A STUDY ON OUTCOME OF COMBINED CUBOID/CUNEIFORM OSTEOTOMY FOR CORRECTION OF RESIDUAL FOREFOOT ADDUCTION DEFORMITY IN IDIOPATHIC CLUBFOOT

Dissertation Submitted to

The Tamil Nadu Dr.M.G.R. Medical University, Chennai

With fulfillment of the regulations for the award of the degree

of

MASTER OF SURGERY (Orthopaedics)
Branch - II

DEPARTMENT OF ORTHOPAEDICS & TRAUMATOLOGY,
MADURAI MEDICAL COLLEGE,
MADURAI – 625 020.

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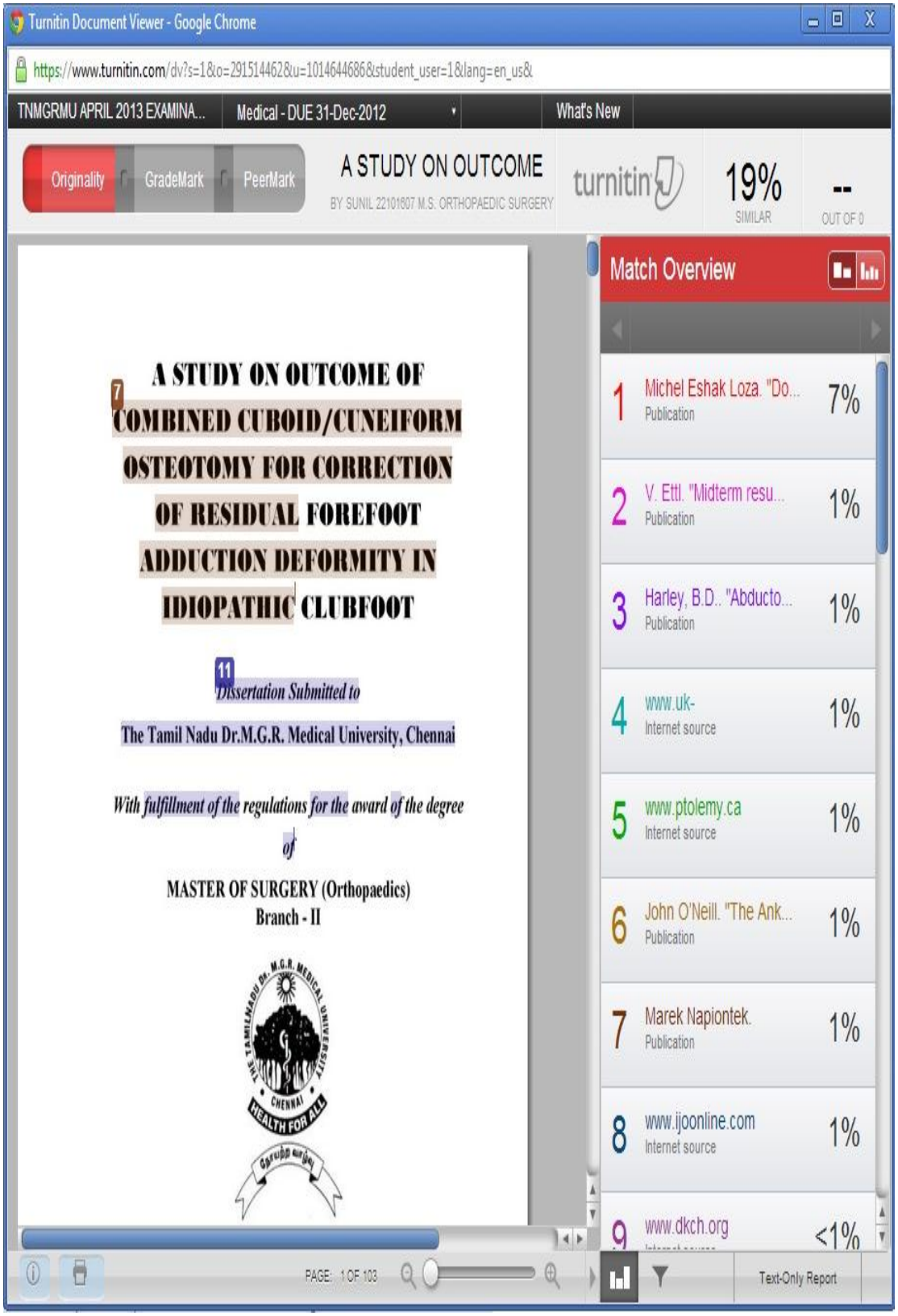
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CERTIFICATE

This is to certify that this dissertation titled "**A Study on outcome of Combined Cuboid/Cuneiform Osteotomy for correction of Residual Forefoot Adduction Deformity in Idiopathic Clubfoot"** submitted by **Dr. SUNIL. S** to the faculty of Orthopaedics, The Tamilnadu Dr. M.G.R. Medical University, Chennai in partial fulfillment of the requirement for the award of MS degree (Orthopaedics), Branch – II is a bonafide research work carried out by him under the direct supervision.

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DECLARATION

I**, Dr. SUNIL. S,** solemnly declare that the dissertation titled "**A Study on outcome of Combined Cuboid/Cuneiform Osteotomy for correction of Residual Forefoot Adduction Deformity in Idiopathic Clubfoot"** has been prepared by me. This is submitted to **The Tamilnadu Dr. M.G.R. Medical University, Chennai,** in partial fulfillment of the regulations for the award of MS Degree (Orthopaedics) Branch II.

Dr.SUNIL. S.

Place : Madurai

Date :

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INTRODUCTION

Recurrence is by definition the development of one or more of the original deformities (equinus, varus, adductus and cavus) after the full correction of the clubfoot is obtained. The cause of recurrence is unknown, but it is the same mechanism that initially caused the deformities to develop and is related to the rapid growth of the foot. Recurrence is rare after the age of 4- 5 years and almost never occurs after 7 years of age. Recurrence is often effectively and easily treatable when discovered at an early stage. Adduction of the forefoot is the most common residual deformity in clubfoot associated with supination of the foot [Tarraf and Carroll]. Undercorrection at the time of initial surgery, medial displacement of the anterior part of calcaneum and navicular bones around the talus were considered to be some of the causative factors.

Fried[16](1959) suggested the posterior tibialis muscle had an indirect action over the forefoot.

Dwyer[19](1963) proposed that residual varus deformity of the hindfoot was caused by the medial deviation of the forefoot and lack of correction of the midfoot as the causes of forefoot adduction deformity.

Steytler and van der Walt [12](1966) proposed internal tibial torsion but was refuted by other authors. They concluded that the source of the deformity was distal to the navicular bone.

Berman and Gartland [15](1971) and Lowe and Hannon [10](1973) described metatarsal deformity as a cause of forefoot adduction.

Turco [18](1971) proposed that the forefoot adduction was due to overcorrection of the hind foot at the initial surgery.

Otremski et al [17](1987) proposed the direct action of the abductor hallucis muscle as the cause of fore foot adduction.

Forefoot adduction can be described as a transverse plane deformity in which the forefoot is in an adducted position relative to the midfoot. In patients two years or younger, with forefoot adduction, early and conservative intervention is highly recommended. Capsulotomies of the tarsometatarsal joints has been advocated after failed conservative management but associated with a high incidence of degenerative joint disease upto 68%.

Soft tissue revision surgery was popularised by Heyman et al [21], but is more difficult because of soft tissue scarring from previous operations and does not take into consideration the deformity of the midtarsal bones.

Soft tissue release can be combined with additional osteotomies such as Dywer, Dillwyn evans, Lichtblau, open wedge osteotomy of first

cuneiform associated with a closing wedge osteotomy of the cuboid and metatarsal osteotomies.

The combination of a shortening osteotomy of the cuboid and elongation of the cuneiform was first described by Mc hale and Lenhart [7]. It has the potential for correction of the deformity of the tarsal bones with minimal additional scarring. We report our experience with this double osteotomy.

AIMS AND OBJECTIVES

1. To analyse the effectiveness of the combined cuboid /cuneiform osteotomy for correction of residual forefoot adduction deformity in idiopathic clubfoot.
2. To study the improvement in forefoot flexibility, gait and overall functional outcome.
3. To study the advantage of this procedure over other techniques of osteotomy.

REVIEW OF LITERATURE

Hippocrates (Circa 400 BC) gave the first written description of clubfoot treatment.He declared two important principles in the treatment of clubfoot, overcorrection of the deformity and maintainance of position to prevent recurrence.

Osseous surgery for forefoot adduction has been described in literature since 1921.

Bankart[3] proposed that the cuboid bone can be removed to offset the effect of congenital absence of the medial cuneiform.

Soft – tissue surgery for adduction deformity of foot was first popularised by Heyman et al [23](1958) and indicated in children between 1- 6 years of age.

Then came a medial approach for soft tissue release effective for children between 6 – 24 months.

Fowler et al (1959)[4] proposed an open wedge osteotomy of the medial cuneiform to supinate and abduct the foot in metatarsus varus.

Steytler and Van der Walt[12] first described metatarsal osteotomies in 1966.

Berman and Gartland (1971)[15] popularised the dome – shaped osteotomies on the metatarsal base from one through five.

Ganley [5] in 1989 stated that the deformity lies within the lesser tarsal region.

Lepird (1981) proposed a metatarsal base osteotomy technique that involves oblique closing wedge osteotomies of all the metatarsal base and rotational osteotomies of the central three metatarsals.

These procedures should be performed on patients older than 7 to 8 years of age. Undercorrection is a common problem because the metatarsal base is usually not at the apex of the deformity.

Tarraf and Carroll,[6] (1992) described forefoot adduction deformity as a result of undercorrection at the time of primary surgery. They described forefoot adduction and supination of the foot as the most common deformities in residual clubfoot. The pathophysiology of forefoot adduction deformity is the imbalance between an elongated lateral column and a shortened medial column.

Mc Hale and Lenhart[7] (1993), reported 6 patients between 4- 10 years operated using an open wedge medial cuneiform and lateral closed wedge cuboid osteotomy. They found good correction of the midfoot supination and forefoot adduction without the need for excessive soft tissue dissection.

The technique described by Fowler et al [4] was later refined to combine a closing wedge cuboid osteotomy that addresses the pathology in two planes.

Ozeki et al (1994)[29] proposed talar neck osteotomy, but the technique was associated with increased risk of vascular compromise.

Kose et al [30](1999) reported closing cuboid and opening cuneiform osteotomies in 10 feet with supination and adduction deformities and three patients with cavovarus deformities.Their results showed satisfactory correction of adduction and supination.

Schaefer et al [8] (2000), used combined cuboid and cuneiform osteotomy to treat 27 feet with residual forefoot adduction deformity with a mean follow up of 5 years.

Lourenco et al [32](2001), treated 39 feet with a closed wedge osteotomy of cuboid and open wedge osteotomy of the medial cuneiform with an average follow up of 4.8 years and saw clinical and radiological improvement in all.

Gordon et al (2003)[36] this procedure should be reserved for patients aged 5 years or older. The osteotomy in cuneiform is difficult since it was small and not fully ossified.

NORMAL ANATOMY OF THE FOOT

A thorough knowledge of the normal anatomy of the foot is essential to the understanding of clubfoot, a deformity that essentially represents a fixed exaggeration of the normal equinovarus position. The foot and ankle should be considered as one unit because of the interrelationship of the mechanics of tibiotalar, subtalar and midtarsal joints.

MUSCLES

The muscles of the lower leg and foot are divided into extrinsic and intrinsic group.

The Extrinsic muscles:

The Gastrocnemius and Soleus. Together, these form the muscle mass described as the triceps surae. The Tendo Achillis, the common tendon of the triceps, inserts on the posterior tuberosity of the calcaneus. It is a powerful plantar flexor of the foot and because of the slight medial attachment to the calcaneus it also inverts the foot.

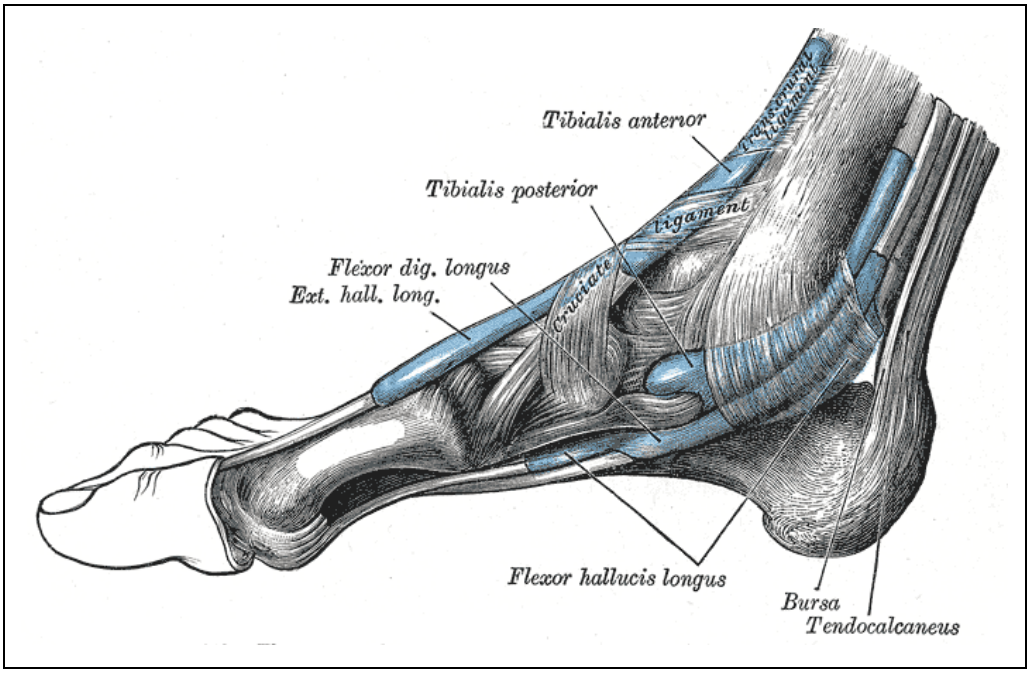
The Flexor Hallucis Longus: This muscle the more lateral of the three deep muscles, arises from the lower two-thirds of the posterior surface of the fibula and the interosseous membrane. From its lateral origin, it runs obliquely downward and medially to form the tendon just

above the ankle joint. The tendon of the flexor hallucis longus, which lies in the groove on the posterior surface of the tibia and talus,continues under the sustentaculum tali then under the navicular, forward in the sole of the foot to insert on the terminal phalanx of the big toe. Often an additional slip runs to the flexor digitorum longus.

