International Journal of Medical Science and Clinical Research
Online-ISSN: 2664-7761; Print ISSN: 2664-7753
Received: 08-10-2020; Accepted: 23-10-2020; Published: 17-11-2020
www.journalofmedical.com
Volume 2; Issue 4; 2020; Page No. 27-33

Correction of clubfoot by ponseti method: Our experience

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Abstract
Background: Congenital idiopathic clubfoot is a complex deformity which occurs in an otherwise normal child. The Ponseti method of clubfoot management has been shown to be effective, producing better results and fewer complications than traditional surgical methods. Weekly manipulation and plaster casting reduce the deformity. Most fe*et al*so require a percutaneous Achilles tenotomy. The correction is maintained by a foot abduction brace (Dennis Browne splint). Recent studies suggest that the Ponseti method can be successful in up to 98% of feet.
Objective: The purpose of this study was to assess the results of correction of idiopathic clubfoot by Ponseti method and its complications in children below 2 years of age.
Methodology: It is a prospective study in 37 children below 2years of age with idiopathic clubfoot treated by Ponseti method. The study was conducted from august 2016 to august 2018 in Yashoda Superspeciality Hospital, Hyderabad.
Observation and Analysis: The mean age of the patient's was 35 weeks (0-120). Of 37 patients, 25 children presented between 0-6 months, 6 between 6 to 12 months and 6 between 1- 2 years. Among 37 children, 29 were male and 8 were female. Most children had grade III and grade IV (Dimeglio *et al.* grading) deformity. The average number of casts was 5.1, 5.5 and 7.4 for the age groups 0-6 months, 6 months to 1 year and 1-2 years respectively. The mean number of casts required was 5.76 (4 to 10). Tenotomy was required in 51 feet (100%). The scores for the entire group ranged from 4.0 to 7.0 (of 10) and 4 to 19 (of 20) in the Dimeglio classification. Pirani scores for the age group 0- 6 months were 4.46, 6 months to 1 year were 5.36 and 1-2 years were 5.75 respectively. The results were excellent in 88.3% and good in 11.7%.The mean of initial and final Pirani score is 3.52083 with a ' p' value is 0.000 which is less than 0.01 hence they are statistically significant.
Conclusion: Congenital talipes equinovarus (C.T.E.V) is the commonest of all the foot deformities being commoner in male children and bilateral in 66% of cases, idiopathic type being the commonest form. We conclude that the Ponseti method is safe and effective treatment for congenital idiopathic clubfoot in children up to 6 years of age.

Keywords: Clubfoot, ponseti, pirani, dimeglio, dennis browne splint, achilles tenotomy

Introduction
Clubfoot is one of the commonest congenital conditions seen in orthopedic practice. It remains an unsolved problem. Though congenital talipes equinovarus (CTEV) exists from time immemorial, its etiology is unknown, pathology is complex and management is full of controversies. From the time of Hippocrates until today, the orthopedic surgeons are constantly confronted with new techniques and operations in its management. It requires judicious selection of cases and use of appropriate method of treatment. We have passed through the phase of forcible manipulation to microsurgical operative techniques and correction by external fixator. In spite of careful research, it remains a source of dissatisfaction even to the most enthusiastic surgeons.
The Ponseti technique was described in the early 1960's, but it is only in the last decade that its benefits in the early treatment of clubfoot deformity have been highlighted. Much has been said and written about the etiology of CTEV but the exact cause has not been determined until today. The etiology of talipes equinovarus deformity can be broadly classified into a) Idiopathic Clubfoot: When deformity is not associated with any other abnormalities in the body. This is the most common type. b) Non Idiopathic Clubfoot: Where the deformity is a local manifestation of systemic musculoskeletal disorder. Our study evaluates the results of idiopathic clubfoot treated conservatively by Ponseti technique.

Aims of the study
To evaluate the effectiveness of correction of clubfoot by Ponseti method.

Objectives of the study
To assess to correction of Idiopathic clubfoot by Ponseti method and to identify the complications associated with the Ponseti method.

