

A PROSPECTIVE STUDY OF SURGICAL CORRECTION OF CTEV BY CINCINNATI APPROACH

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ABSTRACT: BACKGROUND: Surgical correction of congenital talipes equino varus (ctev) is to address adequately all aspects of this complex foot deformity. Various exposures have been elucidated with varying results and complications. This prospective study discusses the cincinnati approach advocated by Mackay to address the various aspects of clubfoot correction. **Objective:** To study the adequacy of exposure, wound healing and problems related to Cincinnati approach. To study the effectiveness of primary surgical correction. **METHODS:** The present prospective study includes treatment of 24 feet in 21 patients with clubfoot treated with posteromedial and lateral soft tissue release by Cincinnati approach and followed up with an average follow up of 6.9 months. 3 (12.5%) were followed up for 1 year and 3 (12.5%) lost for the follow up. 18 (75%) were followed up to 6 months. All were resistant to correction by conservative method. Age at operation averaged 1.6 year, ranged from 9 months to 3 years. **RESULTS:** Results were evaluated using Laaveg and Ponseti functional rating system of clubfoot. Postoperatively the average arc of movement in ankle joint was 37°, which was 50% of normal limb. Inversion, eversion movement of subtalar joint was 23°, bimalleolar angle was 77°. The functional results were excellent in 6 feet (25%), good in 12 feet (50%), fair in 5 feet (20.83%) and poor in 1 foot (4.17%). In our series complications encountered were post-operative focal necrosis in 3 feet (12.5%) and marginal necrosis in 3 feet (12.5%). **CONCLUSION:** Cincinnati incision provides an adequate exposure for extensive surgical release under direct vision, there by bony realignment of talus over calcaneus was restored and hence the restoration of normal bimalleolar angle. Skin closure is not found to be a problem in achieving a primary closure. Wound healing leaves only a thin and cosmetically acceptable scar. **KEYWORDS:** CTEV, cincinnati incision, subtalar release, bimalleolar angle.

INTRODUCTION: Idiopathic clubfoot is one of the oldest and commonest congenital deformities of mankind. Hippocrate (460 BC -377BC)¹ was the first person to describe club foot. The initial treatment of clubfoot is non-operative. It was concluded that most of the club foot can be successfully managed by a series of Plaster casts and wedging without the use anesthetics, or operative procedures with better results.^{2,3}

In neglected, resistant, recurrent, relapsed, failed conservatively treated CTEV pathological contractures of the soft tissues prevented the reduction of the navicular on the head of talus and calcaneum and surgical correction becomes necessary.⁴

The comprehensive soft tissue release in current favor is posteromedial release of Turco. Mukhopadhyay procedure with its variants and circumferential release as described by McKay, Carrol and Simons, etc. are some of more than hundred surgeries described.

The conventional Turcos approach, although widely practiced, is associated with non-acceptable scar something keloid, difficult visualization of the other side of ankle and subtalar joint,

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incomplete soft tissue release, incomplete peritalar release, incomplete subtalar release and incomplete correction of rotation deformity of calcaneum. This could lead on to either persistence or recurrence of deformity.

To predicate the above mentioned problem circumferential Cincinnati approach has been practiced worldwide. A significantly lower incidence of wound complications was seen in the Cincinnati treatment group when compared with the modified Turco.⁵ so we intend to study the surgical management of CTEV by Cincinnati approach in light of the published literature.

OBJECTIVES OF STUDY:

RELATED TO APPROACH: To study the adequacy of exposure, wound healing and problems related to Cincinnati approach.

RELATED TO PROCEDURE: To study the effectiveness of primary surgical correction.

Surgery in the treatment of clubfoot must be tailored to the age of the child and to the deformity to be corrected.

A modified McKay procedure through a transverse circumferential (Cincinnati) incision is our preferred technique

Any approach should be able to address the release in all quadrants, which are as follows:

Plantar: Plantar fascia, abductor hallucis, flexor digitorum brevis, long and short plantar ligaments

Medial: Medial structures, tendon sheaths, talonavicular and subtalar release, tibialis posterior, FHL, and FDL lengthening

Posterior: Ankle and subtalar capsulotomy, especially releasing post talofibular and tibiofibular ligaments and the calcaneofibular ligaments

Lateral: Lateral structures, peroneal sheath, calcaneocuboid joint, and completion of talonavicular and subtalar release

Any approach should afford adequate exposure. Structures to be released or lengthened are the following:

Achilles tendon.

