ANALYSIS OF EFFICACY OF PONSETI METHOD IN MANAGEMENT OF IDIOPATHIC CLUBFOOT

Dissertation submitted in partial fulfillment of the regulation for the award of

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Certificate

This is to certify that this dissertation titled ***"ANALYSIS OF EFFICACY OF PONSETI METHOD IN MANAGEMENT OF IDIOPATHIC CLUBFOOT "*** is a bonefide work done by ***Dr.V.A.Prabhu***, Postgraduate student of Coimbatore Medical College Hospital.This dissertation has been prepared by Dr.V.A.Prabhu under my direct guidance & supervision to my satisfaction in partial fulfillment of the Dr.M.G.R.Tamilnadu Medical University, regulations for the award of M.S.Degree in Orthopaedics.

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Declaration

I declare that this dissertation titled ***"ANALYSIS OF EFFICACY OF PONSETI METHOD IN MANAGEMENT OF IDIOPATHIC CLUBFOOT"*** has been prepared by me, at Coimbatore Medical College Hospital under the guidance of Prof & HOD. Dr.S.Senthilnathan, Coimbatore Medical College Hospital, Coimbatore, in partial fulfillment of Dr.M.G.R.Tamilnadu Medical University, regulations for the award of M.S.Degree in Orthopaedics.

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CONTENTS

PART I

Introduction

Congenital Talipes Equino Varus is a complex developmental deformation occuring in an otherwise normal child.It is one of the most common congenital orthopaedic anomalies first described by Hippocrates as early as 400 BC.However it still continues to challenge the skills of Orthopaedic surgeon as it has a notorious tendency to relapse whether it is treated conservatively or operatively.Part of the reason that the foot relapse is surgeon's failure to recognize the pathoanatomy.

The goal of treatment is to attain a functional, pain-free, plantigrade foot, with good mobility without calluses, and without the need to wear special or modified shoes. . Many of these cases are untreated or poorly treated, leading to neglected clubfoot. These children undergo extensive corrective surgery, often with disturbing failures and complications. Revision surgeries are also thus more common. Although the foot looks better after surgery,functionally it is stiff, weak, and often painful. After adolescence, pain increases and often becomes crippling.

Clubfoot in an otherwise normal child can be corrected in two months or less with the Ponseti method of serial manipulations and plaster cast applications, with minimal or no surgery.This method is particularly suited for developing countries,where there are few orthopaedic surgeons in rural and remote areas. The technique is easy to learn by allied health professionals, such as physiotherapists and orthopaedic assistants. The treatment is economical and safe.

Review of Literature

1. Treatment of congenital club foot with Ponseti method -RA Agrawal, MS Suresh,Rajat Agrawal,Agrawal Orthopaedic Hospital, Gorakhpur, India . Indian J Orthop 2005;39:244-7.

   The Ponseti method is a safe and effective treatment for congenital idiopathic clubfoot and radically decreases the need for extensive corrective surgery . Non compliance with orthotics has been widely reported to be the main factor causing failure of the technique.

2. Comparison of serial casting and stretching technique in children with congenital idiopathic clubfoot Evaluation of a new assessment system-Hanneke Andriesse and Gunnar Hägglund. Acta Orthopaedica 2008; 79 (1): 53–61 53 – 1871.

   The casting technique according to Ponseti seems to be the better of the two for clubfoot correction, regarding mobility and quality of motion.

3. Results of treatment of clubfoot by Ponseti's technique in 40 cases : Pitfalls and problems in the Indian scenario -Atul Bhaskar, Shraddha Rasa. Indian J Orthop 2006;40:196-9.

   A strict protocol and parent education can improve the outcome for all cases with the Ponseti technique.

4. Ponseti’s vs. Kite’s method in the treatment of clubfoot-a prospective randomised study -Akshay Tiwari & Deep Sharma & Sudhir kapoorInternational Orthopaedics (2008) 32:409–413.

Ponseti's method is superior to Kite's method in achieving correction in idiopathic clubfoot in a relatively shorter period of time when used to treat young infant.

5. Evaluation of the utility of the Ponseti method of correction of clubfoot deformity in a developing nation -Ankur Gupta & Saurabh Singh & Pankaj Patel & Jyotish Patel & Manish Kumar Varshney International Orthopaedics (2008) 32:75–79.

   The Ponseti method of correcting clubfoot is especially important in developing countries, where operative facilities are not available in the remote areas and well- trained physicians and personnel can manage the cases effectively with cast treatment only.

6. Conservative management of idiopathic clubfoot: Kite versus Ponseti method - AV Sanghvi, VK Mittal Journal of Orthopaedic Surgery 2009;17(1):67-71.

   The Ponseti method can achieve more rapid correction and ankle dorsiflexion with fewer casts, without weakening the Achilles tendon

7. Treatment of congenital club foot IV Ponseti J Bone Joint Surg Am. 1992;74:448-454.

   Manipulation & serial application of casts supported by limited operative intervention , yielded satisfactory results in 90 % of our patients

8. Treatment of idiopathic clubfoot - M Cooper and FR Dietz. JBJS Am. 1995;77:1477-1489.

   The cavus and adductus deformities are always easily corrected with casts and that the varus deformity of the hindfoot and the equinus determine

whether more ex-tensive operative treatment is necessary to obtain a plantigrade foot.

9. Effect of Cast Removal Timing in the Correction of Idiopathic Clubfoot by the Ponseti Method -Gaston Terrazas- Lafargue, M.D., and Jose A. Morcuende. The Iowa Orthopaedic JournalVolume 27

   Removing the cast just before the new cast is applied significantly decreases the number of casts required for correction and shortens the length of treatment.

10. Treatment of Idiopathic clubfoot – A historical review Matthew Dobbs, M.D.José A. Morcuende, M.D.,Ph.D.Christina A. Gurnett, Ignacio V. Ponseti, M.D.

    Further research will be needed to fully understand them pathogenesis of clubfoot, as well as the long-term results and quality of life for the treated foot.

11. Ponseti treatment in the management of clubfoot deformity–a continuing role in pediatric secondary care centres –Charles , Simon ,Ann R Coll Surg Engl 2007; 89: 510–512.

    Combined care between secondary and tertiary centres,where a common treatment protocol is utilised and with appropriately trained staff, has great benefits and is a safe a effective option in the management of paediatric clubfoot

12. The ClassicCongenital Club Foot: The Results of Treatment- Ignacio V. PonsetiMD, Eugene N. Smoley MD .Clin Orthop Relat Res (2009)

467:1133–1145.

Although the treatment of a mild congenital club foot may be easy, the complete and permanent correction of a severe and rigid club foot is often difficult. Early correction of all the components of the deformity in the shortest possible time is necessary for the proper development of the foot, since plaster-cast treatment prolonged for many months interferes with growth and may cause stiffness of the joints.

13. The Classic Observations on Pathogenesis and Treatment of Congenital Clubfoot Ignacio V.Ponseti MD Jeronimo Campos .Clin Orthop Relat Res (2009) 467:1124–1132.

Morphological studies of 6 clubfeet (2 in a 90-mm crown to rump fetus, 2 in a 7- month-old fetus and 2 in a 3-day-old infant)gave no clues to the pathogenesis of this deformity.Anterior tibial tendon transfer to the third cuneiform is a useful operation for the treatment of cases of severe,relapsing clubfoot

14. Treatment of idiopathic clubfoot using the Ponseti method :minimum 2-year follow-up - Abdelgawad AA, Lehman WB, van Bosse HJ, Scher DM, Sala DA. J Pediatr Orthop B. 2007;16(2):98-105..

When the Ponseti method was fully followed, including initial casting, compliance with brace and treatment of recurrences by recasting, Achilles tenotomy and/or anterior tibial tendon transfer, our success rate was 93%.

15. Ponseti management of clubfoot in older infants.- Bor N,Herzenberg JE, Frick .Clin Orthop Relat Res. 2006;444:224-8.

Most pediatric orthopaedists think that successful clubfoot casting depends ontreatment started immediately after birth. Our data suggest that older infants withclubfoot can be treated successfully without extensive surgery

16. Treatment of idiopathic club foot using the Ponseti method Initial experience.-Changulani M, Garg NK, Rajagopal TS, Bass A, Nayagam SN, Sampath J, Bruce CE. J Bone Joint Surg Br. 2006; 88(10):1385-7.

    Of the 96 feet which responded to initial casting, 31 (32%) had a recurrence, 16 of which were successfully treated by repeat casting and/or tenotomy and/or transfer of the tendon of tibialis anterior. The remaining 15 required extensive soft-tissue release. Poor compliance with the foot-abduction orthoses (Denis Browne splint) was thought to be the main cause of failure in these patients.

17. Initial management of congenital varus equinus clubfoot by Ponseti's method.- Chotel F, Parot R, Durand JM, Garnier E, Hodgkinson I, Berard J. Rev Chir Orthop Reparatrice Appar Mot. 2002; 88(7):710-7

    In 1948, Ponseti proposed reducing the deformity with successive casts. Although cast treatment is a very old method, Ponseti's method is original because it is based on strict rules established from anatomic evidence

18. Evaluation of the treatment of idiopathic clubfoot by using the Ponseti method- Colburn M, Williams M. J Foot Ankle Surg. 2003;42(5):259-67.

    In all recurrent cases, there was a lack of compliance with the straight-last shoe and foot abduction bar regimen. Based on this level of initial success, we believe that posteromedial release is no longer necessary for the majority of cases of congenital clubfeet.

19. Factors predictive of outcome after use of the Ponseti method for the treatment of idiopathic clubfeet.- Dobbs MB,Rudzki JR, Purcell DB, Walton T, Porter KR, Gurnett CA. J Bone Joint Surg Am. 2004 Jan; 86-A(1):22-7.

    Noncompliance and the educational level of the parents (high-school education or less) are significant risk factors for the recurrence of clubfoot deformity after correction with the Ponseti method. The identification of patients who are at risk for recurrence may allow intervention to improve the compliance of the parents with regard to the use of orthotics,and, as a result, improve outcome.

20. Treatment of congenital clubfoot with the Ponseti method.- Eberhardt O,Schelling K, Parsch K, Wirth T Z Orthop Ihre Grenzgeb. 2006;144(5):497-501.

    With the Ponseti method the need for extensive corrective surgery is greatly reduced. We recommend the Ponseti method as standard therapy in clubfoot management.

21. Ponseti technique for the correction of idiopathic clubfeet presenting up to 1 year of age. A preliminary study in children with untreated or complex deformities.-GoksanSB,Bursali A, Bilgili F, Sivacioglu S, Ayanoglu S . Arch Orthop Trauma Surg. 2006;126(1):15-21.

    Ponseti technique is reproducible and effective in children at least up to 12months of age. It can also produce good correction in children presenting with complex idiopathic deformities.

Clubfoot - Etiology

The true etiology of congenital clubfoot is unknown. Most infants who have clubfoot have no identifiable genetic, syndromal, or extrinsic cause. Extrinsic associations include teratogenic agents (eg, sodium aminopterin), oligohydramnios, and congenital constriction rings. Genetic associations include mendelian inheritance (eg, diastrophic dwarfism; autosomal recessive pattern of clubfoot inheritance).Cytogenetic abnormalities can be seen in syndromes involving chromosomal deletion. Clubfoot often coexists with other congenital abnormalities, such as arthrogryposis, myelomeningocele, and other syndromes such as dystrophic dysplasia, Möbius syndrome, Larsen syndrome, Wiedemann-Beckwith syndrome, and Pierre Robin syndrome. Often the syndrome causes abnormal collagen, creating stiff ligaments, capsules, and other soft tissues. It has been proposed that idiopathic CTEV in otherwise healthy infants is the result of a multifactorial system of inheritance.