The Flexor Digitorum longus: The most medial of the three deep muscles, it arises from the posterior surface of the tibia at a higher level than that of the hallucis longus. It passes behind the medial malleolus in a separate tunnel and runs into the sole of the foot under the navicular, where it crosses the hallucis longus. Distally it is joined by flexor accessorius and divides into four tendons that insert on the terminal phalanges.

The Master Knot of Henry: This structure is a hypertrophied thickening of the tendon sheaths of the long flexor tendons and function as a suspensory ligament that holds the two tendons on to the plantar surface of the navicular. This fibrous tissue is located below the navicular tuberosity. It envelopes the two tendons in separate tunnel where the two tendons cross each other.

Figure–1:

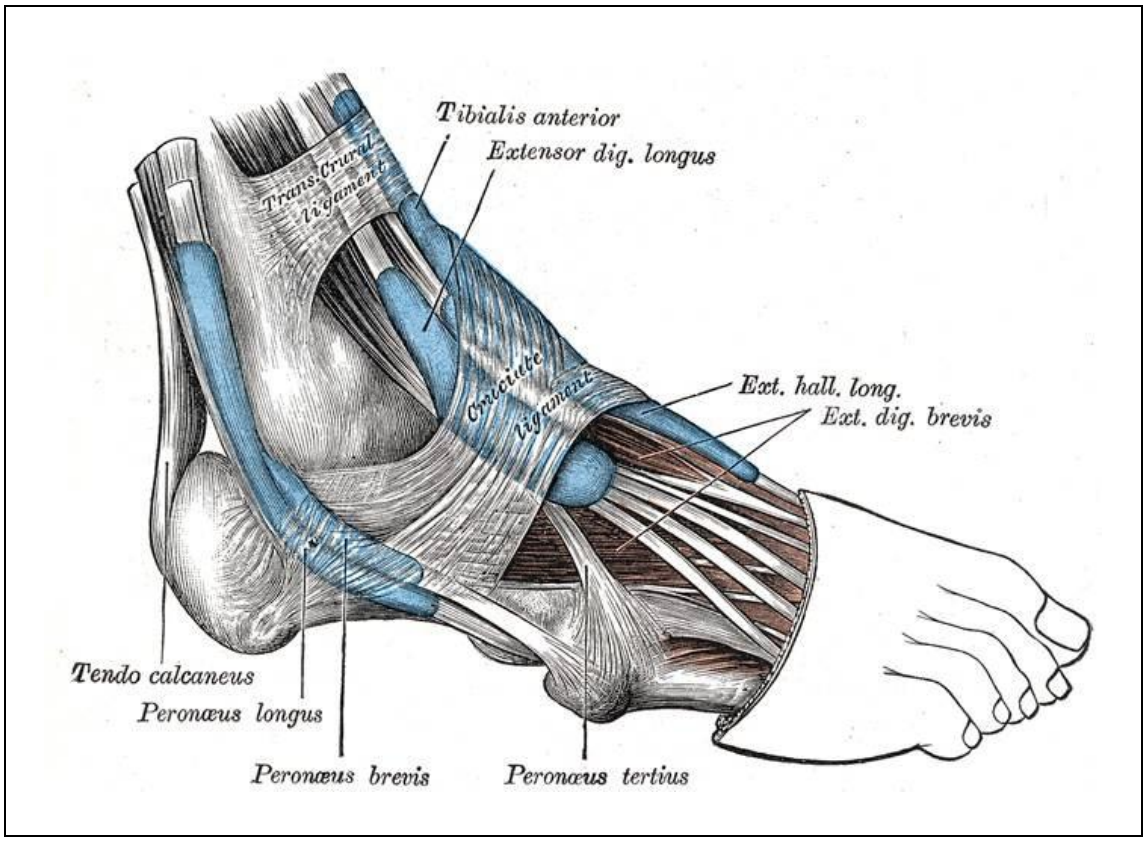


The Tibialis Posterior: The most important muscle in the clubfoot deformity, the muscle lies between the two muscles and distal to the origin of digitorum longus. It arises from the posterior surface of the tibia, the undersurface of the interosseous membrane,and the adjacent surface of the fibula. In the lower fourths of the leg it becomes tendinous as it passes deep and anterior to digitorum longus . Its tendon lies in a groove behind the medial malleolus, enclosed in a separate thickened sheath. It then passes distally along the medial surface of the foot. Its prime insertion is on the tuberosity of the navicular bone, it also gives fibrous insertions on the sustentaculum tali of the calcaneus, the adjacent cuneiforms, the metatarsals and the spring ligament. The tibialis posterior adducts, inverts and plantar flexes the foot.

The Tibialis Anterior : This muscle arises from the anterolateral surface of the tibia and the interosseous membrane and runs downward and medially under the extensor retinaculum to insert on the first cuneiform and on the base of the first metatarsal.

The Peroneus Longus and Brevis : Both of these muscles arise from the lateral surface of the fibula, longus arising from a higher level. Brevis gets inserted to the base of the fifth metatarsal, where as longus runs transversely on the plantar surface of the foot to get inserted to the base of the first metatarsal and adjacent cuneiform .

Figure–2:



The Intrinsic Muscles:

These muscles are important in cases of clubfoot with cavus deformity.The abductor hallucis, flexor digitorum brevis, abductor digiti quinti and flexor accessorious can be considered as a common group of muscles arising from successive layers from medial and plantar surface of the tuberosity of the calcaneus and the plantar aponeurosis

The Plantar aponeurosis : This is essentially a strong superficial ligament that extends from the os calcis to the toes. The central part of the aponeurosis is much stronger and thicker than the medial portion, which covers the under surface of the abductor hallucis.

The Abductor Hallucis : This is the longest muscle of this group. It lies along the medial border of the foot and covers the plantar nerves and vessels and along with the flexor hallucis brevis gets inserted as a tendon on the medial surface of the proximal phalanx of the great toe.

BONES

Ossification of the tarsal bones :

Each of the tarsal bones are ossified from a single center except the calcaneum which has a separate epiphysis for the posterior tuberosity. The ossification centers make their appearance in the following order, the calcaneum and the talus at the 6 th month of fetal life, the cuboid at the 9 th month, the three cuneiforms in the following order, 1 st in 3 rd year, 2 nd in cuneiform and navicular bone in 4 th year, and the 3 rd in the 1 st

year. The epiphysis of the tuberosity of the calcaneum appears at the 10 th year and unite with the rest of the calcaneum after puberty.

THE TALUS:

The talus is the second largest bone and is covered with articular cartilage all over except for small ligamentous attachments. Talus is devoid of any muscular attachments. The talus has three parts – a head , neck and body . The body has three articular surfaces collectively known as the trochlea. The trochlea articulates with the lower end of tibia and with the lateral and medial malleoli. It is important to note that the antero posterior measurement of the superior articular surface of the talus is greater than the corresponding surface on the lower end of the tibia. The trochlear surface is wedge shaped being broader anteriorly. The posterior aspect of the body of the talus has a groove that directs the course of the flexor hallucis longus medially. The lateral tuberosity of this groove is large and serves as an attachment for posterior talofibular ligament. When this lateral tubercle persists as a separate center of ossification, it is known as the os trigonum. In the young child this groove is quite shallow.

THE CALCANEUM:

It is the largest of the tarsal bones, the calcaneum articulates with the talus and cuboid. In its surface, there are three articular facets that support the talus, the posterior articular facet, which is convex, articulates

with the concave facet under the body of the talus. Anterior to the posterior articular facet is the calcaneal sulcus, a groove superior to the calcaneum that lies below a similar sulcus (the talar sulcus) on the under surface of the talus. These grooves together form the "tarsal canal", which contains the talo- calcaneal interosseous ligament.

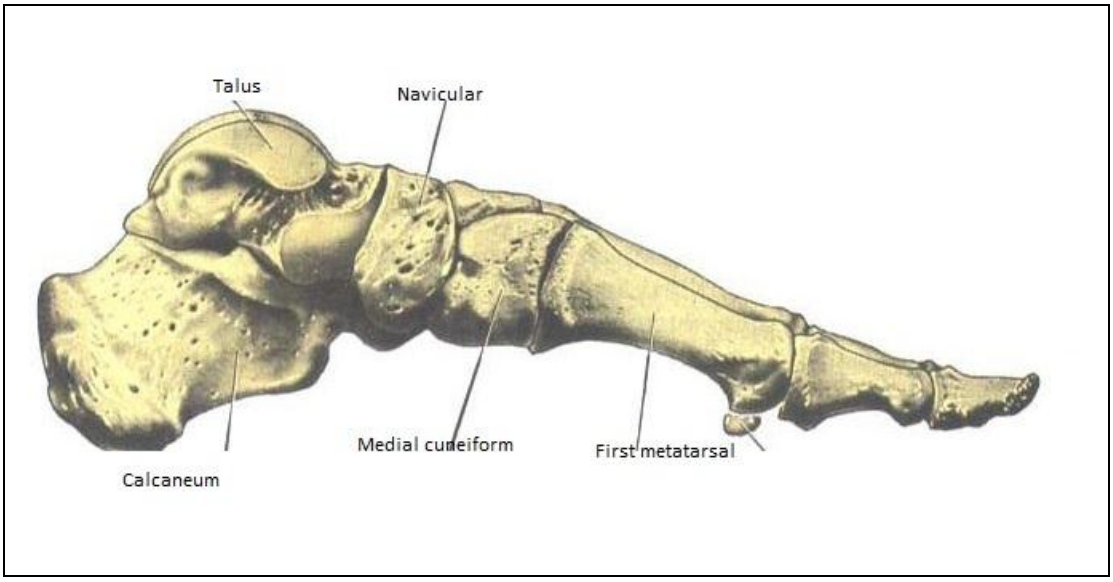
SUSTENTACULUM TALI:

This is a horizontal eminence that protrudes upward from the medial border of the calcaneum. The sustentaculum is located under the middle articular facet of the calcaneum and as it's name implies, supports the head and neck of the talus. A slip of the tibialis posterior is attached to the sustentaculum tali, in addition, the sustentaculum tali provides attachments to the deltoid ligament and the plantar calcaneo - navicular ligament (spring ligament). It also serves as a pulley for the tendon of the flexor hallucis longus. The long axis of calcaneus is directed forwards upwards and somewhat laterally.

THE NAVICULAR:

It is located between the head of the talus proximally and the cuneiform bones distally. The proximal surface is concave so as to accommodate and cover the head of the talus. This concavity functions as a key, alone to support the head of the talus. The distal surface is convex from side to side and is divided into three facets for articulation with the three cuneiform bones. On the medial surface there is prominent tuberosity, on to which the tibialis posterior inserts.

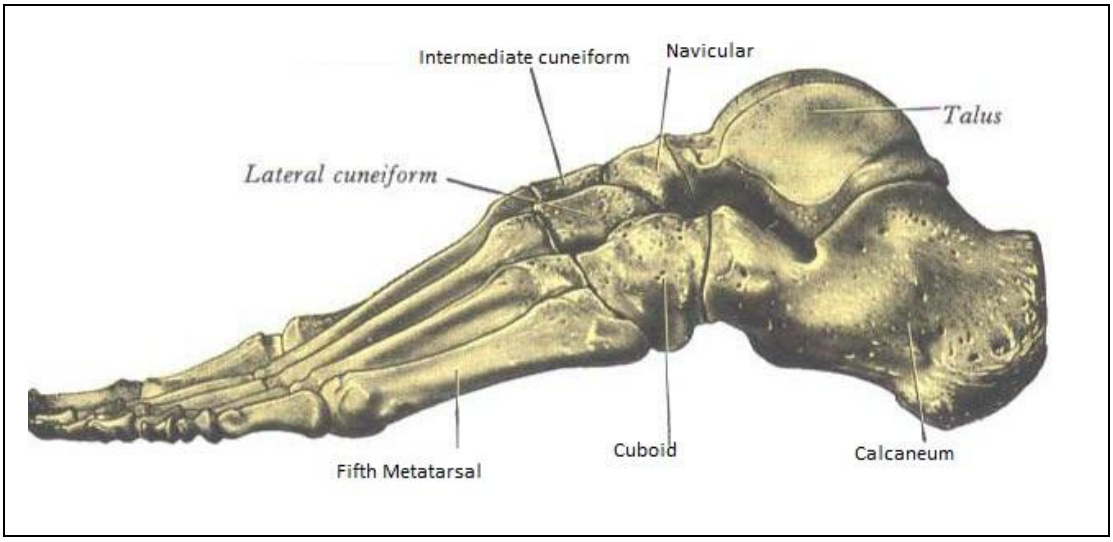
Figure–3:



THE CUBOID:

This bone has three articular surfaces anterior, posterior and medial. Anteriorly it articulates with the fourth and fifth metatarsals, posteriorly with the calcaneum and medially with the lateral cuneiform. Cuboid is firmly wedged between the bones with which it articulates.

Figure–4 :



CUNEIFORM BONES:

They are wedge shaped and articulate with the navicular bone proximally and base of the first, second and third metatarsal bones distally.

JOINTS OF THE FOOT AND ANKLE

In 1911 Henry[38] recognised the close relationship between the foot and the ankle when he described the upper ankle joint and the lower talocalcaneonavicular joint.

The Tibiotalar joint : The upper ankle joint is a hinge - like joint. The trochlea is wedged between medial and lateral malleoli. The tibia and fibula are firmly bound together by interosseous ligaments. Additional stability to the ankle is provided by medial and lateral ligaments of the ankle. Since there are no muscle attachments on the talus its movement is passive. It moves along with other tarsal bones. Because antero -posterior distance of the lateral border of the trochlea is greater than that of the medial, the dorsiflexion and plantar flexion movements are not exactly vertical but slightly oblique. In plantar flexion (equinus), the movement is medial and downward. The navicular moves in the same direction and the calcaneum inverts.The opposite of the same occurs in dorsiflexion.

Ligaments of the Ankle joint : The deltoid ligament is a strong, dense, fan-shaped structure arising from the medial malleolus and

consists of a superficial and a deep layer. The superficial portion has three components that run from the tibia to the navicular bone, to the spring ligament and calcaneum. The deep portion of the deltoid ligament inserts on the neck and the medial surface of the body of talus. The posterior capsule can be considered an extension of the deep part and the talcalcaneal ligament from superficial part. The lateral ligaments radiate from the fibula. The anterior talofibular ligament runs anteriorly to the neck of the talus. The calcaneofibular ligament runs vertically downward to insert onto the calcaneus. The posterior talofibular ligament is deep seated and runs medially in a more horizontal plane to attach to posterior eminence of the body of the talus.