Tendon sheaths of the muscles crossing the subtalar joint.

Posterior ankle capsule and deltoid ligament.

Inferior tibiofibular ligament.

Fibulocalcaneal ligament.

Capsules of the talonavicular and subtalar joints.

Division of associated ligaments around the subtalar joint.

Plantar fascia and intrinsic muscles.

MATERIALS AND METHODS: The present prospective clinical study includes treatment of 24 feet in 21 patients with clubfoot treated with posteromedial and lateral soft tissue release by Cincinnati approach from the period November 2007 to October 2009. Conducted in department of Orthopaedics, Bangalore Medical College and research institute, Victoria, Bowring & Lady Curzon

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Hospitals, Bangalore between November 2007 to October 2009 A prior consent was obtained from all the patients and the study was approved by the Ethical Committee of the Hospital.

METHODOLOGY: Required data was collected from patients admitted in Victoria Hospital, Bowring and Lady Curzon hospitals. All patients included in study were assessed pre-operatively and post operatively (clinical and functional) as per Laaveg and Ponseti functional rating system score.

Children with idiopathic CTEV, more than 6 months of age (Neglected CTEV)-<3years, Rigid CTEV, partially corrected CTEV (failed conservative)/recurrent CTEV were included for the study. X-rays of foot, routine Blood investigations, weight recording done. Cases were followed up at 2 weeks, 6 weeks, 6months and 1year.

EXCLUSION CRITERIA: less than 6 months

- Flexible CTEV.
- Aquired talipes equino varus (trauma, burns, neurogenic, muscular dystrophies-, AMC, Teratological-etc).
- >3 years where bony procedures were needed.

OBSERVATION AND RESULTS: The present study includes treatment of 24 feet in 21 patients with clubfoot treated with posteromedial and lateral soft tissue release by Cincinnati approach from the period November 2007 to October 2009 and followed up with an average follow up of 6.9 months. 3 (12.5%) were followed up for 1 year and 3 (12.5%) lost for the follow up. 18 (75%) were followed up to 6 months. Age at operation averaged 1.6 year ranged from 9 months to 3 years.

Age distribution:

Age in years	Total	unilateral	Bilateral
9 months_1 year	7	5	2
1.1_2 year	9	8	1
2.1_3 year	5	5	0
Total	21	18	3

Table 1: Showing age distribution

Sex distribution:

Sex	No. of cases	Percentage
Male	15	71.4%
Female	6	28.6%
Total	21	100

Table 2: showing sex distribution

Side affected	No. of cases	Percentage
Unilateral	18	86%
Bilateral	3	14%
Total	21	100

Table 3: Table showing side affected

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Foot size	No. of feet	Percentage
8.1_9 cm	6	25%
9.1_10 cm	10	45.84%
10.1_11 cm	2	8.33%
>11 cm	5	20.83%
Total	24	100

Table 4: Table showing foot size

Components of deformity	Grading of deformity				Total
	Severe (passively could not be corrected to neutral)	Moderate (passively overcorrected up to neutral)	Mild (passively overcorrected beyond neutral)	Nil (complete absence of deformity)	
Equinus	14	10	0	0	24
varus	11	13	0	0	24
Forefoot adduction	2	17	5	0	24
cavus	0	5	8	11	24

Table 5: Table showing severity of deformity

Type of incision	No of feet	Percentage
Complete Cincinnati	21	87.5 %
Hemi cincinnati	3	12.5 %
total	24	100

Table 6: Table showing type of incision used

Soft tissue release	No. of feet	percentage
Posteromedial release only	3	12.5%
Posteromedial and lateral release	21	87.5 %

Table 7: Table showing soft tissue release

Subtalar Release	No of feet	Percentage
Medial and posterior release	13	54.17 %
Medial, posterior and lateral release	11	45.83 %
Total	24	100

Table 8: Table showing subtalar release

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Skin complications	No. of feet	Percentage
No necrosis	17	70.54 %
Focal necrosis	3	12.5 %
Marginal necrosis	3	12.5 %
Severe necrosis	1	4.46 %
Total	24	100

Table 9: Table showing wound complications

ROM in deg	Ankle DF	%	Ankle PF	%	Inversion	%	Eversion	%
0_5	1	4.17%	0	0	0	0	11	45.83%
5_10	12	50%	0	0	4	16.67%	13	54.17%
10_15	11	45.8%	1	4.17%	10	41.7%	0	0
15_20	0	0	7	29.16%	10	41.7%	0	0
20_25	0	0	9	37.5%	0	0	0	0
25_30	0	0	7	29.16%	0	0	0	0

