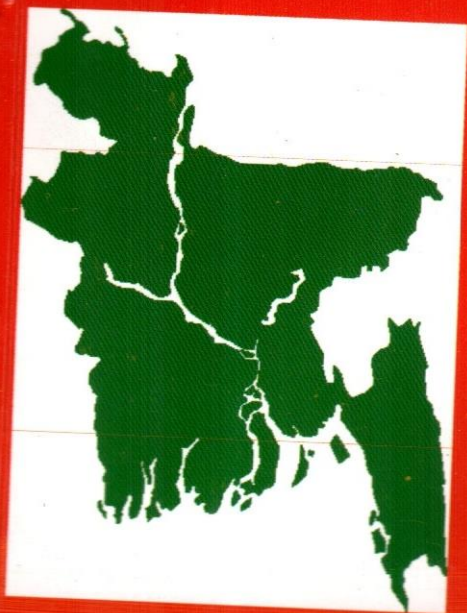


Bangladesh Ponseti Pocketbook



A Guide For
Management Of
Clubfoot In Bangladesh

Essentials

Pathway

Fundamentals

Assessment

Manipulation
& Casting

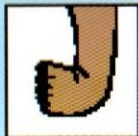
Tenotomy

Bracing

Persistent
Clubfeet

Difficult
Clubfeet

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- 1.2 Epidemiology & etiology
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In Bangladesh there are an estimated 4,000 children per year (1.2 per 1,000 live births) born with clubfoot deformity. Left untreated, club foot causes permanent disability, limits education and employment opportunities, and personal growth.

Ponseti clubfoot treatment has high reported long term outcomes for freedom from pain and preservation of foot function, and is the standard of care advocated by the National Institute of Traumatology, Orthopaedics and Rehabilitation (NITOR) and the Bangladesh Orthopaedic Society (BOS).

Disability is an issue of great importance to the Government of Bangladesh (GOB) as it is major cause of the developmental challenges of ill health and poverty. Sustainable Clubfoot Care Bangladesh (SCCB) is a Canadian funded initiative to build capacity in Bangladesh for ponseti clubfoot teaching and treatment.

The Ministry of Health and Family Welfare (MoHFW) commissioned Sustainable Clubfoot Care in Bangladesh (SCCB) to develop the National Strategy and Guidelines for Clubfoot Care in Bangladesh to implement Ponseti clubfoot treatment in a standardized manner across Bangladesh by the ponseti Clubfoot care Pathway (PCCP).

The Bangladesh Ponseti Pocketbook (BPP), developed by local and international experts, is the national reference document of clinical care of clubfoot in Bangladesh. It contains all relevant clinical details about diagnosis, classification and treatment of clubfoot.

Preface

The BPP was developed by a group of national and international experts including Drs Kh. Abdul Awal Rizvi, Iqbal Qavi, Abdul Gani Mollah, Jahangir Alam and Monaim Hossen from National Institute of Trauma and Orthopaedic Rehabilitation (NITOR) Dr Lynn Staheli from University of British Columbia (UBC) and Dr Shafique Pirani from University of British Columbia (UBC) and Dr Lynn Staheli from university of Washington (UW). It provides one easily digestible source of material on all core information in 2 Parst.

The Author wish to thank Ponseti international organization review, Aaron Rutten (Illustrations) and anna stonehouse (administration and coordination) for their contributionhs.

1

Essentials

1.1 Definition & Clinical Features

- Clubfoot is **easily visible** at birth.
- The **mneumonic** is CAVE.

Definition

- [1] **Clubfoot** is a congenital malformation characterized by the presence of four easily seen foot deformities: Cavus, Adductus, Varus, and Equinus (CAVE).

Clinical features at birth

The four deformities are easy to see:

- [2] **Cavus** – increased height of medial longitudinal arch of the foot.
- [3] **Adductus of forefoot** – deviation of the forefoot towards medial body plane.
- [4] **Varus of heel** – deviation of the heel towards the medial body plane.
- [5] **Equinus** – increased plantar flexion of foot.
 - There are no symptoms at birth or during infancy. Clubfeet do not affect developmental milestones. Sitting and walking are not delayed.

