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Research Article

An Opening Wedge Medial Cuneiform Osteotomy with Closing Wedge Cuboid Osteotomy with combined Fibular Allograft for Metatarsus Adductus in Children

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Abstract

Objective: We performing cuboid/cuneiform osteotomy combined fibular allograft to treat Relapsed Clubfoot and Congenital Metatarsus Adductus.

Materials and Methods: This study was a retrospective study of 54 feet with 36 feet with Relapsed Clubfoot and 19 feet with Congenital Metatarsus Adductus between January 2009 to December 2015. Orthopaedic examination included the gait, the presence of deformities other than that of the foot, the components of the foot deformity, the range of motion. The foot was evaluated for forefoot adduction deformity by Bleck's method. Radiographic evaluation: A visible ossific center in the medial cuneiform on an anteroposterior. Specific parameters measured the length of the medial column, and the length of the cuboid. The axis of the talus, the calcaneus, the axes of the first and fifth metatarsals. In the anteroposterior view of the foot, the anterior talocalcaneal angle, anterior talo-first metatarsal angle, and calcaneo-fifth metatarsal angle and the lateral talo-first metatarsal angle were measured. Surgical technique: Cuneiform and Cuboid osteotomy was combined fibular allograft. Evaluate according to Heymn., *et al*.

Result: There were 16 female and 22 in male; deformities: severe 21. Moderate 33; Average Age at Operation 64 months; Cuneiform/Cubois Osteotomy addition surgical technique: Planar - Fasciotomy: 14/54, Abductor hallucis tendon lengthening: 27/54, Achilles lengthening: 16/54; Duration of Follow-Up: 62.5 months. Total Surgical Results (RCF and CMA): Excellent: 17, Good: 27, Fair: 06; Poor: 04. Accepted Result (Excellent + Good): 44/54 (81.5%).

Conclusion: This combination of medial and lateral column osteotomies has reliably corrected severe forefoot adductus secondary to a variety of causes with a minimum of morbidity. The medial to lateral column relationship is improved, and report of pain secondary to wearing shoes are reliably relieved. At followed-up for more than 5 years. there was no deterioration of results in patients. Double column osteotomy (combined cuboid/cuneiform osteotomy) were combined fibular allograft is a safe operation.

Keywords: *Metatarsus Adductus; Skewfoot; Z-Shaped; Clubfoot; Cuneiform Osteotomy; Cuboid Osteotomy*

Introduction

Metatarsus adductus is one of the most common congenital foot deformities. The incidence of metatarsus adductus is reported to be 0.1 percent of live births [1]. Metatarsus adductus is a relatively common foot deformity of infancy or childhood where there is inward deviation of the forefoot relative to the hindfoot. A description of the anatomical relationships and pathological classification systems used to describe the causative agents of metatarsus adductus. The congenital metatarsus adductus (CMA), commonly known today, is also known as metatarsus varus [2,3], metatarsus adductovarus [4], pes adductus [5], metatarsus supinatus [6], forefoot adductus [7], and hooked forefoot [8] to name a few. Although all names are descriptive of the deformity of the legs, they are inaccurate or incorporate front

planes or hind legs distortions with pure plane distortions in the joints called LisFranc is metatarsus adductus. Metatarsus adductus, or isolation or secondary receding of Relapsed clubfoot (RCF) to deformities elsewhere in the legs such as equinovarus talipes, is a common problem in children. In most cases, non-surgical treatment is successful in adjusting the frontal alignment [9-11].

However, in severe cases, a surgical solution is needed to solve the problem with proper shoes. Various methods have been described; some have attempted to correct the distortion at the at the proximal metatarsal level, others at the joint of Lisfranc, and others in the middle [12-15].

McHale and Lenhart reported the first results from the opening wedge medial cuneiform and closing wedge cuboid osteotomy in the 1991. Others reported the results of patients treated with surgical inserted shaped wedge of the cuboid and opening medial cuneiform [13,15].

Since 2009 we have an opening wedge osteotomy of the medial cuneiform with a lateral closing wedge osteotomy of the cuboid and combined Fibular Allograft to treat Metatarsus adductus. We have used this technique to treat residual or recurrent forefoot adductus associated with clubfoot, skewfoot, and isolated metatarsus adductus.

This study reports the results of this procedure in correcting forefoot adductus in a diverse population.

Material and Methods

From January 2009 to December 2015, we performed in 42 patients (59 foots with Metatarsus Adductus in patients with 39 residual clubfoot (bilateral foots in 11 patients) and 20 Congenital Metatarsus Adductus (bilateral foots in 6 patients).

Four patients (five foots, residual clubfoot in 3 patients with 4 foots and metatarsus adductus in 1 patients) were lost to follow-up. The remaining 38 patients (54 foots as 16 patients had a bilateral foots) formed the basis of this study (10 of 25 patients with bilateral in residual clubfoot and 6 of 13 patients with bilateral metatarsus adductus). There were 24 males (63.2%) and 14 females (36.8%).

Clinical and roentgenographic check-up All patients completed a questionnaire and were interviewed by a member of staff at the study hospital. A complete clinical examination of the foot was performed, which included measurements of the range of movement, position of the foots, carrying angle, and length of the foots. The indication for the procedure was forefoot adductus causing pain associated with shoe wear in children too old for conservative methods such as casting. A visible ossific center in the medial cuneiform on an anteroposterior (AP) radiograph of the foot was a prerequisite for the surgery. The presence of hindfoot valgus was not considered a contraindication to the procedure.

Pre-operative clinical evaluation

Neurological examination was done to exclude a non-idiopathic clubfoot. Assessment included evaluation of muscle tone, motor power, sensation, reflex activity, and gait.

Orthopaedic examination included the gait, the presence of deformities other than that of the foot, the components of the foot deformity, the range of motion (forefoot flexibility), and the skin condition. The foot was evaluated for forefoot adduction deformity by Bleck's method assessing the position of the forefoot with respect to the mid-line axis of the hindfoot [16]. Forefoot adduction deformity was evident in all cases. Contracture of tibialis anterior tendon and abductor hallucis muscle was noted. Cavovarus deformity and its flexibility were assessed by Coleman's block test [17]. Four cases had frank foot pain due to thickened callous and large bursa over the dorsolateral aspect of the foot, excessive scars of previous operations or dorsal subluxation of the navicular. All cases had skin problems of thickened callous and/or scarring of previous operations.

Exclusion criteria

Non-idiopathic, secondary clubfoot, children below 3 years of age, hindfoot deformity, flexible (correctable) foot deformity, and relapsed clubfeet for several times were excluded. The presence of hindfoot valgus was not considered a contraindication to the procedure.

