Zagazig University Medical Journal
www.zumj.journals.ekb.eg
https://doi.org/10.21608/zumj.2024.273920.3220 Volume 30, Issue 9.1, December. 2024, Supplement Issue
Manuscript ID ZUMJ-2403-3220
DOI 10.21608/ZUMJ.2024.273920.3220
Original article

Assessment of the Outcomes of Double Column Osteotomy in Treatment of Residual Forefoot Adduction in Clubfoot

Mohsen Mohamed Mar'ei [1], Sameh Mohamed Holil [1], Salah Salah Hassan Eltayyar[2*], Reda Hussein Elkady [1]
[1]Department of Orthopedic Surgery, Faculty of Medicine, Zagazig University, Egypt
[2] M.B.B.Ch Faculty of medicine, Al Azhar University Damitta, Mansoura Health Insurance Hospital, Egypt

Corresponding Author*:
Salah Salah Hassan Eltayyar

E-Mail:
salahysalah46@gmail.com

Submit Date 01-03-2024
Revise Date 28-03-2024
Accept Date 31-03-2024

ABSTRACT

Background: Following clubfoot surgery, the most frequent remaining deformity is forefoot adduction. For moderate to severe occurrences of this malformation, surgery is frequently necessary. **Aim of the study:** The study aimed to evaluate the outcomes of double column Osteotomy in treatment of residual forefoot adduction in clubfoot to reach better management plan for treating this residual deformity. **Patients and methods:** Twenty children (25 feet) with idiopathic clubfeet between 3-7 years of age were analyzed clinically and radiographically. All of the cases were treated by double column osteotomy with soft tissue releases (plantar fasciotomy and abductor hallucis release). Preoperative measurements of certain foot angles were compared with their postoperative values. **Results:** 11 feet (44%) had excellent, ten (40%) had good, three (12%) had fair and one (4%) had poor outcome. Pain disappeared in almost all cases except two who had mild pain. The forefoot adduction was fully corrected except five cases in which it was partially corrected. Hind foot varus was corrected in all cases except three cases. Supination deformity improved in all cases. Cavus deformity improved in all cases except four cases. Tolerability to footwears/orthoses improved in all cases except three who showed batter tolerability but not optimum. The radiographic foot angles measures improved in all cases at least better than their preoperative measures. There was no major complication. **Conclusion**: Double column osteotomy is a safe operation can be considered superior to other types of bone surgeries in correction of the adduction, cavus and rotational deformities in idiopathic clubfoot.
Key words: Forefoot adduction, Double column osteotomy, Idiopathic clubfoot.

INTRODUCTION

Probably the most prevalent congenital foot ailment requiring extensive treatment is clubfoot. It most likely indicates congenital abnormality of all the musculoskeletal tissues distal to the knee, including the musculotendinous, ligamentous, osteoarticular, and neurovascular systems. Clubfoot, also known as Talipes equinovarus, is a complicated joint system malformation that varies in three dimensions. Clubfoot is a descriptive term generally applied to the clinical condition characterized by hind foot plantar flexion (equinus) and inversion (varus) and forefoot adduction deformity. There may be severe cavus with a medial and plantar midfoot crease. The problem of this deformity starts before birth. From birth, skeletal and soft tissue secondary and adaptive structural alterations are well-established. The male to female ratio is 2.5:1, the frequency of clubfoot is 1 in 2 instances per 1,000 live births, and 50% of cases are bilateral. It needs to be managed as soon as possible after birth **[1]**.

The Ponseti approach, which involves manipulation and the insertion of plaster casts every seven days (typically 4-5 casts), is the non-surgical therapy. In around 85% of instances, an Achilles tendon tenotomy is necessary. After

thereafter, a modified Danis-Browne splint is used until the child is three or four years old. Relapse is the return of the clubfoot deformity following complete repair; it most commonly happens in children between the ages of 1.5 and 4 **[2]**.

The most typical clubfoot residual deformity is adduction of the forefoot. Even though the forefoot adduction is the only thing that remains after the hindfoot is totally corrected, it can lead to functional handicap, and frequently the parents report that the foot looks the same as it did before the first treatment. However, it is often considered a less significant change. The degree of the initial deformity, the patient's age, the surgeon's level of experience, and the effectiveness of the main treatment are only a few of the many variables that affect its incidence **[3]**.There are various surgical techniques that can be used to address forefoot adduction. To solve this issue, some of them use soft tissue releases, while others use a variety of bone procedures **[4]**.

Aim of the study

This study aimed to evaluate the outcomes of double column Osteotomy in treatment of residual forefoot adduction in clubfoot to reach better management plan for treating this residual deformity.

METHOD

Twenty five cases (feet) in twenty children with idiopathic clubfeet were operated upon for residual forefoot adduction deformity in this prospective study in Zagazig university hospital. Patients were enrolled after obtaining informed consent from their guardians. The privacy of the patients and their medical and personal data were kept confidential. Approval was obtained from Zagazig University Institutional Review Board (IRB# 11140). Consent from all patient on participating in the study. This study was carried out in accordance with the Declaration of Helsinki, which is the worldwide medical association's code of ethics for human subjects' research.

Inclusion criteria (for double column osteotomy) Children with idiopathic clubfoot aged 3-10 years have moderate to severe fixed (rigid) forefoot adduction, midfoot supination, and cavovarus abnormalities. **Exclusion criteria** for double column osteotomy ,Secondary clubfoot that is not idiopathic, children under the age of three, hindfoot deformity, flexible (correctable) foot deformity, and many relapses of clubfoot.

All cases underwent double column osteotomy (closing wedge cuboid osteotomy and opening wedge medial cuneiform osteotomy) in association with soft tissue releases (plantar fasciotomy and abductor hallucis release). In addition, six cases with fixed hindfoot varus deformity, four of them underwent complete subtalar release, one case lateral closing wedge calcaneal osteotomy, and one case required both complete subtalar release and calcaneal osteotomy with lateral closure wedge. Four cases with dynamic supination deformity underwent transfer of the tibialis anterior tendon to the lateral cuneiform, in the same sitting of double column osteotomy.