Materials and methods
This is a prospective study conducted in 37 patients aged less than 2 yrs presented with idiopathic clubfoot, treated by Ponseti method in Yashoda Superspeciality hospital, Hyderabad Between May 2016 to April 2018. Complete history including birth history, family history and milestones

were taken. The deformity was classified according to system of Dimeglio *et al.* as Grade I, Grade II, Grade III, Grade IV. According to Pirani, clinical scoring the initial total Pirani score and the final total Pirani score of each foot was calculated. Patients were followed up clinically for a minimum of six months after completion of treatment.

Inclusion criteria

All children with idiopathic clubfoot below the age of two years were included.

Exclusion criteria

Children greater than two years of age or with any congenital anomalies were excluded.

Laboratory evaluation

Routine laboratory evaluation was done for pre-operative evaluation of all the patients. Blood investigations - Hemoglobin %, total count, differential count, blood grouping and Rh typing, bleeding time and clotting time. HIV, HCV and HBsAg.

Ethical clearance

Ethical clearance has been obtained from the ethical clearance committee of Yashoda Superspeciality hospital, Hyderabad.

Pre-operative planning

All patients were evaluated by a detailed history and clinical examination, to identify the etiology.

An assessment of all the deformities was made along with a detailed neurological status, both sensory and motor. Careful preoperative counseling of patients and parents or guardian was done with a detailed explanation of the problem, the treatment options, surgery, duration of cast application, post-operative protocol and type of orthosis. Informed written consent was taken from all the parents or guardians.

Steps in Ponseti cast application

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 [A].

Applying the padding Apply only a thin layer of cast padding [B] to make possible effective molding of the foot. Maintain the foot in the maximum corrected position by holding the toes with counter pressure applied against the head of the talus while the cast is being applied. First apply the cast below the knee and then extend the cast to the upper thigh. Begin with three to four turns around the toes [C], and then work proximally up the leg. Apply the plaster smoothly. Add a little tension [D] 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. Do not try to force correction with the plaster.

Use light pressure. Do not apply constant pressure with the thumb over the head of the talus; rather, press and release repetitively to avoid pressure sores of the skin. Mold the plaster over the head of the talus while holding the foot in the corrected position [E].

Note that the thumb of the left hand is molding over the talar head while the the right hand is molding the forefoot in supination.

The arch is well molded to avoid flatfoot or rocker-bottom deformity.

The heel is well moulded by countering the plater above the posterior tuberosity of the calcaneus.

The malleoli are well moulded. The calcaneus is never touched during the manipulation or casting. Molding should be a dynamic process; constantly move the finger to avoid excessive pressure over any single site. Continue molding while the plaster hardens. Extend cast to the thigh, use much padding at the thigh to avoid skin irritation [F].

The plaster may be layered back and forth over the anterior knee for strength [G] and for avoiding a large amount of plaster in the popliteal fossa area, which makes removal more difficult.

Trim the cast leave the plantar plaster to support the toes [H], and trim the cast dorsally to the metatarsal phalangeal joints, as marked on the cast. Leave the dorsum of all the toes free for full extension. Note the appearance of the first cast when completed [I].

The foot is in equinus, and the forefoot is fully supinated.

Fig 1: Steps of application of plaster in Ponseti s method

Cast removal

Remove each cast in clinic just before a new cast is applied. Avoid cast removal before clinic because considerable correction can be lost from the time the cast is removed until the new one is placed. Although a cast saw can be used, soak the feet in tub of water and remove the plaster. Plaster should not be removed 2 hours before the application of the next corrective cast.

Decision to perform tenotomy

A major decision point in management is determining when sufficient correction has been obtained to perform a percutaneous tenotomy to gain dorsiflexion and to complete the treatment. This point is reached when the anterior calcaneus can be abducted from underneath the talus. This abduction allows the foot to be safely dorsiflexed without crushing the talus between the calcaneus and tibia [E]. If the adequacy of abduction is uncertain, apply another cast or two to be certain.