Incidence in the general population is 1 per 1000 live births.The male-to-female ratio is 2:1. Bilateral involvement is found in 30-50% of cases. There is a 10% chance of a subsequent child being affected if the parents already have a child with a clubfoot.Incidence in first-degree relations is approximately 2%.Incidence in second-degree relations is approximately 0.6%.If one monozygotic twin has a CTEV, the second twin has only a 32% chance of having a CTEV.

Theories of the Pathogenesis

Numerous etiologies have been proposed, discarded, rediscovered by the next generation and represented.Many theories are in vogue because no single theory adequately explains the erratic response of the clubfoot to treatment.

One of the first ones, described by Hippocrates, was the mechanical theory, which postulates that clubfoot results from an elevated intrauterine pressure during pregnancy. This was disputed because of the absence of increased incidence in an overcrowded uterus (twinning, large babies, hydramnios and primiparous uterus). In the past, a neuromuscular etiology has been proposed based on the histochemical analysis of the clubfeet. They observed an increase in Type I:II muscle fiber ratio from 1:2 to 7:1, which suggests a possible neural basis. However, Irani observed no such abnormality.

Several authors have advanced histological theories. Loren *et al* .have shown that abnormal peroneus brevis histology correlates with higher chances of relapse. A primary germ plasm defect was proposed by Glimcher. An increased collagen synthesis was found by Ionasescu.

Ippolito and Ponseti have described the theory of retraction fibrosis of the distal muscles of the calf and supporting connective tissue.Additionally,anatomical abnormalities have been postulated to explain the occurrence of clubfoot. Ippolito demonstrated medial angulation of the neck and medial tilting and rotation of the body of talus. Hootnick and

associates described hypoplasia of the anterior tibial artery in patients with clubfoot.

An alternative theory of arrested fetal development, was proposed by Von Volkmann in 1863 and has subsequently been verified by other authors. According to this theory, the foot is normally in equinovarus and corrects to a pronated foot at birth. The development of the fetal foot is arrested because of an intrinsic error or an environmental insult, which retards the correction of the physiological position to the normal pronated foot and results in the clubfoot seen at birth.

Studies by Palmer and Davies have shown that clubfoot is inherited as a polygenic multifactorial trait, which implies that genetic factors do play an important role, but the mode of inheritance is not clear. A higher prevalence of clubfoot was found in children who were born between December and March than at other times of the year. Edwards *et al* . propose maternal hyperthermia as an adverse environmental factor in the sensitive period of intrauterine development.The consensus theory, which incorporates all of the above mentioned theories, probably best explains the occurrence of clubfoot.

Pathoanatomy

The anatomy was first described by Scarpa in 1800 & subsequently verified by authors like Kite & Turco.According to Scarpa ,clubfoot is a congenital Talocalcaneonavicular dislocation, which is the currently accepted view.In contrast Goldstein believes that the primary abnormality is outward rotation of talus in ankle mortise.

The ankle is in equinus, and the foot is supinated (varus) and adducted (a normal infant foot usually can be dorsiflexed and everted, so that the foot touches the anterior tibia). Dorsiflexion beyond 90° is not possible.The navicular is displaced medially, as is the cuboid. Contractures of the medial plantar soft tissues are present. Not only is the calcaneus in a position of equinus but also the anterior aspect is rotated medially and the posterior aspect laterally.

The heel is small and empty. The heel feels soft to touch (akin to the feel of the cheeks). As the treatment progresses, it fills in and develops a firmer feel (akin to the feel of the nose or of the chin).The talar neck is easily palpable in the sinus tarsi as it is uncovered laterally. Normally, this is covered by the navicular, and the talar body is in the mortise. The medial malleolus is difficult to palpate and is often in contact with the navicular. The normal navicular-malleolar interval is diminished.

The hindfoot is supinated, but the foot is often in a position of pronation relative to the hindfoot. The first ray often drops to create a position of cavus. The Ponseti method of closed management of clubfeet through manipulations and casting describes the elevation of the

first metatarsal as a first step, even if it means seemingly exacerbating the supination of the foot.The tibia often has internal torsion. This assumes special importance in the casting management of clubfoot, where care should be taken to rotate the feet into abduction, avoiding spurious tibial rotation through the knee.Even following correction, the foot often remains short and the calf thin.

Atrophy of the leg muscles, especially in the peroneal group, is seen in clubfeet.The number of fibers in the muscles is normal, but the fibers are smaller in size.The triceps surae, tibialis posterior, flexor digitorum longus (FDL), and flexor hallucis longus (FHL) are contracted.The calf is of a smaller size and remains so throughout life, even following successful long-lasting correction of the feet.There is thickening of the tendon sheaths of tibialis posterior and peroneal tendons.

Contractures of the posterior ankle capsule, subtalar capsule, and talonavicular and calcaneocuboid joint capsules commonly are seen. Contractures are seen in the calcaneofibular, talofibular, (ankle) deltoid, long and short plantar, spring, and bifurcate ligaments.The plantar fascial contracture contributes to the cavus,as does contracture of fascial planes in the foot.

Clinical Features

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Imaging Studies

Antenatal Diagnosis

With the advent of ultrasound, clubfoot can now be diagnosed at 18-20 weeks of gestation. However, this is only 80% accurate. If the antenatal diagnosis is made at <20 weeks, some authors have suggested amniocentesis because of the high incidence (14.2%) of associated genetic anomalies, such as Trisomy18, Larsen's syndrome, neural tube defects and congenital heart defects.

Radiography

Imaging studies generally are not required to understand the nature or the severity of the deformity. Radiographs, however, are a useful baseline prior to and following surgical correction of the feet, closed Achilles tenotomy, or a limited posterior release. Radiographs show the true gain in foot (ankle) dorsiflexion and confirm the appearance of an iatrogenic rockerbottom foot should one result. Occasionally, radiographs are necessary to diagnose clubfeet associated with tibial hemimelias.

Talocalcaneal parallelism is the radiographic feature of clubfeet. Simulated weight-bearing x-rays are used for infants who have not commenced walking. Positioning for foot x-rays is very important. The anteroposterior (AP) view is taken with the foot in 30° of plantar flexion and the tube at 30° from vertical. The lateral view is taken with the foot in 30° of plantar flexion.

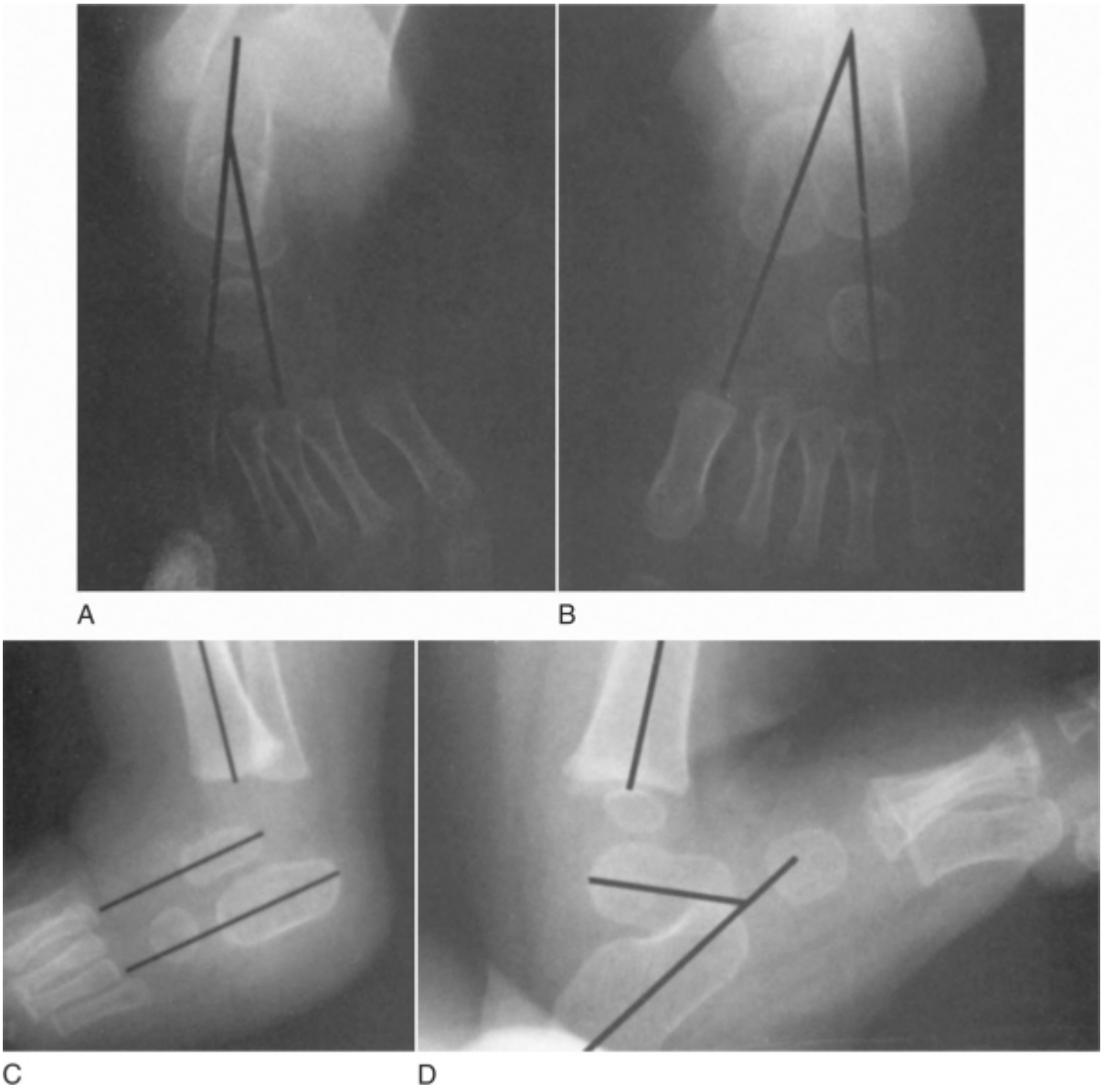
The talocalcaneal angle in the AP and lateral films are measured. AP lines are drawn through the center of the long axis of the talus (parallel to the medial border) and through the long axis of the calcaneum (parallel to the lateral border), and they usually subtend an angle of 25-40°. Any angle less than 20° is considered abnormal.

The AP talocalcaneal lines are almost parallel in clubfeet. As the feet correct with casting or surgery, the calcaneus rotates externally, and the talus reciprocally also derotates to a lesser degree to give a convergent talocalcaneal angle.

