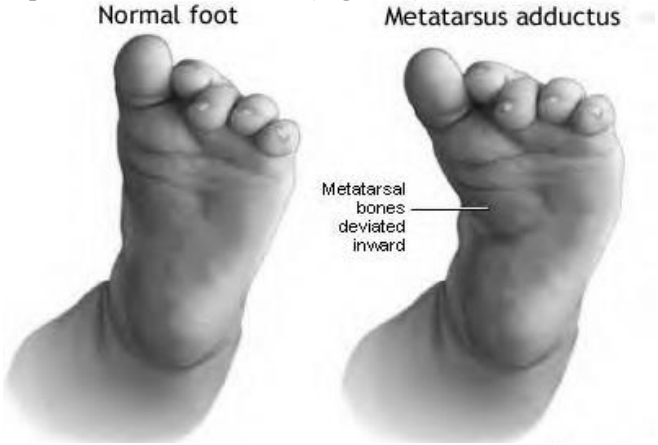

Figure (1): Normal feet and MA (the external side edge of the feet are convex, with a dorsal and lateral prominence at cuboid bone and the base of the fifth metatarsal) [(2)].

Moreover, the external side edge of the feet are convex, with a dorsal and lateral prominence at cuboid bone and the base of the fifth metatarsal. Though the calcaneus is at a valgus position, there is not equines deformity, rather than a clubfoot. The whole deformity is generally increased in weight-bearing and when the peroneal muscles are stimulated by tactile stimulation, the abduction of the forefoot fails to happen [(2)].

If the deformity is not managed, the patient will have an abnormal gait (i.e., the child will walk with the forefoot pointed toward the midline (in-toeing)) and may cause recurrent stumbling, which could have an unfavorable effect on both the parents and child. This dysfunction results in an expanded number of trips due to the child's consequent psychomotor retardation. Moreover, in the long term, the pressure applied by the shoe may be an inclining factor for the development of hallux valgus [(3)].

Management of the foot with metatarsus adductus differs depending on the degree of misalignment, ranging from monitoring and observation in mild cases to the applying of serial casts, thermoplastic splints, and even surgery in severe cases. Many authors agree that the optimum therapeutic choice will depend on the

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initial flexibility of the feet, which differs from observation attitude in mild cases to operative for the stiffest feet. There is general agreement that, in the most flexible cases (grade 1 metatarsus adductus, according to the Virgen Macarena University Hospital classification), parents should be educated foot flexibility exercises for the child to proceed consistently at home. Many studies of semirigid (grade 2) metatarsus adductus have shown that management with serial casts below the knee is the most common treatment. This management is by the applying of position correcting splints and parental observation of the child's sleeping and sitting positions. Severe cases (grade 3) need operative treatment for correction of fixed metatarsus adductus. Many operative procedures were described to manage severe cases of forefoot adduction. Some of them incorporate soft tissue releases others include several different bone surgeries to treat this disease. These procedures incorporate the closing wedge osteotomy of the cuboid and opening wedge osteotomy of the medial cuneiform (the double tarsal osteotomy procedure), tarsometatarsal intertarsal joints release and excision and coalition of the calcaneocuboid joint [(4)].

Double column osteotomy (closing wedge cuboid osteotomy and opening wedge medial cuneiform osteotomy) has advantages over the traditional metatarsal wedge osteotomies by allowing great cancellous bone-to-bone binds for accurate healing potential, sagittal plane stability, easier fixation, and avoidance of the physis of the base of the first metatarsal [(5)].

AIM OF THE WORK

Aim of the work is to establish a protocol for diagnosis and treatment of forefoot adduction deformity in metatarsus adductus, and to evaluate the results of double column osteotomy (closing wedge cuboid osteotomy and opening wedge medial cuneiform osteotomy) (i.e. lateral column shortening with medial column lengthening) in correction of the foot deformity, pain relief, tolerability to orthoses, and overall patient/parent satisfaction.