The indication for the procedure was forefoot adductus causing pain associated with shoe wear in children too old for conservative methods such as casting.

Pre-operative radiographic evaluation

A visible ossific center in the medial cuneiform on an anteroposterior (AP) radiograph of the foot was a prerequisite for the surgery. Specific parameters measured the length of the medial column, and the length of the cuboid. The medial column length was calculated by measuring the distance from the proximal midpoint of the navicular to the most distal extent of the first cuneiform on a standing AP radiograph. The length of the cuboid was measured from the point on the cuboid opposite the midpoint of the fourth metatarsal to the midpoint of the calcaneocuboid joint on the standing AP radiograph. A medial-lateral column ratio was also calculated by dividing the total length of the medial column by the total length of the cuboid as measured on each radiograph.

Weight-bearing anteroposterior and lateral X-ray views of ankles and feet were taken for all patients. The axis of the talus was determined by the bisector of its head and neck (i.e. not necessarily its body). The axis of the calcaneus was determined by the line joining its plantar most points from the tuberosity to the most distal point (i.e. the calcaneocuboid joint). The axes of the first and fifth metatarsals were their bisectors. In the anteroposterior view of the foot, the anterior talocalcaneal angle TCA1 or Kite's angle for varus (normally 20 - 40°) [18], anterior talo-first metatarsal angle TFMA1 (normally 0° to -10°, adduction positive) [18], and calcaneo-fifth metatarsal angle CFMA (normally 0 - 5°) [19] for forefoot adduction were measured. In the lateral view of the foot, the lateral talocalcaneal angle TCA2 (normally 25 - 50°) [18] and the lateral talo-first metatarsal angle or Meary's angle TFMA2 for cavus (normally 0 - 5°) [18] were measured. The variable range of measures of these weight-bearing radiographic angles was recorded; and the mean calculated.

Evaluating foot deformity according to Bleck's Classification [16].

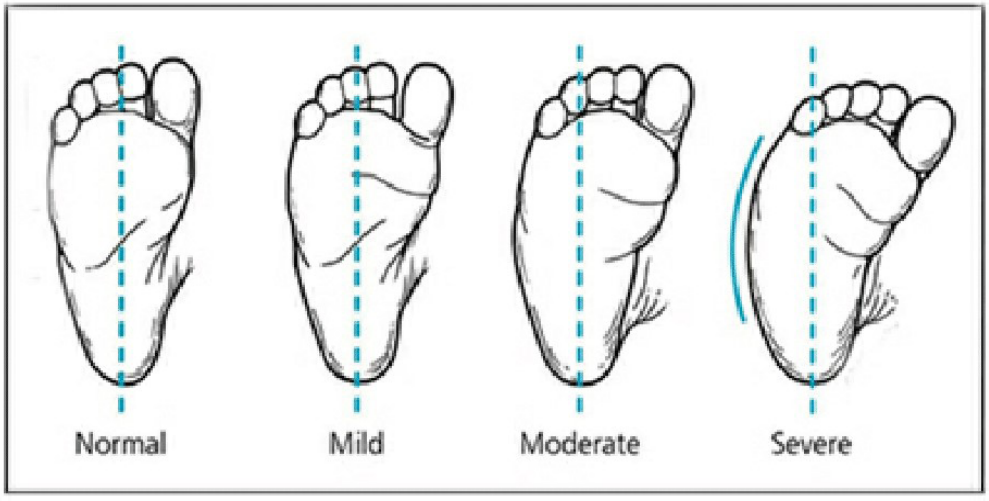


Figure 1: *Heel bisector defines relationship of heel to forefoot from left to right: normal (bisecting second and third toes), mild metatarsus adductus (bisecting third toe), moderate metatarsus adductus (bisecting third and fourth toes), and severe metatarsus adductus (bisecting fourth and fifth toes).*

Operative technique

The patient was placed in a supine position on the operating table. The affected limbs are prepared and draped free during a sterile period. An oblique incision is first created over the medial cuneiform and the medial surface of the cuneiform is exposed sharply. Small arthrotomies are made in the naviculocuneiform joint and the medial cuneiform-first cuneiform joint to confirm the position of the medial cuneiform. It is usually necessary to release the most proximal attachment of the tibialis anterior tendon to visualize the cuneiform-metatarsal joint. Fractional lengthening of the great toe abductor is also performed to relieve the soft tissue tension medially. When hallux varus is present along with metatarsus adductus deformity, abductor hallucis tendon lengthening should be performed. Then perform a vertical osteotomy through its middle wedge with an oscillating saw.

Care is taken to avoid extending the osteotomy laterally into the adjacent second cuneiform. Second lateral longitudinal incision 4 cm to expose cuboid. The chopped operation is then taken down to the level of the cuboid. The inferior edge of the extensor brevis communis muscle is sharply defined and elevated superiorly. The cuboid is exposed extraperiosteally to most of the dorsal and plantar surfaces. Exposure is accomplished by carefully identifying the near and distal joints of the rectangle through small arthrotomies. A laterally based wedge of bone is then removed with a small oscillating saw.

Prepare Fibular Allografting Segment

The fibula allografts that were used in this treatment protocol were imported from bone banks that adhere to the standards of Asia Association Surgery Tissue Bank. These grafts are of a processed type (freeze-dried) which have been proven to be safe [20].

Fibular allograft is prepared after stretch medial cuneiform. Preforming Fibular allograft osteotomy to create wedge of bone graft. The wedge typically measures 10 to 12 mm at its base, depending on the size of the cuneiform (Figure 2). After complete wedge fragment of fibular Allograft, to create two holes by Kirschner wire with oblique insertion about 20 - 30° (Figure 3).

Figure 2: *Preforming Fibular allograft osteotomy.*

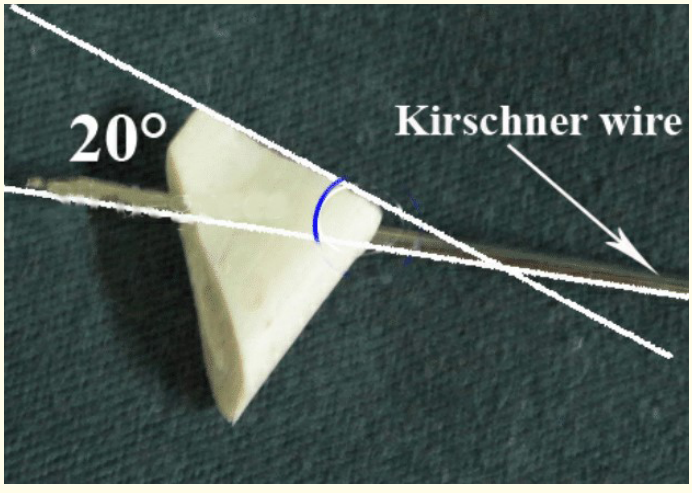


Figure 3: *To create two holes by Kirschner wire with oblique insertion about 20-30°.*