Characteristics of adequate abduction Confirm 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 degree 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. At the completion of casting, the foot appears to be overcorrected 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 over corrected or pronated foot.

Surgical technique

Percutaneous Achilles tenotomy.

Equipment

Select a tenotomy blade such as no 11 (or) no 15.

Skin preparation

Prepare the foot 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.

Anesthesia

General anesthesia

Heel cord tenotomy

The Achilles tenotomy is done approximately 1.5 cm above the calcaneus with the foot held in maximal dorsiflexion by the assistant. Avoid cutting into the cartilage of the calcaneus. A “pop” is felt as the tendon is released. An additional 20 to 25 degrees of dorsiflexion is typically gained after the tenotomy.

Post-tenotomy cast

Apply the fifth cast with the foot abducted 60 to 70 degrees with respect to the frontal plane of the ankle. Note the extreme abduction of the foot with respect to the thigh and the overcorrected position of foot. The foot is never pronated. This cast is left in place for 3 weeks after complete correction. Cast removal after 3 weeks, the cast is removed. Note the correction. Thirty degrees of dorsiflexion is now possible, the foot is well corrected, and the operative scar is minimal. The foot is ready for bracing.

Bracing protocol

The brace is applied immediately after the last cast is removed, 3 weeks after tenotomy. The brace consists of open toe high-top 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, which 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 to16 hours during each 24-hour period. This protocol continues until the child is 3 to 4 years of age. Several types of commercially made braces are available (Dennis Brown brace, Steenbeck foot abduction brace, Mitchel brace, Gootenburg brace, Lyon brace). With some designs, the bar is permanently attached to the bottoms of the shoes. With other designs, it is removable. With some designs, the bar length is adjustable, and with others, it is fixed. Parents should be given a prescription for a brace at the time of the tenotomy. This gives them 3 weeks to organize themselves. To prevent sores and blisters caused by poorly fitting shoes.

Rationale for bracing

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 foot will gradually turn back inward, to a point typically of 10 degrees of external rotation. 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 Achilles tendon. The Ponseti manipulations combined with the percutaneous tenotomy regularly achieve an excellent

result. However, without a Diligent follow-up bracing program, relapse and relapse occur 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

Occasionally, a child will develop excessive heel valgus and external tibial torsion while using the brace. In such instances, the physician should dial the external rotation of the shoes on the bar from approximately 70 degrees to 40 degrees. There is no scientific answer to this question. Severe feet should be braced until age 4 years, and mild feet can be braced until age 2 years.

It is not always easy to distinguish which foot is mild and which is severe, especially when observing them at age 2 years. Therefore, it is recommended that even the mild feet should be braced for up to 3 to 4 years, provided the child still tolerates the night time bracing. Most children get used to the bracing, and it becomes part of their life style. However, if compliance becomes very problematic after age 2 years, it may become necessary to discontinue the bracing to ensure that the child and parents get a good night's sleep. This leniency is not tolerable in the younger age groups. Below age 2 years, the children and their families must be encouraged to comply with the bracing protocol.

Protocol of treatment

We used the protocol described by Ponseti that was started as soon as possible after birth. Simultaneous correction of cavus, forefoot adduction and heel varus (except equinus) followed Ponseti's technique with initial manipulation and immobilization in an above knee plaster cast at weekly intervals for four to 12 weeks.

Tenotomy of tendoachilles was performed, if necessary, under general anesthesia in the operating theatre and not, as described by Ponseti, under local anesthesia as an outpatient procedure. This was followed by the use of a foot abduction orthosis (Denis Browne splint) with 70˚ of external rotation on the affected side and 40˚ of external rotation on the normal side. The brace was used on a full-time basis for three months followed by night- and nap time use for up to four years. In all the patient's cavus was corrected first by supinating the forefoot and dorsiflexing the first metatarsal.

