

Approach To A Clubfoot Deformity Patient: Ponseti Management

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Abstract

Clubfoot is among the most common congenital foot deformities, needing correction, which when left untreated can cause severe cosmetic, functional and social issues. Ponseti method has revolutionized the treatment in favour of nonsurgical serial manipulation and casting. Simultaneous correction of cavus, adductus, and varus followed by correction of equinus by percutaneous tenotomy can be achieved in mean 5 weeks. It is based on sound understanding of the functional anatomy of foot (synchronous movements of the tarsal bones at subtalar joint to unlock the deformity) and biological response of young connective tissue and bone to change in direction of mechanical stimuli which can gradually reduce or almost eliminate deformities of clubfeet. This review article describes, approach to a clubfoot patient, its features, classification, assessment, ponseti method of manipulation and casting and errors of treatment and their management. Aim of this review article is to compile the important information pertaining to clubfoot management which will be useful for the basic orthopaedic surgeon in their clinical practice and for post-graduate students.

Keywords: Club foot, Ponseti method, Manipulation and Casting

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Introduction

Clubfoot is the most common deformity of the bones and joints in new-borns. It occurs in about 1 in 1,000 live births. The chances of having a second child with a clubfoot are approximately 1 in 30. The cause of clubfoot is not exactly known, but it is most likely a genetic disorder with combination of unidentified environmental factors. Boys are affected three times more than girls. Clubfoot is bilateral in about half of the cases [1, 2].

Approach towards a clubfoot patient:

Assessment (diagnosis, classification and grading) At the first consultation in the clubfoot clinic, perform a complete history, visual foot inspection, general and musculoskeletal physical examination. Examine the cardiovascular, respiratory, gastro-intestinal, genito-urinary, and central

nervous systems as well as the spine, upper extremities, hips, and feet to rule out other associated congenital abnormalities such as spina bifida (an open spinal cord), or arthrogyrosis (multiple joint contractures) which suggest a syndrome. Then make a diagnosis of clubfoot, classify its type, and assess the severity of deformity by pirani score. This information helps to guide treatment and reassure parents about the treatment plans [1,4,18].

Diagnosis of clubfoot Congenital club foot has four components (CAVE) [1, 4, 18] (fig. 1):

- Cavus** – increased medial longitudinal arch.
- Adductus** - distal foot is deviated medially due to medial displacement of tarsal bones particularly navicular articulating only with medial part of the talar head, leaving lateral part of the talar head uncovered.

- c. **Varus** -hindfoot is deviated towards the midline, as appreciated by looking from back due to adduction and inversion of calcaneum under the talus.
- d. **Equinus** - severely plantarflexed foot.

Fig 1. Clinical photograph of CTEV child showing cavus (a), adductus (b), inversion (c) & equinus (d) (Drawn from Pirani S. Naddumba E. In: Staheli's Ponseti club foot management. Teaching manual for healthcare providers. 2008;1:1-48)



Classification for clubfoot [1,4,18]

- a. **Positional**—due to intrauterine crowding foot is pushed or squeezed to one side and at birth looks like clubfoot, but is more flexible. They get better quickly after birth and do-not require treatment and prognosis is excellent.
- b. **Congenital idiopathic (typical)** – most common type, only feet are affected and no other major abnormalities are present. It generally corrects in five casts and long-term outcomes are usually good or excellent.
- c. **Syndromic** - clubfoot is part of a syndrome and other body parts are involved or other congenital abnormalities are also present. Ponseti's method is still the standard care but is more difficult, longer and unpredictable. Management of other deformities may complicate and determine the clubfoot management.

Grading by PiraniClubfoot Score[20]

It measures the deformity in clubfoot by changes in severity of six clinical signs, each

scored as 0 (normal), 0.5 (mildly abnormal) or 1 (severely abnormal). It should be done for each clubfoot at every visit and recorded. It helps to assess the deformity objectively; correction achieved and indicates the time for need of Achilles tenotomy to correct the hindfoot pathology.

(A) **Mid foot score (MS)** – It measures the midfoot deformity and is sum of medial crease, curved lateral border and lateral head of talus. Values can range from 0 (no deformity) to 3 (severe deformity).

(i) **Medial Crease (MC)** - Normal arch displaying multiple fine skin lines is score 0. Mild medial contracture with one or two deeper creases that do not alter the arch's contour is score 0.5. A single deep crease indenting the arch's contour suggests severe medial/plantar contracture scores 1.

(ii) **Curved lateral border (CLB)** Normal foot with straight lateral border is score 0. Mild lateral curve with border at metatarsal is score 0.5. Lateral border that curves at calcaneocuboid joint scores 1.

(iii) **Lateral Head of Talus (LHT)** Uncovered talar head is estimated by abducting the deformed foot & palpating the talar head with thumb. Normally, abduction reduces the navicular completely to talar head which is no longer palpable and scores 0. With medial contracture, navicular does not fully cover over the talar head & is partially covers but remains somewhat palpable & scores 0.5. A talar head that does not cover at all & remains easily palpable scores 1.

(B) **Hind foot Score (HS)** – It measures hindfoot deformity and is sum of posterior crease, rigidity of equinus and emptiness of heel. Values can range from 0 (no deformity) to 3 (severe deformity).

(i) **Posterior Crease (PC)** Normal posterior ankle skin shows multiple fine creases and scores 0. Posterior heel with one or two deeper creases scores 0.5. Single deep crease changing the contour of heel scores 1.