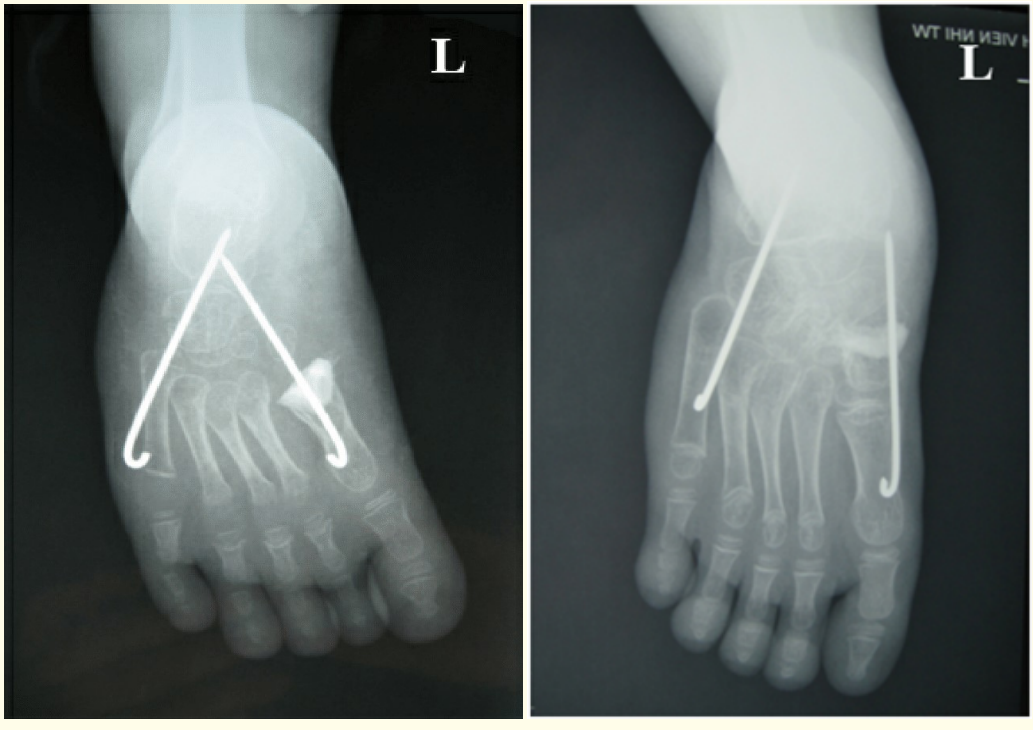
The osteotomy of the cuneiform is then opened with two small towel clips. The Fibular Allograft fragment is then placed into the medial cuneiform osteotomy. The wedge is inserted medially into the 1st cuneiform osteotomy with the fore part of the foot held in as much abduction as possible (Figure 4).

Figure 4: *The bone graft is seated into position of the foot.*

The osteotomies were secured with two Kirschner wires, one from the medial cuneiform into the navicular bone and the other from the cuboid into the calcaneus (Figure 4 and 5A and 5B). Intra-operative Roentgenography was of help to assess the correction of the bony deformity and the position of pins (Figure 6 A and B).

Figure 5A: *Kirschner wires from the medial cuneiform into the navicular bone.*

Figure 5B: *Kirschner wires from the cuboid into the calcaneus bone.*



(A) ***(B)***

Figure 6A and 6B: *Roentgenography was of help to assess the correction of the bony deformity and the position of pins (Figure 6A and 6B).*

The wounds are closed in layers by 3 - 0 or 4 - 0 absorbable suture. The foot is immobilized by non-weight bearing cast.

The K-wires were removed at 12 weeks and a weight-bearing cast was applied till radiographic evidence of bony union, usually at 12 - 16 weeks postoperatively.

Follow-up

Patients were re-examined at three and six weeks, three and six months, one year, and afterwards every year.

At latest follow-up, All patients were examined and evaluated by three other doctors, who classified the foot clinically as having normal appearance, mild residual varus, marked residual varus, or valgus.

In addition, each patient's gait was inspected, patients and parents to receive questions about the pain, problems of shoes, and, or other difficulties.

The results of tile operative procedure were evaluated by the criteria utilized by Heymn., *et al*. [21] in their report on tarsometatarsal mobilization. An excellent result was an asymptomatic foot which had essentially normal alignment and demonstrated no roentgenographic abnormality in the fore part of the foot. A good result was one in which the appearance of the foot deviated only slightly from normal, there were no symptoms, no disability was anticipated in the future, and both parents and the surgeons were satisfied. A fair result was one in which the surgeons was not completely satisfied with either the appearance of the foot or the appearance of the fore part of the foot as demonstrated by roentgenogram but the patient was asymptomatic, no disability was anticipated, and no further treatment was required. A poor result was either a failure of correction or a foot that required further treatment.

Statistical analysis

The data were analysed with Epi Info 6.04 software public domain statistical software for epidemiology, developed by Centers for Disease Control and Prevention (CDC) in Atlanta, Georgia, USA, http://wwwn.cdc.gov/epiinfo/html/prevVersion.htm. We performed the $\chi 2$ test for percentage and the t-student test for mean comparison between the preoperative and postoperative groups. P-values ≤ 0.05 were regarded as statistically significant. All readings were provided as average values together with the appropriate standard deviation.

Results

Clinical results

Evaluating foot deformy according to be Bleck's Classification [16] preoperative with 21 feet (38.9%) in Moderate and 33 feet (61.1%) in Severe (Table 1 and 2). The postoperatively as having an essentially normal appearance in 31 feet (57.4%), mild residual varus in 20 feet (37.0%), marked residual varus in three feet (5.6%).