Table 10: Table showing post-operative ROM

Deformity correction	No of feet	Percentage
Completely corrected	20	83.33%
Partially corrected	4	16.67%
Total	24	100

Table 11: Table showing results of deformity correction

Pt satisfaction	No. of feet	Percentage
Very satisfaction	17	70.83%
Satisfaction	7	29.17%
Un satisfaction	0	0
Total	24	100

Table 12: Table showing functional satisfaction with end result

Functional	No of feet	Percentage
No limitation of activities	11	45.83%
Occasional limitation	13	54.17%
Limitation on strenuous activities	0	0
Limitation in routine activities	0	0
Total	24	100 %

Table 13: Table showing rating system for adequacy of daily living

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Pain	No. of feet	Percentage
Never painful	11	45.83%
Occasionally painful during strenuous activities.	13	54.17%
Usually painful in strenuous activities.	0	0
Occasionally painful during routine activities.	0	0
Total	24	100%

Table 14: Table showing rating system for pain

Position of heel	No. of feet	Percentage
0° varus	18	75%
1_5°	6	25%
6_10°	0	0
>10°	0	0
Total	24	100

Table 15: Table showing position of heel while standing

Results	No. of feet	Percentage
Excellent	6	25
Good	12	50
Fair	5	20.83
Poor	1	4.17
Total	24	100

CASE 1: BILATERAL NEGLECTED CTEV

Pre op photographs



Pre-op photograph showing varus deformity

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Pre op showing equinus deformity intra op showing lateral subtalar release



Wound at second week Wound at second week



A/K POP CAST application with corrective shoes



At 6 months

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CASE 2: BILATERAL CTEV



Pre op photographs



Hemi Cincinatti incision was used



Skin condition at 2 weeks



At 6 months



With corrective shoes at 18 months



At 18 months showing corrected equinus Heel position at 18 months

CASE 3: NEGLECTED CTEV



Pre operative photographs

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Marginal wound necrosis at 2 weeks



At 6 months



Minimal adduction at 9 months



Ankle position at 9 months

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With corrective shoes

CASE 4: BILATERAL CTEV



Pre-operative photographs



Skin condition at second week

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Corrected heel varus



With corrective shoes Heel position while standing

CASE 5: BILATERAL NEGLECTED CTEV



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Pre-operative photographs



Severe skin necrosis at 2 weeks



Healed wound at 6 weeks



DISCUSSION:

Approach and age: CTEV is an abnormality involving the ankle and foot, which causes adduction, supination, varus and equinus deformity. The long term aim of the management is to achieve a functional, pain free, cosmetically acceptable, and mobile as close to normal feet. Surgical treatment is usually required in failed conservatively managed clubfeet, neglected CTEV, rigid CTEV etc.

The general principle of surgical procedure is to prevent multiple procedures to achieve full correction because complications exponentially increase with the number of interventions. Hence a combination of right approach and an extensive soft tissue release including posteromedial release, lateral release, and subtalar release will achieve the goal of the surgical treatment.

In our study we have adopted Cincinnati approach with posteromedial and lateral soft tissue release and subtalar release. Though better results were obtained by posterior and posteromedial soft tissue release in younger children it has been suggested that early surgical treatment lead to severe fibrosis and development of rigid foot. Thus surgery should better be executed between 1 and 2 years of child age^{6,7,8}.

In our study we have 14 children were above the age of 1 year and remaining 7 children were almost nearer to 1 year. 5 children were operated between 2-3 years of age. They belonged to severely neglected CTEV. DePuy and Drennan divided 44 feet treated by PMR in 3 groups which were operated on 4, 9 and 16 months. They did not find significant functional or radiographic difference between the groups. However in younger group less tarsal bone deformity was observed than in older groups.⁹

Foot Size: Simons recommended that the size of the foot rather than the age of the patient be used to determine the optimum time to perform the surgery. He stated that the foot should be ≥ 8 cm long at the time of surgery.¹⁰ The longitudinal length of the foot was measured by taking foot tracing. The bimalleolar plane was marked by connecting lateral and medial malleolar marking. The longitudinal plane of the foot drawn from second toe to the tip of the heel intersecting bimalleolar line is measured for the foot size. Normal bimalleolar angle is 76° .¹¹

We had a poor result with one child operated at age of 10 months. However the foot size of child was 9 cm. Our average foot size in our study was >9 cm in 75% of children. 25% were between 8 and 9 cm. There was no case of less than 8 cm foot in our study. Hence it is difficult to attribute the results of study based on foot size.