Preoperative assessment

Neurological examination assessed muscle tone and motor function,sensory and reflex activity, motion, and gait in order to rule out a non-idiopathic clubfoot.

Orthopedic examination includes the skin condition, the components of the foot deformity, the presence of deformities other than the foot, and the gait.

Radiographic assessment all patients had lateral and weight-bearing anteroposterior and anteroposterior x-ray images of their feet and ankles.

Surgical technique

All twenty patients (25 feet) had double column osteotomy, which consists of an opening wedge medial cuneiform osteotomy and a closing wedge cuboid osteotomy. This process was combined with the relaxation of soft tissues (plantar fascia and abductor hallucis). All cases ranged from 3 years to 7 years of age with an average of 4 years and 7 months.

In all cases double column osteotomy was performed. A wedge of bone with its apex pointed medially was extracted from the cuboid and then this bone wedge was used as the opening graft in the medal cuneiform osteotomy. K-wire fixation was done in 7 patients (10 feet).

Preoperative planning:

The X-ray films were traced using tracing paper. Anteroposterior X-rays were originally used to measure the AP talo-first metatarsal angle (TFMA1) and calcaneo-fifth metatarsal angle (CFMA) in order to assess the extent of forefoot adduction deformity. Next, the cuboid and cuneiforms were carefully cut using scissors. Separating the document into two halves. To

realign the talo-first metatarsal axes, the distal segment was rotated until the forefoot adduction deformity was fully corrected.

After placing a second tracing paper on top of the first, the cuboid drawing was cut so that the two sheets were superimposed. The cuboid drawing's amount of cut corresponded to the necessary wedge's base length. The lateral X-ray film was subjected to a similar procedure until the talar axis aligned with the first metatarsal.

Operative procedure:

The patient is supine while under general anesthesia. The upper thigh is bandaged with a tourniquet. The skin is prepped, the limb is draped, and the knee is left loose to guide rotational alignment.

Skin incisions: The dorsolateral facet of the cuboid bone is the focus of a longitudinal, lateral, curvilinear incision that runs from the calcaneus to the fourth metatarsal shaft. Along the line of the skin incision, subcutaneous tissue and deep fascia separate. The sural nerve is protected as much as possible. A small dorsomdial curvilinear incision is created that starts right behind the navicular's tuberosity and extends distally to finish at the proximal fourth of the first metatarsal. Along the line of the skin incision, the subcutaneous tissue is divided.

In cases of compete subtalar release (no. 4, 9, 21, 22, 24), two incisions are made. A curved medial incision was made with its convexity downwards and backwards. The upper vertical part of the incision is done between the medial malleolus and the tendo Achilles. Passing distally below the level of the tip of the medial malleolus, the incision curved forwards on the medial border of the foot to extend distally along the first metatarsal (postero-medial incision). The lateral incision is made 4cm. lengthy and positioned over the cuboid bone's dorsolateral side. Subcutaneous tissue and deep fascia are divided in line with the skin incision. The peroneus longus and brevis tendons are identified and retracted plantar ward. The extensor digitorum brevis muscle is elevated off the calcaneus and retracted distally.

In cases of lateral closing wedge calcaneal osteotomy (no.3, 22), the peroneus longus tendon's path is parallel to the incision's. 1 cm posterior and inferior to it, it extends over the cuboid bone's dorsolateral aspect. The upper flap is reflected superiorly until the tendon of peroneus longus is exposed.

In cases of tibialis anterior tendon transfer (no.3, 21, 22, 24) an additional longitudinal incision is made over the anterolateral aspect of the tibia in the distal third of the leg.

Operative steps:

Column osteotomy and soft tissue release: The cuboid bone is exposed through the lateral incision (Fig. 1A). A laterally based wedge is removed from the cuboid with a sharp osteotome (Fig. 1B). The size of the wedge is measured according to the predetermined amount of the cuboid cut to correct the forefoot adduction deformity (Fig. 1C). Through the medial incision, the abductor hallucis is exposed, detached *proximally* from its calcaneal origin and reflected plantarward (Fig. 1D). The lateral plantar artery and nerve as well as the medial plantar artery are visible via the opening of the deep fascia. Between the plantar fascia and the fat beneath the foot's sole, a plane is formed. A tunnel formed by the lateral plantar nerve and artery leads to the lateral side of the foot. One scissor blade is positioned in the tunnel for the lateral plantar nerve and artery, and the other blade is placed superficial to the plantar fascia, releasing the plantar fascia, flexor digitorum brevis, and abductor digiti minimi from the calcaneus.

The base of first metatarsal, navicular and medial cuneiform were recognized. The tibialis anterior tendon enters into the base of first metatarsal, while the tibials posterior tendon inserts into the navicular tuberosity. Using a sharp osteotome, a vertical osteotomy of the medial cuneiform was performed (Fig. 1E). To rectify the adduction and supination deformities, the foot is adjusted by moving the midfoot and forefoot into abduction. An osteotome or a lamina spreader is used to open the osteotomy site of the medial cuneiform. With its base oriented medially, the bone wedge extracted from the cuboid bone is placed into the medial cuneiform (Fig. 1F).

In 10 cases (no. 3,4,6,8,9,11,17,19,20, 21), the foot is fixed in the corrected position using two smooth Kirschner wires. One pin passes through the cuboid, beginning at the calcaneus, and the second pin passes through the medial cuneiform, the first web gap. Anteroposterior and lateral pin positions as well as the correction of bone deformities can both be evaluated with the aid of an intraoperative C-arm picture. Complete subtalar release (CSTR) is used in cases (no. 4, 9, 21, 22, 24) where there is a fixed hindfoot varus deformity. It is carried out in four fundamental steps.

Stage (I): Superficial dissection of the medial side of the foot.