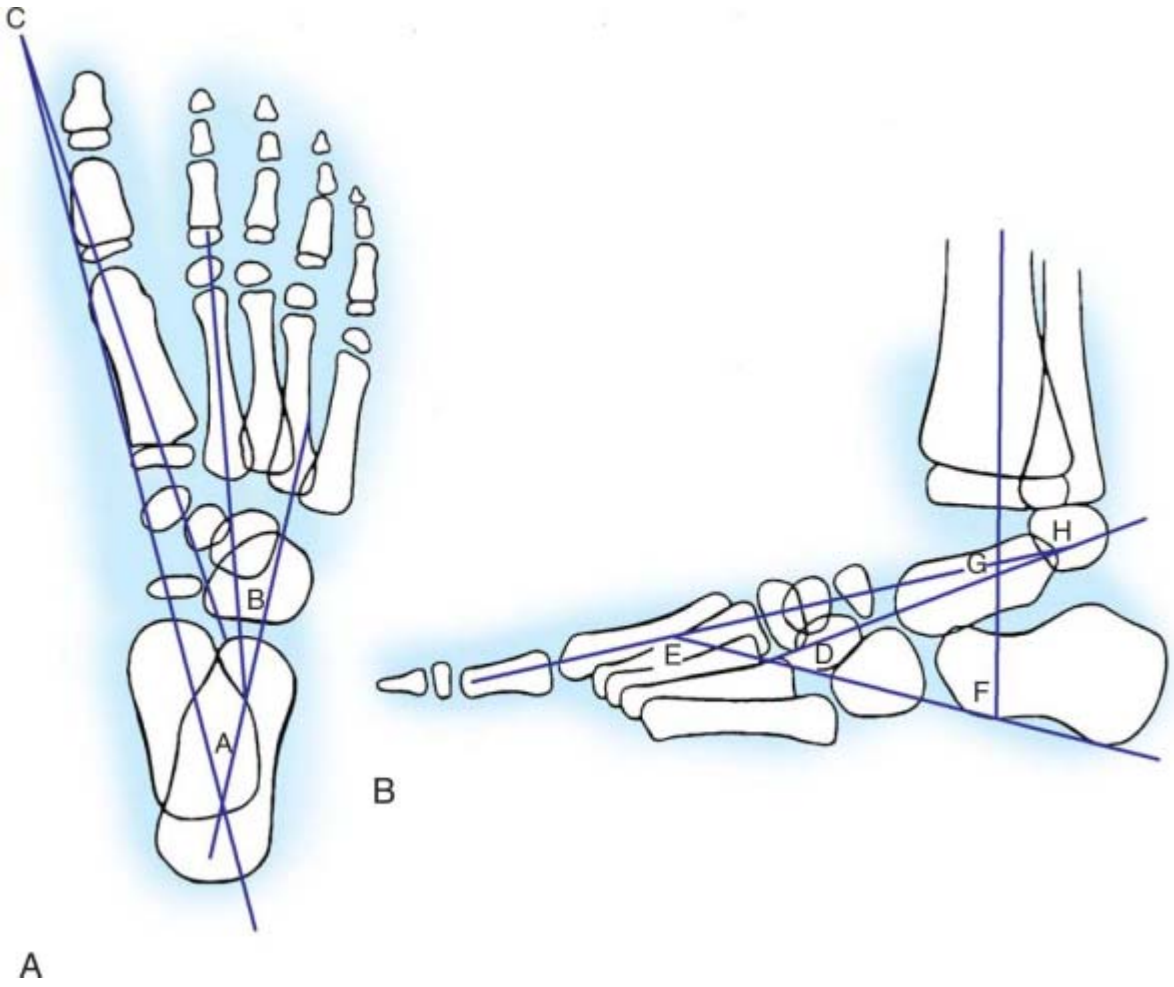
Lateral lines are dawn through the midpoint of the head and body of the talus and along the bottom of the calcaneum, usually 35-50° Clubfoot ranges between 35° and negative 10°.The lateral talocalcaneal lines are almost parallel in clubfeet. As the feet correct with casting or surgery, the calcaneum dorsiflexes relative to the talus to give a convergent talocalcaneal angle.These 2 angles (AP and lateral) are added to derive the talocalcaneal index, which in a corrected foot should be more than 40°.The AP and lateral talar lines normally pass through the center of the navicular and the first metatarsal.

A lateral film with the foot held in maximal dorsiflexion is the most reliable method of diagnosing an uncorrected clubfoot, since the absence of calcaneal dorsiflexion is evidence that the calcaneus is still locked in varus angulation under the talus.

Radiographic evaluation of Clubfoot



A, Anteroposterior view of right clubfoot with decrease in talocalcaneal angle and negative talus–first metatarsal angle. **B,** Talocalcaneal angle on anteroposterior view of normal left foot. **C,** Talocalcaneal angle of 0 degrees and negative tibiocalcaneal angle on dorsiflexion lateral view of right clubfoot. **D,** Talocalcaneal and tibiocalcaneal angles on dorsiflexion lateral view of normal left foot.



Nine angles commonly used for evaluation of clubfoot deformity. **A,** On anteroposterior radiograph: A, anteroposterior calcaneal angle; B, calcaneus–second metatarsal angle; C, anteroposterior talus–first metatarsal angle. **B,** On lateral radiograph: D, lateral talocalcaneal angle; E, calcaneus–first metatarsal angle; F, tibiocalcaneal angle; G, tibiotalar angle; H, lateral talus–first metatarsal angle. Talocalcaneal angle is sum of A and D.

Classification

Clubfoot is classified into Congenital & Acquired. Congenital clubfoot is further classified into Idiopathic or Non-idiopathic types.

Congenital idiopathic clubfoot : Isolated skeletal anomaly, usually bilateral, has a higher response to conservative treatment and a tendency for late recurrence.

Congenital non-idiopathic clubfoot : Occur in genetic syndromes, teratological anomalies, neurological disorders of known (eg.spina bifida) & unknown etiology and myopathies. It is characterized by diametrically opposite deformities in the feet (calcaneovalgus in one foot and equinovarus in another), presence of another anomalies & failure to respond to conservative or operative treatment.

Acquired clubfoot : Has neurogenic causes (eg.Poliomyelitis, meningitis, sciatic nerve damage), Streeter's dysplasia and vascular causes (Volkmann ischemic contracture).

Positional clubfoot : Rarely the deformity is very flexible and is thought to be due to intrauterine crowding. Correction is often achieved with one or two castings.

***Typical clubfoot* :** This is the classic clubfoot and is found in otherwise normal infants. It generally corrects in five casts, and with Ponseti management the long-term oucome is usually good or excellent.

Atypical clubfoot : This category of clubfoot is usually associated with other problems. Start with Ponseti management. Correction usually is more difficult.

Recurrent typical clubfoot : May occur whether the original treatment was by Ponseti management or other methods. Relapse is much less frequent after Ponseti management and is usually due to a premature discontinuation of bracing. The recurrence is most often supination and equinus that is first dynamic but may become fixed with time.

Alternatively treated typical clubfoot: Includes feet treated by surgery or non-Ponseti casting.

Rigid or resistant atypical clubfoot : May be thin or fat. The fat feet are much more difficult to treat. They are stiff, short, chubby, with a deep crease in the sole of the foot and behind the ankle, and have shortening of the first metatarsal with hyperextension of the metatarsal phalangeal joint.This deformity occurs in the otherwise normal infant.

Scoring Systems

There are numerous evaluation systems for grading the severity of clubfoot. All these systems use various parameters to assess the severity and correctability of clubfoot. Harrold and Walker22 were among the first to describe a simple grading system. Although it allowed a basic assessment of the deformity , it was not sensitive enough to evaluate subtle improvements in outcome as a result of a particular intervention. Dimeglio- Bensahel scoring system, Catterall-Pirani system, the modified Hospital for Joint Diseases functional rating system25 have all

been used by workers in this field. Although a large number of evaluation systems have been proposed, there is little agreement on a standard reproducible method. Among these, the Dimeglio-Bensahel and the Catterall- Pirani scoring systems appear to have a number of clinical advantages. Both score the dynamic correctability of the deformity, rely exclusively on clinical assessment and do not involve radiological assessment. This removes some of the inherent errors associated with radiographic interpretation in CTEV.

Pirani Scoring:

The Pirani scoring system, devised by Shafiq Pirani, MD, of Vancouver, BC, consists of 6 categories, 3 each in the hindfoot and the midfoot. The categories are curvature of the lateral border (CLB) of the foot, medial crease (MC), uncovering of the lateral head of the talus (LHT), posterior crease (PC), emptiness of the heel (EH), and degree of dorsiflexion (DF). The first 3 constitute the midfoot score, and the last 3 constitute the hindfoot score. Each category is scored as 0, 0.5, or 1. The least (best) total score for all categories combined is 0, and the maximum (worst) score is 6. The Pirani scoring system can be used to identify the severity of the clubfoot and to monitor the correction.

Hindfoot deformities

- Posterior heel crease
- Empty heel
- Rigidity of equinus

Midfoot deformities

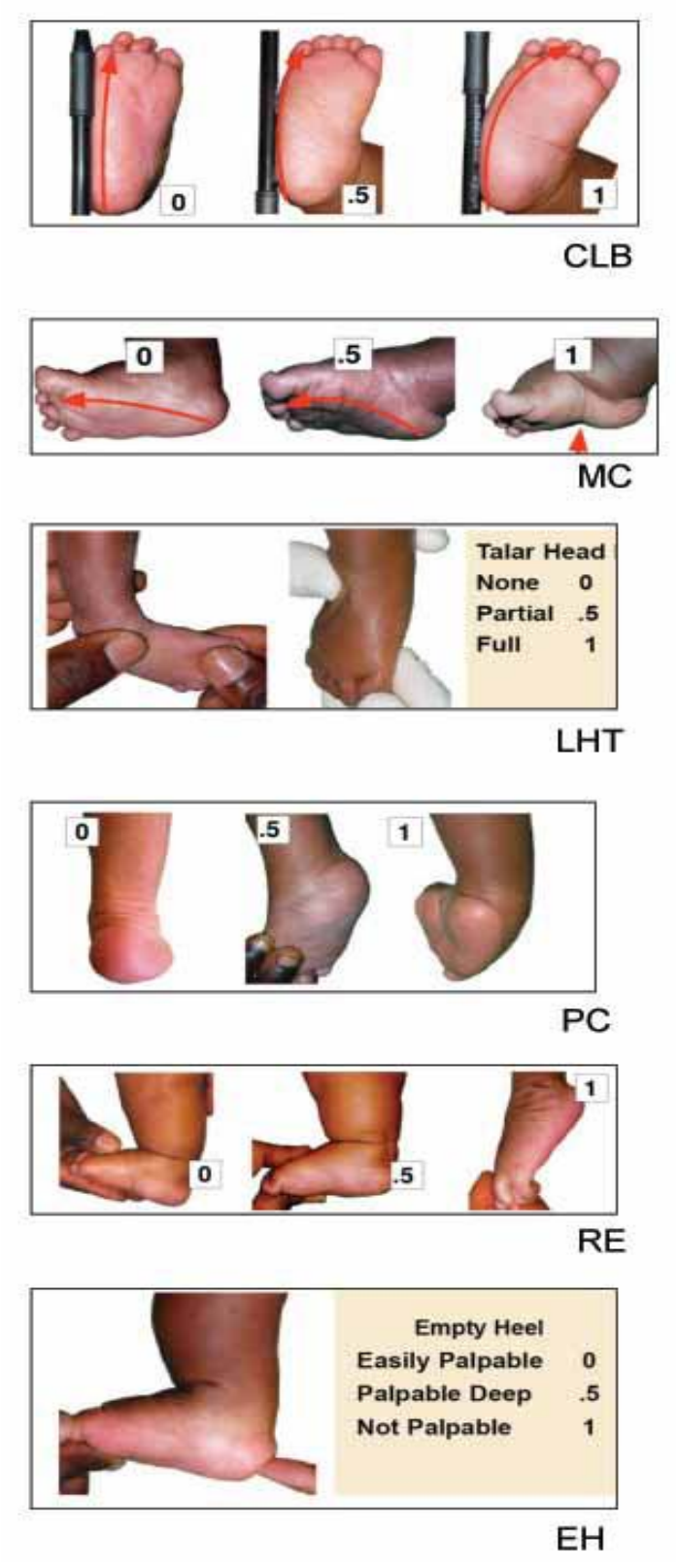
- Curvature of lateral border of foot
- Medial crease
- Lateral head of talus

Total score = [hindfoot + midfoot] deformity scores

Dimeglio - Bensahel scoring system:

The Dimeglio- Bensahel scoring system incorporated eight components: equinus, varus, position of the talo-calcaneal-forefoot unit, forefoot adduction, and the presence of abnormal musculature, cavus, a medial crease and a posterior crease. Points are apportioned according to motion, with 4 points each for equinus, varus of the heel, internal torsion and adduction. One point each may be added for the presence of a posterior crease, a medial crease, cavus and poor muscle condition. A total of 20 points is possible. The higher the number, the more rigid the clubfoot

Pirani Scoring for Clubfoot



Classification of Clubfoot Severity by Diméglio et al.