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Deformity: The deformity was very severe in children above the age of one year. 7 feet in 6 children were less than 1 year and deformity is of less severe. The poor result was noted in less deformed foot. However the fair results were observed in both mild and severely deformed feet. Our study is not very conclusive about the correlation of severity of deformity and the end result.

Severe deformities pose the problem of severe skin contracture on the medial side of foot and ankle, which is notorious for poor nutrition and delayed healing, there by high incidence of wound necrosis. The severe deformities also encounter cavus deformity of foot due to severely contracted plantar fascia and intrinsic muscles of the foot increasing the chances of poor outcome.¹²

Incision: Incision to CTEV falls in to three categories. Turcos posteromedial incision which is oblique and hockey stick like. Since the Turcos incision cuts across the skin crease it causes non-acceptable skin necrosis and ugly scar. This incision being eccentrically placed exposure and visualization of other side of ankle and subtalar joint is difficult there by an incomplete soft tissue release.

Carolls incision includes two separate incisions, a curvilinear medial incision and posterolateral incision to allow adequate exposure for plantar, lateral, medial and posterior structures. He emphasized the release of plantar fascia and capsulotomy of calcaneo cuboid joint were critical in achieving correction.¹⁰

The Cincinnati incision is based on thorough study of anatomy of the foot and ankle. The obvious goal of a good surgical approach is to provide adequate exposure of the pathologically involved structures while at the same time minimizing morbidity resulting from damage to the blood vessels, nerves, tendons, and articular surfaces in the area and allows the surgeon to correct a deformity in all planes simultaneously.

Satisfactory reduction and stabilization of the tarsal bones is easily accomplished under direct vision. The Cincinnati incision also proved to be more acceptable cosmetically than other incisions as it often heals with thin scar. The problems with Cincinnati incision have been minimum like marginal skin necrosis and limited exposure of tendo Achilles.¹³

We have used complete Cincinnati incision in 21 feet (87.5%) and hemi Cincinnati incision in 3 feet (12.5%). We have observed the exposure is very adequate to visualize the medial, posterior and lateral subtalar release under direct vision. The only problem we encountered during the procedure is the limited exposure for tendo Achilles, there by requiring the need of excessive retraction posteriorly for TA lengthening. We have achieved primary wound closure in all cases without any problem.

Skin Necrosis: Marginal skin edge necrosis is seen in 3 feet (12.5%). Small area of focal necrosis in 3 feet (12.5%). 1 foot (4.46%) had severe necrosis. The child with severe necrosis had severe rigid CTEV. The severe and rigid deformity, subcutaneous thicker suture material could have been the reason for severe necrosis. However the wound was completely healed in 10 days of time without eventually affecting the outcome of the functional result. The children with marginal necrosis and focal necrosis host no problem and went on healing without any delay. 71% of feet healed without any delay.

Kalenderer et al, have observed superficial wound necrosis in 25% of their cases and reported that they had difficulty in performing Achilles tendon release.^{6,14} Karakurt et al. described

skin necrosis in 15% and deep necrosis including Achilles tendon in 6%. Dimeglio reported no necrosis in 91 cases.^{6,15}

Zhon-Liau Lee has reported skin problem in 11 feet in total of 60 feet (18.3%). Among them 7 feet had mild patchy necrosis, 3 feet had moderate necrosis and one foot had extensive skin necrosis, wound dehiscence and deep infection.¹⁶ In a retrospective study by Hsu, Wellington K et al., of 217 patients who underwent primary PMR using modified Turco or Cincinnati incision, a significantly low incidence of wound complication is seen in Cincinnati incision than Turcos incision. (6.9% vs 19.6%).⁵

There are various recommendation to prevent wound necrosis^{17,18,13,19,20}.

Benjamin Joseph et al., using hemi Cincinnati incision for posteromedial soft tissue release reported that 42 feet could be put in to neutral plantigrade position at end of operation and found satisfactory healing without any wound necrosis. Wound closure by tension had led on to superficial dehiscence in 14 % of case. Minor degree of wound dehiscence may be avoided if the foot is held in inversion postoperatively.²¹

In our study we have noticed 2 children had very mild wound dehiscence less than 2 mm. One child had wound dehiscence more than 2 mm. However all the wounds healed without posing any problem. We have noticed retaining subcutaneous fat tissue; sharp dissection without undermining the tissue plane, good haemostasis, tension free closure facilitates better healing without any necrosis.