(ii) **Rigid Equinus (RE)** Normal ankle extends at least 15° beyond neutral & scores 0. Ankle extension only to neutral scores 0.5. Extension short of neutral scores 1.

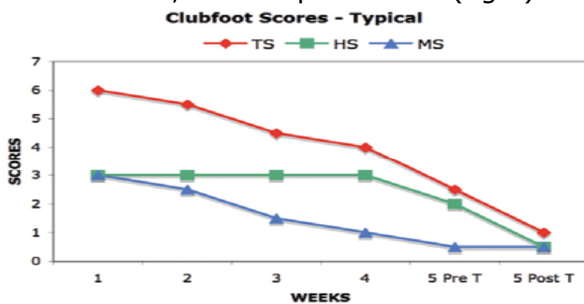
(iii) **Empty Heel (EH)** Normally calcaneus is palpable in extended ankle at heel and scores 0. A calcaneus that is palpable only

deeply scores 0.5 and a calcaneus that is not palpable scores 1.

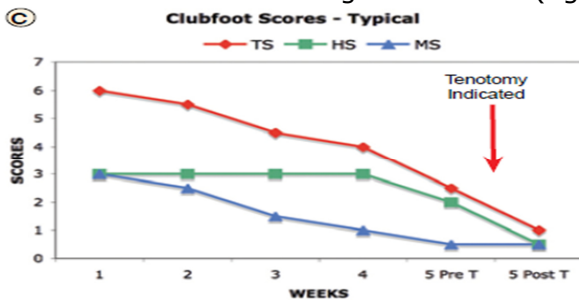
(C) **Total Score (TS)** - This is the sum of the HS and MS and indicates the amount of deformity overall. Values can range from 0 (no deformity) to 6 (severe deformity).

Pirani Score Assessment [4,20]

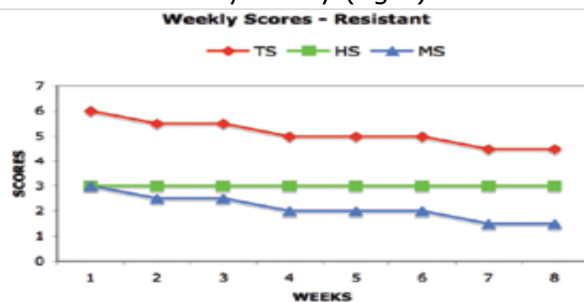
a. **Typical clubfoot**- initially has HS of 3 and MS of 3 (TS of 6), which at 2 to 4 weeks shows decreased MS but same HS i.e. at this time midfoot pathology is corrected (MS < 1) but hindfoot pathology persists (HS > 1). At this stage, Achilles tendon tenotomy is performed to correct hindfoot pathology and after tenotomy HS improved to 0.5, MS remained 0.5, & TS improved to 1 (fig 2).



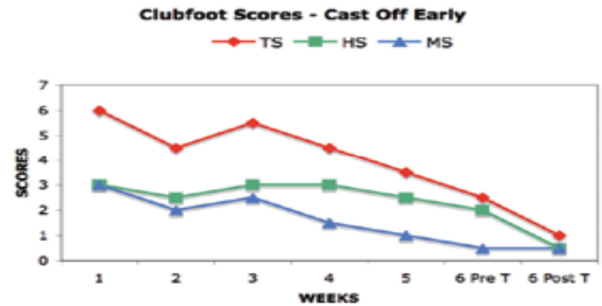
b. **Indication of Achilliestenotomy** - MS is 1 or less and HS is greater than 1 (fig 3).



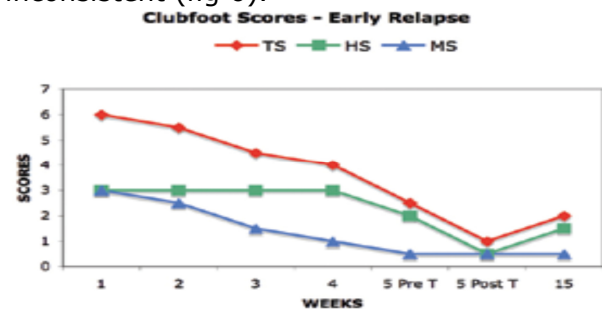
c. **Resistant clubfoot** - All scores drop or normalizes very slowly (fig 4).



d. **Cast removal early** - Scores rebound up during cast treatment if casts are removed before the clinic visit (fig 5).



e. **Early relapse**-Scores rebound up during brace treatment if bracing is inconsistent (fig 6).



History of Clubfoot Management

Treatment has been variable and controversial depending on the era [2,4].

a. **Early treatment** - First treatment was given by Hippocrates, who recognized the importance of starting the treatment early, before the bony deformity occurs [1,4]. William Cheselden at St. Thomas's Hospital, London was first to apply cast made of egg-white-soaked bandages. In 1820's Delpach, Stomeyer and Little were first to do Achilles tenotomy. Plaster of Paris casts were first used by M. Guerin in 1833. William Adams was pioneer to describe clubfoot pathology after dissecting stillborns [1,4]. In 1930, Kite advocated good correction by sequentially correcting the clubfoot deformity, but it took prolonged correction time (average 22 months) as it failed to take advantage of synchronous movements of tarsal bones at subtalar joint [5].

b. **Surgical methods** - Advent of antiseptics, anaesthesia and surgical tourniquet permitted surgical correction of deformity. In 1890, Extensive postero-medial releases were developed by Phelps, Duval, Ogston, and others. But in 1950, Steindler showed poor results (painful & stiff foot) in more

than 50% of surgical cases, leading to a reappraisal of nonsurgical methods [4,6,7].