Parameters Measured	Reducibility (degrees)	Score
Equinus deviation in sagittal plane (Fig. 26-30A)	90 to 45	4
Varus deviation in frontal plane (Fig. 26-30B)	45 to 20	3
Derotation of calcaneopedal block in horizontal plane (Fig. 26-30C)	29 to 0	2
Adduction of forefoot relative to hindfoot in horizontal plane (Fig. 26-30D)	0 to −20	1
	<−20	0
		16
Other elements considered		
Posterior crease marked		1
Mediotarsal crease marked		1
Plantar retraction or cavus		1
Poor muscle condition		1
Possible total score		*20*

Grade	Type	Frequency (%)	Score	Reducibility
I	Benign	20	1-4	>90% soft-soft, resolving
II	Moderate	33	5-9	>50% soft-stiff, reducible, partially resistant
III	Severe	35	10-14	>50% stiff-soft, resistant, partially reducible
IV	Very severe	12	15-20	<10% stiff-stiff, resistant

Treatment of Clubfoot

The treatment of clubfoot can be divided into two phases, the pre-Ponseti era and post-Ponseti era. In the pre-Ponseti era, stress was on conservative treatment and followed by operative treatment if the conservative treatment failed. The Ponseti technique is essentially conservative. This does not suggest that in the post-Ponseti era all the other modalities have been abandoned. Other methods, including surgery, are still being followed depending upon individual preferences.

The first non-operative treatment was proposed by Hippocrates in 400 BC when he recommended gentle manipulation followed by splinting. Plaster casts were used to treat clubfoot when Guerin introduced the plaster of Paris in 1836. Kite was the first to recommend gentle manipulation and cast immobilization.At the annual meeting of the American Academy of Orthopedic Surgeons in 2002, Cummings stated, "There are as many techniques for manipulative treatment of congenital clubfoot as there are authors who write about clubfoot". To circumvent this problem, International Clubfoot Study Group, established in 2003, has approved Kite's, Ponseti's and Bensahel's techniques as the standardized conservative regimes for the treatment of clubfoot all over the world.

Kite’s-method

In Kite's method, the manipulation can be started soon after birth. It was derived from the concept of three-point pressure, such as used in the bending of a wire. The fulcrum is the calcaneocuboid joint. The forefoot is grasped and distracted while the other

hand holds the heel. Applying counterpressure over the calcaneocuboid joint the navicular is pushed laterally. The heel is everted as the foot is abducted. This is followed by the application of a slipper cast, which is extended to below the knee with the foot everted with gentle external rotation. Afterwards, the foot is pushed into dorsiflexion to correct the equinus once the adductus and varus are corrected. The casts are changed every week. Following full correction, the feet are placed in a Denis Browne Bar. The success rate varies from a high of 90% found by Kite to a low of 19% by Fripp and Shaw. According to Ponseti, the average number of casts required for correction by this technique is 20.4.

Kite believed that the heel varus would correct simply by everting the calcaneus. He did not realize that the calcaneus can evert only when it is abducted (i.e., laterally rotated) under the talus.Abducting the foot at the midtarsal joints with the thumb pressing on the lateral side of the foot near the calcaneocuboid joint blocks abduction of the calcaneus and interferes with correction of the heel varus. One should make certain the foot is abducted around the head of the talus.

French method

This technique, also known as the Functional method, was introduced in France in the 1970s by Masse and Bensahel, but it was not until early 1980 that results were available in english literature. It involved daily manipulation of the child's clubfoot by the physical therapist for 30 min. This was followed by stimulation of the muscles around the foot, specially the peroneal muscles, to maintain the reduction achieved by the passive manipulation and then, adhesive strapping was applied. The daily

treatments were continued for approximately two months and then reduced to three sessions per week for an additional six months. Taping was continued until the patient was ambulatory. After ambulation was achieved, a nighttime splint was introduced and used for an additional two to three years. Initially, good results were seen in 50% of the patients and in the remaining cases, the surgery that was required was only a posterior release.

The disadvantages of this method were that it involved daily hospital visits, depended on the manipulation skills of the physical therapist and was costly in the long run. This method was subsequently modified to include placement in a continuous passive motion (CPM) machine for six to eight hours after passive manipulation by the physical therapist and adhesive strapping of the feet. The addition of the CPM machine resulted in fewer patients needing surgery and a less radical procedure for those who required surgery. The success rate was reported to be close to 68%.

Operative Treatment

The list of operative procedures is endless as no single procedure gives a long-lasting correction. The first operative procedure, posterior release, was described by Phelps in 1891. The PMR procedure, which was introduced by Turco (1980), is basically a modification of the earlier procedures elaborated by Phelps, Codvilla (1906), Brockman (1937) and Bost (1960).

The rationale behind Turco's PMR was that the deformity is due to the congenital subluxation of the Talocalcaneonavicular joint, the correction of the abnormal tarsal relationship is prevented by rigid

pathologic soft tissue contractures and the correction of any single component of the deformity is impossible while simultaneously eliminating the others. The two prerequisites for lasting correction are that complete correction of all components must be obtained and this correction must be maintained while the tarsal bones remodel.

The optimal age for surgical intervention has always been controversial. Turco recommends surgery at around one year of age while Osterman and Merikanto recommend surgery at the earlier age of three to six months to utilize the remodeling potential of the foot. Danglemajor advises deferring surgery until one year of age as surgery done earlier has a failure rate close to 65%.The average number of operations per foot was 2.9 to achieve a full correction at skeletal maturity with earlier surgery. In addition to finding a higher incidence of failure, Turco reported the disadvantages of early surgery to be difficulty in the identification of the anatomical structures and in the handling of the small cartilaginous bones when operating on a small foot. Furthermore, when the pins are removed from the talonavicular bones and talocalcaneal bones after a PMR, it is hard to hold the small foot in plaster. Importantly, delaying surgery minimizes the possibility of operating on an unrecognized neuromuscular deformity. One major benefit of operating close to the age of walking is that it takes advantage of the normal physiological stimulus of weight-bearing for remodeling.

Turco's procedure was used with impunity in the 1980s with the average failure rate of 25% being reported by Turco himself. Failure rates, ranging from 13 to 50%, were found by Crawford *et al* . and Vizekelety *et al* . McKay *et al* . and Herzenberg *et al* . have shown

that the presence of an internal rotation deformity of the calcaneus cannot be adequately corrected by a PMR alone. They proposed that beyond 18 months of age PMR should be combined with posterolateral release. This can either be done using a single incision of Cinncinnati or Carrolls two incision technique. The disadvantage of Mckay's procedure is that it results in overcorrection with the heel being placed in valgus in 8-20% of the feet.

The protocol followed for the management of neglected type of feet is surgical either by open surgery as described above or by the use of external fixators such as Iliazarov's and Joshi's External stabilizing system (JESS) fixators. Casting is done to maintain correction after the fixators are removed. The success rate of correction varies from 77 to 90%.As can be seen from above, surgical intervention is often followed by complications, residual deformities or recurrence, which require further surgery.

Ponseti Method

Ponseti had been reporting consistent results since 1950, but it is only recently that he has been given due recognition. His technique is based on the solid understanding of the pathoanatomy of clubfoot. According to Ponseti, the clubfoot usually recurs until four years of age and parents should be warned of this possibility.

Ponseti suggests two reasons for the poor results found with Kite's technique. First, the use of the calcaneocuboid joint as the fulcrum blocks the abduction of the calcaneus and thereby prevents eversion of the calcaneus. Secondly, pronation of the forefoot to correct the cavus actually worsens the cavus. A recent study by Frick highlights the importance of correction of the supination. Based on laboratory studies, Ponseti has shown that the calcaneus everts only when it is fully-abducted.

In Ponseti's technique, the first two casts are applied with the forefoot supinated so as to bring it into alignment with the hind foot.The third cast is applied with the forefoot abducted and simultaneous counterpressure over the head of talus. In the fourth cast, the forefoot is further abducted. Prior to the fifth cast, the degree of dorsiflexion is assessed and if dorsiflexion is not possible beyond neutral, then a percutaneous Achilles tenotomy is required. The tenotomy, if required, is done under local

anesthesia as an outpatient procedure. The casts before the tenotomy are changed at weekly intervals while the cast after the tenotomy is removed at the end of three weeks.

The average number of casts with the Ponseti technique is only 5.4 compared to the 20 casts with Kite's technique and this results in saving time and money for the patient.Following the removal of the last cast, irrespective of whether a tenotomy is done or not, the patient is placed in a modified Foot Abduction Orthosis (FAO), which is used for 23 h a day in the initial four months and then subsequently for nighttime for three years. According to Ponseti, a tenotomy is required in 70% of the cases. In a study by Scher *et al* ., children with clubfeet who have an initial score of ≥5.0 by the Pirani system or are rated as Grade IV feet by the Dimeglio system are very likely to need a tenotomy.

APPEARANCE OF CASTS IN PONSETI METHOD

Clubfoot has a strong tendency to relapse until four years of age and this is attributed to the original pathology. Relapses decrease after age four because the pathology that causes clubfoot ceases to exist. According to Ponseti, 50% of the relapses occurred between 10 months to five years and this was irrespective of the degree of correction that was obtained after casting. The single most important factor that predicts

recurrence is noncompliance with the FAO and the recurrence rate could be reduced to 10% if the patient was compliant with the FAO.

Lehman *et al* . have shown excellent early results with the Ponseti technique and according to them good results were possible if casting was begun prior to seven months of age and the patient was compliant with the FAO. Dobbs *et al* . have reported that noncompliance with the FAO and the educational level of the parents (high-school education or less) are significant risk factors, which predict the increased possibility of recurrence after correction with the Ponseti method.

The identification of patients who are at risk for recurrence may allow intervention to improve the compliance of the parents with regard to the use of the FAO and as a result, improve outcome. Probably, the most extensive review and follow-up of the Ponseti technique has been reported by Dobbs *et al* .,in their evaluation of Ponseti's patients who were treated 25-42 years ago. They found that the corrected clubfeet were less supple and showed no differences in terms of function and performance compared to the normal population. Tibialis anterior tendon transfers were required in 50% of the patients. According to Ponseti, this should be considered part of the technique and not as a separate operative procedure. In a recent study from Israel, Segev *et al* .reported excellent results in 94% of the cases with the Ponseti technique.

Ponseti Technique

Setup : The setup for casting includes calming the child with a bottle or breast feeding. When possible it is good to have a trained assistant. Sometimes it is necessary for the parent to assist. The treatment setup is important. The assistant holds the foot while the manipulator performs the correction.