Subtalar and Midtarsal Joints : During vertical motion in the ankle joint, simultaneous horizontal motions of inversion and eversion are necessary to allow walking on inclines and on uneven terrain possible, thus the combination of upper and lower ankle joint motion allows simultaneous motion in two axes, approximately perpendicular to each other.

The Subtalar joints: Usually, when orthopaedists speak of the subtalar joint they club the three talocalcaneal articulations together. Anatomically, however the subtalar area is divided into two separate compartments with separate synovial cavities. The talocalcaneal interosseous ligament is the structure that divides the subtalar area into

anterior and posterior subtalar joints. This ligament adds stability to the subtalar area.

The Midtarsal or Chopart's joints: The midtarsal area consists of two articulations, the talonavicular and the calcaneocuboid joint. The ball-and-socket talonavicular joint is the most mobile of the intertarsal joints. The S-shaped calcaneocuboid joint and strong ligament attachments firmly stabilize the calcaneocuboid part of the midtarsal area. Cuboid is firmly wedged between calcaneum and the metatarsals. Hence there is little gliding movement of the cuboid and it moves along with the anterior end of the calcaneum.

Naviculocuneiform and Lisfranc joints: Very little gliding motion occurs at the naviculocuneiform articulation. Even less movement takes place at the tarsometatarsal area. The first metatarsal articulates only with the medial cuneiform, which has weak ligamentous attachments and is more mobile. The four lateral metatarsals are firmly attached to each other and to the tarsal bones by strong ligaments and interlocking joints. This anatomic arrangement permits for little gliding motion at the Lisfranc region except for the first metatarsal.

The Talocalcaneonavicular joint : This area is involved in the pathomechanics of all hindfoot and midfoot deformities. The talocalcaneonavicular joint is a complex articulation that includes all articulations between the talar head and the anterior end of the

calcaneum, the navicular, and the spring ligament. The posterior talocalcaneal joint is not included. The talocalcaneonavicular joint has the configuration of a ball and socket joint. The acetabulum for the head of the talus is formed by the posterior concave surface of the navicular, the middle and anterior facets of the calcaneum, and the spring ligament. The spring ligament bridges the interval between the navicular and the sustentaculum tali. It has a fibrocartilaginous structure that supports the head of the talus. Alternating convex and concave facets make the joint quite stable. The fibro-elastic structures of the joint are the talonavicular capsule, the deltoid ligament, the tibialis posterior tendon, spring ligament, calcaneonavicular portion of the bifurcated Y-ligament and posteriorly interosseous ligament. Barclay Smith[39] compared the joint to the hip joint, here the acetabulum moves around the ball and the socket is partly expandable unlike hip joint .

MOVEMENTS OF THE FOOT

Horizontal Motion

Movements at the talonavicular and the anterior and posterior subtalar joints elicits horizontal motions. The anterior end of the calcaneum and the navicular move together in unison around the talar head. Most of the horizontal motion takes place at the talonavicular and the anterior subtalar joints. Less movement occurs at the posterior subtalar and the calcaneocuboid joint. For normal subtalar movement,

the navicular must be free to rotate. Subtalar movement does not occur if the navicular is fixed [35]. It is also demonstrated that movement of the midtarsal joints are reduced when subtalar joint is fixed.

Inversion

Inversion occurs at the talonavicular and the subtalar joints. Cuboid moves along with the calcaneum and no movement occurs at the calcaneocuboid joint. It does not occur at the naviculo-cuneiform and the Lisfranc joints. The navicular rotates around the talus and moves proximally and downward and closer to the medial malleolus. The distance between the navicular and the sustentaculum tali is diminished. The capacity of the socket is diminished. In this position the medial and plantar soft tissues are shortened, the talar head is out of the socket and prominent. On x-ray the foot is similar to uncorrected clubfoot. Hence clubfoot is an fixed exaggeration of normal equinovarus.

Eversion

When the foot is abducted and everted, the movement of the socket is just the opposite of inversion - the calcaneum everts and the navicular moves laterally in relation to the talus. The capacity of the socket is greater, more of the talar head is covered by the acetabulum, and the sinus tarsi is closed.

Dorsiflexion and Plantar flexion.

Plantar flexion: since the talus has no muscle attachment it moves along with the navicular and calcaneum. The muscles tibialis posterior and the Achillis which bring about plantar flexion also causes inversion of the foot. Hence in vivo little inversion and adduction also occurs along with plantar flexion and equinus.

Dorsiflexion: The opposite movements occur. Tibialis posterior and the Achilles relax. The foot dorsiflexes as well as everts. Dorsiflexion occurs at the ankle and subtalar joints and eversion at the talonavicular and subtalar joint.

Adduction - Abduction.

In horizontal movements, the forefoot follows the hindfoot, and additional adduction and abduction movement motions occur at the Lisfranc area, supplementing the motion in the talocalcaneonavicular complex.

ETIOLOGY OF CLUBFOOT

While our knowledge of the pathologic anatomy and treatment of club foot have increased through the years, the etiology of the idiopathic congenital form of this deformity is still unknown and remains as unsolved mystery. Through the years, many theories have been proposed, discarded, rediscovered and represented with renewed enthusiasm. During the past 200 years, the same basic concepts of

etiology, with slight modifications, have enjoyed temporary acceptance as the solution to the unsolved puzzle. A congenital abnormality simply indicates that a child is born with a defect – the abnormality is produced by pathologic changes in the normal developmental process of the embryo. A congenital deformity may result from an inborn genetic defect at the time of conception, or from adverse factors in the uterine environment, affecting normal embryonic development. The diagnosis "congenital club foot " describes a deformity noted at birth and includes idiopathic and non-idiopathic talipes equinovarus. In the non idiopathic clubfoot, the deformity is a local manifestation of a systemic skeletal syndrome, the foot deformity and the associated skeletal anomalies are due to the same etiologic factors that caused the failure of normal fetal development. The non idiopathic club foot can result 1) from muscle imbalance, as in neuromuscular conditions, 2) from fibrosis of soft parts, as seen in Arthrogryposis, or 3) from bone and joint anomalies. In the idiopathic clubfoot, the foot is the only deformity, the musculoskeletal system is otherwise normal.

Theoretical considerations: Many theories have been advocated to explain the etiology of idiopathic club foot. When examined closely, however the evidence supporting each theory falls short on some vital point.

Idiopathic clubfoot could be due to one of these.

1. Mechanical factors in utero
2. Arrested fetal development
3. Primary germ plasm defect
4. Heredity and environment combined.
5. Neuromuscular

1) Mechanical factors in utero : Extrauterine compression or lack of amniotic fluid as in oligohydramnious can cause equino varus condition. But in conditions like twins, large babies, primiparous uteri where uterus is over crowded, the condition is not seen. This negates the theory. But possibility of transient elevation in intrauterine pressure at a vulnerable time cannot be ruled out. However one still cannot rule out the possibility that transient elevation of intrauterine pressure at a vulnerable time could interfere with the normal development of the foot.

2) Arrested fetal development [41]: During embryonic development normal feet resembles clubfoot at 2 months of age. At this stage (Fibula phase) fibula is longer and pushes the calcaneum into this position. In the next stage (Tibial phase) tibial lower end grows and brings the foot to normal position. An arrest at the tibial phase can cause equinovarus. But at any stage of normal development talar changes seen in the clubfoot is not seen in normal development, the talar and other bone changes could be secondary to the deformity.

3) Primary germ plasm defect [30,31,32,33] : It is suggested that the deformity probably results from primary germ plasm defect affecting the head and neck of talus. The most conspicuous and the only constant abnormality is found in the anterior part of the talus. The neck of the talus is always short. That a completely normal shaped head and neck of the talus fails to develop after correction supports this theory. Antagonists of the primary germ plasm defect theory have described the same abnormality of the talus, but they attribute it to secondary adaptive changes. It is not clear how one explains a unilateral deformity resulting from a genetic defect, nor is it known why only the head of the talus is involved, leaving the body of the talus unscathed.

4) Heredity and environment combined [34,35,36] : The cause is unlikely to be purely hereditary. Even though it is multifactorial not all identical twins are affected. Hence the heredity factor is present which combined with environmental factor at a crucial time cause this deformity. Hereditary factor could represent either a primary germ plasm defect or contractile tissue upon which an environmental factor like uterine pressure or arrest in development could act leading to the deformity. Presently this is the accepted theory.

5) Neuromuscular : Several investigators maintain that the equinovarus foot is always the result of neuromuscular defects. At birth, the appearance of the clubfoot deformity in arthrogryposis or muscular dystrophy maybe indistinguishable from idiopathic clubfoot. It is not

known whether the changes in the muscle structure are the cause or the result of the deformity or whether they are primarily or secondarily acquired. There are many factors that make a neurogenic cause unlikely. The association of clubfoot with spina bifida is well known, however it is unlikely that a neurogenic disorder is primarily responsible for all idiopathic deformities because: 1) Not all children with spina bifida have clubfoot. 2) The deformities associated with congenital neurologic defects do not present with same constant characteristics of the idiopathic club foot. 3) The neurologically deformed foot is usually more flexible than the rigid congenital idiopathic foot.

PATHOANATOMY OF CLUBFOOT

As mentioned earlier the pathology could be either due to subluxations around the developing tarsal bones leading to deformity or due to pathological changes in the tarsal bones. Scarpa was the first to publish a vivid description of the pathologic anatomy of the clubfoot. He believed that the deformity resulted from abnormal relationship between the tarsal bones i.e. subluxations and described it as "congenital dislocation of the talocalcaneonavicular joint ". Presently it is accepted that the subluxations are the primary pathology secondarily leading to intraosseous changes in the tarsal bones (Wolffs' law) and soft tissue contractures (law of Davis) [37,38].

Deformity: The typical clubfoot consists of a deformed foot in equinus, varus, adduction and is some cases a cavus component, varying

degrees of deformity can be seen in the newborn. Rigid clubfoot are usually smaller, stubby feet with shortened first metatarsal ray. Feet that are less rigid (flexible) are little longer. The medial border of the foot is concave and elevated and its plantar surface faces upwards, the lateral border is convex and depressed downward. The posterior tuberosity of the heel is pulled upward, inverted, difficult to palpate and less visible. The bony prominence visible and palpable over the dorsolateral aspect of the foot represents the head and neck of the talus which is partially uncovered because the navicular and the calcaneum have been displaced medially. In the normal newborn, the foot is extremely pliable and hypermobile. On passive dorsiflexion, the dorsum touches or approximates the anterior shin which is impossible in clubfoot.

Skin abnormalities: Changes in the appearance of the skin are quite variable. The skin over the dorsolateral aspect of the foot is usually stretched out, thin and atrophied. Some feet have a deep cleft on the medial plantar surface, usually they have severe cavus component with a forefoot that contributes to the equinus deformity. Some feet that are rigid and have a severe equinovarus deformity also have a single deep cleft in the skin just above the heel. The skin creases in the region of the Achilles insertion on the posterior tuberosity of the calcaneum normally present in the normal foot is absent in clubfoot. The presence of which rules out true congenital clubfoot and points to non idiopathic causes. The skin along the medial aspect of the foot below the medial malleolus

is contracted and notoriously poorly nourished an important consideration in surgical treatment.

The Knee and Lower leg : At birth, the knee joint appears normal, with the usual knee flexion contracture seen in the newborn. A hyperextenssion deformity becomes evident later, after the child begins to walk as a consequence of fixed equinus deformity. Genu valgum is common in the older child with severe uncorrected bilateral equinovarus deformity, a compensatory adaptation. Both the deformities get corrected after the correction of primary deformity. The calf atrophy is not present at birth but develops as the child grows.

The Tibia : The incidence of tibia vara in clubfoot is no greater than that seen in the normal children. In the past, internal tibial torsion has been incriminated as a cause of recurrent deformity. However, failures of external derotation osteotomy operations are evidence that this is a misconception.

The Ankle : In the normal foot, the ankle mortise faces slightly laterally. In the clubfoot this external rotation is increased. In resistant feet this lateral orientation of the tibiofibular unit increases with age. This is a compensatory change when the child tries to keep the foot plantigrade to avoid varus adduction and another factor is due to repeated attempts by manipulation to correct the deformity.

Components of the deformity: It is customary to divide the clubfoot into separate Components – equinus, varus, adduction and cavus.

Anatomically equinus, varus, and adduction should be considered composites of deformities which include abnormalities in the ankle, subtalar, midtarsal joints and the forefoot.

Equinus : Equinus deformity occurs at both ankle and talocalcaneonavicular joints and in addition the plantar - flexion deformity of the forefoot also contributes to the component. Equinus deformity is a composite of ankle joint equinus, inversion of talocalcaneonavicular complex and plantar-flexion of the forefoot.