Evaluation of ROM: In Mc. Kay evolution rating system ankle arc of motion of 40⁰-50⁰ scores better than arc of movement 35⁰- 40⁰. Arc of movement less than 35⁰ face poorly¹¹. Indeed the radiographic studies shows, most motion of plantar flexion and dorsiflexion occur not in true ankle joint but at the mid tarsal joint.²²

Boone and Ayen reported an estimate of 71⁰ of total ankle motion for normal male children²³. Gianneestros considered 60⁰ to be normal passive ankle motion in children²⁴. Jerry B Magone et. al., report 51⁰ as the average ankle arc of movement in normal feet in their study.²² Stauffer reported the average ROM during walking gait is 24.4⁰.²⁵

Simons was the only investigator who compared radiographic true ankle motion in clubfeet pre operatively and post operatively. The average pre-operative ROM was 31⁰ and post-operative ROM was 29⁰. But the arc of motion directed more towards dorsiflexion by 10⁰. In our study a significantly improved range of ankle motion from preoperative range of 26⁰ to post-operative range of 37⁰ of arc of motion as been giving good functional result.

Subtalar Release: Turcos posteromedial release though widely used deformity may persist or recur as the calcaneus has not been fully freed to allow it to rotate beneath the talus. Mc Kay described the concept of calcaneal rotation and subsequently reported by Ghali et al., confirmed the correctness of Mc Kay concept. The posteromedial release does not permit full correction. Only the complete subtalar release accomplishes the full de rotation of calcaneus in single procedure. The complete subtalar release was performed in four basic stages:

1. Superficial medial release.
2. Posterior soft tissue release.
3. Lateral soft tissue release and
4. Deep medial soft tissue release.

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The optional additional procedures are calcaneo cuboid capsulotomy, calcaneo cuboid osteotomy and plantar release.²⁶

Excellent and good short-term results have been reported in congenital clubfoot in 71% of the cases by McKay, in 72% of the cases by Simons, in 69% of the cases by Rumyantsev and Ezrohi, in 83% of the cases by Centel et al., in 63% of the cases by Magone et al., and in 84% of the cases by Turco, which were treated by extensive surgical dissection. Denis reports 76.6% of good and excellent results in extensive soft tissue release.

Dobbs et al, has evaluated the long term result of 60 feet with extensive soft tissue release and 14 with limited soft tissue release. All the 14 feet with limited release showed poor result and some of the extended released feet also had poor result. They observed and found that the poor outcome could be significantly correlated with inadequate surgical release. 67% of their poor outcome was noticed and found to be significantly correlated with inadequate surgical release.⁶

Bimalleolar angle/axis: Measurement of foot bimalleolar angle is an objective, simple and effective method for foot classification prior to treatment and evaluation of its results in congenital clubfoot. The feet in CTEV were classified on basis of bimalleolar angle into four types:

- Type I 75° - 85°
- Type II 70° - 74° and 86° - 90°
- Type III 65° - 69° and $>90^{\circ}$
- Type IV $< 65^{\circ}$.

Deniz et al, in his long term evaluation study found that all type IV feet (less than 65°) had poor functional score. A.K.Jain et al, in their study on evaluation of FBM in management of CTEV have observed the mean FBM angle of 73.2° in grade I deformity (mild CTEV), mean FBM of 66.6° in grade II deformity (moderate CTEV), mean FBM of 54.7° in grade III deformity (severe deformity).²⁷

In our study we had 1 poor result in type IV feet with bimalleolar angle less than 65° . We had average pre-operative bimalleolar angle of 73° and average post-operative bimalleolar angle of 77° .