To correct the varus and adduction, the foot in supination was abducted while counter pressure was applied with the thumb against the head of the talus. Casts were changed every week after proper manipulation of the foot until correction was achieved. If residual deformity is observed after adduction of the foot and varus deformity of the heel has been corrected, a simple percutaneous tenotomy of the Achilles was done under local or short general anesthesia. After tenotomy, a cast was applied and left in place for three weeks for Achilles to regenerate. Dennis- Browne splint was used to prevent relapse of the deformity.

The brace was fitted on the same day as the last cast was removed. We used well fitted, open toed, high top, straight last shoes attached to Dennis- Browne bar of length equal to the distance between the child's shoulders. The corrected foot was maintained in 70 degrees of external rotation with ankle dorsiflexion.

The normal foot in a unilateral deformity was placed in 40 degrees of external rotation. The brace is worn for 23hrs a day for the first three months and then for 16hrs a day up to 4 years of age. The patients were followed up on a weekly basis during the initial stages of treatment. After the brace was applied, patients were seen on a monthly basis for three months and then once every three months till the child is 4 years of age.

The patient was also followed up every 6 months to 1year until skeletal maturity is achieved. During each follow up, we analyzed the functional status of foot, checked for any recurrences, and advised about the strict bracing protocol. The parents were asked to remove the casts before coming making sure the time interval between cast removal and application is within 2- 21/2 hours. The children coming from far off places casts were removed in OPD.

Follow Up

Patients were followed up for a minimum period of 6 months after application of the cast. During each follow up, the patients were assessed clinically about recurrence of deformity. The presence of any complications was also looked for.

Evaluation of results

Each foot was evaluated cosmetically, functionally and rated according to the following criteria:-

A. Excellent
1. Complete correction of all components of the deformity
2. Plantigrade cosmetically acceptable foot
3. Pliable subtalar motion
4. Dorsiflexion equal to the normal side or above the right angle in bilateral deformities

B. Good
1. Complete correction of all components of deformity
2. Fully plantigrade and mobile foot with a minor degree of persistent metatarsus adductus

C. Fair
1. Plantigrade and functionally acceptable foot
2. Cosmetically less acceptable
3. Some loss of initial correction, which is correctable by re manipulation and casting

D. Poor
1. Loss of correction and recurrence of the deformity which requires soft tissue release.

3. Results

In present series, we have treated 37 children with idiopathic clubfoot by Ponseti method of correction of serial manipulation and casting. The mean age of the patients was 35 weeks (0-120). Of 37 patients 25 children presented between 0-6 months, 6 between 6 to 12 months and 6 between 1- 2 years. Among the 37 children, 23 had unilateral and 14 bilateral involvement. Among 37 children, 29 were male and 8 were females. Most patients had grade IV and grade III deformity. The average number of casts was 5.1, 5.5 and 7.4 for the age groups 0-6 months, 6 months to 1 year and 1-2 years respectively. The mean number of casts required was 5.76 (4 to 10).

Tenotomy was required in 51 feet (100%). The scores for the

entire group ranged from 4.0 to 7.0 (of 10) and 4 to 19 (of 20) in the Dimeglio classification. By using, the 10- point Pirani scoring system we calculated the average Pirani score for the age group 0- 6 months is 4.46, 6 months to 1 year is 5.36 and 1-2 years is 5.75.

There is correlation between the initial Pirani score and number of casts required for the correction which showed increase in number of casts as the score increased. For 20–point Dimeglio scoring there were 3 children with grade II (5.8%), grade III were 16 (32.3%), grade IV 32 (62.7%). The average Dimeglio score was 3.375, 3.7, and 4 for the age groups 0-6 months, 6 months- 1 year and 1-2 years of age. None of the feet required extensive soft tissue release. In 4 of our feet there was a relapse of the deformity.

Three of them required repeat plasters and Achilles tenotomy. One patient underwent lateralization of tibialis anterior tendon. One patient had plastic deformity distal tibia, which was treated by immobilization by above knee cast for three-weeks.

This patient was lost for follow- up. Three children had pressure sores over the neck of the navicular, which healed subsequently. The results were excellent in 88.3% and good in 11.7%.The mean of initial and final Pirani score is 3.52083 with a ‘ p’ value is 0.000 which is less than 0.01 hence they are statistically significant.