- c. **Ponseti method** - With advent of Ponseti method in 1990s, without doubt, the primary treatment of CTEV has remarkably shifted to Ponseti method all over the world [8-11].

Rational of Ponseti method

Ponseti's treatment is based on sound understanding of the functional anatomy of foot and biological response of young connective tissue and bone to change in direction of mechanical stimuli which can simultaneously correct cavus, adductus, and varus followed by correction of equinus, in mean duration of 5 weeks. He took advantage of synchronous movements of the tarsal bones at subtalar joint to unlock the deformity [4,12,13].

Patho-anatomy, biology and kinematic coupling by Ponseti

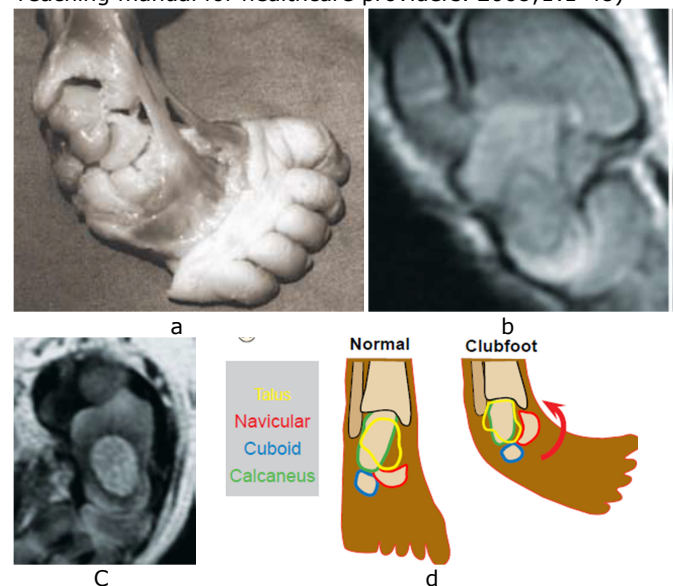
In 1966, with dissection of stillborn club feet, Ponseti revealed abnormalities in tarsal bones, tendons and ligaments, posteriorly and medially and abnormal intertarsal relationships, particularly navicular (fig 7). Muscles of the foot and leg were smaller, thick and taut than normal. According to him CTEV foot, fails to pronate, because the calcaneum cannot abduct, evert and dorsiflex, as it is locked under the talus in adducted, flexed and supinated position [13,14].

The bones of the new-born's foot are cartilaginous, which are less rigid and more easily moulded by external forces. Ponseti showed on MRI that this cartilage and young growing connective tissue (tendons and ligaments) responds biologically to low load tensions exerted by his manipulation and casting technique that stretches the contractures and remodels the abnormal tarsal cartilage [4,14-18].

He also analysed tarsal bone movements in normal and clubfeet and explained the kinematic coupling of tarsal bone movement by cine-radiographic studies that **Calcaneal adduction** is accompanied by inversion and flexion of the calcaneus and **Calcaneal**

abduction is accompanied by eversion and extension. He used this for CTEV correction stating that, simultaneous calcaneal inversion or varus will correct only if it is abducted. To do so, he advised to abduct the forefoot with counter pressure against the head of the talus. This causes the calcaneus to abduct. As calcaneus abducts, subtalar motion interdependencies ensure simultaneous eversion and dorsiflexion. The clinical deformities of midfoot adduction, heel varus and equinus arising from calcaneal plantarflexion are therefore corrected together. It is very important not to touch the heel or block the cuboid from abducting because this blocks normal subtalar motion. Calcaneal dorsiflexion occurs mainly during terminal abduction. Therefore, a clubfoot is not adequately corrected until full abduction i.e. more than 70° abduction is obtained [4,14-18].

Fig 7. Dissection (a) MRI section (b and c) of stillborn & illustration (d) of clubfoot showing tarsal abnormalities & abnormal intertarsal relationships (Drawn from Pirani S. Naddumba E. In: Staheli's Ponseti club foot management. Teaching manual for healthcare providers. 2008;1:1-48)



Acceptance of Ponseti Method

Ponseti performed clinical trials of his technique of manipulation and casting on several occasions (1963, 1972, 1980, 1992), but since the pathology and biology was poorly understood by clinicians, they did not adopt his method. Further his reports were not given due credit because they were not read accurately. It was only in 21st century that his technique was widely accepted, because of

very satisfactory long-term outcomes by independent observers, documented clinical proven effectiveness, MRI proven studies, parent demand of non-surgical treatment and re-emphasis on technical aspects along with clarification of common errors. It is universally accepted now that best treatment for clubfeet regardless of cost is Ponseti Method [8-11].

Ponseti manipulation and casting [1,4,18,21,22]

The foot is most receptive at or within a few weeks after the birth for Ponseti treatment by straightening the clubfoot by gently pushing the foot towards the correct position and retaining the corrected position applying a holding cast. Hence treatment should be started earliest. Cast (average 5 to 7 casts) are changed weekly or biweekly with additional corrections added at each visit. Correction is completed by a small cut just above the heel before the final cast, followed by bracing until 4 years of age to prevent relapse.