Syndromic clubfoot

Some clubfeet are associated with a syndrome (Syndromic clubfeet) and should be identified if possible at birth. . Common syndromes include:

- [6] **Spina bifida** – note the posterior mid-line meningocele.
- [7] **Arthrogryposis** – note multiple joint contractures. Typically, the knees and wrists are flexed and the elbows extended. Sometimes the hips are flexed, adducted, and dislocated.
 - Children with syndromes should first be seen by a paediatrician. When stable, the child can be referred back to the clubfoot clinic for treatment

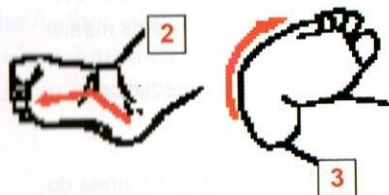
Clubfoot after walking age

- [8] **Weight-bearing** clubfeet become increasingly symptomatic. The child stands on the side of the foot. Weight is born on the skin over the lateral part of the distal calcaneus and the head of the talus. This results in pain with walking and impairs mobility and function.

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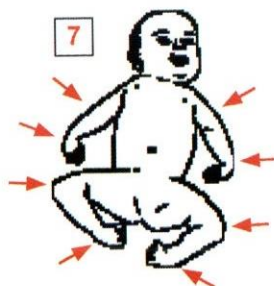
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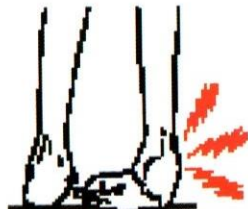
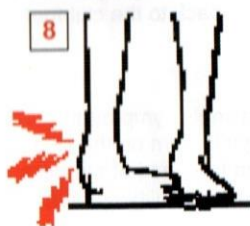
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Essentials

1.2 Epidemiology & Etiology

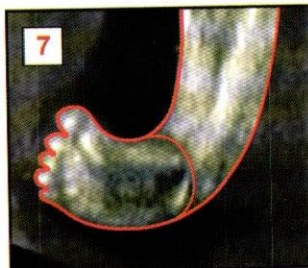
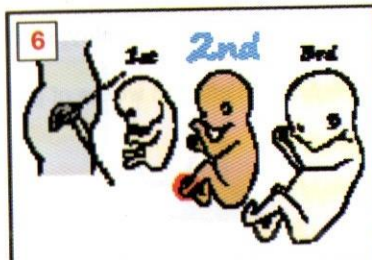
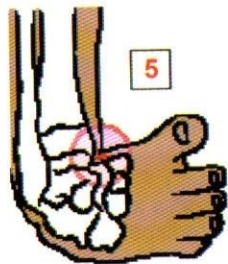
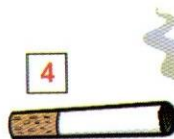
- The **risk** of clubfoot at birth varies in different groups.
- Its precise **cause** is unknown, but thought to involve a postero-medial retracting fibrosis.

Epidemiology

- (1) **Worldwide incidence** = 1-2 per 1000 live births, with male:female ratio = 2:1.
- (2) **Geographic area & races at increased risk:**
 - New Zealand Mauri = 0.81%, Australia Aboriginal = 0.35%,
 - China = 0.39%, South Pacific = 0.69%
- (3) **Positive family history** increases risk of clubfoot for future pregnancy. Image shows father and son with bilateral clubfeet. Increased risk is:
 - 1% if 1st degree relative
 - 10% if a parent and sibling affected
 - 33% for monozygotic twins
 - 2% for dizygotic twins.
- (4) **Environmental risks:**
 - Heavy maternal smoking = 0.16%.
 - First trimester amniocentesis = 1.3%.
 - Mid-trimester amniocentesis = 0.1%.
 - Maternal diabetes = 0.24%.

Etiology

- (5) Clubfoot likely arises as a result of an environmental factor that triggers a genetic predisposition. This leads to a **posteromedial retracting fibrosis** resulting in **tarsal bone deformations and misalignments**.
- (6) Clubfoot is a **2nd trimester developmental abnormality**, usually after the 16th week of gestation.
- (7) **Antenatal ultrasound** can show clubfeet after 18 weeks of gestation.



Essentials

1.3 Assessment & Diagnosis

- A detailed history and careful physical examination are sufficient to make a diagnosis and determine the type of clubfoot.
- Imaging is not usually necessary.