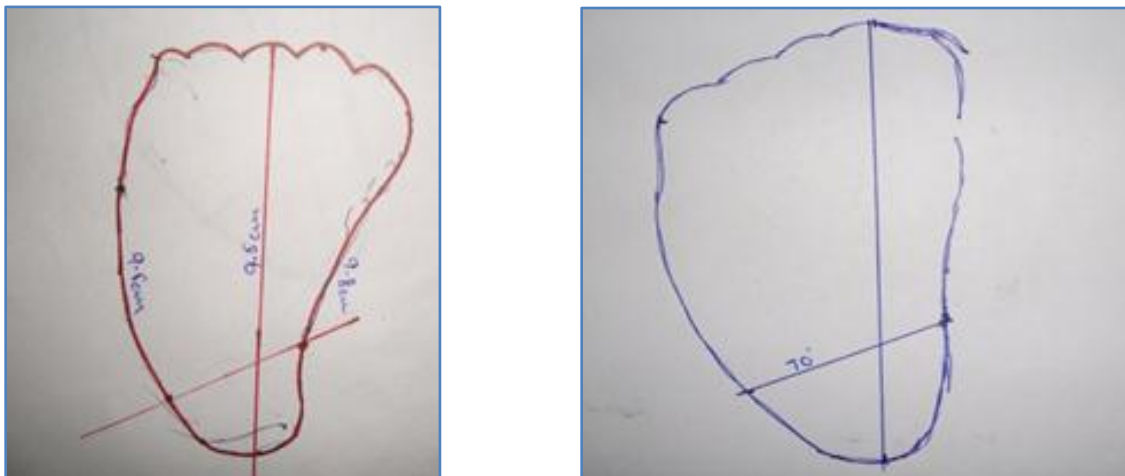


Figure showing pre op FBM of 66° and post op FBM values of 70°

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The fundamental principles of soft tissue release are:

1. To achieve bony realignment in talo navicular articulation and in subtalar articulation,
2. Proper alignment of bi malleolar axis.
3. Improve the range of motion.

In our study 5 feet with fair functional result had only medial and posterior soft tissue release. In all the feet with extensive soft tissue release, result was good to excellent.

Position of heel after surgery reflect optimised bimalleolar axis. Heel position of 0-5° varus gives an optimal correction. Valgus position of heel tends to reduce the bimalleolar axis reflecting the poor result. However certain degrees of varus position of heel also suggest non-optimal bimalleolar axis and resultant poor function. Heel position can be graded as normal neutral heel, heel in mild varus (1-5°), heel in moderate varus (6-10°) and heel in valgus (>5° valgus). Heel in moderate varus and heel in valgus tends to give poor results.

In our study we have 75% of feet were of 0° varus and 25% of feet having 0-5° varus reflecting good restoration of bimalleolar axis. This again reflects adequate soft tissue release medially, posteriorly and laterally.

Almost all patients in our study never had intoeing gait. Intoeing gait without metatarsus adductor deformity could be due to posterior displacement of lateral malleolus reducing bimalleolar axis. This intoeing gait could be prevented by

1. The foot bimalleolar axis should be intraoperatively adjusted to 90° as suggested by Mc Kay.
2. Foot should be casted in external rotation as recommended by Carroll.

RESULTS: In a study by Douglas W. Mc Kay²⁸, of 55 feet he found excellent in 36.36%, good in 45.46%, fair in 3.64% and poor result in 14.54%. D.I. Broughman et al²⁹ reported that in his series with 32 feet he found excellent in 21%, good in 54% and poor in 25% of feet. In a study by Jack C. Y. Cheng,³⁰ of 70 feet he reported excellent in 60%, good in 18.6%, fair in 11% and poor in 11.4%. Gokmen Deniz et al,⁶ reported that in his series with 35 feet he found excellent in 16 feet (45.7%), good in 11 feet (31.4%), moderate in 3 feet (8.6%) and poor in 5 feet (14.3%). The functional results were evaluated at the end of the study showed excellent in 6 feet (25%), good in 12 feet (50%), fair in 5 feet (20.83%) and poor in 1 foot (4.17%).

Series	Excellent	Good	Fair	Poor
Douglas W. McKay ²⁸	36.36%	45.46%	3.64%	14.54%
D.I. Broughman et al ³¹	21%	54%	0	25%
Jack C. Y. Cheng ³⁰	60%	18.6%	11%	11.4%
Gokmen Deniz et al ³²	45.7%	31.4%	8.6%	14.3%
Our study	25%	50%	20.83%	4.17%

Table 17: Table showing comparative study with other series

CONCLUSION: The goal of any clubfoot surgery is to obtain a cosmetically acceptable, pliable, functional, painless and plantigrade foot. Cincinnati incision for the surgical correction of CTEV provides an adequate exposure for extensive surgical release under direct vision, there by bony realignment of talus over calcaneus was restored and hence the restoration of normal bimalleolar

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angle. Skin closure is not found to be a problem in achieving a primary closure. Wound healing leaves only a thin and cosmetically acceptable scar.

However the only problem noticed is limited exposure of ten do Achilles tendon for z-plasty. Complete subtalar release is essential to effectively correct the deformity and proper realignment of tarsal bones. Post-operative marginal wound necrosis and wound dehiscence is of no consequences.

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