Manipulation and casting: is started as soon after birth as possible.The infant and the family are made comfortable.The infant is allowed to feed during the manipulation and casting processes.

The head of the talus is exactly located : This step is essential . First, the malleoli is palpated with thumb and index finger of hand A while the toes and metatarsals are held with hand B. Next,the thumb and index finger of hand A is slided forward to palpate the head of the talus in front of the ankle. Because the navicular is medially displaced and its tuberosity is almost in contact with the medial malleolus, one can feel the prominent lateral part of the talar head barely covered by the skin in front of the lateral malleolus.The anterior part of the calcaneum will be felt beneath the talar head.While moving the forefoot laterally in supination, one will be able to feel the

navicular move over so slightly in front of the head of the talus as the calcaneus moves laterally under the talar head.

Manipulation: The manipulation consists of abduction of the foot beneath the stabilized talar head. The head of the talus is located. All components of clubfoot deformity,except for the ankle equinus, are corrected simultaneously. To gain this correction, one must locate the head of the talus, which is the fulcrum for correction.

The cavus is reduced: The first element of management is correction of the cavus deformity by positioning the forefoot in proper alignment with the hindfoot. The cavus, which is the high medial arch is due to the pronation of the forefoot in relation to the hindfoot. The cavus is always supple in newborns and requires only elevating the first ray of the forefoot to achieve a normal longitudinal arch of the foot. The forefoot is supinated to the extent that visual inspection of the plantar surface of the foot reveals a normal appearing arch neither too high nor too flat. Alignment of the forefoot with the hindfoot to produce a normal arch is necessary for effective abduction of the foot to correct the adductus and varus.

Steps in cast application: Dr. Ponseti recommends the use of plaster material because it is less expensive and more precisely molded than fiberglass.

***Preliminary manipulation*:** Before each cast is applied, the foot is manipulated.The heel is not touched to allow the calcaneus to abduct with the foot .

***Applying the padding* :** Only a thin layer of cast padding is applied, to allow molding of the foot. The foot is maintained in the maximum corrected

position by holding the toes with counterpressure applied against the head of the talus while the cast is being applied.

Applying the cast **:** First, the cast is applied below the knee and then the cast is extended to the upper thigh. The cast is begun with three to four turns around the toes , and then worked proximally up to the knee. The plaster is applied smoothly. A little tension is added to the turns of plaster above the heel. The foot should be held by the toes and plaster wrapped over the "holder's" fingers to provide ample space for the toes.

Molding the cast **:** Forced correction with the plaster is avoided.One should not apply constant pressure with the thumb over the head of the talus, rather it is pressed and released repetitively to avoid pressure sores of the skin. The plaster over the head of the talus is molded while holding the foot in the corrected position. The arch is well molded to avoid flatfoot or rocker-bottom deformity. The heel is well molded by countering the plaster above the posterior tuberosity of the calcaneus. The malleoli are well molded. The calcaneus is never touched during the manipulation or casting. Molding should be a dynamic process; the fingers being moved constantly to avoid excessive pressure over any single site. Molding is continued while the plaster hardens.

The cast is extended to thigh One should use much padding at the proximal thigh to avoid skin irritation. The plaster may be layered back and forth over the anterior knee for strength and for avoiding a large amount of plaster in the popliteal fossa area, which makes cast removal more difficult.

The cast is trimmed The plantar plaster is left to support the toes , and the cast is trimmed dorsally to the metatarsal phalangeal joints, as marked on the cast.A plaster knife is used to remove the dorsal plaster by cutting the center of the plaster first and then the medial and lateral plaster.The dorsum of all the toes are left free for full extension. The appearance of the first cast when completed is noted. The foot is in equinus, and the forefoot is supinated.

Characteristics of adequate abduction It is confirmed that the foot is sufficiently abducted to safely bring the foot into 0 to 5 degrees of dorsiflexion before performing tenotomy.

The best sign of sufficient abduction is the ability to palpate the anterior process of the calcaneus as it abducts out from beneath the talus.

Abduction of approximately 60 degrees in relationship to the frontal plane of the tibia is possible.

Neutral or slight valgus of os calcis is present. This is determined by palpating the posterior os calcis.

Clubfoot is a three-dimensional deformity Hence these deformities are corrected together. The correction is accomplished by abducting the foot under the head of the talus. The foot is never pronated.

The final outcome at the completion of casting, the foot appears to be over-corrected into abduction with respect to normal foot appearance during

walking. This is not in fact an overcorrection. It is actually a full correction of the foot into maximum normal abduction. This correction to complete, normal, and full abduction helps prevent recurrence and does not create an overcorrected or pronated foot.

Complications of Casting

Using careful technique, as described, complications are uncommon.

Rocker-bottom deformity is due to poor technique by dorsiflexing the foot too early against a very tight Achilles tendon.

Crowded toes are due to tight casting over the toes.

Flat heel pad will occur if, while casting, pressure is applied to the heel rather than molding the cast above the ankle.

Superficial sores are managed by applying a dressing and a new cast with additional padding.

Pressure sores are due to poor technique. Common sites include the head of the talus, over the heel, under the first metatarsal head, and popliteal and groin regions.

Deep sores are dressed and left out of the cast for one week to allow healing. Casting is then resumed with special care to avoid relapse.

Cast removal

Each cast is removed in clinic just before a new cast is applied. Cast removal is avoided before coming to clinic because considerable correction can be lost from the time the cast is removed until the new one is placed.

Options for removal Using a cast saw is avoided because it is frightening to the infant and family and may also cause injury to the skin.

Cast knife removal The cast is soaked in water for about 20 minutes, and then wrapped in wet cloths before removal. This can be done by the parents at home just before their visit. One can use a plaster knife, to avoid cutting the skin.The above-knee portion of the cast is removed first and finally, below-knee portion of the cast is removed .

Soaking and unwrapping This is an effective method, but requires more time. Cast is soaked thoroughly in water and when completely soft, it is unwrapped. To make this process easier, the end of the plaster is left free for identification.

Common Management Errors

Pronation or eversion of the foot This position worsens the deformity by increasing the cavus. Pronation does nothing to abduct the adducted and inverted calcaneus, which remains locked under the talus. It also creates a new deformity of eversion through the mid and forefoot, leading to a beanshaped foot. ***"Thou shall not pronate!"***

External rotation of foot to correct adduction while calcaneus remains in varus This causes a posterior displacement of the lateral malleolus by externally rotating the talus in the ankle mortise. This displacement is an iatrogenic deformity.Avoid this problem by abducting the foot in flexion and slight supination to stretch the medial tarsal ligaments, with counter-pressure applied on the lateral aspect of the head of the talus. This allows the calcaneus to abduct under the talus with correction of the heel varus.

Casting errors

Failure to manipulate The foot should be immobilized with the contracted ligaments at maximum stretch obtained after each manipulation. In the cast, the ligaments loosen, allowing more stretching at the next session.

Short-leg cast The cast must extend to the groin. Short-leg casts do not hold the calcaneus abducted .

Premature equinus correction Attempts to correct the equinus before the heel varus and foot supination are corrected will result in a rocker-bottom deformity. Equinus through the subtalar joint can be corrected by calcaneal abduction.

Failure to use appropriate night bracing Using a short leg brace is avoided as it fails to hold the foot in abduction. The external bar brace should be used full time for 3 months and at night for 4 years. Failure of appropriate bracing is the most common cause of relapse.

Attempts to obtain perfect anatomical correction It is wrong to assume that early alignment of the displaced skeletal elements will result in normal anatomy. Long-term follow-up radiographs show abnormalities. However,

good long-term function of the clubfoot can be expected. There is no correlation between the radiographic appearance of the foot and long-term function.

Tenotomy

Indication for tenotomy Tenotomy is indicated to correct equinus when cavus, adductus, and varus are fully corrected but ankle dorsiflexion remains less than 10 degrees above neutral. It is made certain that abduction is adequate for performing the tenotomy.

Characteristics of adequate abduction The foot is sufficiently abducted to safely bring the foot into 0 to 5 degrees of dorsiflexion before performing tenotomy.The best sign of sufficient abduction is the ability to palpate the anterior process of the calcaneus as it abducts out from beneath the talus. Abduction of approximately 60 degrees**,** in relationship to the frontal plane of the tibia is possible.

Neutral or slight valgus of os calcis is present. This is determined by palpating the posterior os calcis.

Remember that this is a three-dimensional deformity and that these deformities are corrected together. The correction is accomplished by abducting the foot under the head of the talus. The foot is never pronated.

Preparing the family The family is prepared by explaining the procedure.The family is explained that tenotomy is a minor procedure performed under local anesthetic in the outpatient clinic.

Equipment No.11 or No.15, or any other small blade, such as an ophthalmic knife may be useful.

Skin preparation The foot is prepared thoroughly from midcalf to midfoot with an antiseptic while the assistant holds the foot from the toes with the fingers of one hand and the thigh with the other .

Anaesthesia A small amount of local anesthetic may be infiltrated near the tendon. Too much of local anesthetic makes palpation of the tendon difficult and the procedure may become more complicated.

Setup for the tenotomy With the assistant holding the foot in maximum dorsiflexion, a site about 1.5 cm above the calcaneus is selected for tenotomy. A small amount of local anesthetic is infiltrated just medial to the tendon at the site selected for the tenotomy. The anatomy is kept in mind. The neurovascular bundle is anteromedial to the heel cord. The heel-cord tendon lies within the tendon sheath

Tenotomy The tip of the scalpel blade is inserted from the medial side, directed immediately anterior to the tendon . The flat part of the blade is kept parallel to the tendon. The initial entry causes a small longitudinal incision.

Care must be taken to be gentle so as not to accidentally make a large skin incision. The tendon sheath is not divided and left intact . The blade is then rotated, so that its sharp edge is directed posteriorly towards the tendon. The blade is then moved a little posteriorly. A “pop” is felt as the sharp edge releases the tendon. The tendon is not cut completely unless a “pop” is appreciated. An additional 15 to 20 degrees of dorsiflexion is typically gained after the tenotomy .

Post-tenotomy cast After correction of equinus by tenotomy, the fifth cast is applied with the foot abducted 60 to 70 degrees with respect to the frontal plane of the ankle, and 15 degrees dorsiflexion. The foot looks over-corrected with respect to the thigh. This cast holds the foot for 3 weeks after complete correction. It should be replaced if it softens or becomes soiled before 3 weeks. The baby and mother may go home immediately. No analgesic is necessary. This is usually the last cast required in the treatment program.

Cast removal After 3 weeks, the cast is removed. Twenty degrees of dorsiflexion is now possible. The tendon is healed. The operative scar is minimal. The foot is ready for bracing . The foot appears to be over-corrected into abduction. This is often a concern to the caregiver.

Errors during tenotomy

Premature equinus correction Attempts to correct the equinus before the heel varus and foot supination are corrected will result in a rocker-bottom deformity. Equinus through the subtalar joint can be corrected only if the calcaneus abducts. Tenotomy is indicated after cavus, adductus, and varus are fully corrected.

Failure to perform a complete tenotomy The sudden lengthening with a "pop" or "snap" signals a complete tenotomy. Failure to achieve this may indicate an incomplete tenotomy. The tenotomy maneuver is repeated to ensure a complete tenotomy if there is no "pop" or "snap.