SUBJECTS AND METHODS

Methods: In this prospective study sixteen patients with seventeen feet with metatarsus adductus were operated upon for forefoot adduction deformity in Zagazig University Hospitals since 2018. All cases underwent double column osteotomy; closing wedge cuboid osteotomy and opening wedge medial cuneiform osteotomy.

Inclusion criteria: Failure of conservative treatment, severe fixed (rigid) forefoot adduction, in children between 4-12 years of age with severe metatarsus adduction.

Exclusion criteria: Secondary cases which result from management of club foot, children below 4 years old and above 12 years old and flexible (correctable) foot deformity.

Surgical Technique:

By using general anesthesia, children were put in the supine position. A tourniquet was used in the upper thigh in all the cases. Skin was prepared and limb was flexed, with the knee allowed to give direction to rotational arrangement. A longitudinal lateral curvilinear incision from the calcaneus and expand to the fourth metatarsal was done focused over the dorsolateral aspect of the cuboid bone. Subcutaneous tissue and deep fascia were isolated in accordance with skin entry point. Caution was taken to avoid damage of the sural nerve. A slight dorsomedial curvilinear incision was done starting promptly posterior to the tuberosity of the navicular and expanded distally to end at the proximal one fourth of the first metatarsal.

The subcutaneous tissue was separated in accordance with the skin entry point. The cuboid bone was uncovered over the lateral incision. A laterally wedge was expelled from the cuboid with saw or a sharp osteotome. The wedge was prepared according to the predetermined amount of the cuboid cut to correct the forefoot adduction deformity. Over the medial incision, we expose the abductor hallucis by detaching it proximally from its calcaneal origin and reflecting plantar ward. The deep fascia was cut to expose the medial plantar nerve and artery and the lateral plantar nerve and artery. A plane was formed between the fascia of plantar and the fat under the sole of the foot. The lateral plantar nerve and artery create a tunnel which crosses toward the lateral side in the foot. The abductor digiti minimi, flexor digitorum brevis and plantar fascia were liberated out from the calcaneus by setting one blade of the scissor into the tunnel for the lateral plantar nerve and artery and one blade superficial to the plantar fascia. The base of the first metatarsal, navicular, and medial cuneiform were distinguished.

The tibialis posterior tendon and the tibialis anterior tendon insert into the tuberosity of the navicular and into the base of the first metatarsal sequentially. A vertical osteotomy of the medial cuneiform was achieved with a small and sharp osteotome. The foot was controlled by bringing the mid foot and forefoot in abduction, editing the adduction deformity. The osteotomy place of the medial cuneiform was splitted with a lamina spreader or an osteotome. The wedge of bone excised from the cuboid bone was incorporated

into the medial cuneiform, the base of the cuboid wedge straight medially. Two smooth Kirschner wires were applied to fix the foot in the corrected (abduction) position in eight cases. One pin into the cuboid, beginning from the calcaneus and the second pin into the first web space, medial cuneiform. Intraoperative C-arm images were useful to evaluate the correction of bony deformity and the sites of pins in two planes: anteroposterior view and lateral view.

Radiological evaluation: Weight bearing anteroposterior and lateral x-ray views of ankles and feet were taken for all patients. In the anteroposterior view of the foot the metatarsus adductus angle (MAA), anterior talocalcaneal angle (Kite's angle) (TCA1), the calcaneal-fifth metatarsal angle and anterior talo-first metatarsal angle (TFMA1) were measured.

Ethical consideration and Written informed consent: Approval of the study was obtained from Zagazig University academic and ethical committee. Every patient signed informed written consent for the acceptance of the operation.

Statistical analysis

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Qualitative data were expressed as frequency and percentage.

RESULTS

A grading system was suggested in our study for assessment of metatarsus adductus deformity depending on clinical and radiographic measures and interconnecting them with scores.

The scoring system in this current study is similar in idea to the international rating system of **Bensahel *et al.*** [6] supported by the International Club Foot Study Group (ICFSG) which ranges from 0–60 points. Four groups of results are introduced as excellent, good, fair and poor.