The flexor digitorum longus and tibialis posterior are covered by an open fascia. Retraction of the neurovascular bundle is seen in Fig. 2A. Z-plasty is used to divide the tibialis posterior tendon, as shown in Figure 2B. The flexor hallucis longus is identified by opening the sheath of the flexor digitorum longer and proceeding distally to the master knot of Henry (Fig. 2C). One Z-plasty was used to separate these two tendons.

Stage (II): Dissection of the posterior part of the foot and ankle.

The tendo Achilles is separated in the sagittal plane (Fig. 2D), exposing itself and dividing the proximal, lateral half from the triceps surae and the distal, medial half from the calcaneus. The subtalar and ankle posterior capsules are opened.

Stage (III): Dissection of the lateral side of the foot.

The calcaneofibular ligament is revealed by identifying and retracting the peroneus longus and brevis tendons. There is a division in the posterior talofibular and tight calcaneofibular ligaments (Fig. 2E). The superior, medial, and plantar capsules are divided to expose the calcaneocuboid joint. The lateral portion of the talonavicular joint is capsulotomized, and the interosseous talocalcaneal ligament is freed to the greatest extent possible.

Stage (IV): Deep dissection of the medial side of the foot.

The subtalar joint's anterormedial aspect is freed (Fig. 2F). The flexor digitorum longus is situated behind the incision of the *posterior segment* of the deep deltoid ligament alone. After that, any remaining interosseous talocalcaneal ligament is cut. The talonavicular joint was opened circumferentially after the navicular was separated from the medial malleolus. At this time, the long axis of the talus and calcaneus resume their divergence, and the talus body is reduced into the ankle mortise. The forefoot's adduction and supination are adjusted.

Lateral closing wedge calcaneal osteotomy:

The lateral aspect of the clacaneus is exposed through the lateral incision. A wedge of bone with its base 8-12 mm in width based laterally is osteotomized down to the medial cortex of the calcaneus (Fig.2G) .The wedge of bone is removed and the medial cortex is broken manually to close the lateral opening and to correct fixed heel varus deformity (no. 3,22).

Lateral transfer of tibialis anterior tendon:

Transfer of tibialis anterior tendon to the lateral cuneiform is performed in cases associated with dynamic adduction and supination deformity especially in swing phase (no. 3, 21, 22, 24). The tibialis anterior tendon is located and severed from its insertion at the base of the first metatarsal through the medial incision (Fig.2H). The muscle–tendon structure is identified in the proximal incision by tugging distally on the sectioned tendon stump. The tendon is pulled through into the leg incision (Fig. 2I). A no. 1/2 proline thread held on either end over two round eyeless (non- traumatic) needles is passed transfixing the tendon from proximal to distal till the two ends of the thread come out from the free distal end of the tendon.

A subcutaneous tunnel is made from the upper wound to emerge in the third incision over the outer side of the dorsum of the foot. A long haemostat is then passed proximally along the tunnel from the distal wound to emerge in the leg wound. Through the tunnel goes the threaded tendon and brough out through the lateral foot incision. Just lateral to the foot's midline, a drill hole is produced through the lateral cuneiform. This should be large enough to accommodate the full thickness of the tendon without fraying . A secure pull is made on the tendon inside the drill hole and the suture is tied securely over a small gauze pad on the sole of the foot while the foot is held in mild eversion and the ankle in neutral position (Fig.2J).

All wounds were closed in layers. The skin is closed by either interrupted or subcuticular 0/3 vicryl sutures.

Postoperative POP cast and bracing support:

With the exception of cases nos. 4, 9, 21, 22, and 24, where an above knee plaster of Paris (POP) cast is applied for Achilles tendon lengthening, a well-padded, nonweight-bearing below knee POP cast was applied in nearly all of the cases. Splitting the cast as soon as possible after surgery is advised to prevent oedema. Once two weeks have passed, the wounds are examined; the sutures should remain in place, and a more form-fitting, non-weight-bearing cast is placed. After six weeks, the K-wire is taken out and a weight-bearing cast is put on. This cast is worn for eight weeks, or until the bony union becomes visible on an X-ray. After soft tissue release and osteotomy, a plastic ankle-foot orthosis (AFO) was used to stop relapse (Fig. 3).

Postoperative follow-up regime

All cases are required to undergo gait training for a minimum of six weeks following the removal of the cast. A follow-up case was for duration of one year and ten months on average, with a range of one year to two years and six months. Every patient was found to be clinically and radiographically satisfying.

Radiographically; Anteroposterior and lateral weight-bearing radiographs of the ankle and foot were taken the day following the procedure, six weeks after the cast was changed and the K-wires were removed, eight weeks after the cast was removed, and two months later. Measurements were made of the calcaneo-fifth metatarsal angle (CFMA), the lateral talo-calcaneal angle (TCA2), the lateral talo-first metatarsal angle (TFMA2), the anterior talo-calcaneal angle (TCA1), and the anterior talo-first metatarsal angle (TFMA1). By comparing the post-operative and preoperative measurements, the degree of correction of the angle measures was computed.

Statistical Analysis

All data was entered using the Excel program, data cleaning was done before transforming the data to SPSS. All statistical calculations were done using SPSS (statistical package for the social science; SPSS Inc., Chicago, IL, USA) version 22. Data were statistically described in terms of number and percentages when appropriate. Comparison of quantitative variables was done using student t test for normally distributed data and Mann Whitney U test for non-normally distributed data. For comparing categorical data, Chi square ($\chi 2$) test was performed. ANOVA One Way Test for assess the statistical significance of the difference between more than two study group means. Kruskal Wallis test for not normally distributed quantitative variables, to compare between more than two studied groups. Fischer's exact test was used instead when the expected frequency is less than 5. The significance level was set at $P < 0.05$

RESULTS

This study proposed a grading system for the assessment of resideual forefoot adduction deformity based on radiographic and clinical measures and their correlation with scores. The following standards form the basis of the clinical evaluation (10 points) (Table 1); the two points are the existence or lack of discomfort. The adduction deformity's repair (2 points). The varus malformation of the hindfoot (1 point) or not. Supination deformity–presence or absence (1 point). Cavus deformity: present or absent (1 point). The footwear orthoses' tolerability (2 points). The satisfaction of the patient (or parent) (1 point).