No.	Sex	Size	Degree Deformity	Age at initial Operation (Months)	Age at date of operative relapsed clubfoot (Months)	Cuneiform/Cubois Osteotomy addition surgical technique	Duration of Follow-Up (Months)	Results
1	Fem	L	Moderate	25	55	Abductor hallucis tendon lengthening,	48	Excellent
2	Fem	R	Moderate	16	41	Abductor hallucis tendon lengthening,	59	Excellent
3	Mal	Bil.	L-Moderate R-Severe	20	54	Planar – Fasciotomy Achilles lengthening	66	L. Good F. Good
4	Fem	L	Severe	9	60	Planar – Fasciotomy Abductor hallucis tendon lengthening, Achilles lengthening	90	Good
5	Fem	R	Severe	18	52	Abductor hallucis tendon lengthening,	38	Fair
6	Mal	Bil	Both Severe	12	64	Planar – Fasciotomy Abductor hallucis tendon lengthening,	42	R. Good L. Fair
7	Mal	R	Moderate	16	54	Abductor hallucis tendon lengthening, Achilles lengthening	78	Excellent
8	Fem	Bil	Both Moderate	25	77	Abductor hallucis tendon lengthening,	94	L. Good R. Good
9	Fem	L	Moderate	18	62	Abductor hallucis tendon lengthening, Achilles lengthening	69	Good
10	Mal	R	Moderate	11	65	Abductor hallucis tendon lengthening,	78	Good
11	Mal	R	Moderate	17	58	Abductor hallucis tendon lengthening,	42	Excellent
12	Fem	Bil	R-Moderate L-Severe	28	69	Planar – Fasciotomy, Achilles lengthening	55	R. Good L. Fair
13	Mal	L	Moderate	22	62	Abductor hallucis tendon lengthening,	39	Excellent
14	Mal	Bil	L-Moderate R-Severe	13	83	Planar – Fasciotomy Abductor hallucis tendon lengthening,	96	R. Excellent L. Good
15	Fem	Bil	L-Moderate R-Severe	15	78	Planar – Fasciotomy Achilles lengthening	84	R. Execellent L. Good
16	Fem	R	Moderate	18	57	Abductor hallucis tendon lengthening,	45	Excellent
17	Mal	L	Moderate	17	66	Abductor hallucis tendon lengthening,	64	Excellent
18	Mal	R	Severe	25	86	Abductor hallucis tendon lengthening, Achilles lengthening	83	Poor
19	Fem	Bil	Both Severe	14	67	Abductor hallucis tendon lengthening, Achilles lengthening	95	R. Poor L. Good
20	Mal	R	Severe	12	56	Abductor hallucis tendon lengthening, Achilles lengthening	81	Fait
21	Fem	L	Severe	14	84	Abductor hallucis tendon lengthening, Achilles lengthening	39	Poor
22	Fem	Bil	Both Moderate	22	82	Abductor hallucis tendon lengthening,	56	R. Excellent L. Good
23	Mal	Bil	Both Moderate	14	62	Planar – Fasciotomy Abductor hallucis tendon lengthening,	45	R. Good L. Good
24	Fem	L	Moderate	16	68	Abductor hallucis tendon lengthening, Achilles lengthening	61	Good
25	Fem	Bil	Both Severe	12	71	Planar – Fasciotomy Achilles lengthening	48	R. Good L. Good
	Fem: 14 Mal: 11	Bil: 10 L: 7 R: 8	Severe: 15 Moderate: 20	17.16 SD = 4907333	65.32 SD = 11.41169	Planar – Fasciotomy: 14/35 Abductor hallucis tendon lengthening: 27/35 Achilles lengthening: 16/35	63.8 SD = 19.7252	Excellent: 10 Good: 18 Fair: 04 Poor: 03

Table 1: *Data and Surgical technique for Metatarsus Adductus in residual Clufoot.*

Fem: Female; Mal: Male; R: Right; L: Left; Bil: Bilateral.

Sex: Female in 14 patients, Male in 11 patients; Bilateral in 10 patients, Left foot in 7 patients, Right foot in 8 patients; Degree Deformity: Severe: 15, Moderate: 20 Age at initial Operation 17.16 months (SD=4907333); Age at date of operative Relapsed clubfoot 65.32 months (SD = 11.41169); Cuneiform/Cubois Osteotomy addition surgical technique: Planar – Fasciotomy: 14/35, Abductor hallucis tendon lengthening: 27/35, Achiles lengthening: 16/35; Duration of Follow-Up 63.8 months (38-96 months) (SD = 19.7252); Latest Results: Excellent: 10, Good: 18, Fair: 04; Poor: 03. Accepted Result (Excellent + Good): 28/35 (80.0%).

No.	Sex	Size	Degree Deformity	Age at date of operative (Months)	Cuneiform/Cubois Osteotomy addition surgical technique	Duration of Follow-Up (Months)	Results
1	Mal	Bil.	Both Moderate	44		49	L. Good R. Good
2	Fem	R	Moderate	62		63	Excellent
3	Fem	L	Severe	54	Abductor hallucis tendon lengthening	68	Good
4	Fem	Bil.	L-Moderate R-Severe	66	Abductor hallucis tendon lengthening	85	L. Excellent R. Good
5	Fem	Bil	Both Severe	58	Abductor hallucis tendon lengthening	39	R. Fair L. Good
6	Mal	L	Severe	69	Abductor hallucis tendon lengthening	45	Excellent
7	Mal	R	Moderate	55		71	Excellent
8	Fem	Bil	Both Moderate	82		89	L. Good R. Fair
9	Fem	Bil.	Both Moderate	65		66	R. Good L. Excellent
10	Mal	L	Moderate	64		75	Good
11	Mal	R	Moderate	62	Abductor hallucis tendon lengthening	46	Excellent
12	Fem	Bil	R-Moderate L-Severe	73		58	R. Good L. Poor
13	Fem	L	Moderate	62		42	Excellent
	Fem: 8 Mal: 5	Bil: 6 R: 3 L: 4	Severe:6 Moderate: 13	62.76923 SD = 9.32875	Abductor hallucis tendon lengthening: 5	61.23977 SD = 16.36131	Excellent: 07 Good: 9 Fair: 02 Poor: 01

Table 2: *Data and Surgical technique for Congenital Metatarsus Adductus.*

Fem: Female; Mal: Male; R: Right; L: Left; Bil: Bilateral.

Sex: 8 Patients were Female, and 5 patients were Male; Bilateral in 6 patients, Left foot in 4 patients, Right foot in 3 patients; ; Degree Deformity: Severe: 6, Moderate: 13; Age at date of operative 62.76923 (SD=9.328753); Cuneiform/Cubois Osteotomy addition surgical technique: Abductor hallucis tendon lengthening: 5; Duration of Follow-Up 61.23 months (39 - 89 moths) (SD = 16.36131); Latest Results: Excellent: 7, Good: 9, Fair: 02; Poor: 01. Accepted Result (Excellent + Good): 16/19 (84.2%).

Latest Results: Excellent: 10, Good: 18, Fair: 04; Poor: 03. Accepted Result (Excellent + Good): 28/35 (80.0%) in RCF; Excellent: 7, Good: 9, Fair: 02; Poor: 01. Accepted Result (Excellent + Good): 16/19 (84.2%) in CMA.

Total Latest Results (RCF & CMA): Excellent: 17, Good: 27, Fair: 06; Poor: 04. Accepted Result (Excellent + Good): 44/54 (81.5 %).

Compare accepted results between RCF and CMA with P value 0.98161 was not statistically significant.