The clinical evaluation (10 points) is based on the following criteria (Table 1).

The absence or presence of pain (2 points), the correction of the adduction deformity (2 points), the absence or presence of supination (1 point), the tolerability of footwear orthoses (2 points), the presence or absence of complication (1 points), the patient (or parent) satisfaction (2 point).

Score Clinical results:

Table (1**):** Score of the clinical results

Clinical results	Score
1- Pain:	
- Absent	2
-Mild pain	1
-Persistent pain	0
2- Adduction deformity:	
- Full correction (no adduction)	2
- Partial correction (adduction <50)	1
-Adduction >50	0
3-Supination:	
-Absent	1
-Present	0
4- Tolerability to footwear / brace:	
-Optimum	2
-Better than before surgery	1
-Intolerant (callus, ulcer, … etc.	0
5- Complication	
-No complication	1
-Occurring of complication	0
6- Patient (or parent) satisfaction:	
-both parents Satisfied	2
-one of parents satisfied	1
-both parents unsatisfied	0

The radiographic evaluation (10 points) is calculated on the following angles (Table 2):
Metatarsus adductus angle (MAA) measures (3 points), the anterior talocalcaneal angle (TCA1) measure (3 points), the calcaneo-fifth metatarsal angle (CFMA) measure (2 point), the anterior talo-first metatarsal angle (TFMA1) measure (2 points).

Score of the radiographic results:

Table (2**):** Score of the radiographic results

Radiographic results	Score
1-Metatarsus Adductus angle (MAA)	
<20	3
20˚- 26˚	2
27˚- 33˚	1
34˚- 40˚	0
2- Anterior talo-calcaneal angle (TCA1)	
30°-40°	3
20°-29°	2
10˚-19˚	1
<10°	0
3- Calcaneo-fifth metatarsal angle (CFMA)	
<10°	2
10°-20°	1
>20°	0
4- Anterior talo-first metatarsal angle (TFMA1)	2
<10°	1
10°-20°	0
>20°	

The results are classified into four categories as excellent, good, fair and poor depending on the total calculated score, if the total score was *19-20*, the result would be considered *excellent, 16-18* would be *good, 10-15* would be *fair*, and *less than 10* would be *poor*. Depending on this grading system, there were 12 excellent results, 3 good results, 2 fair results, and no poor result.

The Excellent Results: There were twelve cases with excellent results nearly (70%). There was no pain everywhere in the foot. The forefoot adduction deformity was completely corrected. There was no supination in whole cases. Whole cases showed no complaints of the footwear or braces. Whole cases were pleased and their parents revealed gratification of the foot position and walk.

The Good Results: There were three cases with good results (18%). All of them underwent double column osteotomy and soft tissue releases. The clinical assessment was exactly the same as that of the excellent results regarding the absence of pain and the absence of supination deformity.

The Fair Results: There were two cases with fair results (12%). All of them underwent double column osteotomy and soft tissue releases only. Deep and superficial wounds infection occurred in these cases.

DISCUSSION

MA is one of the comparatively common deformities of the foot in children. MA is the deviation of whole forefoot into the medial aspect of foot. Many different operative procedures were described in the past for the management of metatarsus adductus. Authors excised the abductor halluces muscle, reducing the medial soft tissue contracture [(7)].

Lichtblau[(8)] proved that a transverse dividing of the abductor hallucis tendon close to its insertion was efficient early in those cases in which a tense abductor halluces was presented. **Kendrick *et al.*** [(9)] portrayed a transection of the plantar, dorsal and interosseous ligaments and capsules of Lisfranc's joint to mobilize the soft tissues, permitting manual correction of the forefoot adduction.

In spite of the prior described soft tissue releases can be helpful procedures early in the recognition of MA

deformities, osseous surgeries become needful in resistant cases and those that go without treatment into adolescence. **McCarthy and Drennan** [10] stressed that treatment of the forefoot adduction in infancy is most significant, dissipating the legend that these feet will spontaneously correct if left without treatment.