- Attitude** – Be kind, sensitive and reassure the parents making them understand overview of management and the importance of each step.
- Position** - Casting requires two skilled persons – a manipulator and an assistant along with the mother to hold the infant in her lap. All should be seated, with manipulator sitting laterally and assistant medially, with respect to affected foot, both facing the foot.
- Manipulation and casting** - The manipulator manipulates the foot to correct the deformity as much as possible without hurting the infant to stretch medial and plantar soft tissues. To do this, the manipulator's left hand moves up the leg and correction is maintained by gentle left thumb pressure over the upper leg. The manipulator's right hand continues holding the forefoot in the corrected position by applying some pressure to the talar head laterally and the assistant applies the padding and the cast over the foot and leg beginning from toes to knee (fig 8). If the child is at discomfort, then slow down, reduce pressure and allow child to calm.

Correction of deformities [1,4,18,21,22] (fig 8)

Correct cavus (first cast) - Cavus is due to pronation of the forefoot in relation to the hindfoot, which is supple in new-borns. Elevating the first metatarsal for about 30 seconds to stretch the plantar tissues and supinating the forefoot by the manipulators right hand will correct the cavus restoring normal longitudinal arch aligning it with the hindfoot, this is followed by abducting the foot. Cast 1 corrects cavus and can correct some adduction, which is necessary before correcting the adductus and varus.

Fig. 8. Ponseti's manipulation showing cavus correction by supination (a) & correction of adduction & inversion by abduction and counterpress at talar head for 2nd to 4th cast (b) and application of cast (c), moulding (d) and final photo after cast (e). (Drawn from Pirani S, Naddumba E. In: Staheli's Ponseti club foot management. Teaching manual for healthcare providers. 2008;1:1-48)



Correct adduction & heel varus (2nd to 4th cast) - Forefoot adduction is due to medial displacement of navicular on talar head and cuboid on calcaneus. Heel varus is due to adducted and inverted calcaneus under the talus. Both deformities are corrected by manipulating and casting the supinated foot gradually into full abduction, by holding the entire foot in gradually increasing abduction and pressing the lateral talar head with thumb with casts 2, 3 and 4. For identification of talar head, palpate the lateral malleolus with thumb and then slide the thumb forward 1 to 1.5 cm to palpate the head of the talus. Heel varus and adduction will correct simultaneously when the entire foot is fully abducted.

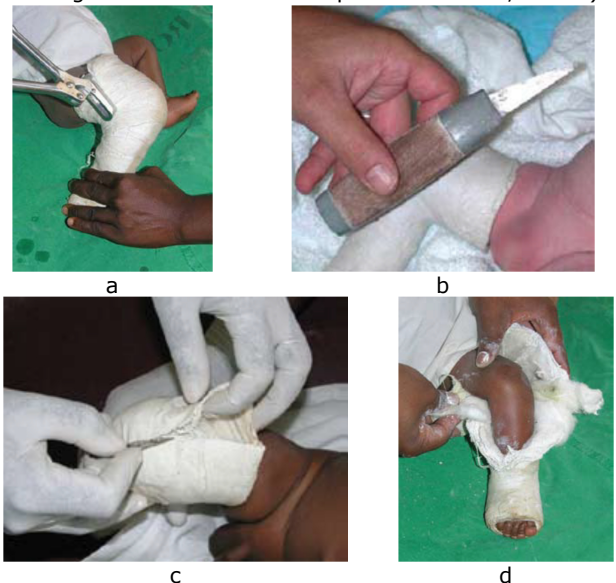
Correct equinus (5th cast) after achieving 70° abduction start correcting equinus by dorsiflexion of foot or it may need percutaneous tenotomy of the tendoachillies. Full abduction correction can usually be achieved with cast 5.

- d. **Moulding** – The manipulator stabilizes the knee and holds foot in corrected position while the assistant moulds the cast by his left hand at the arches and bony prominences and right hand give counterpressure. The assistant's hands and fingers move continuously to reduce the risk of pressure sores while the plaster sets. Moulding causes the cast to fit snugly, gives appearance of the foot and prevents slippage, pressure sore or secondary deformity.
- e. **Above knee extension** –Once lower section is set, the cast is extended above the flexed knee (90 degrees) to avoid the possibility of the cast slipping off the leg.
- f. **Trimming** – The child is cleaned and cast is trimmed to remove excess plaster to leave the toes uncrowded but supported [H].
- g. **Instruction**–Parents are reassured, encouraged and asked to regularly observe toes for change colour/swell, swelling, baby cries, or not feeding or the cast gets wet. In case, this happens instruct them to revisit or soak the cast and remove it immediately.
- h. **Cast removal** - Casts should be removed in clinics just before a new cast is applied else correction can be lost from the time the cast is removed until the new one is placed. Initially soak the cast in water for about 20 min, then softened cast can be removed by unrolling the plaster (easiest if end knob is found), by plaster shear blade, plaster knife or scalpel cutting obliquely. Electric cast saw are not recommended. Start cutting from anterior or lateral side of groin moving downward cutting only cast not the padding, removing first above knee part followed by below knee part (fig 9).
- i. **Cast appearance** – With each cast foot shows improvement and progressively abducts 20° each time. After 4th cast, full cavus, adductus, and varus correction is

seen. Equinus also gradually improves because the calcaneus dorsiflexes as it abducts under the talus so no direct equinus correction is required, but it may require a percutaneous tenotomy of the achilles tendon. Attempted dorsiflexion against tight tendo-achilles causes a rocker bottom foot deformity.

- j. **Complications of casting** – superficial and deep pressure sores can occur specially at talar head or heel. **Superficial sores** are managed by applying a dressing and a new cast with additional padding. **Deep sores** are dressed and left out of the cast for one week to allow healing and after healing Casting is resumed.