The parents classified the foot as improved in 44 feet (81.5%), unchanged in six feet (11.1%), and worse in four foot (7.4%).

Average Age at date of operative 87.5 months (41- 83 months), there was 1 patient under 41 months old (number 2 in table 1). A average duration of Follow-Up was 62.5 months (38 - 96 months). Surgical results: Excellent in 17 feet (31.5%), Good in 27 feet (50.0%), Fair 6 in feet (11.1%), and Poor in 4 feet (7.4%). Accepted Result (Excellent + Good): 44/54 (81.5%).

No	Talo 1st Metatarsal (Nor. 0 to 10° [18])		Lateral talocalcaneal (Nor. 25 to 50° [18])		Calcaneo 5th metatarsal (Nor. 0 to 5° [18])		Anterior talocalcaneal (Nor. 20 to 40° [18])		Lateral talo-first metatarsal (Nor. 0 to 5° [18])	
	Pre.	Post.	Pre.	Post.	Pre.	Post.	Pre.	Post.	Pre.	Post.
1	25	4	38	32	28	9	13	24	31	10
2	22	6	27	26	24	8	33	29	29	5
3	26	12	41	36	16	10	17	36	38	8
	23	14	49	35	26	6	8	24	29	9
4	25	7	45	30	17	7	25	28	19	12
5	28	8	33	28	27	6	19	24	15	11
6	38	15	43	33	28	8	7	21	22	8
	49	9	50	30	15	11	9	23	33	4
7	74	14	24	26	16	6	19	21	35	3
8	32	8	45	36	19	9	18	26	39	4
	39	11	41	28	25	5	16	24	32	5
9	58	14	44	32	22	3	18	23	28	6
10	42	9	34	36	20	8	10	26	34	10
11	36	10	50	29	15	10	21	29	36	12
12	44	15	45	35	25	11	27	20	24	9
	35	19	33	29	18	11	24	38	28	7
13	28	9	43	25	21	4	16	27	21	9
14	38	5	46	28	24	8	19	28	32	4
	44	10	38	26	18	9	25	29	27	9
15	51	7	45	30	17	8	14	35	31	10
	37	12	46	29	28	11	15	21	23	6
16	48	9	38	26	19	12	22	24	35	4
17	45	14	45	29	18	12	19	29	34	9
18	32	6	41	26	16	14	24	22	36	8
19	42	8	54	35	22	12	21	20	29	12
	58	11	54	37	21	11	26	21	40	11
20	36	20	50	34	16	11	14	28	37	7
21	48	8	45	27	19	10	23	30	35	9
22	38	6	33	28	28	12	19	29	32	8
	29	8	43	22	25	9	16	20	24	6
23	35	6	45	38	23	10	20	29	35	4
	49	5	38	27	21	12	23	33	20	15
24	38	12	45	28	17	7	28	22	43	9
25	42	9	42	25	19	6	19	29	32	8
	38	6	51	34	21	9	22	21	37	5
Average	39.2	9.88	42.4	30.14	20.97	9.0	19.11	26.08	30.71	7.88
SD	11.07	3.901	6.941	4.131	4.17	5.56	5.81	4.755	6.546	2.867
P *value*	< 0.05		< 0.05		< 0.05		< 0.05		< 0.05	

Table 3: *Analysis of radiographic parameters averaged in Relapsed Clubfoot with Metatarsus Adductus.*

Nor: Normal; Pre: Pre-Operation; Post: Post-Operation.

Roentgenography for all angle of the foot with Metatarsus Adductus were compared preoperative and Follow-up was statistically significant

No	Talo 1st Metatarsal (Nor. 0 to 10° [18])		Lateral talocalcaneal (Nor. 25 to 50° [18])		Calcaneo 5th metatarsal (Nor. 0 to 5° [18])		Anterior talocalcaneal (Nor. 20 to 40° [18])		Lateral talo-first metatarsal (Nor. 0 to 5° [18])	
	Pre.	Post	Pre.	Post	Pre.	Post	Pre.	Post	Pre.	Post
1	23	5	36	31	22	4	12	25	40	11
	22	12	25	28	20	8	34	30	28	5
2	25	6	41	31	24	6	26	29	26	8
3	29	9	35	29	23	11	21	35	33	12
4	71	12	27	26	19	6	18	22	34	6
	19	4	44	29	22	12	19	23	27	4
5	25	11	54	33	18	11	18	26	25	4
	27	12	52	22	19	10	23	29	38	9
6	29	8	45	24	20	4	19	23	29	5
7	28	9	36	24	22	5	25	36	37	12
8	44	15	45	25	21	8	23	29	15	9
	19	7	40	21	24	4	28	23	27	4
9	37	12	48	31	18	9	19	28	29	10
	45	9	41	26	22	11	27	34	26	5
10	30	9	45	28	26	12	29	28	36	7
11	28	12	36	16	20	6	34	32	25	9
12	54	14	41	29	22	6	26	27	27	10
	20	4	28	21	23	11	21	36	34	5
13	26	7	35	22	15	10	18	29	29	10
Average	31.63	9.315	39.68	26.10	21.05	8.10	23.15	28.63	29.73	7.63
SD	13.16	3.266	7.93	4.40	2.59	2.88	5.73	4.43	5.91	2.81
P *value*	< 0.05		< 0.05		< 0.05		< 0.05		< 0.05	

Table 4: *Analysis of radiographic parameters averaged in Metatarsus Adductus.*

Nor: Normal; Pre: Pre-Operation; Post: Post-Operation.

Radiographic analysis at follow-up showed a statistically significant improvement in parameters measuring.

Radiographic results

The average talo-first metatarsal angle decreased from 39.2 preoperatively to 9.88 at final follow-up in RCF, and 31.6 to 9.315 in CMA. The changes in each of these angles represent nearly complete radiographic correction of the adductus deformity.

Other angles were measured at pre - postoperative: lateral talocalcaneal 42.4 - 30.1 in RCF, and 39.7 - 26.1 in CMA; Calcaneo 5th metatarsal: 20.9 - 9 in RCF, and 21.1 - 8.1 in CMA; Anterior talocalcaneal: 19.1 - 26.1 in RCF, and 23.2 - 28.6 in CMA; Lateral talo-first metatarsal: 30.7 - 7.8 in RCF, and 29.7 - 6.6 in CMA.

The average length of the medial column increased from 3.0 cm preoperatively to 3.9 cm at latest follow-up. The mean cuboid or lateral column length was 2.5 cm preoperatively and at latest follow-up. These average length changes led to an increase in the ratio of medial-to-lateral column length from a mean value of 1.2 preoperatively to an average value of 1.6 at latest follow-up, an increase of 33%.