Varus : It is due to inversion at the talocalcaneonavicular joint. Since the forefoot follows the inverted hindfoot its medial border faces upward (no contribution at tarsometatarsal joints)

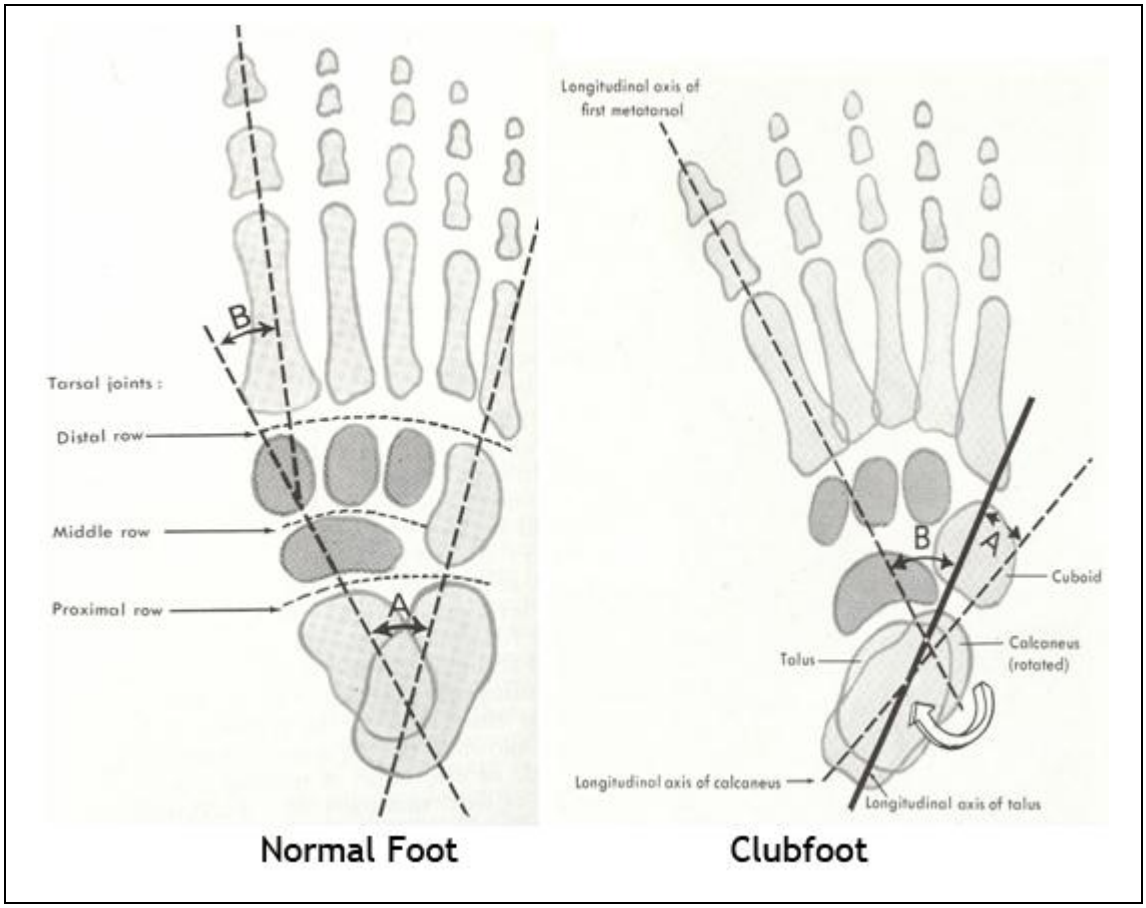
Adduction : The adduction occurs at talonavicular and anterior subtalar joint. In addition it occurs at tarsometatarsal area which contributes to this part of the deformity.

Cavus : It is due to forefoot plantar flexion at tarsometarsal joints.

Osseous Deformities

Many investigations have observed that the overall size of all tarsal bones is smaller in clubfoot than in the normal foot, thus producing an asymmetric size in a unilateral deformity. Both legs are usually equal in length.

Figure–5 :



The Talus : While talus is the least displaced, it undergoes the most severe and consistent changes in form. The anterior part of the body of the talus which is mainly outside the ankle mortise has the articular surface. Anterior part of the body is broad, the neck is deviated medially and downward and internally rotated. The articular surface to the navicular is on the inferior surface of the head. The anterior, middle and the posterior subtalar articular surfaces are small. The anterior and middle subtalar articular surfaces are continious and are underdeveloped.

Figure-6 : Calcaneum in Clubfoot

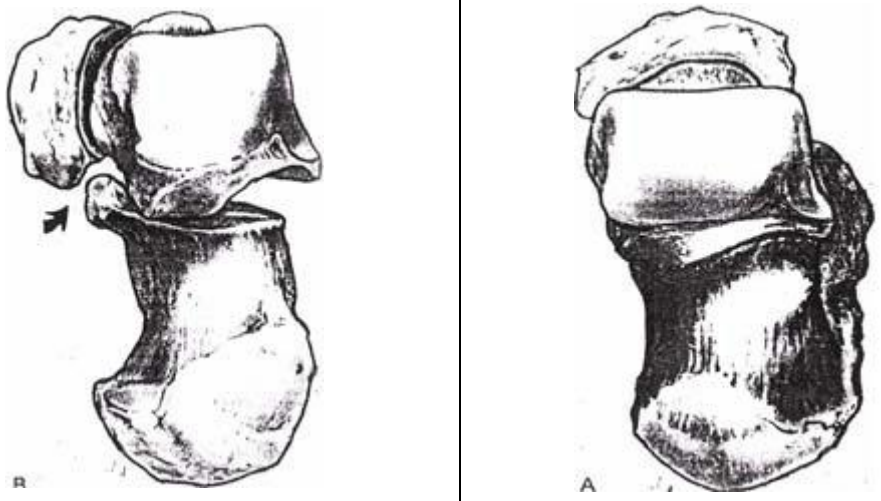
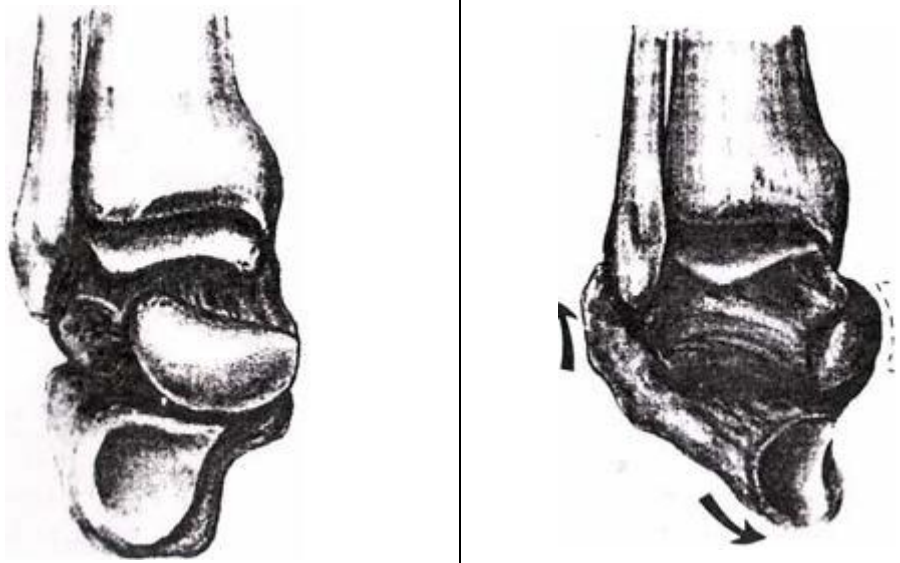


Figure -7 : Calcaneo Talo navicular relation



The Calcaneum : In general, the normal shape is maintained except for changes that occur in the articular surfaces and region of sustentaculum tali. The sustentaculum tali is underdeveloped. The anterior and middle facets are continuous. The whole calcaneum is inverted and adducted while the posterior end is displaced upward. The subtalar joint articular surface are developed according to the position after subluxation (interosseous changes).

The Navicular : Is rotated so that its long axis is nearly vertical and touching the medial malleolus, also forming the facet of the medial malleolus. it Is subluxated medially and downward to the head of the talus and the articular surface is flat and is slightly dorsolateral. Tuberosity is elongated in older children.

Cuboid : No change is seen intraosseous or interosseous. It is just carried along with anterior end of calcaneum.

The cuneiforms and metatarsals : The medial migration and inversion are seen with plantar subluxation.

Soft-tissue contractures :

Soft tissue contractures include the muscles, tendon, tendon sheaths, ligaments, joint capsules and skin. The contractures conform to the abnormal tarsal relationship. The degree of shortening varies, the same contractures are not present in all cases to the same degree. The Achilles tendon, tibialis posterior, deltoid, spring ligament and the

talonavicular capsule are the prime contractures common to all patients. To correlate pathology with the deformity, contractures are divided into the following four groups: posterior, medial plantar, subtalar and plantar.

Calf muscles : Atrophy of gastronemius and soleus is seen. Histologically, there is decreased number and size of muscle fibres and increase in the fibrous tissue.

Posterior contractures : Tendoachilles, tibiotalar capsule, talocalcaneal capsule, posterior talofibular ligament, calcaneofibular ligament are contracted. Contractures of tendoachilles, talocalcaneal capsule and calcaneofibular ligament prevent dorsiflexion of calcaneus. Contractures of posterior ankle joint capsule and talofibular ligament prevents movement at tibiotalar joint.

Figure – 8. Posterior contractures

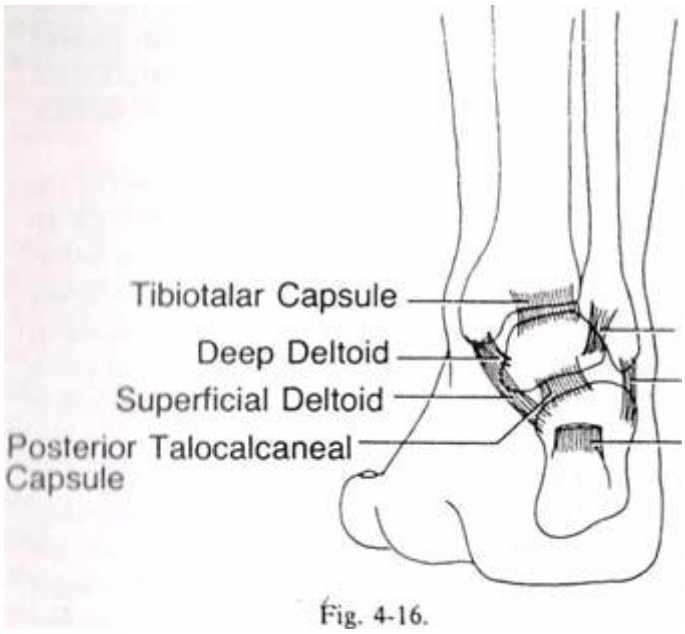
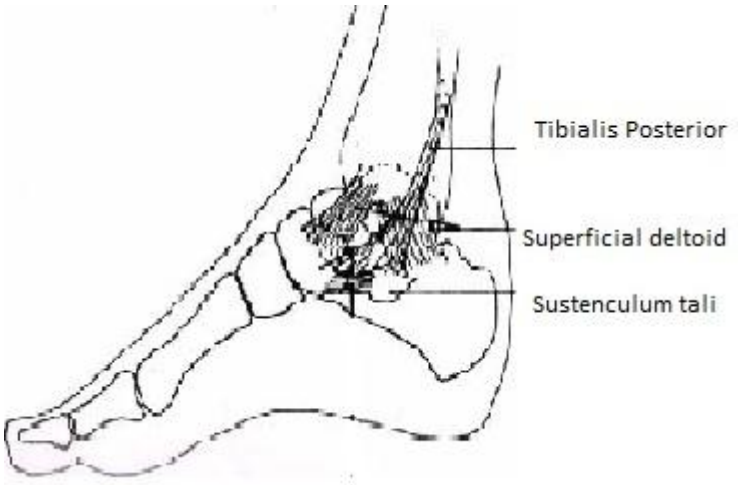


Fig. 4-16.

Medial contractures : Fibrosis of tibialis posterior sheath with tendon, deltoid ligament, talonavicular capsule and spring ligament which is shifted partly medially from plantar aspect forms a mass of indistinguishable scar which prevents the midtarsal and subtalar joint movements. Tibialis posterior insertion onto sustentaculum tali, spring ligament and navicular bone may be broadened. Flexor digitorum and flexor hallucis longus tendons are shortened and their sheaths are thickened and at the Henry's knot may be attached to the navicular preventing movement. Sometimes thick fibrocartilagenous disc is seen on the medial side [40].

Figure – 9. Medial Posterior contractures



Subtalar contractures : Interosseous ligament is severly contracted in older children than in the younger. Bifurcated 'y' ligament is also contracted although less common.

Plantar contractures : Abductor hallucis, intrinsic toe flexors, extrinsic toe flexors and plantar aponeurosis are contracted. The abductor hallucis may have accessory abnormal attachments – origin from tendon sheaths (medial 3 tendons) and the navicular tuberosity. Anterior tibial tendon may have broad accessory insertion on the shaft of 1st metatarsal which may extend down to the midshaft.

Joint changes :

Ankle joint :

The upper articular surface of the talus is narrower posteriorly and broader anteriorly, and in long standing cases it leads on to rigid equinus deformity. Normally in plantarflexion the talus is medially rotated but in clubfoot it remains laterally rotated or in neutral position.

Talocalcaneal joint :

Normally there are three articular surfaces but in clubfoot the anterior talocalcaneal joint is absent or grossly abnormal. The posterior talocalcaneal joint shows inversion and lateral displacement of the calcaneum towards the fibula. The calcaneo fibular ligament is shortened and thick. The dorsiflexion is restricted by the posterolateral tether which

is formed by the superior peroneal retinaculum, the peroneal tendon sheath and the posterior talocalcaneal ligament.

Talo – navicular joint : It is subluxated in extreme position of medial plantar displacement, leaving part of the head outside the ankle mortise which is exposed and palpable over the skin. The medial plantar subluxation reduction is prevented by the medial tether contributed by the tibialis posterior tendon, deltoid and spring ligament and talonavicular capsule.

Calcaneo – cuboid joint : The cuboid displaces medially under the navicular so that cuneiform bone and the calcaneum does not articulate fully with it.

Vascular changes : Absence of the dorsalis pedis is reported in as many as 85% of severely deformed clubfeet, this may have a possible bearing on the causation of a defect in the talus.

CLASSIFICATION AND CLINICAL FEATURES

CLASSIFICATION: Idiopathic clubfoot is of 2 types.

1. Flexible clubfoot
2. Rigid clubfoot.

The classic appearance of heel in marked equinus, foot inverted and forefoot adducted and in cavus is unmistakable.

Figure–10: Rigid Clubfoot

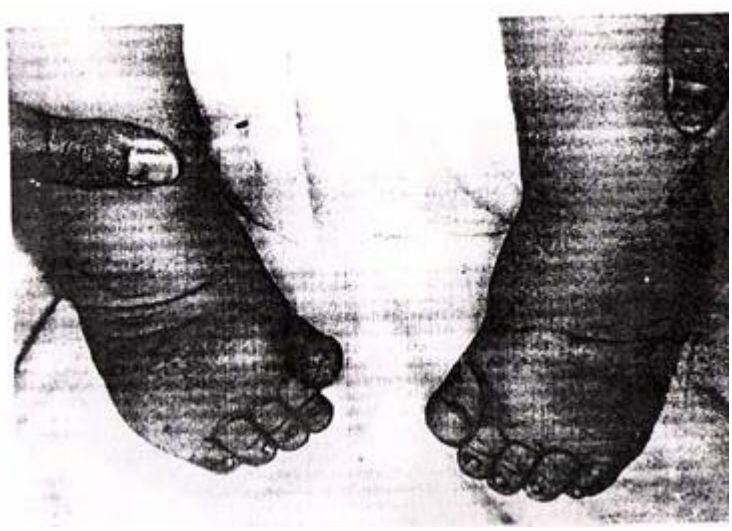


Figure 11 : Flexible Clubfoot

Differential Diagnosis :

1. Postural clubfoot : The deformity is completely correctable manually.
2. Neurogenic clubfoot : Neurological deficit is present in the lower limbs.