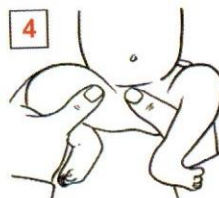
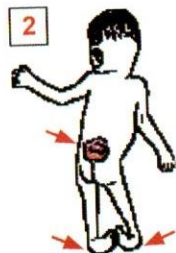
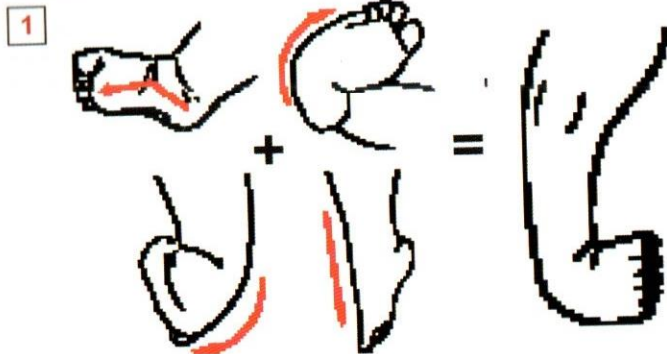
History, Examination, and Diagnosis

- **History.** Record details of pregnancy, delivery, family history of clubfoot, social history, other medical history, and treatment of clubfoot to date if any.
- (1) **Examine the feet** for Cavus, Adductus, Varus, and Equinus. (CAVE). All four signs are required to confirm the diagnosis of clubfoot in children without prior clubfoot treatment. With prior treatment and partial correction, only one or two of these signs may be present.
- Look for signs of other congenital musculoskeletal abnormalities.
- (2) **Examine the spine** for mid-line defects (e.g. myelomenigocele).
- (3) **Examine other major joints** and hands for contractures as you might see in arthrogryposis.
- (4) **Examine the hips** for DDH with the Ortolani and Barlow tests.

Differential Diagnoses

These include congenital vertical talus, metatarsus adductus, and calcaneovalgus. Management differs from clubfoot. Flexible deformities correct spontaneously within a few months. Stiff deformities should be carefully assessed.

- (5) **Congenital Vertical Talus.** The foot is stiff with a rocker-bottom shape. It does not plantar flex when pressure is applied to the dorsum of the foot. Early diagnosis and treatment is essential. Untreated, it can lead to serious disability.
- (6) **Metatarsus Adductus.** The forefoot is medially deviated, but is flexible and corrects with gentle manipulation. The hind foot is normal. No treatment is required.
- (7) **Calcaneovalgus.** The whole foot appears to be pushed up and out against the front of the leg. However, it is flexible and corrects with gentle downward pressure on the dorsum of the foot. No treatment is required.



Essentials

1.4 Ponseti Clubfoot Treatment

- This is the standard of care worldwide for clubfoot treatment at birth and early childhood with better outcomes than surgery.
- Ponseti treatment consists of correcting the deformity and preventing relapse.

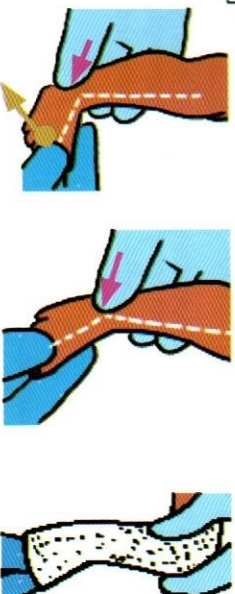
Correct deformity

- (1) **Manipulation and casting.** Tarsal bones in infants and children are mostly formed of soft cartilage. Serial gentle accurate manipulations can gradually correct the deformations and misalignments seen in clubfeet. Well molded plaster casts maintain correction achieved between manipulations.
- (2) **Progressive correction.** Every week for usually about 4-5 weeks, the child returns to the clinic to have the old cast removed, and a new cast applied after a further corrective manipulation. The foot should look better each week. Cavus, adductus and varus are almost always corrected by manipulation and casting.
- (3) **Percutaneous Achilles tenotomy.** This is usually necessary to complete correction of equinus. It is performed in the clinic under local anaesthetic. The last cast is then applied with the foot in a fully corrected position. Pain medications are normally not needed.