Peabody and Muro [11] portrayed an osseous surgery in which an abductory osteotomy was performed on the base of the fifth metatarsal with an excision of the central bases of the three metatarsals and a medial mobilization with reducing the articulation of the first metatarsal with cuneiform. **Steytler and Van der Walt** [12] portrayed a V-shaped metatarsal osteotomy of metatarsals 1 into 5 in which the "V" shaped was done obliquely with the apex in the direction of the hindfoot. The medial arm was made vertical and the lateral arm was made more horizontal, they felt they could move the osteotomy with more stability because no fixation was used.

Berman and Gartland [13] then described crescentic osteotomy of metatarsals 1 into 5 with lateral translation then fixation of the first and fifth metatarsals only. **Fowler *et al.*** [14] described an opening wedge osteotomy of the medial cuneiform with the insertion of bone graft into the medial wedge. The same, **McHale and Lenhart** [15] portrayed a closing wedge osteotomy of the cuboid in which the wedge of bone was placed in the incision site medially in the opening medial cuneiform wedge. Putting a bone graft in the medial column prolongs the soft tissue structures of the medial column, may cause resistance to correction because the foot was held in abduction.

The double osteotomy manages the deformity by elongating the medial column employing the wedge excised from the lateral column. In this procedure the two sides of the deformity corrected giving superior correction than an isolated procedure in only one column [16].

Kose *et al.* [17] in 1999 described a transcuneiform osteotomy in which closing cuboid and opening medial cuneiform osteotomies was done in ten feet to manage adduction and supination deformities and another 3 patients with cavovarus deformity.

If the forefoot adduction is not severe enough to produce functional problems, it would be preferable to wait till the child is elderly enough to do the double osteotomy. It would be necessary that the medial cuneiform ossification center be well developed (commonly older than 3 years). **Lourenco *et al.*** [18] in 2001, announced that surgery is supported in children older than age 4 years, or when the medial cuneiform ossific nucleus is well formed. The scoring system in our study is similar in concept to the international rating system of **Bensahel *et al.*** [6] supported by the International Club Foot Study Group (ICFSG) which ranges from 0–60 points. Four groups of results are described as excellent, good, fair and poor. The outcome valuation should be carried out at 6 years old and at the end of the growth.

Loza *et al.* [16] plied the same scoring system in their study double column osteotomy for correction of residual adduction deformity in idiopathic clubfoot. Their results were eight feet (40%) had excellent, eight (40%) good, three (15%) fair and one (5%) poor outcome. But they used this procedure for adduction that result from management of club foot. In our study, we used this procedure in management of primary forefoot adduction, so our outcomes were better by utilizing a similar scoring system.

Our results suggested that a clinically satisfactory result is more likely to happen than radiographically satisfactory one. These clinical radiographic results had been previously described by **Wynne–Davies *et al.*** [19], they noticed more radiographic than clinical deformities in managed clubfeet.

Our indication for this procedure was based mainly on the clinical deformities, however, a radiographic study of the foot is important before operative. Both cosmetic and functional results were satisfactory. We approved that the double osteotomy is a very good procedure for treatment of metatarsus adductus. Tibialis anterior tendon transfer is essential with cases which have supination with forefoot adduction. We currently choose to observe till the child is older than four years of age prior proceeding with the surgery.

Whilst the discussion over management of forefoot adduction continues with the use of metatarsal osteotomy and another kind of tarsal osteotomies being suggested; our double osteotomy procedure has produced excellent outcomes, with a straight foot and no indication for other aggressive intervention.

CONCLUSION

Double column osteotomy (combined cuboid/cuneiform osteotomy) is a safe operation, which allows satisfying correction of forefoot adduction deformity in severe rigid metatarsus adductus.

Conflict of interest: the authors declare no conflict of interest.

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