3. Syndromic clubfoot : Is associated with Down's syndrome, Larsen's syndrome, arthrogyposis multiplexa, diastrophic dysplasia, Mobius or Freeman sheldon syndrome, fetal alcohol syndrome.

DIAGNOSIS AND EVALUATION OF SEVERITY

Idiopathic clubfoot is diagnosed after excluding other abnormalities in the body and spinal abnormality.

Assessment of severity: There are many systems for severity assessment. Dimeglio's assessment of severity score is a objective and reproducible one. It is a detailed scoring system based upon four parameters.

1. Equinus in sagittal plane
2. Varus deviation in the frontal plane
3. Derotation around the talus of the calcaneo- forefoot block
4. Adduction of the forefoot on the hindfoot in the horizontal plane

The scale includes 4 additional points for the presence of the medial crease, a posterior crease, cavus and poor calf musculature. The deformity is graded from I- IV.

Cummin classified clubfoot as :

- **Supple** : the foot can be brought to normal position, all the joints are mobile.
- **Recurrent** : it's a type of relapse , the cause being muscle imbalance which was overlooked initially.
- **Rigid** : the forefoot deformity is corrected but the hindfoot deformities remain uncorrected after conservative treatment.
- **Neglected** : the patient has not received any form of treatment for 9 months.
- **Relapsed** : it means that the deformities are corrected initially but appear again in later years partially or totally.
- **Resistant** : it is a type of clubfoot where there is no correction after conservative treatment.

Management :

Non operative : in children < 6 months of age

Manipulation : The mother or grandmother is taught to mould the infants foot after breast feeding. The technique is directed at stretching the contracted tissues gradually and repeatedly over a period of time. The adduction and varus components are addressed first.

Pop application : The Ponseti plaster technique is most frequently followed. It corrects all the components of the foot simultaneously

except equinus. Treatment requires 10 casts or less. The equinus deformity is corrected in the end with percutaneous tendoachilles lengthening at the final casting. After final cast patients were placed in a Denis Brown splint for full time then part time till 6 years of age.

Other methods incude the Kite's method and the French method. Complications include rocker bottom foot, bean shaped foot, pressure sores and failure of correction.

Surgical corrections :

Its indicated in rigid, recurrent, relapsed, resistant and neglected clubfoot. The type of surgical procedure depends on the age of the patient and the deformity. In children less than one year of age, soft

tissue release is preferred as bony procedures can damage the articular cartilage resulting in small feet.

Postero – medial soft tissue procedures (children 6 months upto 3 years)

Turco ‘s incision is made along the medial border of the foot beginning at the proximal end of 1 st metatarsal and extending proximally to just below the medial malleolus and continuing proximally to the tendoachilles. The tibialis posterior tendon, flexor digitorum longus, flexor hallucis longus are identified. The contracted tendon sheaths are incised, the master knot of Henry, spring ligament and the abnormal origin of the abductior hallucis are divided. Tendo Achilles lengthening done by Z plasty. The posterior capsule of ankle joint and subtalar joint are incised and the posterior tibiofibular ligament and calcaneofibular ligaments are released. The tibialis posterior tendon is divided just above the medial malleolus. The superficial deltoid ligament, talonavicular capsule and spring ligament are released. The foot is placed in the corrected position, the talonavicular joint is reduced and stabilised with a K- wire. Post operatively the leg is immobilised in an above knee cast with knee in 90 degree flexion. K – wires are removed at 6 weeks and cast is continued for 4 months.

The other incisions used are :

Cincinnati incision: Used for posteromedial and posterolateral soft tissue release. The incision provides excellent exposure of the subtalar joint.

Carrolls incision : It is a double incision technique. The medial incision starts from the center of the heel, to the front of the medial malleolus and then to the base of the first ray in the form of a triangle. The posterolateral incision runs obliquely from the midline of distal calf posteriorly to a point midway between the tendo Achilles and the lateral malleolus. Complications include loss of correction, dorsal subluxation of the navicular, valgus overcorrection, stiffness of the subtalar joint, skew foot, avascular necrosis of the talus and dorsal bunion.

Relapse: The incidence relapse after clubfoot surgery is around 25% and these cases need revision or additional surgeries. The causes of failure of primary surgery may be several, but main causes are :

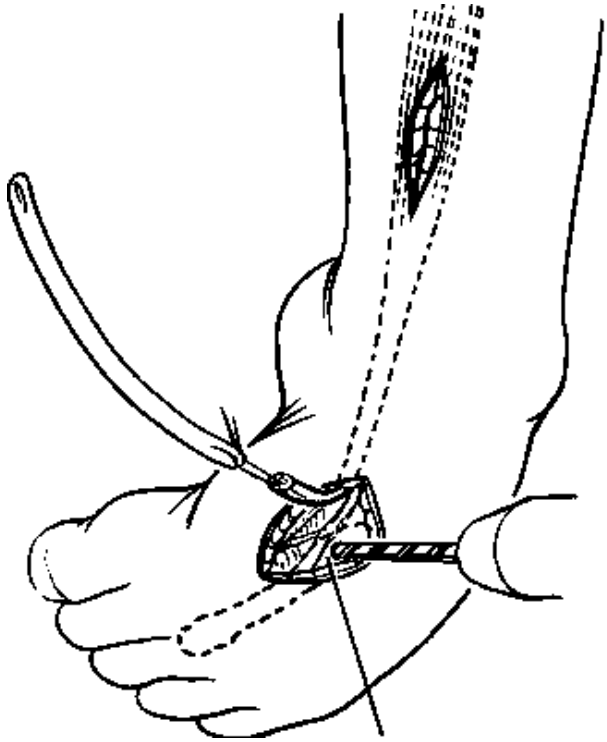
1. Insufficient release such as lateral tether and calcaneocuboid capsulotomy
2. Overcorrection, such as cutting of interosseus ligament in all cases of subtalar/ complete release procedure
3. Adhesions of lengthened flexor tendons in scars.
4. Infection after surgical procedures

5. Giving way of sutured zones in attempt of achieving full correction.
6. Infection after surgical procedure
7. Missing of associated anomalous muscles like accessory soleus or flexor digitorum accessorious
8. Inadequate management in post operative period
9. None or inadequate compliance from the parents and attenders with Foot Abduction Orthosis(FAB)

Soft tissue procedures:

In ambulating children who have dynamic supination, and the deformity is corrected on static examination, soft tissue procedures are advisable. Tibialis anterior tendon transfer described by Garceau (1960) and Ponseti (1963), is commonly performed in relapsed clubfoot in children between 3- 6 years of age with weak peroneii. The tendon is transferred to the middle of cuneiform (Garceau ‘s), when transferred to the base of the 5 th metatarsal (modified Garceau ‘s). Sometimes tibialis anterior tendon transfer may supplemented with a soft tissue release / capsulotomy of calcaneocuboid joint. Fried and Gartland proposed the tibialis posterior transfer in clubfoot. The principle is to eliminate the deforming force of the tibialis posterior and to utilise it as a corrective force to correct toe in gait, cavus, weak peroneii. The tibialis posterior is transferred anteriorly through the interossoeus membrane and fixed to the 3 rd cuneiform.

Figure–12 : Tibialis anterior transfer



Bony procedures:

In children between 3 – 10 years, combined cuboid / cuneiform osteotomy and multiple metatarsal base osteotomies have been described for correction of residual forefoot adduction deformity. For correction of hindfoot varus Dywer's osteotomy (isolated heel varus), Dilwyn – Evans procedure (short medial column), Lichtblau's procedure (long lateral column) are done. In children older than 10 years with multilple deformities, triple arthrodesis is the procedure of choice.

Lateral column shortening osteotomies :

Dillwyn evans procedure :

Its indicated in children with midfoot varus due to talonavicular and calcaneocuboid subluxation. It is done in children between 4- 8 years, in children less than 4 years there is a large amount of cartilage to achieve calcaneo-cuboid fusion. The lateral side of the foot is shortened by wedge resection osteotomy and the medial side is released by dividing the contracted soft tissues. The navicular is then placed in the normal position within the talus and the calcaneum allowing fusion with the cuboid to hold the foot in the corrected position. The procedure includes four stages :

- A closed tenotomy of the plantar fascia is performed and the plantaris deformity is corrected using a Thomas wrench.
- The structures on the medial side are released
- Posterior capsulotomy and division of the ligaments
- The calcaneocuboid joint is fused by longitudinal pins or staples.

Lichtblau procedure :

It is done when the hindfoot includes heel varus and residual internal deformity of calcaneum with a long lateral column of foot. It can be done in children less than 4 years of age and its not associated with any long term stiffness. It is an alternative to calcaneocuboid fusion where there is a lateral closed wedge osteotomy of the calcaneus with medial soft tissue release. The complication is Z deformity.

Medial column lengthening procedures:

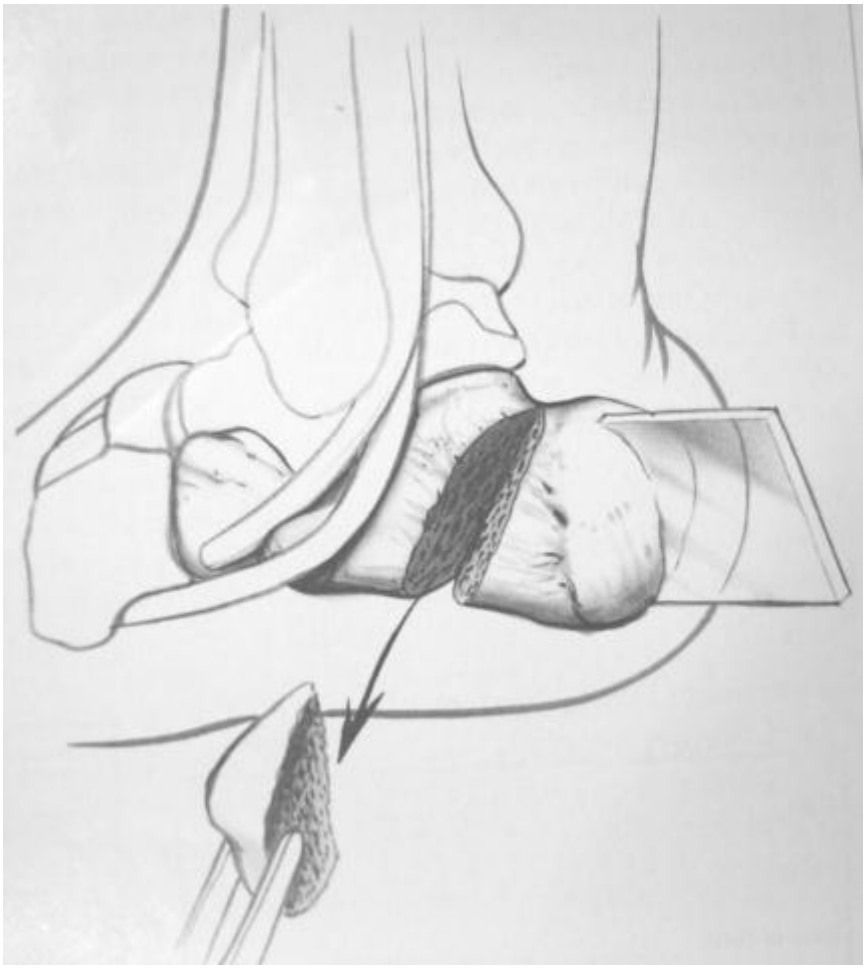
Fowler ‘s procedure and Hoffman’s procedure.

Dwyers calcaneal osteotomy:

Its indicated in persistent varus deformity of the heel, when other soft tissue surgeries are not possible. It is done in children between 3 to 4 years of age. He initially described the procedure for lateral closed osteotomy for pes cavus but later reversed the procedure by doing a medial open wedge in the calcaneum. The wedge of bone is taken from the tibia. Some surgeons prefer a lateral closed wedge osteotomy

(modified Dwyer) because of the sloughing of skin due to tension caused by the open wedge osteotomy. The complications include wound dehiscence and skin necrosis.

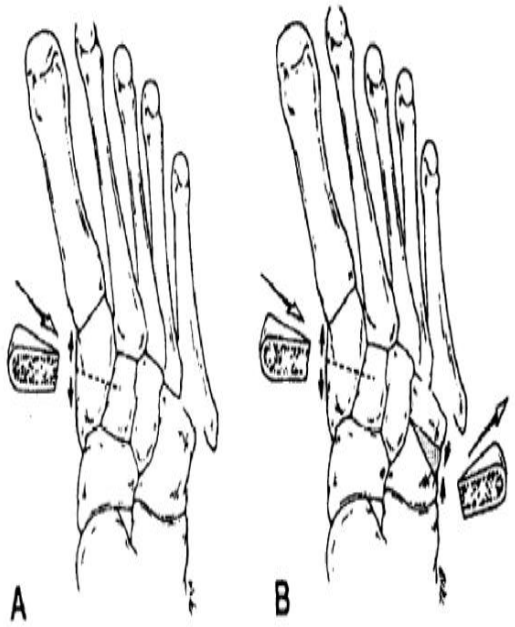
Figure –13 :



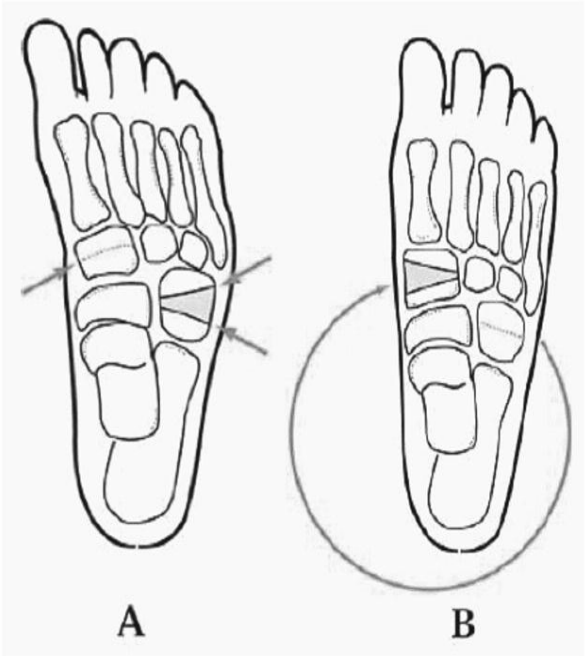
Combined procedures :

Combined / Cuboid cuneiform osteotomy for correction of residual forefoot adduction deformity in relapsed clubfoot.

Figure–14: The wedge of bone taken from the cuboid is inserted into the osteotomy site of medial cuneiform.