Prevent relapse

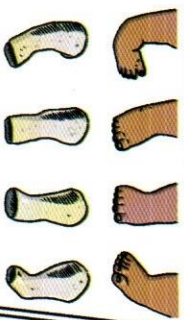
- The final cast is removed after 3 weeks. The tendon is healed. To prevent relapse, the foot needs to be braced in the fully corrected position for several hours each day. The only brace that works is a foot abduction brace (FAB) – 2 shoes held connected by a bar.
- (4) **Initial Bracing.** A FAB is fitted the same day the last cast is removed and worn 23 hrs a day for the first 2 months.
- (5) **Later bracing.** The brace is then worn only at night (during sleep) until 4 years of age. Routine clinic visits monitor for relapse and brace fit. This prolonged treatment period can be difficult for parents and children.
- (6) **Discharge.** Children with fully corrected feet at 4 years of age can stop wearing the brace and are discharged from the clinic.

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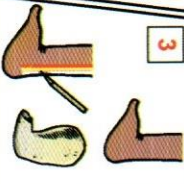


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Essentials

1.5 Burden of Neglect & Treatment Outcomes

- ❑ Neglected clubfoot creates a burden for affected children, their families, and society.
- ❑ Ponseti clubfoot treatment is challenging, but worth the effort as it gives the best short and long term outcomes.
- ❑ Long-term outcomes following surgery are generally poor.
- ❑ Surgical treatment should be avoided if possible.
- ❑ This information should encourage parents and surgeons to persist with Ponseti treatment despite challenges.

Burdens of untreated clubfeet in Bangladesh

[1] Parents

- ❑ Carry the burden of guilt and shame.
- ❑ Feel the child was born deformed as the result of a curse.

[2] Children/Adults with neglected clubfeet

- ❑ Weight bearing feet become painful and impair mobility.
- ❑ School access may be limited, if children have to walk to school.

- ❑ Social and employment opportunities further limited (compounded by cosmetic concerns) leading to demoralization, despair, and high-risk for poverty.

- ❑ Women may be less likely to get married and have children.

[3] Society

- ❑ Carries the financial burden of clubfoot-associated disability and poverty.

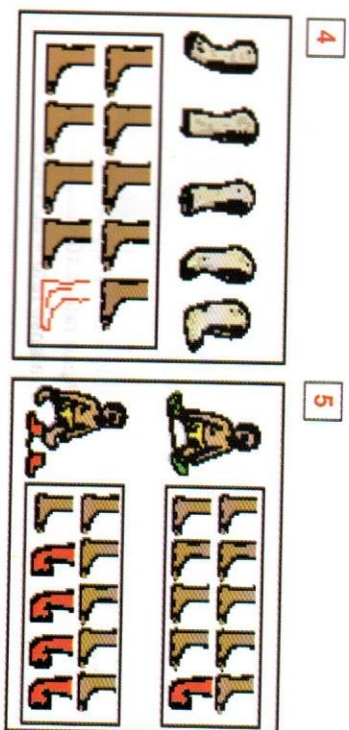
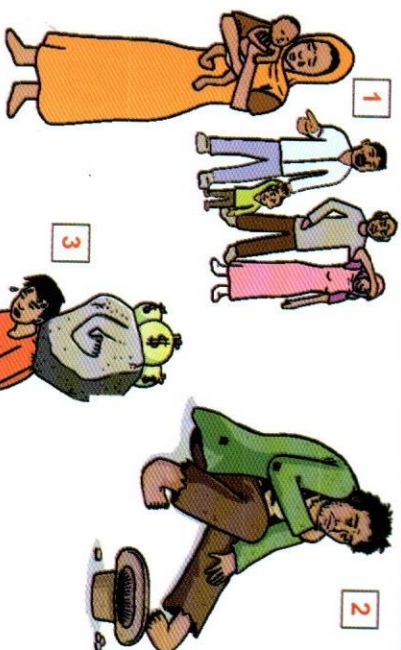
Short term outcomes – Ponseti

(4) Deformity correction occurs within a few weeks:

- ❑ Ponseti correction rate in 5-7 casts > 90%.
- ❑ Necessity for major surgery < 10%.