Table 1: Dimeglio Grade vs Number of Feet

Dimeglio Grade	Number of Feet	Percentage
I	0	0.0
II	3	5.8
III	16	32.3
IV	32	62.7

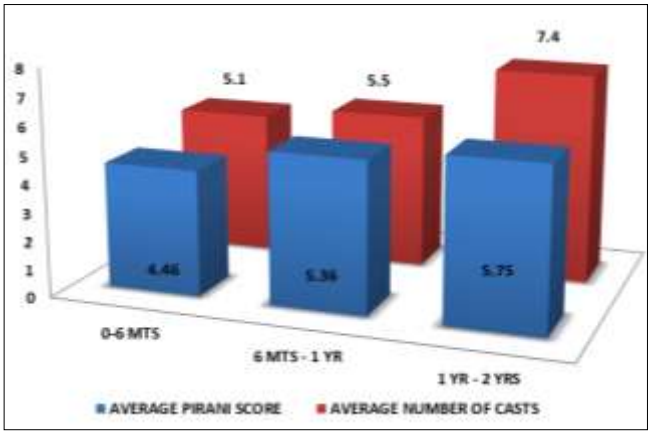

Fig 2: Average Pirani Score Vs Average Number of Casts

Table 2: Results

Results	Number of foot	Percentage
Excellent	45	88.3
Good	06	11.7
FAIR	00	0.0
Poor	00	0.0

Fig 3: Results

Table 4: Standard Deviation

	N	Mean Age	STD Deviation	Minimum	Maximum
Pirani Scoring Baseline	51	3.56	0.616	2	4
Pirani Scoring Final	51	0.0417	0.140	0	0.5

Table 5: Paired Difference and ‘P’ Value

	Paired Difference			T	DF	‘P’ Value
	Mean	SD	Se of Mean			
Pirani Scoring Baseline – Pirani Scoring Final	3.52083	0.60105	0.08675	40.584	47	0.000

4. Discussion

Congenital talipes equinovarus is the commonest of all the deformities forming about 80 % of the cases. Its incidence is about 1 in every 1000 live births being commoner in India, when compared to western countries. The condition is bilateral in about 66% of cases being commoner in males. Idiopathic being the commonest type. In 1948, Ponseti proposed reducing the deformity with successive casts. Although treatment with cast is a very old method, Ponseti’s method is based on strict rules established from anatomic evidence. The goal is not to correct the apparent deformation, but on the contrary, to impose a simultaneous supination and abduction of the foot. Once the calcaneopedal block has been derotated, percutaneous tenotomy of Achilles is performed. Extensive open surgery like posteromedial release is commonly associated with long-term stiffness and weakness, which is avoided by the Ponseti technique. Ponseti reported that open surgery is avoided in 89% of cases by this technique of manipulation, casting and limited surgery. Correction of heal varus and increased declination angle of neck of the talus are better in a clubfoot treated by Ponseti method of management as compared to traditional casting methods. Posteromedial soft-tissue release was avoided in 81% of our cases, but percutaneous tenotomy was required in 85%.