Bracing

Bracing is essential At the end of casting, the foot is abducted to an exaggerated amount, which should measure 60 to 70 degrees (thigh-foot axis).After the tenotomy, the final cast is left in place for 3 weeks. Ponseti's protocol then calls for a brace to maintain the foot in abduction and dorsiflexion. This is a bar attached to straight-last open-toe shoes. This degree of foot abduction is required to maintain the abduction of the calcaneus and forefoot and prevent relapse. The medial soft tissues remain stretched out only if the brace is used after the casting.

In the brace, the knees are left free, so the child can kick them "straight" to stretch the gastrosoleus tendon. The abduction of the feet in the brace, combined with the slight bend (convexity away from the child), causes the feet to dorsiflex. This helps maintain the stretch on the gastrocnemius muscle and heel-cord tendon. Ankle-foot orthoses (AFO's)

are not useful because they only keep the foot straight with neutral dorsiflexion.

Bracing protocol

Three weeks after the tenotomy, the cast is removed and a brace is applied immediately. The brace consists of open-toe hightop straight-last shoes attached to a bar . For unilateral cases, the brace is set at 60 to 70 degrees of external rotation on the clubfoot side and 30 to 40 degrees of external rotation on the normal side . In bilateral cases, it is set at 70 degrees of external rotation on each side. The bar should be of sufficient length so that the heels of the shoes are at shoulder width .A common error is to prescribe too short a bar, that the child finds uncomfortable. A narrow brace is a common reason for a lack of compliance. The bar should be bent 5 to 10 degrees with the convexity away from the child, to hold the feet in dorsiflexion.

The brace should be worn full time (day and night) for the first 3 months after the last cast is removed. After that, the child should wear the brace for 12 hours at night and 2 to 4 hours in the middle of the day, for a total of 14 to 16 hours during each 24-hour period. This protocol continues until the child is 3 to 4 years of age. Occasionally, a child will develop excessive heel valgus and external tibial torsion while using the

brace. In such instances, the physician should reduce the external rotation of the shoes on the bar from approximately 70 degrees to 40 degrees.

Importance of bracing The Ponseti manipulations combined with the percutaneous tenotomy regularly achieve an excellent result. However, without a diligent follow-up bracing program, relapse occurs in more than 80% of cases. This is in contrast to a relapse rate of only 6% in compliant families (Morcuende et al.).

When to stop bracing How long should the nighttime bracing protocol continue? As it is often difficult to determine severity, we recommend that all feet should be braced for to 3 to 4 years. Most children get used to the bracing, and it becomes part of their lifestyle. If after 3 years of age compliance becomes a problem, it may become necessary to discontinue the bracing. The child is closely followed for evidence of relapse. Should early relapse be observed, bracing should be promptly started again.

Types of braces Modifications of the original Ponseti brace provide some advantages. To prevent the foot from sliding out of the shoe, a pad may be placed in the counter of the shoe. New designs make the foot more secure in the brace, more easily applied to the infant, and allow the infant to move.

This flexibility may improve compliance. Several of the brace options are shown.

John Mitchell has designed a brace under Dr. Ponseti's direction. This brace consists of shoes made of a very soft leather and a plastic sole that is molded to the shape of the child's foot, making this shoe very comfortable and easy to use.

Dr. Matthew Dobbs of the Washington University School of Medicine in St. Louis, USA developed a new dynamic brace for clubfoot that allows the foot to move while maintaining the required rotation of the foot. An ankle-foot orthoses are required as part of this brace to prevent ankle plantar flexion.

M.J. Markel developed a brace that allows the parent to first place the shoes on the infant and then "click" each shoe onto the bar .

Dr. Jeffrey Kessler of the Kaiser Hospital in Los Angeles, USA developed a brace that is flexible and inexpensive. The bar is made of 1/8" thick polypropylene. The brace may improve compliance because it is well accepted by the infant.

Increasing Brace Compliance The most compliant families are those who understand Ponseti management and the importance of bracing.

Continued education Every opportunity is taken to educate the family about Ponseti management.

Written material is very helpful when available. Often published material is more convincing than information given verbally .

During weekly casting questions from the parents or other family members are answered. Failures are most likely due to premature discontinuation of bracing. This phase of management is repeatedly emphasized. The families should be aware that maintaining the correction with bracing is equally important to gaining the correction by casting and tenotomy.

Instructions for bracing

Assigning responsibility Once correction has been achieved, the responsibility is clearly passed on to the family to maintain the correction with bracing. Assigning that responsibility to the father may be appropriate in some situations.

Demonstrate families' ability to apply the brace Demonstrate how to apply the brace. Remove the brace and ask the parent to apply the brace while being supervised. Make certain the infant is comfortable in the brace. If the infant is uncomfortable, remove the brace and examine the skin for evidence of irritation with reddening of the skin .

Preparing the infant For the first few days, the brace may be removed for brief periods to improve tolerance. The parents are adviced to avoid removing the brace if the infant cries. If the infant learns that by crying the brace will be removed, the pattern will be difficult to correct. The family is encouraged to make the bracing a part of the normal life of the infant .

Follow-up

A return visit is scheduled in 10–14 days to monitor the use of the brace. If the bracing is going well, the next visit will be in about 3 months. At that

time, the bracing may be discontinued during the day. The brace must be applied for naps during the day and sleep during the night.

Relapses

Recognizing relapses Once the cast is removed and the bracing is started, plan to see the child back at the following schedule to check for compliance and for evidence of relapse:

At 2 weeks to check for compliance of full-time bracing.

At 3 months to graduate to the nights-and-naps schedule.

Until age 3 check every 4 months to monitor compliance and for relapses.

Age 3 to 4 years check every 6 months.

From 4 years until maturity check every 1 to 2 years.

Early relapses The infant shows loss of foot abduction and/or of dorsiflexion correction with recurrence of adductus and cavus.

Relapses in toddlers Check for evidence of deformity both by examining the foot with the infant on the mother's lap, and while walking. As the child walks toward the examiner, look for supination of the forefoot. Supination is due to the tibialis anterior muscle overpowering the weaker peroneals . As the child walks away from the examiner, look for heel varus . The seated child should be examined for ankle range of motion and loss of passive dorsiflexion. Check the range of motion of the subtalar and midtarsal joints. These joints should move freely. A loss of free mobility is evidence of relapse.

Reasons for relapses

The most common cause of relapse is noncompliance of the bracing program. Morcuende found that relapses occur in only 6% of compliant families and in more than 80% of noncompliant families. If relapse occurs in infants who are braced, the cause is an underlying muscle imbalance of the foot that can lead to stiffness and relapse.

Casting for relapses

At the first sign of relapse, apply one to three casts to stretch the foot out and regain correction. This cast management is the same as the original Ponseti casting program. Once the deformity is corrected by casting, start the bracing program again. Even in the child with a severe recurrence, sometimes casting is very effective.

Equinus relapse

Recurrent equinus is a deformity that can complicate management. The tibia seems to grow faster then the gastrosoleus tendon unit. The muscle is atrophic and the tendon appears long and fibrotic. Continue weekly casting until the foot can be brought to about 10˚ of dorsiflexion. If this is not achieved in 4–5 casts in children under 4 years of age repeat the percutaneous heel-cord tenotomy. Once the equinus is corrected, the nighttime bracing program is resumed.

Varus relapse

Varus heel relapses are more common than equinus relapses. They can be seen with the child standing and should be treated by re-casting in the child between age 12 and 24 months, followed by resuming of a strict bracing program.

Dynamic supination

Some children, usually between ages 3 and 4 years, with only a dynamic supination deformity will benefit from an anterior tibialis tendon transfer. This transfer is only effective if the deformity is dynamic and not fixed. The procedure is delayed until after 30 months of age when the lateral cuneiform becomes ossified. Normally, bracing is not required after the transfer.

Anterior Tibialis Tendon Transfer

Indication

Transfer is indicated if the child is more than 30 months of age and has a second relapse. Indications include persistent heel varus and forefoot supination during walking; the sole shows thickening of the lateral plantar skin.

The deformity is corrected It is made certain that all fixed deformities are corrected by two or three casts before performing the transfer. Usually cavus, adductus, and varus are corrected. Equinus may be resistant. If the foot easily dorsiflexes to 10 degrees, only transfer is needed. Otherwise a tenotomy of the heelcord is needed.

Anaesthesia, positioning and incisions The patient is put under general anesthetic and positioned supine. A high-thigh tourniquet is used.A dorsilateral incision is made centered on the lateral cuneiform. Its surface marking is a proximal projection of third metatarsal in front of the head of the talus . The dorsomedial incision is made over the insertion of the anterior tibialis tendon.

Anterior tibialis tendon is exposed and detached at its insertion. Extending the dissection too far distally is avoided to avoid injury to the growth plate of the first metatarsal.

Anchoring sutures are placed with multiple passes through the tendon to obtain secure fixation.

The tendon is transferred subcutaneously to the dorsolateral incision . The tendon remains under the retinaculum and the extensor tendons. Subcutaneous tissue is freed to allow the tendon a direct course laterally.

Lateral cuneiform is located using an X-ray.Site for transfer is identified and a drill hole (3.8–4.2) is made in the middle of the lateral cuneiform large enough to accommodate the tendon.

Sutures are thread through a straight needle on each of the securing sutures. One needle is passed into the hole. The first needle in the hole is left while passing the second needle to avoid piercing the first suture.

A heel-cord tenotomy is performed if required.

Two needles are placed through a felt pad and then through different holes in the button to secure the tendon. Tendon is secured with the foot held in dorsiflexion and the tendon is pulled into the drill hole by traction on the fixation sutures and the fixation suture tied with multiple knots.

Supplemental fixation done by suturing the tendon to the periosteum at the site where the tendon enters the cuneiform, using a heavy absorbable suture .

In neutral position without support , the foot should rest in neutral plantar flexion and neutral valgus-varus. Cast immobilization in a long-leg cast is applied with the foot abducted and dorsiflexed.

Postoperative care Usually, the patient remains hospitalized overnight. The sutures absorb. The cast is removed at 6 weeks. The child may mobilize weight-bearing as tolerated. No bracing is necessary after the procedure. The child is again seen in 6 months to assess the effect of the transfer.

PART II

Aim of the Study

The aims of the study are

1. To analyse the efficacy of Ponseti method of serial manipulation and casting in the management of Congenital Idiopathic Clubfoot.
2. To evaluate the efficacy of Ponseti method in reducing the need for corrective surgeries and its complications.
3. To compare the educational status of the parents and their compliance in bracing and follow up.
4. To analyse the usefulness of Ponseti method in Idiopathic Clubfoot in a developing country like India.

Materials & Methods

The study was carried out in patients having classical idiopathic clubfeet who were less than 5 months of age (5 to 90 days) attending the clubfoot clinic in the Department of Orthopaedics ,Coimbatore Medical College Hospital ,Coimbatore , Tamilnadu , India. Thirty two children (47 feet) were treated by the Ponseti method between June 2007 to June 2009 and followed for a period of 6mo to one year.

The cases were referred to us from paediatric wards, paediatric surgery wards and obstretics wards. Four babies manipulated and given serial casting & declared failure elsewhere, were referred for treatment. All the patients were treated on an outpatient programme. An informed consent was taken from the parents regarding management, complications & compliance. Older patients or those having non-idiopathic deformities were excluded from the study Every clubfoot under Ponseti management was “scored” each week for HS (hind-foot score), MS (mid-foot score), and G (total score). Manipulation and casting were carried out without any anaesthesia or sedation.