There was one complication (1.9%), displacement of Kirschner wires had been used to secure the cuboid osteotomy to out and infective wound occurred in patients at post-operative 09 moths (Figure 7). In the roentgenography didn't show osteomyelitis or destruction of fibular allograft segment (Figure 8A). Bone interface between bone graft and host bone, have shown new bone cell (Biopsy of material obtained 9 months post-operation) (Figure 8B). Patient had removed Kirschner wires and intravenous antibiotics were used. The foot at final follow-up with clinically improved and evaluated surgical result was fair (Number 9 in Table 1). Three of the 54 (5.6%) feet required medial Kirschner wire removal because of reports of prominence or discomfort. Mild pain persisted on the medial aspect of the foot in the two patient after Kirschner wire removal (3,7%); the patient has refused further intervention because of the minimal nature of the pain.

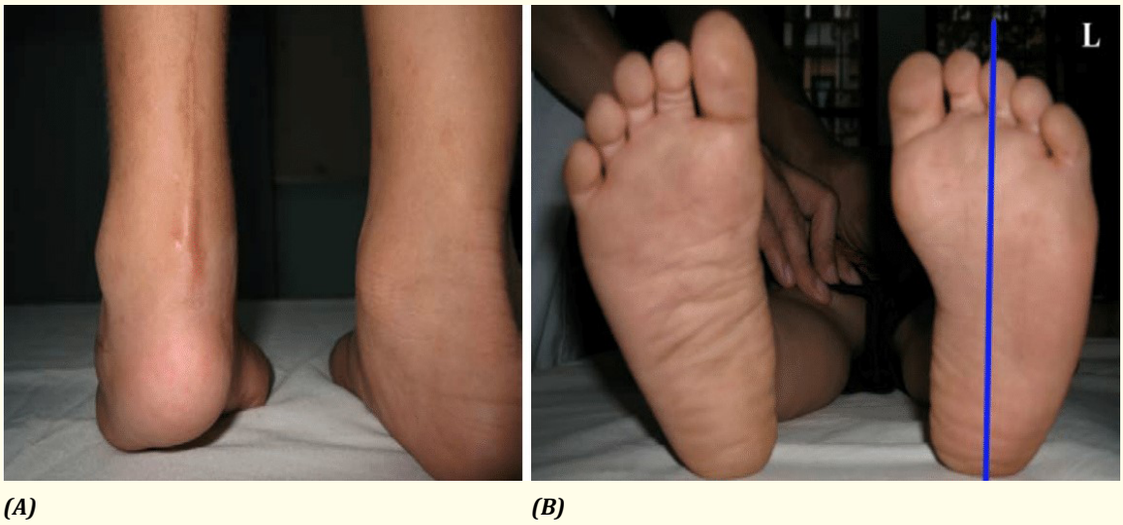
Figure 7: *Displacement of Kirschner wires.*

(A) ***(B)***

Figure 8A and 8B: *A. Aspiration of tissue at area bone allograft Fibular Allograft segment at post-operatively 9 months; B. Bone interface between bone graft and host bone, have shown new bone cell (Biopsy of material obtained 9 months post-operation).*

Illustration

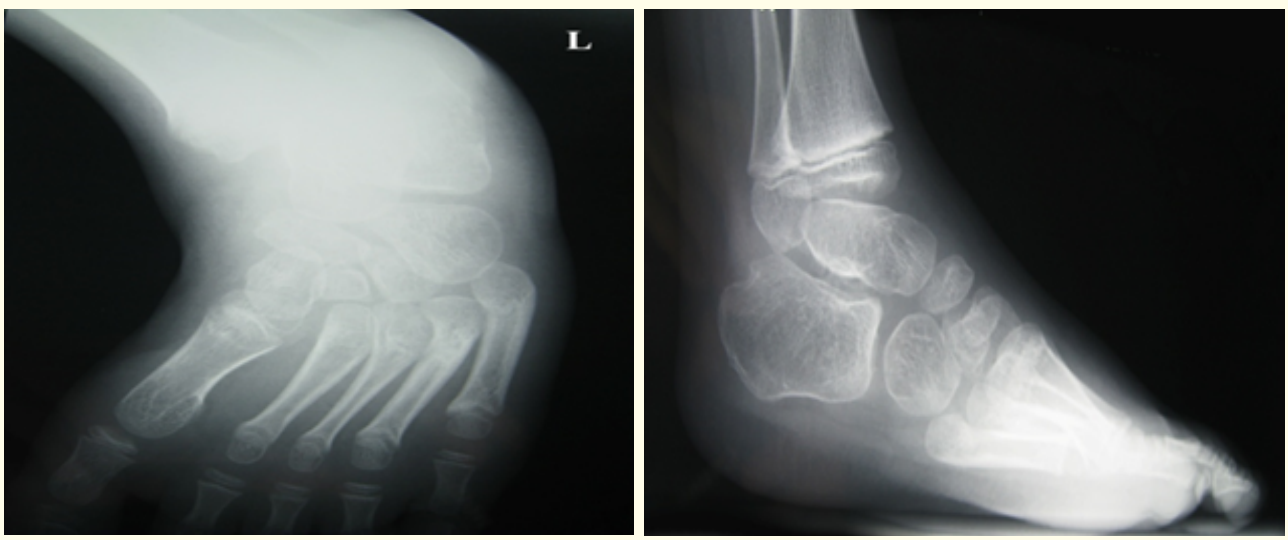
Patient number 9 (Table 1-RCF): A girl, Age at initial Operation was 18 months; Age at date of operative relapsed clubfoot was 62 months. Degree deform was Moderate (Figure 8A and 8B).



(A) ***(B)***

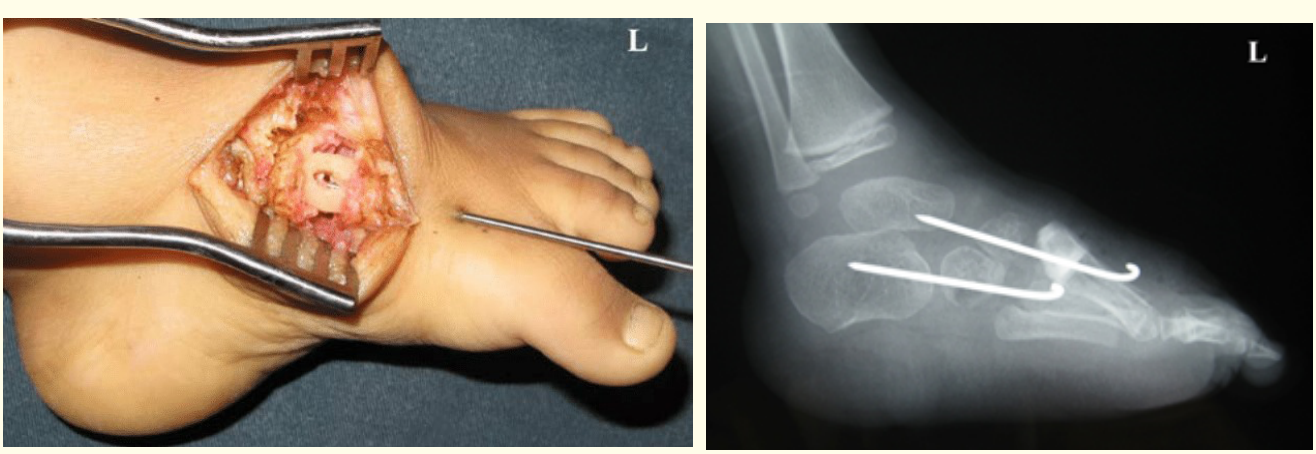
Figure 9A and 9B: *A. Relapsed Clubfoot and B. with Degree deform was Moderate.*