Ponseti reported transfer of Tibialis anterior tendon occurring in 35% of his patients older than 2.5 years. The most recent experience reported by Ponseti's group11 suggests a rate of relapse of 10%. The reduction in the rate of relapse was attributed to an increased emphasis on the need for careful follow-up treatment with the foot abduction orthosis. Tenotomy of the Achilles tendon is an integral part of Ponseti's technique for the treatment of clubfeet. In our series we have excellent results in 45 (88.3%) and good in 6 (11.7%) children using Ponseti method. Recurrent equinus in four feet required a second percutaneous tenotomy of tendoachilles due to non-compliance with the abduction brace. This reason has widely been accepted to be the main factor causing failure of technique. One child required transfer of Tibialis anterior tendon to medial cuneiform. Three children presented with recurrence of metatarsus adductus who required plaster application for 3 weeks followed by application of Denis Browne splint. All children required Achilles tenotomy to correct eqinus. In most cases, we believe that the cause of the relapse was related to a lack of compliance in the application of the Denis Browne splint. Many parents reported difficulty in keeping the foot/feet in this splint. Some found it difficult to apply the splint single-handed and others reported that their child was unable to kick the legs freely and was unable to roll over in bed with the feet in the splint. These problems caused frustration in the family and often-sleepless nights leading to poor compliance. In four children, recurrence was seen due to non-compliance with the abduction brace, which was corrected by reapplication of plaster and Achilles tenotomy in three and tibialis anterior tendon transfer in one child. Thacker *et al.* 14 reiterated the fact that compliance with the foot-abduction orthosis is essential for the success of the Ponseti technique. Another complication noted was shoe breakage in 6 children in older age group with mothers complaining of the child trying to stand on the splint. This has also caused straightening of the rod which resulted in loss of maintenance of reduction. One patient had plastic deformity distal third tibia, which was treated by immobilization of cast for three weeks. This was the complication seen during our early phase of treatment this child was lost for follow- up. Three children had pressure sores, which healed subsequently. Another complication was removal of the plaster at home by the parents as the child could not sleep during the initial phase of treatment which was overcome by counseling of the parents. None of them had complications such as swelling of toes, bruising of feet, skin necrosis, neurovascular injury, and plaster loosening were seen. Dobbs *et al.* reported bleeding complications after percutaneous tenotomy for congenital clubfoot and in our series, damage to neurovascular structures occurred in one child. This was managed by open exploration, ligation of the artery and primary repair of the nerve. We did not encounter any complications after tenotomy. In all children, the deformity was corrected avoiding the need for posteromedial soft-tissue release. The average initial Pirani score was 5.10 and the final total Pirani score was 0.54. The average initial Pirani score for the ages 0-6 months, 6 months-1 year and 1-2 years was 4.46, 5.36 and5.75 respectively. The most striking finding is a strong link between the initial Pirani score and the duration of treatment shown, this is the best evidence yet that a more deformed foot requires greater intervention.10. All wore normal shoes, did not complain of pain, were able to walk without a limp, and participated in the normal activities of daily living. Both the children and their parents were satisfied with the result of treatment.

5. Conclusion

Congenital talipes equinovarus (C.T.E.V) is the commonest of all the foot deformities being commoner in male children and bilateral in 66% of cases, idiopathic type being the commonest form. The Ponseti method is safe and effective for treatment for congenital idiopathic clubfoot in children up to 6 years of age. This technique can also be used in relapses. This method reduces the need for extensive corrective surgery, which are associated with complications. Although the foot looks better after surgery, it is stiff, weak, and often painful. After adolescence, pain increases and often becomes crippling. Ponseti method is economical and easy on babies, when well implemented, it will greatly decrease the number of clubfoot cripples. We have seen that correction started earlier required less number of casts. Our initial experience with the use of the Ponseti method suggests that it is a simple and effective method of treating congenital idiopathic clubfoot. We have also found the Pirani scoring system to be practicable, reproducible and helpful in the management of idiopathic clubfeet by the Ponseti method in the assessment of initial and final Pirani score and the final outcome. We conclude that Ponseti method is an easy, effective, efficient and economical mode of management of congenital idiopathic clubfoot.

6. Summary

Congenital talipes equinovarus is the commonest of all the deformities forming about 80 % of the cases. Idiopathic clubfoot is the commonest of all the deformities forming about 80 % of the cases. The treatment of severe deformities has been a challenge over the years with poor results. The Ponseti method of treatment has changed the face of Orthopedics and assessment of this method in the treatment of idiopathic clubfoot was the objective of this study. The results show that this method is effective in the treatment of severe, recurrent and complex deformities. Many complications can be anticipated and prevented, or treated with the same method. Our results are comparable with the results worldwide. This method should be the recommended method in the correction of idiopathic clubfoot as a first mode of treatment

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