The anterior talo-calcaneal angle (TCA1) measure (2 points) is used to calculate the radiographic evaluation (10 points) based on the angles shown in Table 1. The measurement of the anterior talo-first metatarsal angle (TFMA1) is two points. The measurement of the calcaneo-fifth metatarsal angle (CFMA) is two points. The measurement of the lateral talocalcaneal angle (TCA2) (2 locations). The measurement of the lateral talo-first metatarsal angle (TFMA2) (2 points)

Based on the total computed score, the outcomes are categorized as excellent, good, fair, and poor. It would be deemed exceptional if the final score was 19–20, good if it was 16–18, average if it was 10–15, and subpar if it was less than 10. This rating approach yielded the following results: 11 excellent, 10 good, 3 fair, and 1 poor (Table 2).

The excellent results (Table 3); there were eleven cases with excellent results (44 %) (no. 2,4,5,6,8,9,11,14,17,21,22). Three of them (no.9,21,22) were treated by complete subtalar release, one of them (no. 22) was treated by lateral closing wedge calcaneal osteotomy, and two case (no. 21,22) were treated by lateral transfer of tibialis anterior tendon in the same sitting of double column osteotomy and soft tissue releases.

Table 4 showed that the **Pain** there was no pain anywhere in the foot**. Adduction deformity** the forefoot adduction deformity was fully corrected**. Hindfoot varus** there was no heel varus deformity in all cases**. Supination** there was no supination deformity in all cases**. Cavus** there was no cavus deformity in all cases. **Tolerability to footwear / orthosis;** all casesn showed no complaints of the footwear or braces. **Satisfaction;** All cases were satisfied and their parents revealed satisfaction of the foot position and gait**. The anterior talocalcaneal angle (TCA1)** there was improvement of the anterior talocalcaneal angles measures in all cases. Preoperative measures ranged from 10° to 35° with an average of 20°, while the postoperative measures ranged from 15° to 39° with an average of 27°. **The anterior talo-first metatarsal angle (TFMA1)** there was improvement of the anterior talo-first metatarsal angles measures in all cases. Preoperative measures ranged from 19° to 60° with an average of 39°. Postoperative measures ranged from -10° to 6° with an average of 1°. **The**

calcaneo-fifth metatarsal angle (CFMA) there was improvement of the calcaneo-fifth metatarsal angles measures in all cases. Preoperative measures ranged from 15 to 51° with an average of 31°. Post-operative measures ranged from -10° to 8° with an average of 3°. **The lateral talocalcaneal angle (TCA2)** there was improvement in the lateral talocalcaneal angles measures in all cases. Preoperative measures ranged from 5° to 32º with an average of 18º. Postoperative measures ranged from 13° to 30° with an average of 23º . **The lateral talo-first metatarsial angle (TFMA2):** there was improvement in the lateral talo-first metatarsal angles measures in all cases. Preoperative measures ranged from 4º to 27º with an average of 14º. Postoperative measures ranged from 5º to 11º with average of 8º.

The Good Results table 5 showed that there were ten cases with good results (40 %) (no. 3,7,10,12,13,15,16,20,24,25). All of them underwent double column osteotomy and soft tissue releases. One of them (no. 3) underwent additional lateral closing wedge clacaneal osteotomy and lateral transfer of tibialis anterior tendon. One of them (no.24) underwent additional complete subtalar release and lateral transfer of tibialis anterior tendon.

The clinical evaluation precisely matched the outstanding outcomes in terms of the lack of pain, heel varus, and supination deformity. The only exception were cases no.7, 10 who had cavus deformity and case no. 25 who had residual adduction deformity less than 5° and unsatisfied. As shown at **table 6**. The anterior talocaneal angle (TCA1): Preoperative measures ranged from 8° to 33° with an aveage of 22°. Post-operative measures ranged from 15° to 40° with an average of 27°. The anterior talo-first metatarsal angle measures (TFMA1); all cases showed improved anterior talo-first metatarsal angle measures. Preoperative measures ranged from 16° to 62° with an average of 34o postoperative measures ranged from 0° to 20° with an average of 11°. The calacaneo- fifth metatarsal angle (CFMA); Al cases showed improved calcaneo-fifth metatarsal angles measures. Preoperative measures ranged from 13° to 42° with an average of 26° Postoperative measures ranged from 0° to 20° with an average of 13°. The lateral talocalcaneal angle (TCA2); Preoperative measures ranged from 2º to 35º with an average of 18°. Postoperative measures ranged from 20º to 30º with an average of 24°. The lateral talo-first metatarsal angle (TFMA2); Except for cases no. 13,15,20 in which the angle measure remained unchanged, all other cases showed improvement in the angles measures. Preoperative measures ranged from 0° to 36° with an average of 17°. Postoperative measures ranged from 0° to 20° with an average of 11°.

The fair results **(Table 7)** showed that there were three cases with fair results (12%) (no. 18, 19, 23). They all had soft tissue releases and double column osteotomies.