The general principles of the Ponseti method for manipulative correction were followed : correcting all components simultaneously, starting from pronation and leaving equinus for the last.Weekly manipulation & below-knee casts were given & extended to above-knee casts with knee in 90 degrees of flexion.These were applied for four weeks and further, as per correction achieved. Tenotomy was done when HS>1, MS<1 and after the head of the talus is covered. Before performing tenotomy, it was assured that the foot is sufficiently abducted. This was done in the operation theatre as a short day-care procedure and the patients were discharged on the same day. Just before tenotomy, the brace

measurements were taken so that by the time the patient was to be fitted with the brace it would be ready.Completion of cast treatment was determined by three factors viz 1.when after the last cast at least 30° of passive dorsiflexion was possible, 2.the foot was well corrected, and 3.the tenotomy scar was minimal.

A Dennis Brown brace was applied immediately after the last cast is removed, three weeks after tenotomy. For unilateral cases, the brace was set at 70° of external rotation on the clubfoot side, and 40° on the normal side. In bilateral cases, it was set at 70° of external rotation on each side. The bar should be of sufficient length so that the heels of the shoes are at shoulder width. The bar should be bent 5–10° with the convexity away from the child, to hold the feet in dorsiflexion. The brace should be worn full-time , day and night, for the first three months after the tenotomy cast is removed, then the brace should be worn for 12 hours at night and two to four hours in the middle of the day, for a total of 14–16 hours ie.,nights and naps protocol, during each 24-hour period. After applying the brace for the first time after the tenotomy cast was removed, the child returns according to the following schedule.

– Two weeks ….to check for compliance issues

– Three months ….to teach the nights-and-naps protocol
– Every four months until age three years ….to monitor compliance and check for relapses
– Every six months until age 4 years
– Every one to two years until skeletal maturity

At walking age, the babies wore specially designed straight last high-top lace-up shoes during daytime. Bracing & shoes were to be continued for up to four years of age.

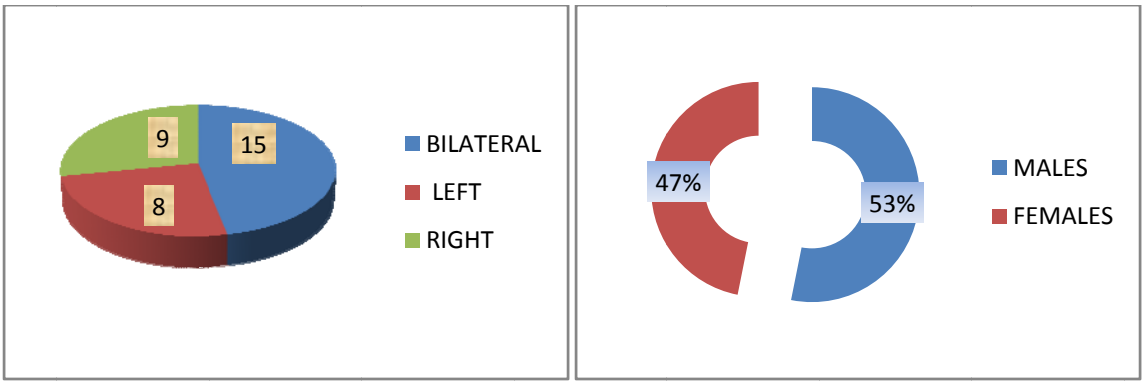
During follow-up, the relapses, if any, were treated appropriately. Equinus required repeat tenotomy, while forefoot adduction, cavus and intoeing were all treated with repeat casting. Special clubfoot clinics were organised, where patients on splints were called and used to share their experience with the new patients in casts. We maintained a good photographic record of all the patients and showed these to the new patients, which assured them about this relatively new method for them.

Achieving no correction by 9 months was considered a failure, after which surgery was planned with the parents' consent. No infections, skin necrosis, neurovascular compromise, or profuse bleeding were observed following tenotomy.

Observations & Results

A total of 47 feet [17 males (53%) and 15 females (47%)] in 32 children were treated by the Ponseti method and the results were assessed in the present series, carried out from June 2007 to June 2009 followed for a period of six to twelve months.

Fifteen children had bilateral clubfeet , nine were unilateral on right side and eight were left sided. Forty one feet (87%) were of first-born children. Forty one feet (87%) were of children born full-term.



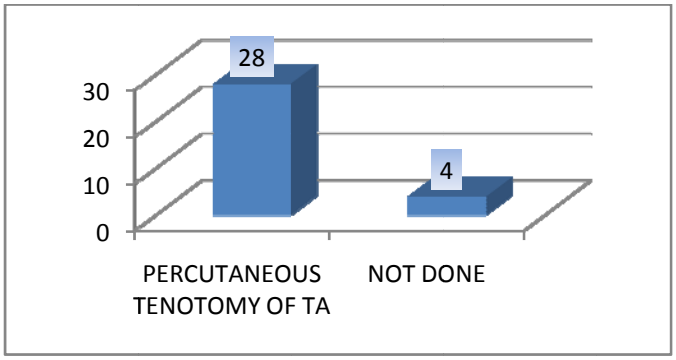
The most common associated congenital anomaly in our studies was Umblical hernia (four cases). Next common was Developmental dysplasia of hip (two cases). Internal tibial torsion was seen in one of the cases.

Twenty eight cases (87.5%) presented within six weeks. The total mean score at presentation was 3.79. The corresponding

HS(hindfoot)score and MS(midfoot)score were 1.96 and 1.83 respectively. The majority of cases (84%) required less than six casts to complete correction, with a mean of 5.3.

Pirani Score at 6 mo	Number of Cases	Percentage
0	21	65.6%
0.5	4	12.5%
1.0	3	9.3%
>2.0	4	12.5%

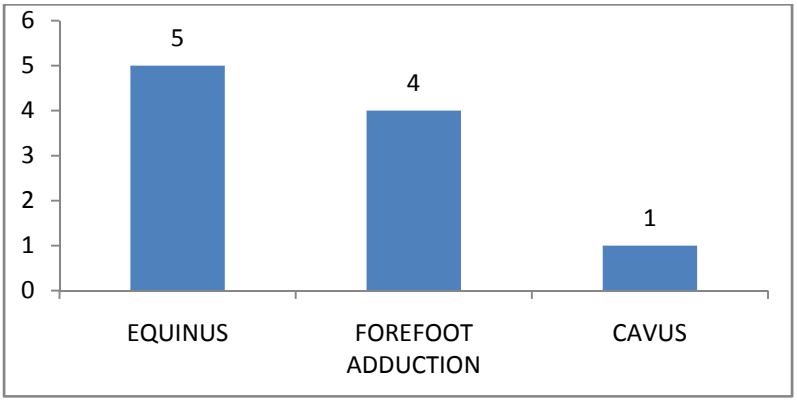
The average duration of cast application was 5.3 weeks. Tenotomy was required in 28 cases (87.5%) and most of these had Pirani scores of more than 3. The average duration of follow-up was 9 months .



Ten cases of relapses were encountered during follow-up. Of these four were forefoot adduction, five were equinus and one cavus. Equinus required repeat tenotomy, while the rest were all treated with repeat casting. Correction without surgery was obtained in twenty eight cases. Four

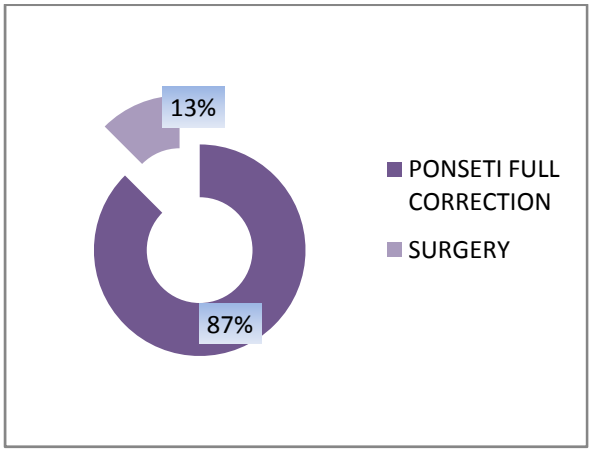
(12.5%) patients were considered failure after treatment by the Ponseti method & required corrective Posteromedial soft tissue release. Following surgery, all the four patients had Pirani score of less than 1.0. No postoperative wound infection was noted.

RELAPSES



Discussion

Clubfoot or congenital talipes equinovarus is a complex deformity of foot that requires meticulous and dedicated efforts on the part of the treating physician and parents for the correction of the deformity. In general, the treatment needs to be started as soon as possible and should be followed under close supervision. Our study demonstrates the effective use of manpower, integration with other programs and guided motivation to identify the cases and correction of the deformity in all the cases (87.5%) without surgical intervention.

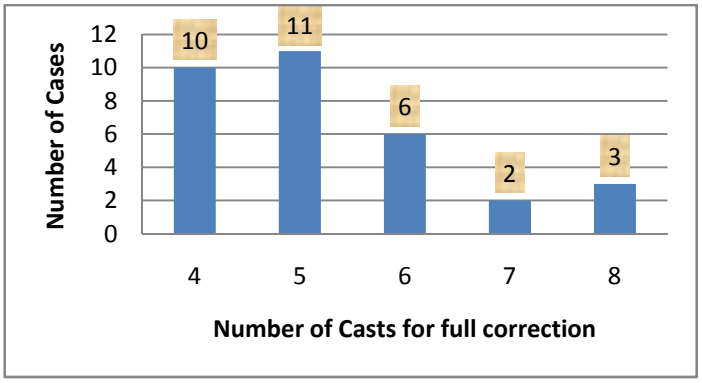


The order of birth seemed to have an influence on the occurrence of clubfoot, with 87.5% of cases in the first-born child, which is in accordance with various other studies. There was no relationship of clubfoot to the type of birth.

Of the children with clubfoot presented to us, 87.5% were within six weeks of birth, because of good inter-departmental co-ordination . We conducted special clubfoot clinics for new patients, where our old patients on night splints were made to interact with the new patient's parents and

assure them about the treatment and compliance. Results were better if this method of treatment was started as early as possible after birth.

The earliest cast applied was at an age of one day. The maximum age at which a cast was applied was at five months.



The average duration of cast application was 5.3 weeks. Those feet which required a greater number of casts in our study had a Pirani score of 6 at the onset of treatment. The duration of casts for more than 85% of feet was five weeks or less .The duration decreased over time as we mastered the technique and started getting earlier correction.Ponseti et al. reported 5–12 weeks' duration of casts (average, 9.5 weeks). In another study by Laaveg etal., the average duration was 8.6 weeks. Morcuende reported that 90% of the patients required five or fewer casts.

In our study, tenotomy was needed in 87.5% of the cases and these patients had initial Pirani score > 3.5. It shows that tenotomy was required in those patients who initially have severe deformity. Tenotomy was done when there is equinus deformity, after achieving full forefoot abduction. Pirani

carried out tenotomy in over 90% of his clubfoot patients. Laaveg et al. did tenotomy in 78% cases. In the study by Dobbs et al., tenotomy was required in 91% cases.We did not come across any complication following tenotomy.

We included those patients with follow-up of more than 6 months. Ponseti had a series with a long follow-up. The results for the current series have been very encouraging. The results of our series are comparable with other studies.

The most common relapse seen was forefoot adduction (four cases); this was due to non-compliance of the brace and also partly due to application of the brace incorrectly at home. Since most of the patients in the current study are from the lower class , educational level is low and thus they fail to understand the importance of the proper way to reapply the brace to maintain correction.