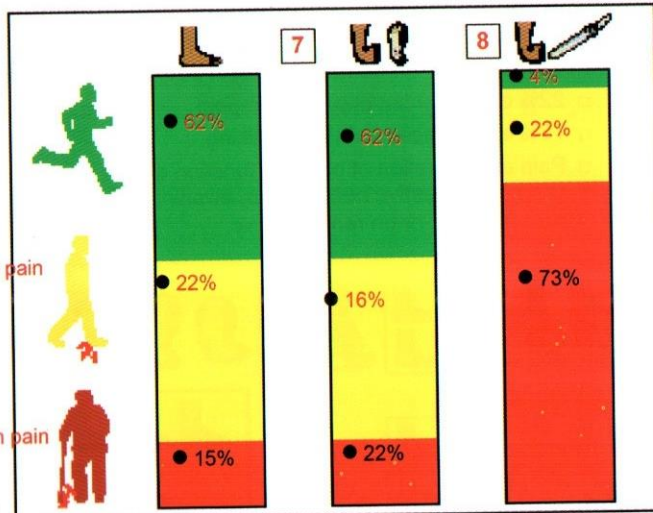
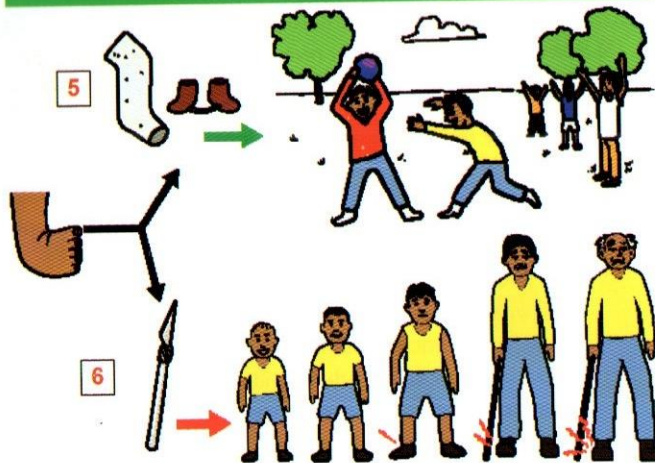
(5) Prevention of relapse. Bracing to age 4 yrs is critical:

- ❑ With regular bracing, the relapse rate < 10%.
- ❑ Without regular bracing, the relapse rate = 30 - 40%.



Long-term outcomes – Ponseti vs. surgery

- [5] **Ponseti treated clubfeet** remain plantigrade, strong, flexible, and pain-free for decades in most cases, comparable to adults without a history of clubfeet.
- [6] **Surgically treated clubfeet** can look corrected immediately after surgery, but scarring and joint incongruity predispose to early joint degeneration, stiffness, pain, and disability by early adulthood.
- [7] **35 yr outcomes study after Ponseti treatment.** (Cooper and Dietz, 1995)
 - 62% could run without pain.
 - 16% could run but with pain.
 - 22% experienced pain with walking.
- **Comparison group of adults** with no history of clubfoot had:
 - 62% could run without pain.
 - 22% could run but experienced pain.
 - 15% experienced pain with walking.
- [8] **25 yr outcomes study after invasive surgical** (Dobbs et al 2006)
 - Outcomes after major surgery are dramatically worse:
 - Only clubfoot 4% could run without pain.
 - 22% could run but experienced pain.
 - 73% experienced pain with walking.
 - Pain and limitation of physical function similar to patients with chronic congestive heart failure, awaiting coronary artery bypass surgery, or on renal dialysis.