Pre & post-operative angle measures of the fair result **(table s1)** showed the **Pain;** here was mild pain in case no. 19 while it was absent in all other cases. There was residual adduction deformity but less than 5º in allcases. **Hindfoot varus** there was residual hindfoot varus deformity in one case (no.18) while it was absent in all other cases. **Supination** there was no supination deformity in all cases**. Cavus:** there was cavus deformity in cases no. 18 while it was absent in all other cases. **Tolerability to footwear / orthoses** there was better tolerability to footwear or brace in cases no. 18, 19 while all other cases showed no complaints of footwear or brace. **Satisfaction:** All cases were unsatisfied**. The aneterior talocalcaneal angle (TCA1);** all cases showed improvement in the angle measures. Preperative angle measures ranged from 15° to 25º with an average of 19o. Post-operative angle measures ranged from 20° to 31° with an average of 27°. **The anterior talo-first metatarsal angle (TFMA1);** all cases showed improvement in the angle measures. Preoparative measures ranged from 33° to 64° with an average of 46°. Postoperative measures ranged from 0° to 25° with an average of 11°. **The calcaneo-fifth metatarsal angle (CFMA);** all cases showed improvement in the angle measures. Preoperative measures ranged from 25° to 33º with an average of 28°. Postoperative measures ranged from 13° to 16° with an average of 14º. **The lateral talocalcaneal angle (TCA2);** Preoperative measures ranged from 3° to 19° with an average of 12°.Post-operative measures ranged from 6° to 15° with an average of 10°. **The lateral talo-first metatarsal angle (TFMA2);** Preoperative measures ranged from 4° to 33° with an average of 21°.Postoperative measures ranged from 13° to 21° with an average of 17°.

Table 9; showed that the Poor results one case showed poor result (4%) (no.1). It underwent double column osteotomy and soft tissue releases only.

Table 10; showed that the Pre & post-operative angle measuring of poor results. **Pain** there was mild pain post operatively. **Adduction deformity** there was residual adduction deformity but less than 5°. **Hindfoot varus t**here was heel varus postoperatively. **Supination t**here was no supination deformity**. Cavus** there was cavus

deformity. **Tolerability to footwear (orthoses)** there was better tolerability to foot wear. **Satisfaction**: The patient and his parents were unsatisfied**. The anterior talocalcaned angle (TCA1)** there was improvement in the angle measure. Preoperation angle measure was 12°. Postoperation angle measure was 35°.
The anterior talo-first metatarsal angle (TFMA1) the improvement in the angle measure. Preoperation angle measure was 74°. Post-operative angle measure was 9°. **The calcaneo-fifth metatarsal angle (CFMA)** there was improvement in the angle measure. Preoperation angle measure was 27°. Post-operative angle measure was 20°.
The lateral talocalcaneal angle (TCA2) the angle measure remained unchanged. Pre and post-operative angle measure was 0°. **The lateral talo-first metatarsal angle (TFMA2)** the improvement in the angle measure. Preoperative angle measure was 42°. Post-operative angle measure was 29°

Analysis of the results; there were twenty five cases following double column osteotomy (cuboid/cuneiform osteotomy) and soft tissue releases (plantar fasciotomy and abductor hallucis release). Nineteen cases of them underwent no other kind of surgery. Six cases underwent, in addition to these procedures, other complementary operations in the same sitting; five cases underwent complete subtalar release, two cases lateral closing wedge calcaneal osteotomy, and four cases tibialis anterior tendon transfer to the lateral cuneiform.

Pain: Most cases had no pain postoperatively, except two cases (no.1, 19) who had mild pain, In contrast with two patients having frank foot pain and eight cases having foot discomfort during walking or on weight –bearing preoperatively. During the postoperative gait training and physiotherapy phase, the pain subsided. Other non-mechanical pain, such as that near the location of k-wires or sutures, was insignificant because it was transient and went away on its own.

Adduction deformity: The degree of forefoot adduction improved in all cases, but only five cases (no.1, 18, 19, 23, 25) had residual adduction less than 5º at the last follow-up. These were due to the following; severe preoperative forefoot adduction, cases (no.1, 18). Medial tethering due to postoperative scarring, cases (no.1, 18, 19). Failure to maintain correction case (no.25). Complete slip of the graft, cases (no.19, 23). Residual hindfoot varus, cases (no.1, 18).

In all cases, the postoperative anterior talo-first metatarsal angle (TFMA1), and calcaneo-fifth metatarsal angle (CFMA) were satisfactory. The residual less than 5º adduction was accepted.

Heel varus: three cases (no. 1, 3, 18) had residual hindfoot varus post- operatively, in contrast with twelve cases (no.1, 3, 4, 8, 9, 14, 15, 17, 18, 21, 22, 24) having hindfoot varus deformity preoperatively.

Supination: all cases had no supination deformity postoperatively, in contrast with four cases (no.3, 21, 22, 24) having dynamic supination deformity preoperatively.

Cavus: four cases (no.1, 7, 10, 18) had cavus deformity postoperatively, in contrast with thirteen cases (no.1, 3, 6, 7, 8, 10, 11, 14, 15, 17, 18, 21, 22) had cavus deformity preoperatively.

Footwear / orthoses: there was better tolerability to footwear or brace in three cases (no.1, 18, 19) while all other cases showed no complaints of footwear or brace.

Patient (or parents) satisfaction: Five cases (no.1, 18, 19, 23, 25) was unsatisfied, three of them (no.1, 18, 19) had mild pain and residual adduction less than 5º. The other cases (no.23, 25) had only residual adduction less than 5º. The elimination of preoperative pain and suffering, the correction of the foot deformity, the improved footwear, and the general improvement in gait were the reasons for the satisfaction of all other instances.

The anterior talocalcaneal angle (TCA1): there was improvement of the anterior talo-calcaneal angle measures. Preoperative measures ranged from 8º to 35º with an average of 21º. Postoperative measures ranged from 15º to 40º with an average of 27º.

The anterior talo-first metatarsal angle (TFMA1): There was improvement of the anterior talo-first metatarsal angle measures. Preoperative measures ranged from 16º to 74º with an average 39º. Postoperative measures ranged from -10º to 25º with an average of 7º.

The calcaneo-fifth metatarsal angle (CFMA): there was improvement of the calcaneo-fifth metatarsal angle measures. Preoperative measures ranged from 13º to 51º with an average 28º. Postoperative measures ranged from -10º to 20º with an average 9º.

The lateral talo-calcaneal angle (TCA2): There was improvement of the lateral talo-calcaneal angle measures. Preoperative measures ranged

from 0º to 35º with an average 17º. Postoperative measures ranged from 0º to 30º with an average 21º.