An average angles were measured at pre - postoperative: Talo–first metatarsal: 58 – 3; lateral talocalcaneal 44 – 32; Calcaneo 5thmetatarsal: 22 – 3; Anterior talocalcaneal: 18 – 23; Lateral talo-first metatarsal: 28 – 6.



(A) ***(B)***

Figure 10 A and 10B: *The average talo-first metatarsal angle decreased from 58 preoperatively to 14, lateral talocalcaneal 44 to 32, Calcaneo 5thmetatarsal: 22 to 3, Anterior talocalcaneal: 18 to 23, and Lateral talo-first metatarsal: 28 - 6 at latest follow-up.*



(A) ***(B)***

Figure 11 A and 11B: *Cuneiform/Cubois Osteotomy and addition surgical technique: Abductor hallucis tendon lengthening, Achiles lengthening.*

(A) ***(B)***

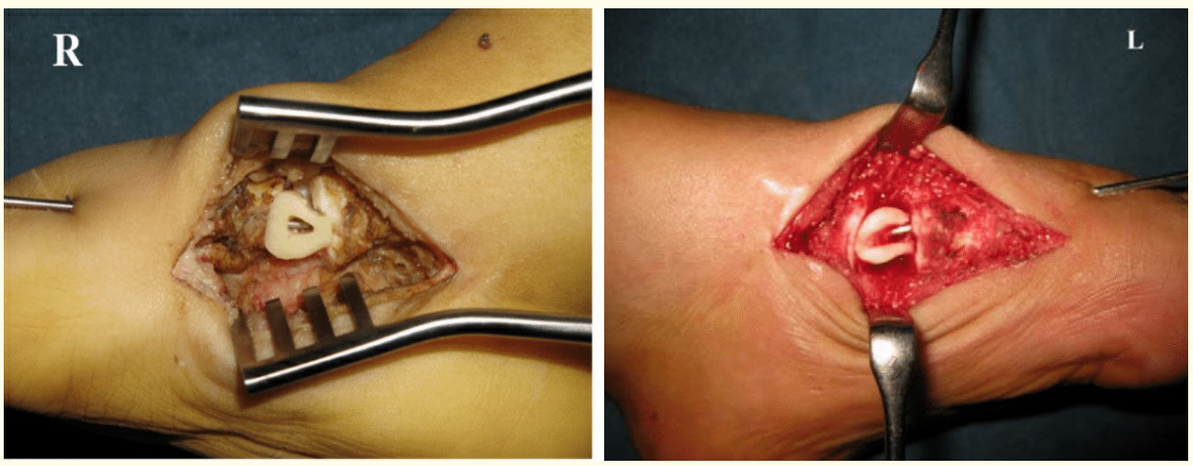
Figure 12: *Post-operative 69 months, latest Follow-up: Left are Good.*

Patient number 8 (Table 2 - CMA): A Female, Age at Operation was 82 months; Both feet with Degree deform was Moderate (Figure 13).

Figure 13: *Both feet with Degree deform was Moderate.*

Figure 14: *An average angles were measured at pre - postoperative:*

- *Right foot: Talo-first metatarsal: 23 - 5; lateral talocalcaneal 36 - 31; Calcaneo 5th metatarsal: 22 - 4; Anterior talocalcaneal: 12 - 25; Lateral talo-first metatarsal: 40 - 11.*
- *Left foot: Talo-first metatarsal: 22 - 6; lateral talocalcaneal 25 - 28; Calcaneo 5th metatarsal: 20 - 8; Anterior talocalcaneal: 34 - 30; Lateral talo-first metatarsal: 28 - 5.*



(A) ***(B)***

Figure 15A and 15B: *Cuneiform/Cubois Osteotomy for both feet.*

(A) ***(B)***

Figure 16A and 16B: *Post-operative 89 months, latest Follow-up: Left are Good, and Right are Fair.*

Discussion

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 cause is secured by two reasons. First, if the causal relationship can be identified for any defect, it can be prevented by reducing the deformation 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 plans depends 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 [1,22].

This is supported by studies showing that an asymmetric number of infants are affected in prima gravida mothers [23]. Genetics has only accounted for two to four percent of all metatarsus adductus cases [3]. However, the percentage of men is slightly lower than the 1.3: 1 ratio reported by most authors. Kite felt that muscle imbalance was responsible for metatarsus with tibialis anterior and tibialis posterior overpowering the weaker peroneal muscles [3]. This theory was opposed by Reimann and Werner, who showed that varicose lactic can only be replicated in the pedicle by extending the capsulotomy even with extreme tension placed on the tibialis anterior tendon [24].

Other theories of causal relationship have been proposed including abnormal tendon insertion of tibialis anterior [5,25], tibialis posterior [26], and abductor hallucis muscles [27]. Osseous malformations include absence of the medial [5], and the arrest of natural growth [27]. The combination of these factors has also been suggested [28].

Clinical Evaluation

Diagnosis of metatarsus adductus usually can be made based on clinical presentation. Deformity can be diagnosed at birth, however, many researchers say that this distortion is often not recognized until the child is a few months old. Deformity can be bilateral or unilateral cases occurred with less frequency [3].

Examination of the infant's foot with metatarsus adductus deformity shows that 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. The medial foot border is concave with a deep vertical skin crease located at the first metatarsocuneiform joint level.

Hallux can be widely separated by second digits and the lesser digits will usually be adducted at their bases. ln some cases the abductor hallucis tendon may be palpably taut just proximal to its insertion into the inferomedial aspect of the proximal phalanx.

The grading and classification system has been proposed by some investigators to identify patients who will spontaneously correct or require conservative therapy only. However, efforts to use clinical standards to determine which cases will become stubbornly 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 [28]. His classification system is still useful, however, in the clinical presentation description of metatarsus adductus.