Figure–15: The lengthening of the medial column and the shortening of the lateral column seen.



Salvage procedures :

Triple arthrodesis and talectomy generally are salvage operations for uncorrected clubfoot in older children and adolescents with multiple deformities. Some authors suggested that triple arthrodesis is functionally and cosmetically more superior to talectomy. Functional results are generally improved despite of post operative joint stiffness. Triple arthrodesis is indicated in children more than 10 years of age with painful, stiff foot with poor function, difficult to accommodate foot wear and when all other corrections fail.

RADIOGRAPHIC EVALUATION

Standard roentgenograms include standing anteroposterior and lateral views of both feet. The mother holds the legs with knee flexed and foot 20 to 30 degree plantar on the cassette for AP view. Lateral view is taken with foot on the plate and the X ray beam directed perpendicular along the lateral surface of the foot.

Angles seen on the AP view:

1. Talocalcaneal
2. Calcaneal-fifth metatarsal
3. Talus-first metatarsal

Angles seen on lateral view:

1.Talocalcaneal

2.Talo -first metatarsal

4.Calcaneo -first metatarsal.

The radiographic evaluation can only be used for evaluating the progression during the treatment and cannot be used to assess the outcome as the angles have wide normal range (especially of talocalcaneal angles) and vary with age and position of the foot when x-ray is taken.

Footprint / Podogram : it is a very useful and cheap method of investigating a foot problem. A static imprint is used to assess weight bearing pattern of the foot. A dynamic imprint is used to study the gait pattern of the patient.

MATERIALS AND METHODS

16 cases (feet) in 11 children, who presented to our institution between November 2010 and November 2012 with residual forefoot adduction deformity. The parents complaints included in toeing gait and difficulty in wearing normal footwear in their children. All had undergone a full posteromedial soft tissue release using the Turco's incision with lengthening of tendoachilles for idiopathic clubfoot, and followed up for a period 2 years. Ethical committee approval was obtained for the procedure.

INCLUSION CRITERIA:

1. Rigid forefoot adduction deformities with associated cavus, equino varus deformities.
2. Age group between 3 – 10 years
3. Children with idiopathic clubfoot who have failed to respond to conservative treatment and soft tissue procedures.

EXCLUSION CRITERIA:

1. Clubfoot secondary to arthrogryposis multiplexa, amniotic band syndrome, spasticity
2. Children < 3 years of age, > 11 years of age
3. Relapsed clubfeet for several times.

The mean age at the time of surgery was 6.5 years (range 3- 10 years). There were 7 boys (10 feet), 4 girls(6 feet). The right foot in 9 children and left foot in 7.

Pre operative clinical examination:

Secondary causes of clubfoot was ruled by a through neurological examination. The gait evaluated along with the presence of other associated deformities. The components of foot deformity, flexibility of the forefoot and skin condition assessed. The forefoot adduction deformity was assessed using Podograms. Associated deformities included equinus (9 feet), cavus (6 feet), varus (5 feet), supination (3 feet). two cases (4 feet) had thickened callous over the dorsolateral aspect of foot.

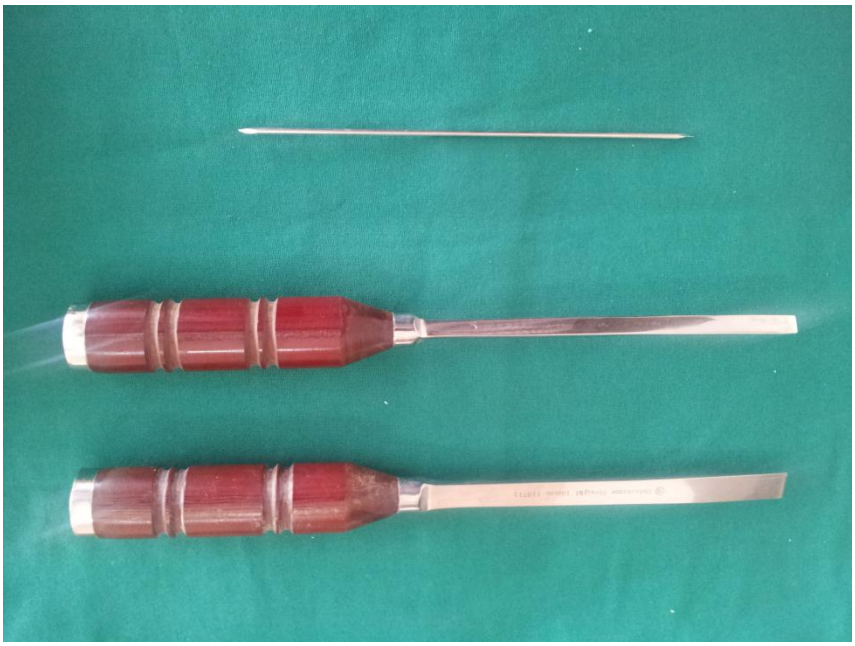
Pre operative radiographic evaluation :

Standing anteroposterior (AP) and lateral X Rays of ankles and feet taken for all patients. Podograms using ink were taken to measure forefoot hind foot angle. in the AP view the talo-calcaneal angle or Kites's angle for varus (normal 20- 40 degrees), talo – first metatarsal angle (0- -10 degrees, adduction positive) and calcaneo- first metatarsal angle (0 – 5 degrees) for forefoot adduction were measured. In the lateral view, the talo-calcaneal angle (normal 25- 50 degrees) and the talo- first metatarsal angle or Meary's angle for cavus (normal 0-5 degrees) were

measured. The range of values of these weight bearing angles was recorded and the mean calculated.

Instruments used :

Figure–10: 0.5 and 1.0 osteotome, k- wires

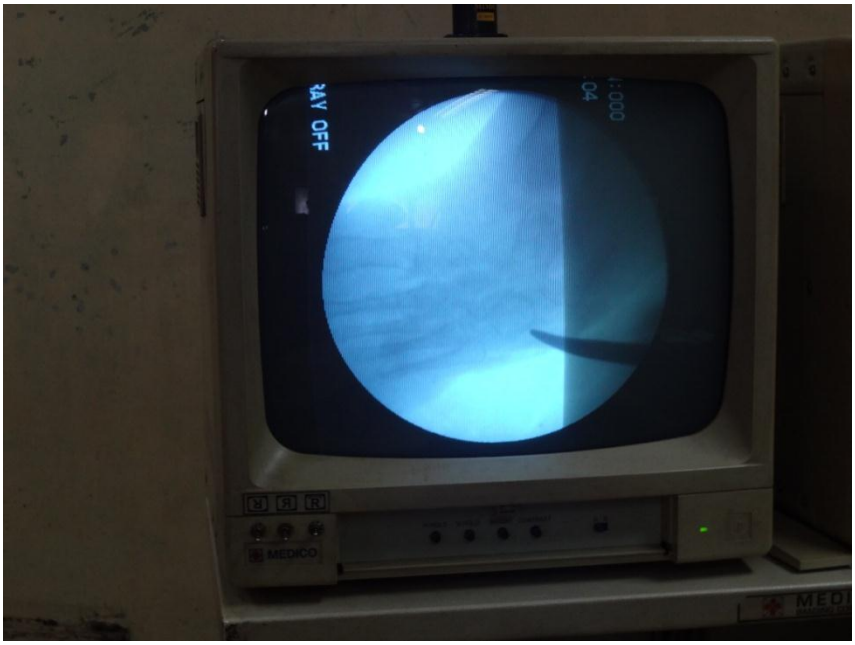


Operative procedure :

Cuboid laterally based closing wedge :

The cuboid was identified using image intensifier. Through a 6 cm incision over the lateral surface of cuboid,skin superficial fascia incised and the cuboid bone was exposed. A wedge of bone was removed from the cuboid with its base on the lateral surface using a sharp osteotome. The width of the wedge was approximately one third that of the cuboid on its lateral side.

Figure–11: Cuboid identified under fluoroscopy



Figure–12. Opening wedge osteotomy made in cuboid

Figure–13: Wedge of bone harvested

Medial cuneiform opening wedge osteotomy:

The medial cuneiform was identified using image intensifier. A medial incision is made over the cuneiform, skin superficial fascia incised, the abductor hallucis muscle was retracted inferiorly. A straight osteotomy of the medial cuneiform was made, the forefoot and midfoot are abducted to correct the adduction and supination deformity and to close the osteotomy site laterally. A lamina spreader or thin osteotome is used to open the osteotomy site. The wedge of bone taken from the cuboid was inserted into the osteotomy site of the medial cuneiform with the base of the wedge facing along the medial surface. the foot is fixed inn the corrected position with two smooth 1.2 mm K- wire, one from the

medial cuneiform into the navicular bone and the other from the cuboid into the calcaneus.

Figure–14 : Medial cuneiform identified under fluoroscopy

Figure–15: Osteotomy made in medial cuneiform and osteotomy site distracted with lamina retractor and wedge of bone placed

Figure–16: Foot manipulated by adbucting the forefoot and midfoot to close the osteotomy site laterally

Figure–17: Graft is fixed using 1.2 mm Kirshner wires

Complementary procedures :

Tendoachilles lengthening by Z Plasty in 9 feet, plantar fasciectomy in 6 feet.

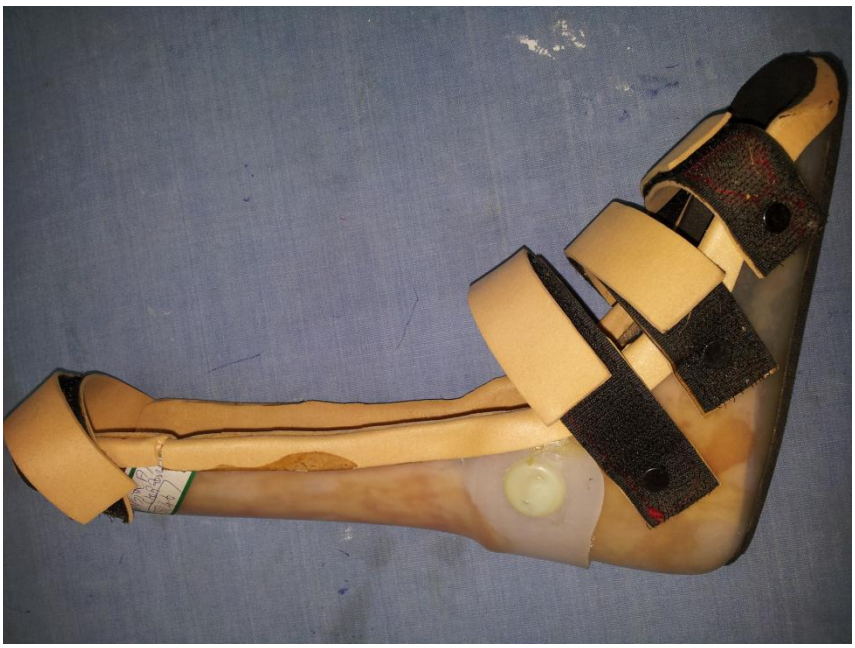
Figure–18: ' Z 'plasty for tendoachilles done.

Postoperative care :

Figure–19. Limb immobilised in above knee cast

A well padded above knee plaster of paris (POP) slab was applied in all feet, which was subsequently converted to cast after suture removal and maintained for 4 weeks. The above knee cast is converted to a below knee cast and maintained for two weeks. The K wires were removed at 6 weeks and a weight bearing is allowed with the cast till radiological bony union seen usually at 8 weeks. Plastic night splints used after cast removal and patient allowed weight bearing in custom made CTEV boots till 12 weeks later advised to wear normal shoes. All the feet were assessed clinically and radiographically and a scoring system (Bensahel et al) supported by the International clubfoot society, a total score of 20 marks was used for the evaluation.

Figure–20 : Night Splint



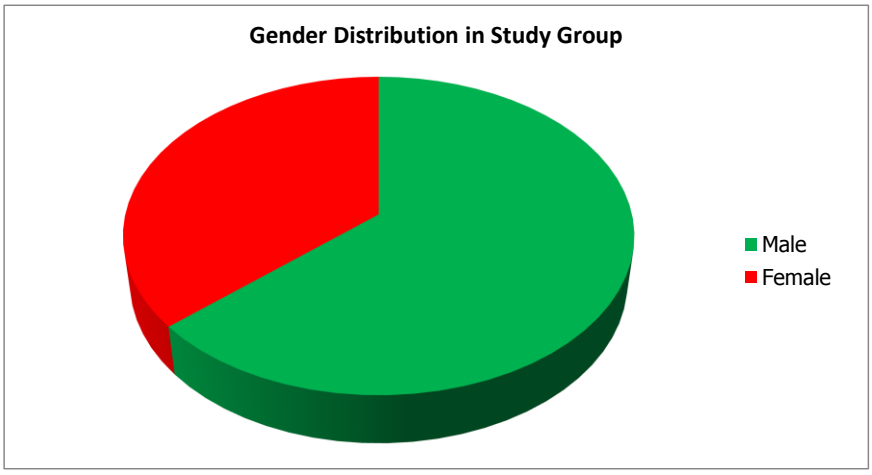
OBSERVATION AND RESULTS

Sex distribution : out of the 11 children 7(64%) were male and 4(36%) were female.

Table 1. Gender distribution in Study Group

Sex	No. of cases	Percentage
Male	7	64%
Female	4	36%
TOTAL	**11**	**100%**

Figure 19. Gender distribution in Study Group

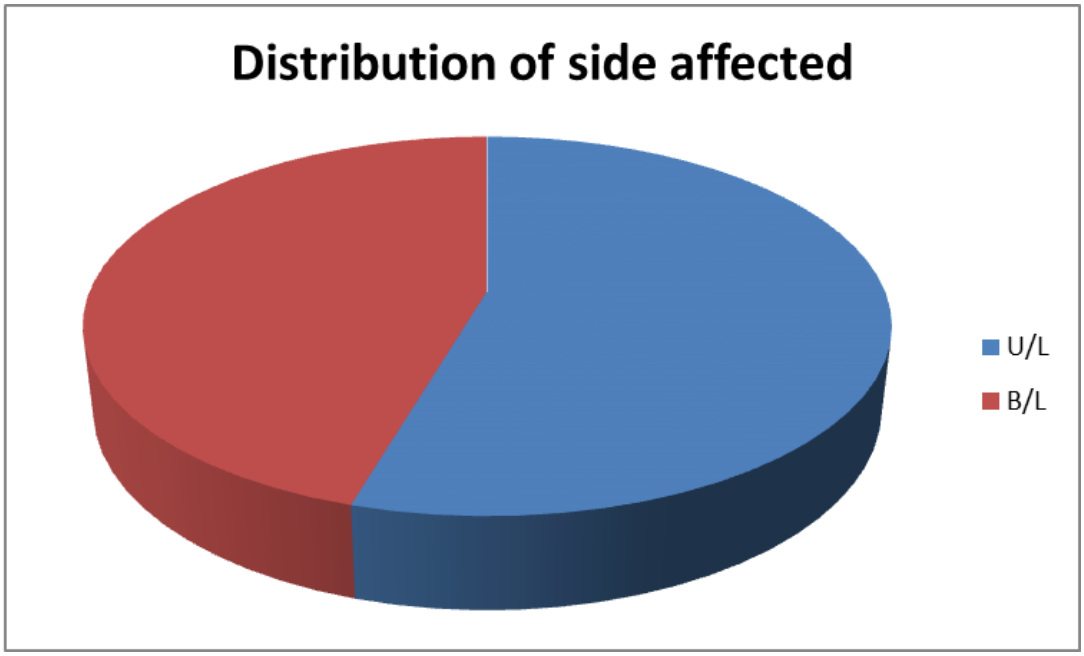


Side Affected :

Table–2.