The lateral talo- first metatarsal angle (TFMA2): There was improvement of the lateral talo-first metatarsal angle measures. Preoperative measures ranged from 0º to 42º with an average 16º. Postoperative measures ranged from 0º to 29º with an average 11º.

Table 1: Score of the clinical and Radiographic Results

Clinical results	Score
1- Pain :	
- Absent	2
-Mild pain	1
-Peristent pain	0
2- Adduction deformity :	
Full correction (no adduction)	2
Partial correction (adduction <5º)	1
Adduction >5º	0
3- Hindfoot varus:	
- Absent	1
- Present	0
4-Supination :	
-Absent	1
-Present	0
5- Cavus:	
-Absent	1
-Present	0
6- Tolerability to footwear / brace:	
-Optimum	2
-Better than before surgery	1
-Intolerant (callus, ulcer, … etc)	0
7- Patient (or parent) satisfaction :	
-Satisfied	1
-Unsatisfied	0
Radiographic results	**Score**
1- Anterior talo-calcaneal angle (TCA1)	
20º-40º	2
10º-19º	1
<10º	0
2- Anterior talo- first metatarsal angle (TFMA1)	
<10o	2
10o-20o	1
>20o	0
3- Calcaneo –fifth metatarsal angle (CFMA)	
<10o	2
10o-20o	1
>20º	0
4- Lateral talo-calcaneal angle (TCA2)	
25º-50º	2
10º-24º	1
<10º	0
5- Lateral talo-first metatarsal angle (TFMA2)	
<10o	2
10o-20o	1
>20o	0

Table 2: Categories and number of cases

Result	Total score	No. of cases
Excellent	19-20	11
Good	16-18	10
Fait	10-15	3
Poor	<10	1

Table 3: Operations of the excellent results

Operations	Number of cases
Double column osteotomy and soft tissue release	11
Complete subtalar release	3
Lateral closing wedge calcaneal osteotomy	1
Lateral transfer of tibialis anterior tendon	2

Table 4: Pre –& postoperative angle measures of the excellent results.

Preoperative					
Case no.	**TCA1**	**TFMA1**	**CFMA**	**TCA2**	**TFMA2**
2	14	29	16	24	5
4	11	50	30	6	9
5	13	28	15	23	4
6	31	26	28	22	21
8	12	57	47	20	16
9	10	55	29	5	9
11	30	25	29	21	22
14	29	19	18	32	11
17	10	60	46	20	15
21	35	25	29	12	16
22	28	57	51	12	27
Postoperative					
Case no.	**TCA1**	**TFMA1**	**CFMA1**	**TCA2**	**TGMA2**
2	26	1	3	26	8
4	38	6	8	21	6
5	25	0	2	25	8
6	28	2	5	22	7
8	17	5	4	26	9
9	39	5	8	20	5
11	27	1	4	20	7
14	35	0	9	30	11
17	15	4	3	25	9
21	26	-10	-10	25	9
22	20	2	1	13	9

Table 5: Operations of the good results

Operation	No. of cases
Double column osteotomy and soft tissue releases	10
Complete subtalar release	1
Lateral closing wedge calcaneal osteotomy	1
Lateral transfer of tibiales anterior tendon	2

Table 6: Pre & post-operative angle measures of the good results.

Preoperative					
Case No.	**TCA1**	**TFMA1**	**CFMA**	**TCA2**	**TFMA2**
3	8	62	28	2	26
7	32	32	42	20	36
10	33	36	40	18	30
12	22	17	15	25	9
13	23	20	18	20	0
15	25	16	13	35	17
16	22	30	28	22	15
20	26	36	29	20	9
24	8	56	19	5	0
25	20	36	27	17	10
Post-operative					
Case No.	**TCA1**	**TFMA1**	**CFMA**	**TCA2**	**TFMA2**
3	40	8	20	20	20
7	35	0	20	25	20
10	33	7	18	30	15
12	29	15	14	24	0
13	23	20	18	20	0
15	32	0	13	25	17
16	19	14	8	26	8
20	26	17	10	22	9
24	15	14	0	21	9
25	15	20	9	25	9

Table (7): Operations of the fair results.

Operation	No. of cases
Double column osteotomy and soft tissue releases	3

Figure. 1A: The cuboid bone is exposed through the lateral incision

Fig. 1B: A laterally based wedge is removed from the cuboid

Fig. 1C: The size of the wedge

Fig. 1D: The abductor hallucis in exposed proximally

Fig. 1E: The medial cuneiform osteotomy

Fig. 1F: The wedge of bone taken from the cuboid bone is inserted into the medial cuneiform

Fig. 2A: Neurovascular bundle

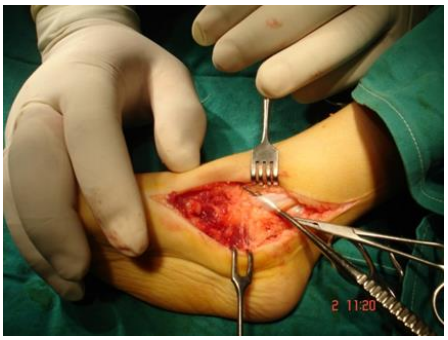

Fig. 2B : The tibialis posterior and flexor digitorum longus tendons

Fig. 2C : The flexor hallucis longus tendon

Fig. 2D: The tendo Achilles

Fig. 2E: The tight calcaneofibular and posterior talofibular ligments are divided

Fig. 2F: The anteromedial aspect of the subtalar joint is released

Fig. 2G: Lateral closing wedge calcaneal osteotomy

Fig. 2 H: Tibialis anterior tendon is identified

Fig. 2 I: The tibialis anterior tendon is pulled through into the leg incision

Fig. 2J: The tibialis anterior tendon is pulled into the dill hole and the suture is tied over a small gauze pad on the sole

Pre operative x ray

Post operative x ray

Fig. 3: Plastic ankle-foot orthosis and medical shoes

DISCUSSION

Forefoot adduction and supination, which were present in 95% of the feet, were the most prevalent long-term abnormalities in treated clubfeet. Undercorrection during the initial procedure was the cause of many abnormalities. There are a number of explanations in the literature regarding the reason why clubfoot causes forefoot adduction. **[5]**.