Strict instructions for the brace application, motivation, peer comparison and more frequent follow-up have led to increased compliance of the brace for these patients and early detection of any relapse. Morcuende et al.reported a 6% relapse rate in compliant patients and 80% in non-compliant patients. The underlying cause for the relapse in the compliant group was underlying muscle imbalance of the foot and ligament stiffness.

We encountered five cases of equinus relapse, which was due to brace removal by patient. This was corrected by repeat percutaneous tenotomy and application of corrective casts for three weeks. Cavus and forefoot adduction was encountered initially due to non-compliance of the brace but later on with regular follow-up and strict brace compliance these relapses were encountered less often. In the study by Morcuende et al., who used the accelerated

Ponseti protocol for clubfoot on 230 patients (319clubfeet), 36 had relapses (11.65%). Ponseti et al.reported a high incidence of relapse in their earlier studies(56%). In another study by Laaveg et al., relapse was seen in 47% (49 clubfeet).

The feet of patients compliant with the brace use remained better corrected than the feet of those patients who were not compliant. We used a Dennis Brown foot abduction brace in our study. After six months of treatment (at the time when patients were on night splints) the Pirani score had become zero for most of the patients , indicating successful correction of the clubfoot deformity.

Ponseti method of conservative clubfoot treatment is an excellent method of club foot treatment, of which there have been successful results in western countries .The follow-up of patients treated with this deformity has been over 40 years in some of these studies and these persons are leading a normal life now.

Ponseti method avoids the complications of surgery and gives a painless, mobile,normal-looking, functional foot which requires no special shoes and allows fairly good mobility. Results of the clubfoot treatment by Ponseti technique in our study have been good and rewarding and now all the clubfeet are treated in our institution by this technique only. Our study shows that managing a good referral by proper education and motivation, along with integration into other departments, improves the outcome not only in terms of age at presentation but also for deformity correction. Proper motivation and persuading the parents to accept long-term brace treatment helps maintain the correction over a longer period of time and prevents relapse.

Conclusion

The Ponseti method is a very safe, efficient treatment for the correction of Idiopathic Clubfoot that decreases the need for extensive corrective surgery and its complications. Following the principles and technical details of Ponseti method will assure optimal results in almost all patients.

Babies presenting early have an excellent chance of achieving full correction with fewer casts with or without percutanoeus tenotomy of tendoachilles. Babies of parents, who are better educated have more compliance in following instructions regarding splint and shoes application and follow up.

In a developing country like India, where there is dearth of proper operative facilities in remote areas, Ponseti technique is an easy, safe, result-oriented and economical method of Clubfoot management.

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ANNEXURES

CLINICAL PHOTOGRAPHS

CASE I - BILATERAL CTEV

AT PRESENTATION

PRE TENOTOMY

POST TENOTOMY

FULL CORRECTION

DENNIS BROWN SPLINT

CASE II - BILATERAL CTEV

AT PRESENTATION

PRE TENOTOMY

POST TENOTOMY

FULL CORRECTION

DB SPLINT

CASE III - BILATERAL CTEV

AT PRESENTATION

PRE TENOTOMY

POST TENOTOMY

FULL CORRECTION

DB SPLINT

CASE IV - LEFT CTEV

AT PRESENTATION

PRE TENOTOMY

POST TENOTOMY

FULL CORRECTION

DB SPLINT

CASE V - LEFT CTEV

AT PRESENTATION

PRE TENOTOMY

POST TENOTOMY

FULL CORRECTION

DB SPLINT

CASE VI - LEFT CTEV

AT PRESENTATION

PRE TENOTOMY

POST TENOTOMY

FULL CORRECTION

DB SPLINT

CASE VII - RIGHT CTEV

AT PRESENTATION

PRE TENOTOMY

POST TENOTOMY

FULL CORRECTION

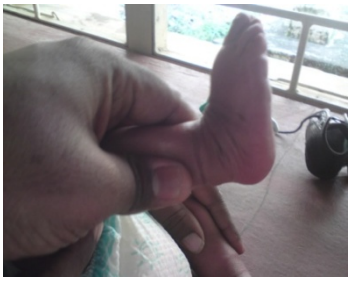
DB SPLINT

CASE VIII - RIGHT CTEV

AT PRESENTATION

PRE TENOTOMY

POST TENOTOMY



FULL CORRECTION

DB SPLINT

CASE IX - RIGHT CTEV

AT PRESENTATION

PRE TENOTOMY

POST TENOTOMY

FULL CORRECTION

DB SPLINT

CTEV BOOTS

CASE X - BILATERAL CTEV – FAILURE

AT PRESENTATION, 3 MO

AFTER 7 CASTS

BEFORE SURGERY

CASE X - CONTINUED

AFTER SURGERY

DB SPLINT

CASE XI - LEFT CTEV - FAILURE

AT PRESENTATION,5MO

AFTER 8 CASTS

BEFORE SURGERY

AFTER SURGERY

FULL CORRECTION

DB SPLINT

S. No	Name of Baby/Sex	Deli-very	Age at First Cast	Assoc-lated Dis	Parents Educ-ation	Later ality	Pirani Score		Total No Of Casts	Percuta-neous Tenot-omy	DB/ CTEV Shoes	Compl-iance	Outcome Pirani Score At 6mo	Relapse	PMR
							Mid Foot	Hind Foot							
1	B/O Mariammal FEMALE	FTND	2 Days	-	X Std	Bilat-eral	1.5	1.5	4	✓	✓	Good	0	-	-
2	B/O Komalavalli MALE	LSCS Pre-term	4 Wks	-	XII Std	Right	1.5	2	5	✓	✓	Good	0	-	-
3	B/O Vasanthi FEMALE	FTND	5 Days	-	X Std	Right	1.5	1.5	4	✓	✓	Good	0	-	-
4	B/O Amutha MALE	LSCS Full Term	1 Day	DDH	X Std	Left	2	2.5	6	---	✓	Good	0.5 equinus	PC-Teno -tomy done	-
5	B/O Valliammai FEMALE	FTND	3 Wks	-	XII Std	Right	1.5	1.5	7	✓	✓	Good	0	-	-
6	B/O Tamilarasi MALE	FT Breech	2 Wks	-	X Std	Bilat eral	2	2	4	✓	✓	Good	0.5 Forefoot adduction	POP Correc-tion	-
7	B/O Jeyamma MALE	LSCS Full Term	10 Days	Umb hernia	BSc	Right	2.5	1.5	5	✓	✓	Good	-	-	-
8	B/O Meenakshi FEMALE	FTND	4 days	-	XII Std	Left	1.5	1.5	4	---	✓	Good	-	-	-

S. No	Name of Baby/Sex	Deli-very	Age at First Cast	Associ-Ated Dis	Parents Educ-Ation	Later-ality	Pirani Score		Total No Of Casts	Percuta-neous Tenot-omy	DB/ CTEV Shoes	Compli-ance	Outcome Pirani Score A t 6mo	Relapse	PMR
							Mid Foot	Hind Foot							
9	B/O Thangam FEMALE	FTND	3 Days	Umb hernia	X Std	Left	2	2.5	4	---	✓	Good	0.5 equinus	PC-Teno-tomy done	-
10	Krithik MALE	LSCS Pre-Term	3 Mo	-	Un educa-ted	Bilat eral	2.5	3.5	7	✓	✓	Bad	3.5	-	✓
11	B/O Radha FEMALE	FTND	2 Wks	-	B Com	Right	1.5	2	5	✓	✓	Good	1.0 Equinus, Forefoot adduction	PC-Teno-tomy & POP	-
12	B/O Sundari MALE	LSCS Full Term	2 Wks	-	Un Educa-ted	Right	2	2.5	6	✓	✓	Good	-	-	-
13	B/O Saraswathi FEMALE	FT Breech	5 Wks	-	X Std	Left	1.5	2.5	6	✓	✓	Good	-	-	-
14	B/O Arulselvi MALE	FTND	2 Days	-	VI Std	Left	1.5	3	5	✓	✓	Good	-	-	-
15	B/O Gowri MALE	FTND	2 Wks	Umb hernia	V Std	Bilat eral	1.5	1.5	6	✓	✓	Good	-	-	-
16	B/O Roseline FEMALE	FTND	5 Mo	-	X Std	Left	2.5	2.5	8	✓	✓	Good	3.5	-	✓

S. No	Name of Baby/Sex	Deli-very	Age at First Cast	Associ-ated Dis	Parents Educ-ation	Later-ality	Pirani Score		Total No Of Casts	Percuta-neous Tenot-omy	DB/ CTEV Shoes	Compl-iance	Outcome Pirani Score At 6mo	Relapse	PMR
							Mid Foot	Hind Foot							
17	B/O Vasantha FEMALE	LSCS Full Term	1 Wk	-	XII Std	Right	1.5	2.5	5	✓	✓	Good	-	-	-
18	B/O Savithri MALE	LSCS Full Term	9 Days	-	V Std	Left	1.5	1.5	4	✓	✓	Bad	-	-	-
19	B/O Anbuselvi FEMALE	FT Breech	12 Days	-	VII Std	Left	2.5	1.5	4	✓	✓	Bad	3.0	-	✓
20	B/O Thilaga FEMALE	Pre Term	15 Days	-	Un Educa-ted	Bilat eral	1.5	1.5	5	✓	✓	Good	0.5 Cavus	POP Correc - tion	-
21	Paramesh MALE	FTND	4 Mo	-	VIII Std	Bilat eral	2	1.5	8	✓	✓	Good	1.0 Equinus, Forefoot adduction	PC-Teno -tomy & POP	-
22	B/O Sahaymary MALE	Pre Term	2 Wks	-	IX Std	Right	2.5	1.5	4	✓	✓	Good	-	-	-
23	B/O Jeyarani MALE	FTND	12 Days	DDH	XII Std	Bilat eral	3.5	2.5	5	✓	✓	Bad	2.5	-	✓
24	B/O Nirmala FEMALE	LSCS Full Term	5 Days	-	X Std	Bilat eral	1.5	2.5	5	✓	✓	Good	-	-	-

S. No	Name of Baby/Sex	Deli-very	Age at First Cast	Associ-Ated Dis	Parents Educ-ation	Later ality	Pirani Score		Total No Of Casts	Percuta-neous Tenot -omy	DB/ CTEV Shoes	Compl-iance	Outcome Pirani Score At 6mo	Relapse	PMR
							Mid Foot	Hind Foot							
25	B/O Jesce FEMALE	FTND	4 Wks	-	VI Std	Bilat eral	2.5	1.5	4	✓	✓	Good	-	-	-
26	B/O Selvi MALE	FTND	3 Wks	-	IX Std	Bilat eral	2	1.5	5	✓	✓	Good	-	-	-
27	Malar FEMALE	LSCS Full Term	4 Mo	Umb hernia	X Std	Bilat eral	1.5	2	8	✓	✓	Good	1.0 Equinus, Forefoot adduction	PC-Teno -tomy & POP	-
28	B/O Indrani MALE	FTND	10 Days	-	XII Std	Bilat eral	2	2.5	6	✓	✓	Good	-	-	-
29	B/O Anandhi MALE	FTND	2 Wks	-	X Std	Bilat eral	1.5	1.5	5	✓	✓	Good	-	-	-
30	B/O Kavitha MALE	FTND	15 Days	-	XII Std	Bilat eral	1.5	2.5	4	✓	✓	Bad	-	-	-
31	B/O Jothi MALE	FTND	2 Days	-	X Std	Bilat eral	2	2.5	6	---	✓	Good	-	-	-
32	B/O kamalaveni MALE	FTND	2 days	-	X Std	Right	2	2	5	✓	✓	Good	-	-	-