Fig 9. Clinical photos showing cast removal by plaster cutter (a), knife and blade (b), initially removing above knee and then below knee (c & d). (Drawn from Pirani S. Naddumba E. In: Staheli's Ponseti club foot management. Teaching manual for healthcare providers. 2008;1:1-48)



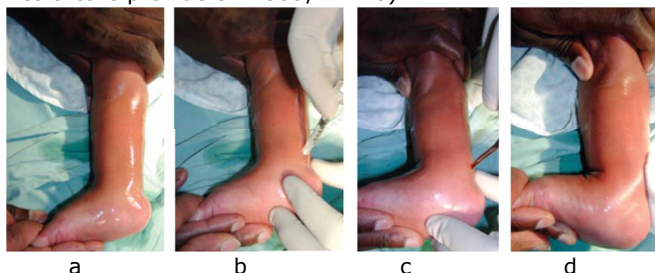
Step 3 – Achilles tenotomy

Tenotomy is done to correct equinus when cavus, adductus, and varus are fully corrected but ankle dorsiflexion remains less than 10° above neutral. It is only a small cut just above the heel before the final cast not an extensive surgery, which can be done in the clinic under local anaesthetic (fig 10) [1,4,18,21,22].

- a. **Indication** - There are two ways to tell if tenotomy is indicated. Firstly, clubfoot is sufficiently corrected to proceed with tenotomy when the anterior calcaneus is abducted away from under the anterior

talus and with sufficient abduction of 70° , the talar head becomes unpalpable laterally. Secondly, tenotomy is indicated when the Midfoot Score is one or less and the Hind foot Score is more than one (the Lateral Head of Talus Sign should be zero).

Fig 10. Clinical photographs showing steps of tenotomy (a to d) (Drawn from Pirani S. Naddumba E. In: Staheli's Ponseti club foot management. Teaching manual for healthcare providers. 2008;1:1-48)



b. **Position** – The baby is placed at the end of the examination table with surgeon at the feet, and the assistant to the ipsilateral side. With one hand, the assistant holds the limb firmly at the knee, holding the knee straight. The other hand dorsiflexes the foot to stretch the achilles tendon.

c. **Preparation and anaesthesia** - The surgeon preps the foot thoroughly from midcalf to midfoot with an antiseptic and then palpates the spot where the tendon feels most prominent, usually about one to one and a half centimetres above the calcaneus, and infiltrating a small amount of local anaesthetic just medial to this point. Be aware that too much local anaesthetic makes palpation of the tendon difficult and the procedure more complicated.

d. **Technique of Heel cord tenotomy** - Insert the tip of the scalpel blade from the medial side, directed immediately anterior to the tendon. Keep the flat part of the blade 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 blade is then rotated, so that its sharp edge is directed posteriorly towards the tendon. The blade is then moved a little posteriorly and a "pop" is felt as the sharp edge releases the tendon. The tendon is not cut completely unless a "pop" is

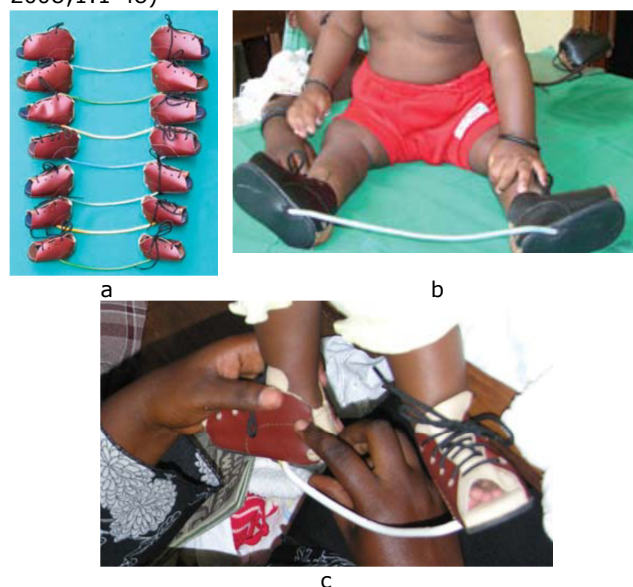
appreciated. An additional 15° to 20° of dorsiflexion is typically gained after the tenotomy. A small amount of bleeding is normal. A piece of clean gauze is placed over the incision and above-knee plaster cast applied.

- e. **Post tenotomy cast** - After correction of equinus by tenotomy, with the foot abducted 60° to 70° & 15° dorsiflexion, last cast is applied for 3 weeks. The foot looks overcorrected with respect to the thigh. It should be replaced if it softens or becomes soiled before 3 weeks. Usually no analgesic is necessary.
- f. **Cast removal** - After 3 weeks, the cast is removed and 20° of dorsiflexion is now possible and foot is ready for bracing.

Step 4 – Bracing

Bracing is in-dispensable for preventing relapse of deformity by holding the foot in the corrected position. Follow-up at regular intervals for compliance of brace is essential and critical for successful management. Brace should hold the foot abducted and dorsiflexed – hence the term **foot abduction brace** (fig 11)[4,18,21,22].

Fig 11. Foot abduction brace of different sizes (a) and clinical photograph of child with brace (b and c) (Drawn from Pirani S. Naddumba E. In: Staheli's Ponseti club foot management. Teaching manual for healthcare providers. 2008;1:1-48)



- a. **Type** - Can be commercially available foot abduction braces (such as the Markell or Mitchell Brace) or custom made.