Laterality	No. of cases	Percentage
Unilateral	6	55
Bilateral	5	45
TOTAL	**11**	**100%**

Figure 20. Distribution of Side affected

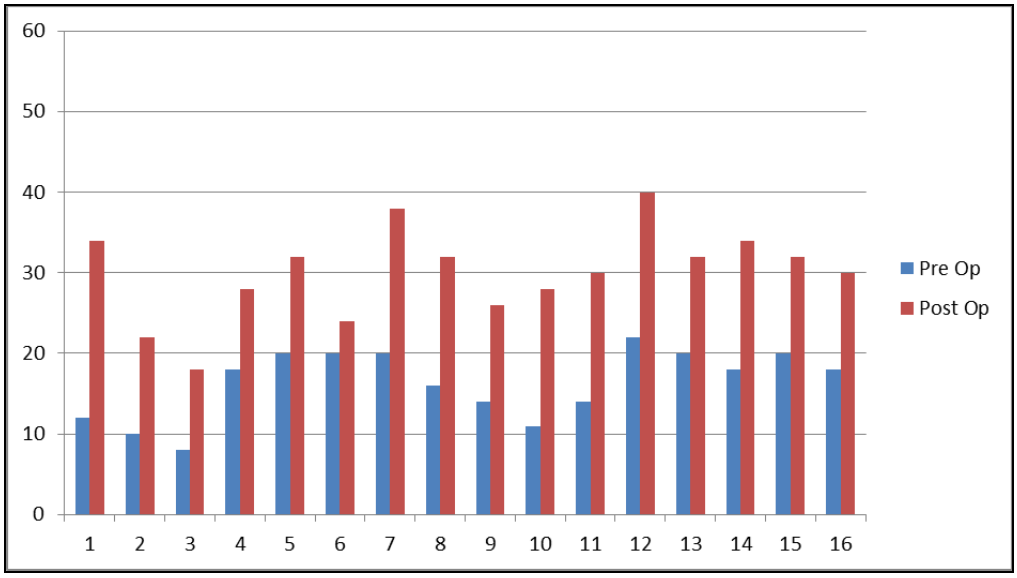


Radiological parameters :

Talo- Calcaneal angle (AP) :

No. of patients along the 'X 'axis and angle in degrees along 'Y' axis

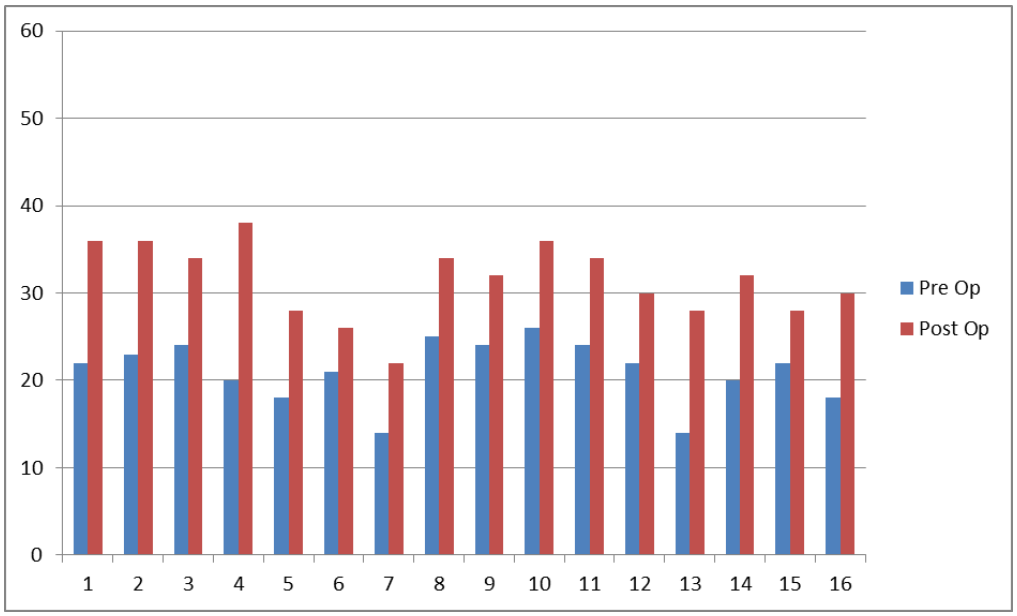
Figure 21.



Talo – Calcaneal angle (LAT)

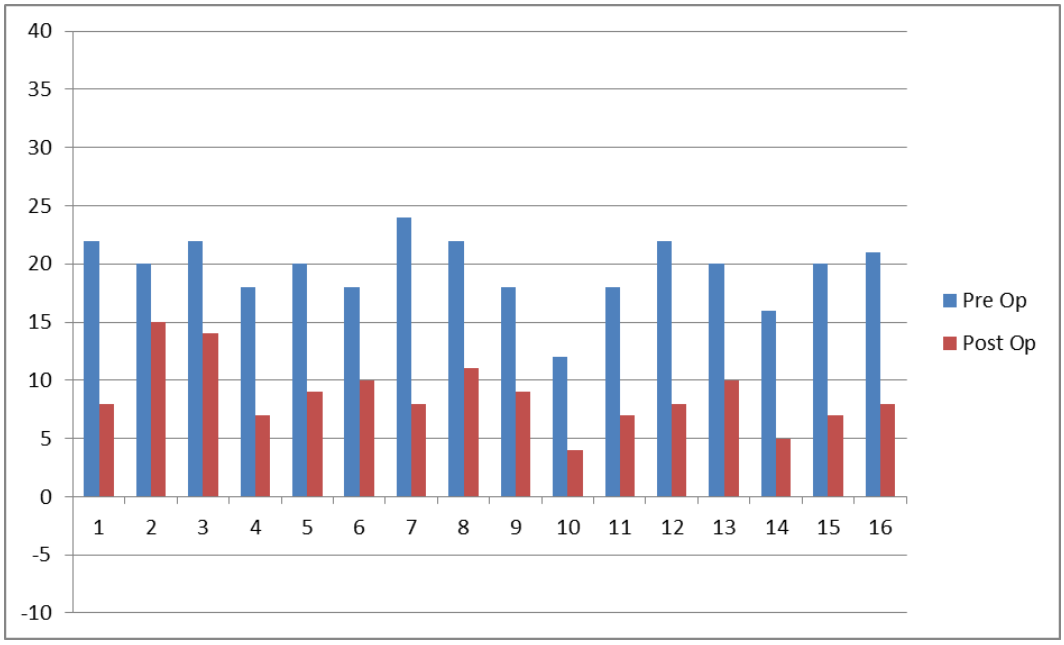
No. of patients along the 'X 'axis and angle in degrees along 'Y' axis

Figure 22.



Talo – 1 st Metatarsal angle :

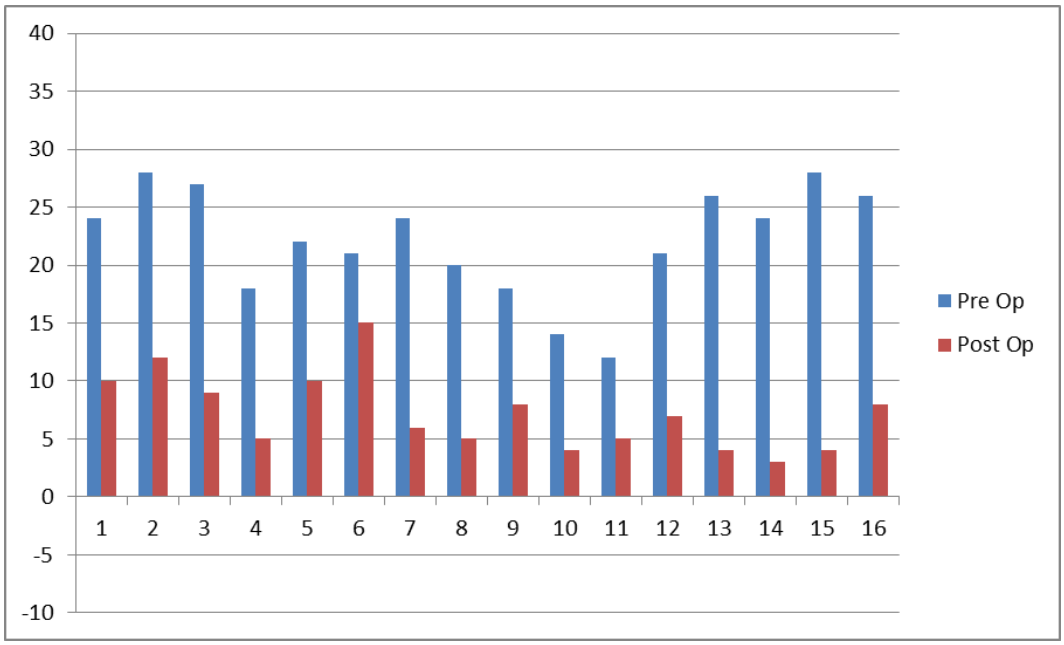
Figure 23.



Calcaneo – 5 th Metatarsal angle :

No. of patients along the 'X 'axis and angle in degrees along 'Y' axis.

Figure 24.



Talo – calcaneal parameters :

Table 3.

Pre operative			Post operative		
Talo – Calcaneal Angle (DEGREES) AP LAT		Talo – Calcaneal Index	Talo – Calcaneal Angle AP LAT		Talo – Calcaneal Index(DEGREES)
16	21	35	30	31	61

Table 4.

Angle	Pre operative (mean)	Post operative (mean)
Talo - Calcaneal (AP)	16.3	30.0
Talo - Calcaneal (LAT)	21.0	31.5
Calcaneo - 5 th Metatarsal (AP)	22.0	7.81
Talo - 1 st Metatarsal (AP)	19.5	8.75

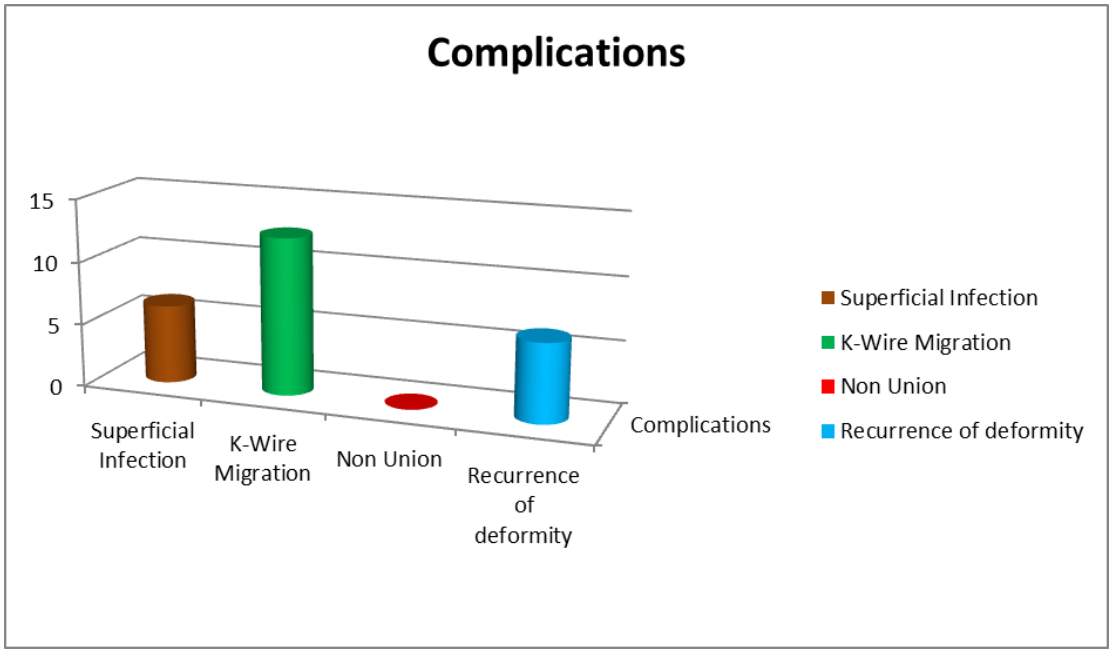
There was a significant difference in the mean postoperative values achieved .

Complications : the complications encountered were superficial skin infection in one foot (6.25%), K- wire migration / slippage in two feet (12.5%) and a persistent deformity in one foot(6.25%).

Table 5.

Serial No.	Complication	No. of feet	Percentage
1.	Superficial skin infection	1	6.25
2.	K- wire migration / Slippage	2	12.5
3.	Non union of graft	-	0
4.	Persistent deformity	1	6.25

Figure 25.