Tarraf and Carroll [6] claim that the undercorrection was caused by the plantar fascia and calcaneocuboid joint not being released. The cause of persisting intoeing, slight equinus, and apparent varus of the heel can be an inadequate release of the posterolateral tethers that is, the calcaneofibular ligaments. The deformity under investigation may have resulted from residual metatarsus varus (metatarsal adduction) or residual talonavicular subluxation.

Steytler and Van der Walt [7] claimed that internal tibial torsion caused this deformity; however, this is improbable since other authors have disputed the possibility of internal tibial torsion in clubfoot.

We also don't agree that forefoot adduction is brought on by metatarsal abnormalities. as recommended by **Berman and Gartland [8]** and **Lowe and Hannon [9]**. It is more often a result than a cause of recurrent forefoot adduction. Because of this, it should be uncommon to recommend metatarsal osteotomies to address forefoot adduction. **Steytler and Van der Walt** were the first to describe metatarsal osteotomies in [7], which are suggested when the adduction deformity arises distal to the navicular. In addition, metatarsal osteotomies have been linked to a number of problems, such as nonunion, malunion, and shortening of the metatarsals, as well as recurrence of the deformity and delayed wound healing.

Fried [10] suggested that forefoot adduction was caused by the tibialis posterior muscle. This muscle tends to induce a hindfoot varus more often than an indirect action over the forefoot. This notion can be disregarded since, as was the case for the patients in our study, these two abnormalities are not always present in the clubfeet that need reoperation.

According to **Thomson [11] and Otremski [12],** the abductor hallucis is the only muscle that can cause adduction of the forefoot through direct muscular action. Nevertheless, not every one of our patients had this muscle tightened at the time of operation.

While **Dwyer [14]** proposed that residual varus of the hindfoot is what causes medial deviation of the forefoot, **Turco [13]** thought that overcorrection of the hindfoot is the source of forefoot adduction. Despite this, we think that a varus hindfoot may lead to forefoot adduction, and we are reminded that the talocalcaneus index of **Beatson and Pearson [15]** indicates that our patients' hindfoot correction was sufficient.

Forefoot adduction may result from failure to correct the midfoot (calcaneocuboid, talonavicular, or both). While we were positive that all of our patients received appropriate talonavicular correction, there may have been a residual sublaxation of the calcaneocuboid joint in rare cases. Patients who underwent the "hockey-stick" incision for the main soft tissue release demonstrated this. According to **Nimityongskul et al.[16],** the adduction deformity was not, however, more severe in these patients than in those who

underwent the Cincinnati incision. To rectify the adduction of the forefoot at the stage prior to the double osteotomy, a simple calcaneocuboid joint release would not be sufficient.

A risk of degenerative arthritis was observed by **Kendrick et al. [18]** in relation to the classic tarsometatarsal mobilization approach, which is one of the soft tissue releases to treat forefoot adduction that **Heyman et al. [17]** described. This technique has been criticized extensively in the literature.

As previously mentioned, **Evans [19]** is recognized as the author of the principle of an elongated lateral column associated with a shortened medial column, which is essential in treating residual forefoot adduction. However, his suggestion to restore the balance between the two columns by means of the calcaneocuboid fusion may result in a reverse deformity with an abducted foot. **Ozeki et al. [20]** suggested talar neck osteotomy, which carries a higher risk of vascular complications. Another issue with medial column lengthening is that it necessitates bone graft harvesting from another location.

By employing the wedge that was removed from the lateral column to lengthen the medial column, the double osteotomy solves the issue. It corrects the deformity on both sides, which is better than a single surgery in a single column. The anterior talo-first metatarsal angle and calcaneo-fifth metatarsal angle (25º) indicate that our patient's adduction was corrected to a greater extent than that of **McHale and Lenhart [21],** whose average correction was 9º. This could be as a result of their patients having low talocalcaneal indexes and insufficient hindfoot rectification.

We did not measure the forefoot's supination in any way. **McHale and Lenhart's [21]** lateral talo-first metatarsal angle does not directly assess forefoot supination, which is typically present to some extent when the forefoot is adducted. However, there is no denying that the supination can also be corrected by double osteotomy, which involves resecting a cuboid wedge that may be more dorsal than lateral.

We can therefore wait to do the double osteotomy on the child till they are older if the deformity is not severe enough to pose functional issues. The medial cuneiform ossification center, which is typically older than three years, must be well-formed. Above all, there should be a clinical rationale for the doube osteotomy to treat forefoot adduction. In addition to recording the degree of adduction, a radiographic study (anteroposterior and lateral standing radiography of the foot) is essential to rule out any additional deformities, such as a medial deviation of the metatarsals that exhibits a severe adduction deformity or a medial sublaxation of the navicular.

According to our findings, there is a greater likelihood of a clinically satisfying outcome than a radiographically satisfactory one. **Wynne-Davies [22]** and **Lowe and Hannon [9]** had previously discussed these clinical radiographic outcomes; they found that operated clubfoot had more radiographic than clinical abnormalities.

The primary clinical abnormality served as our justification for this technique; nevertheless, prior to surgery, a radiographic examination of the foot is essential. Both the functional and aesthetic outcomes met expectations. In our opinion, a very good substitute for treating residual forefoot adduction is a double osteotomy. It is possible to execute a plantar fascia release and an abductor hallucis simultaneously. We now prefer to postpone the procedure till the child is older than four years old.

While the use of external fixators and other tarsal osteotomies are being considered as treatments for forefoot adduction, our double osteotomy method has shown outstanding results with a straight foot and no sign of the need for more aggressive intervention **[10, 11]**.