- Commercially available braces are expensive and availability is an issue.
- b. **Feature** – It should be simple, easily available, effective in maintaining correction, easy to use, easy to fabricate, inexpensive, and ideally suited for widespread use.
 - c. **Shape** –Brace has two shoes and round connecting iron bar. Shoes are open toe, leathered, with lace closures and holes in heel to check position. Abduction and dorsiflexion can be changed by bending the bar.
 - d. **Position and length**–the brace should maintain foot abduction 70° and dorsiflexion 15° . Length of foot abduction bar i.e. distance from the inside of one shoe-heel to the other shoe-heel equals the width of the child's shoulders.
 - e. **Design** -Heel has low posterior or deep cup design (at the level or below the level of the anatomical ankle joint) in plantar flexion to prevent foot from slipping out and to promote normal shaped foot development. In contrast, if the heel leather is increased and it reaches above the ankle joint, it acts as a fulcrum causing the heel to lift up from the shoe when the child attempts to plantarflex the ankle.
 - f. **Fitting** - properly fitted brace should not be painful. If the child cries, they should check for sore areas and needs brace adjustment to fit properly.
 - g. **Time and duration** –It should be used full time for 3 months and at night time until 4 years of age regularly and without skipping even one day.
 - h. **Availability** –Stock FABs in the clubfoot clinic so that they are available for immediate initial fitting and replacement, reducing relapse and transportation costs.
 - i. **Follow-ups**- should be done at regular intervals to minimize problems and to detect relapse early. First at 2 weeks and then every 3 monthly till 2 years' age and then 6 monthly till 4 years' age.
 - j. **Discontinue** –brace can be discontinued after age of 4 years if there is no sign of relapse. If there is any sign of relapse, reapply a series of corrective casts.
 - k. **Compliance** - Failure to comply with bracing protocols is the most common

cause of relapse. To prevent relapse, educate, demonstrate, reassure and ensure consistency.

Outcome of Ponseti Method

Correctly applied cast is successful in almost all the cases, and it depends on experience of treating team, compliance of family and degree of stiffness of foot. Feet treated by this method are strong, flexible, and pain free, allowing a normal life, although affected feet and leg may be slightly shorter and narrower than the normal foot, but it makes no difference [8-11, 19].

Recommended visits

About total 20 visits over four years leads to optimal outcomes.

Corrective phase - requires 7 visits – 5 weekly visits for five casts, 6th visit after 3 weeks of tenotomy for fitting of FAB, and 7th visit 2 weeks later for brace-wearing compliance check.

Maintenance phase - every 3 monthly till walking age, and then every 6 months till 4 years' age for assessment of relapse and brace compliance.

Development & modification in Ponseti technique

The technique is equally effective in hands of paramedical hands and corrects deformity even in older child, complex, atypical and syndromic clubfeet. But it is complicated and may take longer duration (average 10 to 12 casts). Accelerated protocol with cast changes every 4 to 5 days can shorten duration time [23].

Errors or cause of failure in management [24]

- a. **Failure to recognize clubfoot** - is a result of lack of awareness of clinical features of clubfoot or knowledge that it can be treated. Can be overcome by education, awareness and performing visual foot inspection.
- b. **Manipulating without accurately identifying talar head** -This error is commonly due to inexperience. Successful correction of deformity depends on abduction of the calcaneus under the talus,

- by counter-pressure on the head of the talus. Failure to counter-press talar head will impede the correction. This can be prevented by accurately identifying the head of the talus, by palpating the lateral malleolus and move forward to identify the next bony prominence – the head of the talus.
- c. **Pronation of the foot** - This worsens the deformity by increasing the cavus. Pronated forefoot with adducted and inverted calcaneus cannot be abducted and remains locked under the talus. So foot should never be pronated.
 - d. **Failure to cast** - Performing frequent manipulations and not casting is an error. The foot should be casted with the contracted ligaments at the maximum stretch obtained after each manipulation. The stretched ligaments loosen sufficiently to facilitate further stretching at the next manipulation.
 - e. **Using below-knee casts** - Below-knee casts do not hold the calcaneus abducted. Above-knee casts are needed to prevent ankle and talus from rotating within the cast.
 - f. **Applying cast alone, without help** -It jeopardizes the correction by introducing the possibility of immobilizing the foot in an incorrect position. It is preferable to have a parent/helper to hold the foot during cast manipulation.
 - g. **Premature equinus correction** - Attempts to correct the equinus before the heel varus and foot supination results 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.
 - h. **Failure to perform a complete tenotomy**- Sudden lengthening with "pop or snap" signals a complete tenotomy, Failure to achieve this 'pop or snap' indicates an incomplete tenotomy, requiring to repeat the tenotomy manoeuvre.
 - i. **Errors during bracing** Bracing is done in fully corrected position with foot abduction and ankle extension. Bracing into pronation, eversion or external rotation, can cause relapses and treatment failure.
 - j. **Using braces other than FAB -Ankle foot orthosis (AFO)** controls ankle extension but cannot maintain the adduction of calcaneus under the talus. **Knee-ankle-foot-orthosis** controls for foot abduction, but is inefficient at controlling for ankle extension, as it keeps knee in a permanent 90° flexion so does not stretch the gastrocnemius muscle satisfactorily. Hence, when child starts standing with extended knees foot will have an equinus contracture.
 - k. **Failure to recognize relapse early** - Relapse can be identified early by observing the child's gait, which shows early heel rise (child walking away from examiner), swing phase dynamic supination (child walking towards examiner) and loss of ankle dorsiflexion to less than 10°. These relapses can be managed by repeat corrective casting.
 - l. **Management without bracing** - Avoiding the brace entirely is tempting and has shown 90% relapse rates at age of 1 year. Relapse is rare after 4 years, hence bracing until 4 years of age is necessary to reduce relapse.
 - m. **Attempts to obtain perfect anatomical correction** - It is impossible to achieve complete anatomic correction by Ponseti treatment. Long-term follow-up radiographs show some abnormalities, but it does not correlate with long term, good clinical and functional, supple and plantigrade foot, obtained by Ponseti method.
 - n. **Non-compliance**- irregular follow up in casting phase, not using brace until 4 years, will cause relapse.