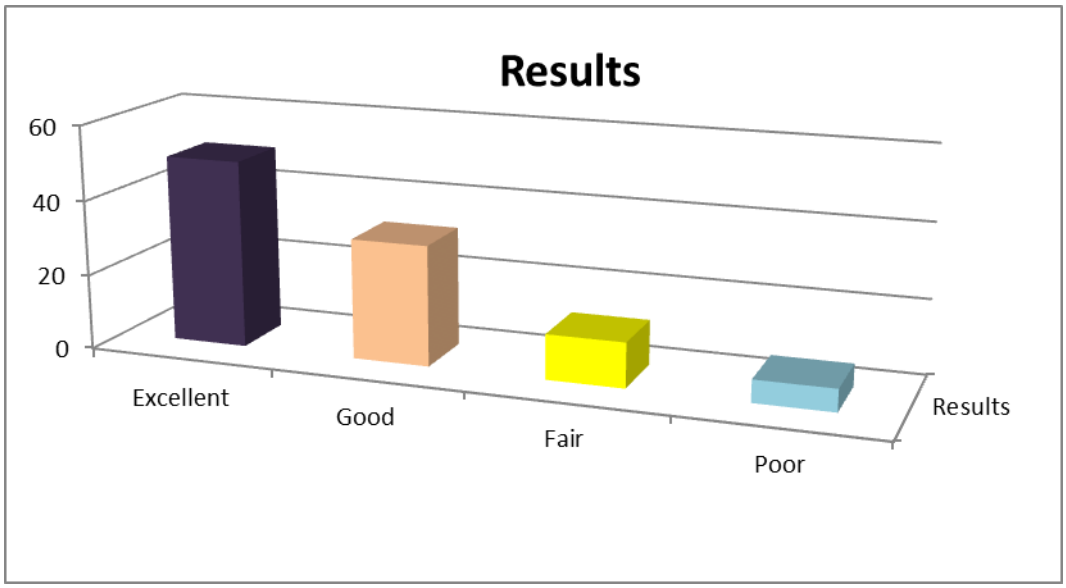


RESULTS

Results according to point scoring system : (modified Bensahel et al) approved by the International clubfoot study group . Of the 16 feet treated, 8 feet (50%) had excellent results, 5 feet (32%) good, 2 feet (12%) fair and 1 foot (6%) poor results.

Results according to point scoring system used : (modified Bensahel et al) approved by the International clubfoot study group. Of the 16 feet treated, 8 feet (50%) had excellent results, 5 feet (32%) good, 2 feet (12%) fair and 1 foot (6%) poor results.

Figure 26.



Case 1:

Pre-Op Clinical Photo	***Pre-Op X-Ray : AP View***	
		
Post Op X – Ray	***Clinical Photo of Correction at 6 months follow up.***	***Clinical Photo of one year follow up.***
		

Case–2 :

Pre Op Clinical Photo	***Pre Op X-Ray***	***Podogram***
		

Per Op Photo	***Post Op X-Ray***
	

Post Op Clinical Photo after One year follow up

Case–3 :

Pre Op Clinical Photo	***Per Op Photo***
	

Wedge Graft Harvested	***Post Op Clinical Photo***
	

Post Op Clinical Photo at two years follow up

Case–4 :

Pre Op Clinical Photo

Pre Op X-Ray

Pre Op X-Ray

Per Op Clinical Photo

Post Op Clinical Photo at two years follow up

Case–5 :

Pre Op Clinical Photos	***Pre Op Clinical Photos***
	

Post Op Photo after 6 weeks

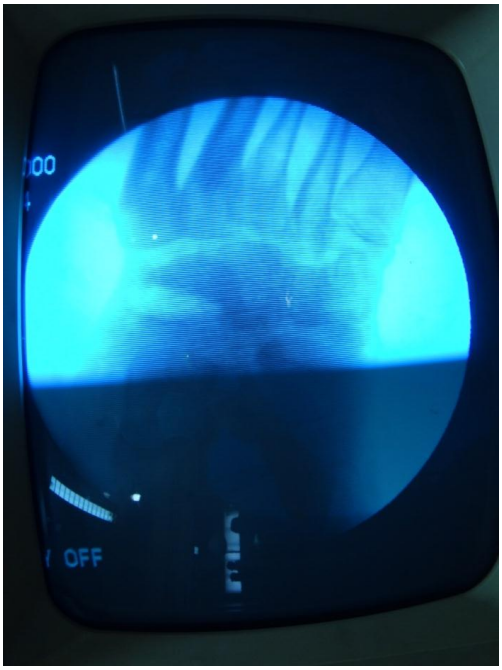
Post Op Clinical Photo after 12 Weeks

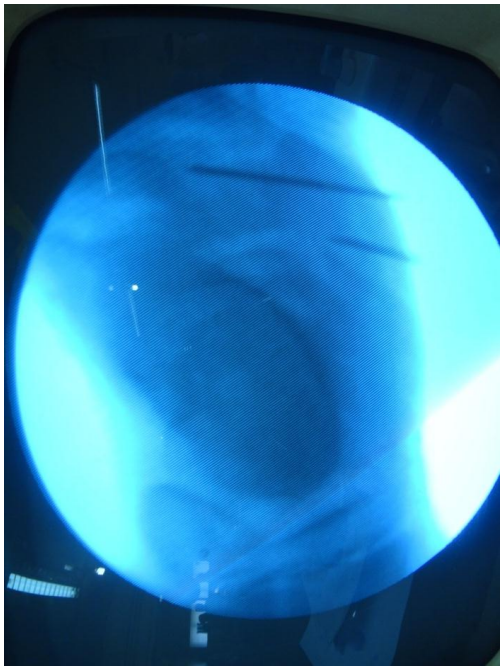
Case–6 :

Pre Op Clinical Photos

Per Op Clinical Photo

Per Op C-Arm Images





Per Op Correction achieved

Post Op X-Rays

Post Op Clinical Photo at two years follow up

DISCUSSION

The principle of combined cuboid/cuneiform osteotomy was investigated in a cadaver study by Mc Hale and Lenhart[7]. They used metal wedges, to study the best position for the osteotomy, the influence of medial and lateral osteotomy and the need for additional soft – tissue releases. It was concluded that the combination of both the procedures gave the best correction compared with isolated osteotomies. The correction was reproducible and that additional soft tissue procedures were not necessary. The main drawback was that the experiment was carried out on normal cadaver feet lacking the soft tissue rigidity of club foot. The procedure was then undertaken in seven patients. Clinically all cases showed satisfactory results except one which showed no correction following a mean follow up of 2 years. The authors concluded that every case should be treated individually, some feet over correction at the time of surgery and additional soft tissue releases may help in preventing subsequent relapse.

In Schaefer et al [7], study there were 27 feet with male predominance, age ranging from 2- 10 years, the follow up period was 5 years. All patients were able to wear normal shoes except one. The correction of adduction obtained was 9 degrees(mean) measured by talo-

1 st metatarsal angle and 11 degrees by calcaneal – 2nd metatarsal angle. There was no incidence of non union and one case developed superficial infection.

In the study of Eugene and Patrick [41], concluded that cast application was best for flexible deformities, age less than 3 years. The problems with metatarsal base osteotomy was incomplete correction and the added difficulty in maintaining the correction. Of the 27 feet that were operated, 13 feet showed satisfactory correction.

In Muhamed and Tarek study[42], of the 32 feet operated upon which was boys predominantly, and bilateral predominance. All with a history of previous surgical release satisfactory results with an average correction of the adduction achieved being 17 degrees measured by the talo – 1 st metatarsal angle and 19 degrees for calcaneo- IV th metatarsal angle. The follow up period being 3 years and only one case showed complication of skin necrosis which was treated by medications.

Shoemaker et al[25] operated on patients with metatarsus adductus with no history of previous surgery, with the same procedure and obtained satisfactory results.

Kose et al [30] reported closing cuboid and opening cuneiform osteotomies in 10 feet with supination and adduction deformities and three patients with cavovarus deformities.Their results showed satisfactory correction of adduction and supination

Loza and Barbary et al[43], operated on 20 feet with age between 3 to 7 years, predominantly male. The right foot being affected more than the left. 40 % of the cases showed excellent results and the complications included superficial infection, slippage of graft, and K- wire migration.

Lourenco et al [26] , treated 39 feet with a closed wedge osteotomy of cuboid and open wedge osteotomy of the medial cuneiform. They were predominantly male unilateral in 19 and bilateral in 10. All cases underwent a prior surgery using the cinncinatti incision. The average correction of adduction achieved was 15 degrees and no complications were reported.

Gordon et al [29] this procedure should be reserved for patients aged 5 years or older. The osteotomy in cuneiform is difficult since it was small and not fully ossified.

In our study, we did not carry out overcorrection in our cases as proposed by Mc Hale and Lenhart [7] and neither our data allow us to identify those patients at risk of recurrence and the long term effect of overcorrection of a midfoot or forefoot deformity. Our aim was complete correction of the deformity by double osteotomy. In our study there was a predominance of males 7 (44%) and right sided in 9 feet(56%). Equinus deformity was seen in 12 feet and cavus in 5 feet which was corrected by tendoachilles lengthening by ‘Z’ plasty, plantar fasciectomy respectively.The correction in adduction achieved as measured by the Talo - 1 st metatarsal angle was on an average 11 degrees and calcaneo –

5 th metatarsal angle 14 degrees (average) .The results were excellent in 50 % of the cases (8 feet). None of the cases complained of pain prior to surgery and after surgery.One case had recurrence of deformity at 1 year follow up due to insufficient size of the graft wedge, 2 patients had a superficial infection which was treated and 2 cases had K- wire migration. All patients were satisfied with the operation, suggesting that the recurrence of the deformity does not necessarily influence the patients satisfaction with the results. This suggests that the ability to wear normal shoes and the absence of pain are more important than the prevention of recurrence.The limitations of the study were inadequate sample size and a follow up of 2 years, hence the long term effects of the correction could not be assessed.

There is an increasing need for osteotomy as a part of revision surgery to correct forefoot adduction deformity. Tarraf and Carroll [5] noted an incidence of soft tissue operations of 46.5 % compared with 4.4% of bony procedures at first revision, 25% compared with 20 % at second and 27.3% compared with 54.5 % at third, the remainder being combinations of both. The increasing frequency of osteotomy was attributed to the presence of extensive soft tissue scarring, making soft tissue release more difficult. Scar tissue also promotes recurrence. Osteotomy also has the added advantage of correcting the deformities of the tarsal bones which undergo deformation during the growth phase in idiopathic club foot.

CONCLUSIONS

1. The most common deformity seen after surgical correction of idiopathic clubfoot is forefoot adduction .
2. The etiology is unknown , but the most probable cause being undercorrection at time of primary surgery and irregularity in wearing brace postoperatively .
3. The combined osteotomy is a safe procedure and allows satisfactory correction of the residual forefoot adduction deformity and achieving a straight plantigrade foot .
4. No modified foot wear or shoes were required to be worn for a long term after the correction was achieved unlike other procedures.
5. The operation is not suitable for non-idiopathic clubfoot , secondary clubfoot , and in those feet with repeated relapse and unsuitable skin condition .
6. The long term morbidity must be evaluated by regular follow up to assess the functional outcome

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ANNEXURE–1

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ANNEXURE–2

PROFORMA

Name : **DOA :**

IP NO. :

Fathers Name : **Patient No. :**

Foot No. :

DOS :

Date of birth and age :

Sex :

Address :

Complaints and duration :

Treatment history :

Ponseti casting

Postero medial soft tissue release

Local examination :

Inspection : Unilateral/ Bilateral

Type of deformity : Rigid/ Flexible

Examination of back :

	RIGHT	LEFT
1. Fore foot adduction	Y/N	Y/N
2. Equinus	Y/N	Y/N
3. Cavus	Y/N	Y/N
4. Forefoot supination	Y/N	Y/N

Gait

X- Ray Foot :- **AP and LATERAL**

Angles	Normal values	Pre OP	Post OP	Difference
Talo- Calcaneal angle (AP)	30-55 degree			
Talo- Calcaneal angle (LAT)	25- 50 degree			
Talar- 1st metatarsal Angle (AP)	5- 10 degree			
Talar- 1st metatarsal Angle (LAT)	0-5 degree			
Calcaneo – 5 th Metatarsal angle (AP)	0-5 degree			

Post operative period :

Duration of POP

Time of K – wire removal

ANNEXURE–3

GRADED POINT SCORING SYSTEM

(International Clubfoot Study Group)

- **Clinical evaluation:**
  - Pain (2 Points)
  - Adduction deformity(2 Points)
  - Hindfoot varus(1 Points)
  - Supination(1 Points)
  - Cavus(1 Points)
  - Tolerability to orthosis (2 Points)
  - Parents satisfaction(1)
- **Radiographic evaluation :**
  - Talocalcaneal angle(AP) - (2 Points)
  - Talo- 1 st metatarsal angle(AP) - (2 Points)
  - Calcaneo -5th metatarsal angle(AP) - (2 Points)
  - Talocalcaneal angle (LAT) - (2 Points)
  - Talo 1 st metatarsal angle(LAT) - (2 Points)

TOTAL SCORE= 20

- Excellent 19-20
- Good 16-18
- Fair 10-15
- Poor <10

ANNEXURE–4

MASTER CHART

S. No	Name	IP NO	Case No	Foot No	Age / Sex	UL / BL	Type of Foot	Previous Procedure	DOA	DOS	Cast Duration	Complication	Results
1	Ajmeer Ali	34820	1	1	10 / M	UL	Relapse	PMSTR at 6 Months	01.06.	28.06.	6 Weeks	-	Excellent
2	Naveen Kumar	52322	2	2,3	3 / M	BL	Relapse	PMSTR at 5 Months	14.08.; 21.10	23.06.; 25.10	6 Weeks	-	Good (R) Fair (L)
3	Lavanya	61785	3	4	9 / F	UL	Relapse	PMSTR at 6 Months	27.09	3.1	6 Weeks	Superficial infection	Good
4	Swetha	5986	4	5,6	5 / F	BL	Relapse	PMSTR at 6 Months	25.01	31.01	6 Weeks	-	Good (R) Fair (L)
5	Prabaharan	6189	5	7	3 ½ / M	UL	Relapse	PMSTR at 6 Months	26.01	4.02	6 Weeks	-	Excellent
6	Manisha	43	6	8,9	5 / F	BL	Relapse	PMSTR at 5 Months	10.05	16.05; 12.06	6 Weeks	K - Wire Migration	Excellent (R) Good (L)

7	Dhiwakar	47	7	10,11	3 / M	BL	Relapse	PMSTR at 5 Months	10.05	30.05; 27.06	6 Weeks	-	Good (R) Fair (L)
8	Arumugam	30643	8	12	7 / M	UL	Relapse	PMSTR at 6 Months	3.05	14.05	6 Weeks	-	Excellent
9	Baskaran	122	9	13	9 / M	UL	Relapse	PMSTR at 6 Months	7.06	12.06	6 Weeks	-	Good
10	Hariharan	160	10	14	8 / M	UL	Relapse	PMSTR at 5 Months	16.08	22.08	6 Weeks	-	Excellent
11	Malini	8527	11	15,16	5 / F	BL	Relapse	PMSTR at 6 Months	4.10	17.10	6 Weeks	-	Excellent

PMSTR – Posteromedial Soft Tissue Realease; BL – Bilateral; UL – Unilateral