Conclusions: Double column osteotomy is a safe operation can be considered superior to other types of bone surgeries in correction of the adduction, cavus and rotational deformities in idiopathic clubfoot.

Declaration of interest

The authors report no conflicts of interest. The authors along are responsible for the content and writing of the paper.

Funding information

None declared

REFERENCES

1- Chen W, Pu F, Yang Y, Yao J, Wang L, Liu H, Fan Y. Correcting congenital talipes equinovarus in children using three different corrective methods: a consort study. Med. 2015 Jul;94(28); e1004.

2- Dibello D, Colin G, Galimberti AM, Di Carlo V. Ten year challenge with Ponseti method for clubfoot: our experience. Acta Bio Medica: Atenei Parmensis. 2019; 90(Suppl 12): 127–30.

3- Loza ME, Bishay SN, El-Barbary HM, Hanna AA, Tarraf YN, Lotfy AA. Double column osteotomy for correction of residual adduction deformity in idiopathic clubfoot. Ann R Coll Surg Engl. 2010 Nov;92(8):673-9.

4- Lourenco AF, Dias LS, Zoellick DM, Sodre H. Treatment of residual adduction deformity in clubfoot: the double osteotomy. J Pediatr Orthop. 2001 Nov 1;21(6):713-8.

5- Ponseti IV: Common errors in the treatment of congenital clubfoot. Int Orthop. 1997; 21 (2): 137-41.

6- Tarraf YN, Carroll NC. Analysis of the components of residual deformity in clubfeet presenting for reoperation. J Ped Orhop. 1992; 12: 207.

7- Steytler JCS, Van der Walt ID. Correction of resistant adduction of the forefoot in congential clubfoot and congenital metatarsal varus by metatarsal osteotomy. Br J Surg. 1966; 53: 558-60.

8- Berman A. Gartland JJ. Metatarsal osteotomy for the correction of aduction of the fore part of the foot in children. J Bone Joint Surg (Am) 1971; 53: 498-506.

9- Lowe LW, Hannon MA. Residual adduction of the forefoot in treated congential clubfoot. J Bone Joint Surg (Br). 1973; 55: 809-13.

10- Fried A. Recurrent congenital clubfoot: The role of the tibialis posterior in etiology and treatment. J Bone joint Surg Am. 1959; 41: 243-52

11- Thomson SA. Hallux varus and metatarsus varus. Clin Orthop. 1960; 16: 109-18.

12- Otremski I. Salama R. Khermosh O. Wientroub S: Residual aduction of the forefoot. J Bone Joint Surg (Br.) 1987; 69: 832-4.

13- Turco VJ. Surgical correction of the resistant clubfoot. One-stage posteromedial release with internal fixation: a preliminary report. J Bone Joint Surg (Am). 1971; 53: 477-97

14- Dwyer FC. The treatment of relapsed clubfoot by the insertion of a wedge into the calcaneum. J. Bone Joint Surg (Br). 1963; 45: 67-75.

15- Beatson TR. Pearson JR. A method of assessing correction in clubfeet. J Bone Joint Surg (Br) 1966; 48: 40-50.

16- Nimityongskul P. Anderson LD. Herbert DE. Surgical treatment of clubfoot: a comparsion of two technique. Foot Ankle . 1992; 13: 116-24.

17- Heyman CH. Herndon CH. Strong JM. Mobilization of the tarsometatarsal and intermetatarsal joints for the correction of resistant adduction of the fore part of the foot in congenital clubfoot or congenital metatarsus varus. J Bone Joint Surg (Am). 1958; 40:299-309.

18- Kendrick RE, Sharma NK. Hassler WL. Herndon CH. Tarsometatarsal mobilization for resistant adduction of the fore part of the foot. J Bone joint Surg (Am). 1970; 52: 61-70.

19- Evans D. Relapsed clubfoot. J Bone Joint Surg [Br] 43: 722, 1961.

20- Ozeki S, Yasuda K, Iisaka H, Kaneda K, Monji J, Matsuno S. The results of talar neck osteotomy in resistant congenital clubfoot. Clubfoot. Present and a View of the Future. 1994; (pp. 351-360).

21- McHale KA. Lenhart M. Treatment of residual clubfoot deformity- the "bean-shaped" foot-by opening wedge medial cuneiform ostotomy and closing wedge cuboid osteotomy: clinical review and cadaver correlations. J Pediatr Orthop 1991; 11: 374-81.

22- Wynne-Davies R. Talipes equinovarus: a review of eighty-four cases after completion of treatment. J Bone joint Surg (Br). 1964; 46: 464-76.

Citation

Mar'ei, M., Holil, S., Hassan Eltayyar, S., Elkady, R. Assessment of the Outcomes of Double Column Osteotomy in Treatment of Residual Forefoot Adduction in Clubfoot. ***Zagazig University Medical Journal,*** **2024; (4842-4858): -. doi: 10.21608/zumj.2024.273920.3220**

Table s1: Pre & post-operative angle measures of the fair result.

Pre-operative					
Case No.	**TCA1**	**TFMA1**	**CFMA**	**TCA2**	**TFMA2**
18	15	64	26	3	33
19	25	33	25	19	4
23	24	40	33	13	25
Post-operative					
Case No.	**TCA1**	**TFMA1**	**CFMA**	**TCA2**	**TFMA2**
18	29	7	16	8	21
19	20	25	13	15	13
23	31	0	14	6	18

Table s2: Operations of the poor results

Operations	No. of cases
Double column osteotomy and soft tissue releases	1

Table s3: Pre & post-operative angle measuring of poor results

Pre-operative					
Case No.	**TCA1**	**TFMA1**	**CFMA**	**TCA2**	**TFMA2**
1	12	74	27	0	42
Post-operative					
Case No.	**TCA1**	**TFMA1**	**CFMA**	**TCA2**	**TFMA2**
1	35	9	20	0	29