Other Clubfeet Situation

Most idiopathic congenital clubfeet correct with about five well-applied Ponseti casts. Some clubfeet, however, can be considered "difficult" as they have some unique characteristics that demand a modified approach for management [1,4,18,21,22,25].

Relapse [1,4,18,21,22,25]

Ponseti method corrects deformity, but it does not remove the cause and so it has tendency to recur.

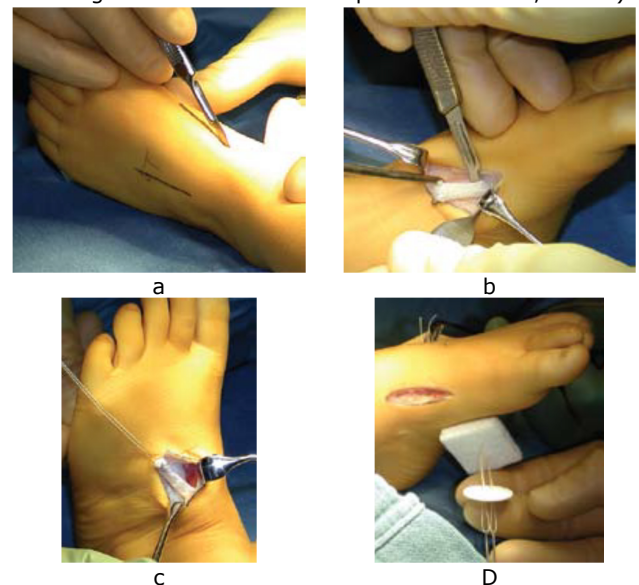
- a. **Cause** – It is almost always due to failure or incorrect bracing and may indicate neuromuscular disorder.
- b. **Age of presentation** - relapse occurs before 5 years of age and is very rare after age 7.
- c. **Sequence** - Early relapse presents as a loss of dorsiflexion, later, heel varus and adductus develop and rarely significant cavus may recur. Early relapse is therefore easier to correct than late relapse.
- d. **History** – take history relating to bracing difficulties (pain, inconsolable crying, sore areas,) that led to inconsistent use or improper use like heel not touching down on the footplate of the shoe.
- e. **Signs of relapse** – are different for before walking and after walking age.
 1. **Before Walking Age** – Suspect relapse if the brace has incorrect angle of abduction and dorsiflexion, if the talar head remains palpable with the foot in maximal abduction, if the calcaneus cannot be abducted and extended, if heel cannot go into valgus or if dynamic supination present (involuntary supination of foot with active ankle dorsiflexion representing tibialis anterior hyperactivity unopposed by weak peroneal).
 2. **After Walking Age** - Observe the child's feet in standing and while walking towards and away in swing and stance phases of gait. In early relapse, ankle dorsiflexion is less than 10^0 above neutral with knee extended, though foot appears plantigrade, the heel may not touch the ground and heel rise occurs on walking. In late relapse, the medial forefoot is raised off the ground, or the foot bears weight on the lateral border. When child is walking towards examiner foot tends to supinate in swing phase (dynamic supination) and bears weight lateral rays whereas when child walks away, heel-strike is absent, and there is fixed stance-phase heel varus. Subtalar joint involvement (as loss of full calcaneal abduction or incomplete talar head coverage) indicates late relapse. Active ankle dorsiflexion may be accompanied by supination of foot due to tibialis anterior

over activity and Sole of foot may show thickening of the skin laterally.

- f. **Treatment or relapse** - Do not ignore relapse, as early relapse is much easier and less complicated than late relapse. Relapse is treated with repeat manipulation and casting, adding tenotomy if needed, followed by bracing. After 30 months of age, relapse along with repeat manipulation, casting and tenotomy needs, transfer of the tibialis anterior to the lateral cuneiform to turn the deforming force of tibialis anterior into a corrective force.

Anterior Tibialis Tendon Transfer [1,4,18,21,22,25] (fig 12)

Fig 12. Clinical photograph of tibialis anterior transfer for dynamic supination showing incision (a), tibial anterior harvest (b), transfer of tendon to cuneiform (c) and securing tendon plantarwards (d). (Drawn from Pirani S. Naddumba E. In: Staheli's Ponseti club foot management. Teaching manual for healthcare providers. 2008;1:1-48)



- a. **Indication** – It is indicated when child had second relapse with persistent heel varus and forefoot supination during walking and the sole shows thickening of the lateral plantar skin.
- b. **Age** – child should be more than 30 months old.
- c. **Prior deformity correction** - Fixed deformity should be corrected by casts before tendon transfer. Usually cavus, adductus, and varus corrects, but equinus may be resistant. If the foot easily dorsiflexes to 10^0 , only the transfer is needed, else heel cord tenotomy is added.

d. Anaesthesia, positioning and incisions

- Under general anaesthesia in supine position with high thigh tourniquet, dorsolateral incision centred on the lateral cuneiform is made. The dorsomedial incision is made over the insertion of the anterior tibialis tendon.

e. Procedure - Anterior tibialis tendon is detached at its insertion and anchoring sutures are placed by multiple passes through the tendon to obtain secure fixation. Transfer the tendon to the dorsolateral incision under the extensor retinaculum and extensor tendons.