Metatarsus varus is different in that the forefoot is inverted in relation to the rearfoot. Adduction at LisFranc's joint is present and is often a serious component of this deformity.

The rearfoot is usually in valgus position to complete the presentation of a skewfoot. Normally rearfoot valgus is considered compensatory to metatarsus varus; however, in newborns, this does not happen due to weight and the need for compensation has not yet occurred.

Occasionally, metatarsus adductus or its variants are confused with congenital clubfoot. Variation is, however, simple since the rearfoot is usually neutral for valgus alignment in patients with the rearfoot, whereas infants with clubfoot exhibit significant varus and equinus of the rearfoot.

Radiographic Evaluation

The radiographic analysis of these feet is challenging, because different authors use different parameters to evaluate the forefoot deformity [13,29].

Although the average talo-first metatarsal angle of view for the group reflects clinical and radiological quality adjustments, we have found a calcaneo-second metatarsal angle viewpoint, according to Simons [29,30].

To be more consistent and reproducible. Evaluation of the preoperative and postoperative medial to lateral column ratio confirmed that the procedure improved the of the columns

Total angles were compared Pre - postoperation with P valuate < 0.05, Radiographic analysis at latest follow-up showed a statistically significant improvement in parameters measuring (Table 3 and 4).

There were 12 / 38 patients (31.6%) were younger than 60 months in this study. We have found that the medial cuneiform typically has not sufficiently ossified to allow staple fixation until age 5. So we didn't use staple fixation bone resected from the cuboid instead of fibular Allograft and inserted Kirschner wire (Table 1 and 2). The osteotomies were secured with two Kirschner wires were inserted through two holes in fibular allograft segment, one from the medial cuneiform into the navicular bone and the other from the cuboid into the calcaneus (Figure 11). We didn't see to move fibular Allograft. We believe this procedure is indicated in children younger than 5 years old and easily perform in operation with severe forefoot adductus. Radiological evaluation is extremely important in assessing adductus metatarsus deformity. Need to order carry weight anteroposterior and lateral views must be ordered [31]. The Anterior break in Cyma line [9] increased in Kite's angle Increased talar attenuation, decreased calcaneal tilt, and an increase in cuboid abduction can be seen.

Surgical Procedures

Bone grafts are widely used in paediatric orthopaedicsurgery. Autogenous bone grafts remain the "gold standard" in reconstructive surgery because of their osteoinductive, osteoconductive, and non-immunogenic properties. The iliac crest is the most common donor site because of easy access and procurement, and availability of large quantities of both cortical and cancellous bone.

Some authors have been performed acetabuloplasty with bone allograft such as: Trevor DLJ and Fixen JA 1975 [32], Kessler., *et al.* 2001 [33], Grudziak and Ward 2001 [34] Wade 2010 [35], Hung 2013 [36]. Harley., *et al.* 1995 [37] use an allogeneic bone graft for Metatarsus Adductus. In this study, we used single fibular allograft only.

The fibular allograft is contoured to conform to the configuration of the osteotomy position. This is similar to the triangular shape of the contour allograft and significant surface area there because of its width contributes to the stability of the graft, which is further enhanced by the inherent rigidity of the foot.

A Kirschner wire through Fibular graft segment to navicular, this stability is evident intra-operatively by the graft not being able to be translated or rotated or slipped. This graft extrusion or displacement was not encountered in our series.

Many different surgical procedures have been described to treat metatarsus adductus. Surgical procedures for metatarsus adductus close to the joint of Lisfranc are rarely described. Fowler., *et al*. [38] describe an open wedge osteotomy of medial wedge shaped with insertion of bone graft into medial wedge.

In 1990, Jawish., *et al*. [39] mentioned the principle of combining the opening wedge osteotomy of cuneiform with the closing wedge osteotomy of cuboid, and what is taken out of the cuboid is filled in wedge-shaped wedge opening first cuneiform. Similarly, McHale and Lenhart [14] in 1991 talked about the combination of shortened osteotomy of cuboid and prolongation of osteotomy of the cuneiform.

A semicircular tarsal osteotomy was described by Gupta and Kumar in 1993 [40], but they did not address the imbalance between the long and short intermediate columns between the characteristic of the deformed foot.

In 1994, Jawish [41] in a next study, reported the use of the double osteotomy of cuneiform/cuboid in a series of children with multiple causes of forefoot deformities, resistant metatarsus adductus, Z-shaped foot, and resistant clubfoot.

Many authors, Schaefer., *et al*. [15], Lourenco AF [42], Pohl., *et al*. [19] and Gordon., *et al*. [43] have published the results of this technique and advocated for surgery. For children over 4 years of age, when the medial cuneiform ossification nucleus is well developed.

In 2009, for children under 5 years old, Mahadev., *et al*. [44] described a procedure for treatment of the Metatarsus Adductus combining a closing wedge cuboid osteotomy and trans-midfoot rotation procedure without a medial opening wedge osteotomy. They believed the medial cuneiform osteotomy should be performed once the ossific nucleus has become well defined. However, as mentioned above, a significant difference should be considered between the cause of the valgus of the heel.

Valgus deformity can be corrected spontaneously adjusted after double osteotomy of the medial and lateral columns, but in other cases it requires intensive treatment.

The first condition corresponds to the metatarsus adductus resistance to the Z-shaped foot. The second is observed at the complex clubfoot, when a posterior subtalar imbalance is generated after operative correction of the varus of the heel. In this condition the repositioning of the rearfoot needs particular correction.

We suggest that every cases should be treated individually. In some feet an overcorrection at the time of surgery and additional soft-tissue releases may be helpful in preventing subsequent loss of correction. In this study with mean follow-up of 5 years and 2.5 months

(38 - 96 months), at latest follow-up (RCF and CMA): Excellent: 17, Good: 27, Fair: 06; Poor: 04. Accepted Result (Excellent + Good): 44/54 (81.5%). Compare accepted results between RCF and CMA with P valuate 0.98161 were not statistically significant.

Conclusion

In conclusion, this combination of medial and lateral column osteotomies has reliably corrected severe forefoot adductus secondary to a variety of causes with a minimum of morbidity. The medial to lateral column relationship is improved, and reports of pain secondary to wearing shoes are reliably relieved. There was no deterioration of results in patients followed-up for more than 5 years. Double column osteotomy (cuboid/cuneiform osteotomy) combined fibular allograft is a safe operation and improvement of surgical Result.

Limitations

This study has limitations: First, this study was retrospective; Second, this is an interim outcome report as most patients were not followed-up until skeletal maturity; Third, the subjects of this study were not homogenous in terms of the implants used.

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