Localize lateral cuneiform radiographically and make a drill hole in the middle of the lateral cuneiform large enough to accommodate the tendon. Thread a straight needle on each of the securing sutures and pass both needles into the hole and penetrates the sole of the foot, with needles **Passing through** different holes of secure button placed plantarly, with foot held in dorsiflexion, pull the tendon into the drill hole by traction on the fixation sutures and tie the fixation suture with multiple knots.

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

g. Local anaesthetic and closure - Inject long-acting local anaesthetic into the wound to reduce immediate postoperative pain and close wound with absorbable subcutaneous sutures.

h. Cast immobilization- apply a long-leg cast with foot in abduction & dorsiflexion.

i. Postoperative care - Usually, the patient remains hospitalized overnight. Remove the cast and button at 6 weeks. The child may mobilize weight-bearing as tolerated.

j. Bracing and follow-up - No bracing is necessary after the procedure. See the child again in 6 months to assess the effect of the transfer.

Neglected / Untreated clubfoot in the older child [1,4,18,21,22,25]

Late presenters or neglected CTEV are common in our country due to social stigma,

lack of education, poverty and lack of proper health services and are difficult to treat due to severe deformity, contractures, deformation of bones, callosities and ulcers.

Treatment–Ponseti method continues to be effective even after walking age but these cases need longer treatment, and may have residual deformity, necessitating further treatment like calcaneo-cuboid fusion for residual calcaneo-cuboid subluxation.

Complex congenital clubfoot (atypical clubfoot)(fig 13)

Fig 13. Clinical photo of complex club feet (a & b) showing are deep crease just above the heel and at sole, and short hyperextended big toe with an edematous dorsum of the foot and (c) modified treatment by extending all metatarsals to align forefoot with midfoot. (Drawn from Pirani S. Naddumba E. In: Staheli's Ponseti club foot management. Teaching manual for healthcare providers. 2008;1:1-48)



It is recently described variant of congenital clubfoot. It is important to recognize it, as treatment needs modification and there is an increased risk of relapse [1,4,18,21-25].

a. History – often history of casts slipping is present such that the toes slowly disappear inside the plaster

b. Examination - Signs of complex clubfoot are rigid equinus, plantaris (severe plantarflexion of all metatarsals), a deep crease just above the heel, a deep transverse crease across the sole of the midfoot, a short hyperextended big toe, abnormal “flattened” shape to heel and an oedematous dorsum of the foot.

c. Why Modify treatment - Use of classic Ponseti method, in this atypical clubfoot results in secondary deformity (Persisting cavus, increase in plantaris and abduction of metatarsals at the Lisfranc joint rather than abduction of calcaneus) and hence modification is needed

- d. **Modification** –For correction of plantaris, all metatarsals are extended simultaneously with both thumbs. Following this start abducting foot with counter press at lateral talar head. Apply casts with the above-knee portion in 110° flexion to prevent slippage. Average 10 casts can be needed.
- e. **Tenotomy** A tenotomy is necessary in all cases. Perform the tenotomy when plantaris corrected. At least 10° dorsiflexion is necessary. Sometimes it is necessary to change casts at weekly intervals after the tenotomy to gain more dorsiflexion, if sufficient dorsiflexion is not achieved immediately after the tenotomy.
- f. **Bracing** Reduce abduction on the affected side to 40° in the foot abduction brace. The follow-up protocol remains the same.

Syndromic clubfoot

Congenital abnormalities, such as arthrogyrosis, myelomeningocele, and other syndromes, often have abnormal collagen forming their ligaments, capsules, and other soft tissues. Hence syndromic clubfeet are difficult to treat. Many syndromic clubfeet, correct and plantigrade foot can be achieved with standard Ponseti method however; correction may require more casts than usual. Long-term functional outcome usually depends more on the underlying syndrome than the clubfoot [1,4,25].

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Resistant clubfoot

Rarely, idiopathic congenital clubfeet do not correct completely with accurately applied Ponseti treatment due to co-existing pathology such as tarsal coalition the surgical correction by posterior or posteromedial release is necessary [1,4,25].

Conclusion

Neglected club foot can affect adversely on functions and cosmetic appearance; hence treatment should start at earliest as possible. Ponseti method, based on sound understanding of functional anatomy and biological response of tissue, showed excellent results with nonsurgical serial manipulation and casting, simultaneously correcting all the deformities. Cavus is corrected in first cast by supinating the foot followed by correction of varus and adduction, by abduction the foot, with counter pressing lateral talar head, followed by correction of equinus by percutaneous tenotomy in mean 5 weeks. Post treatment bracing is necessary to prevent the relapse till age of 4 years. The technique is equally effective in hands of paramedics, in older child, complex atypical and syndromic clubfeet, although it may take longer duration to correct. Feet treated by this method are strong, flexible, and pain free, although affected feet are slightly shorter and narrower. Pirani score can objectively document this correction and also identify early relapse.

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