● add numbers

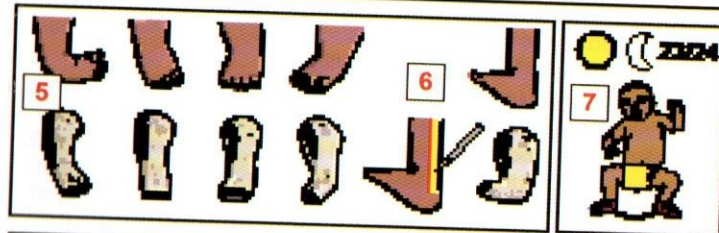
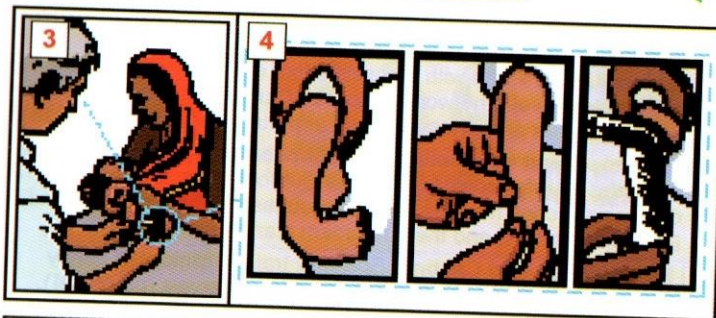
Ponseti Clubfoot Care Pathway

2.1 The Pathway

- Ponseti clubfoot treatment is prolonged – up to 4 yrs.
- It's best thought of as a pathway of many steps both in the community and in specialized clubfoot clinics.
- Good outcomes depend on successful completion of every step. Delayed or missed steps can jeopardize the outcome.

Overview of the Ponseti Clubfoot Care Pathway (PCCP)

- [1] Screening.** All newborns should be screened for foot deformity at the first examination after birth. This is easily done by physicians, midwives, nurses and community health workers (pgs. 15-16).
- [2] Referral.** All children with a possible foot deformity should be referred to one of a network of Ponseti Clubfoot Clinics across Bangladesh for proper assessment and management (pgs. 15-16).
- [3] Diagnosis and counseling.** An orthopaedic surgeon carefully assesses all referred children at the clubfoot clinic. If clubfoot diagnosis is confirmed, parents are counseled about clubfoot and Ponseti treatment, and then treatment starts (pgs. 19-22).
- [4] Manipulation and Casting.** Specially trained clinic staff gently manipulate and cast the clubfoot at weekly intervals (pg. 23-24).
- [5] Progressive correction.** The foot should look better each week. Cavus, adductus and varus are almost always corrected with about 4 to 5 weeks manipulation and casting (pgs. 23-24).
- [6] Tenotomy.** About 90% of feet require Achilles tenotomy to correct equinus before the application of the last cast (pgs. 23-24).
- [7] Bracing.** The foot is fully corrected on removal of the last cast. To prevent relapse, the child should wear a brace that holds the feet in corrected alignment for 23 hrs a day for 2 mos and then only at night while sleeping until about age 4 yrs (pgs. 23-24).
- [8] End of treatment** – children with well-corrected feet can stop wearing the brace at 4 years of age (see pgs. 23-24).
- [9] Outcome** – normal function and freedom from pain.



Ponseti Clubfoot Care Pathway

2.2 Overcoming Barriers Faced by Parents

- Parents face numerous barriers in following Ponseti treatment protocols.
- Community Health Workers (CHW) can help parents overcome barriers.

Barriers parents face during care

- Lack of awareness/misconceptions.** Parents often are not aware that clubfeet can be corrected and treatment is available.
- Poverty.** Parents may have limited financial resources to pay for transport to get to the clinic.
- Guilt and shame.** Parents may feel their child's clubfoot is their fault.
- Care for other children.** Parents may be unable to find care for other children and family members during clinic visits.
- Prolonged treatment.** Parents may find four year treatment protocol too demanding.

How Community Health Workers help overcome barriers

- In Bangladesh CHW make regular home visits & can play a vital role in delivery of preventative/basic healthcare. Many have been specially orientated in PCCP and to counsel parents on strategies to help overcome barriers.
- CHW carefully listen to parents to learn about and acknowledge the specific barriers parents are facing in their community.
- CHW discussing options for parents to consider in order to overcome barriers:

- Inform parents that clubfoot can be treated
- Reassure parents that they are not at fault. They did not cause the clubfoot. They should not feel guilt or shame for causing the clubfoot in the child. **Recruit neighbours/family** to assist in the care of children at home whilst they take the child to the clubfoot clinic.
- Encourage adherence to treatment protocols. With successful treatment, the child's feet will be corrected and the child can be fully active.



Ponseti Clubfoot Care Pathway

2.3 Screening & Referral

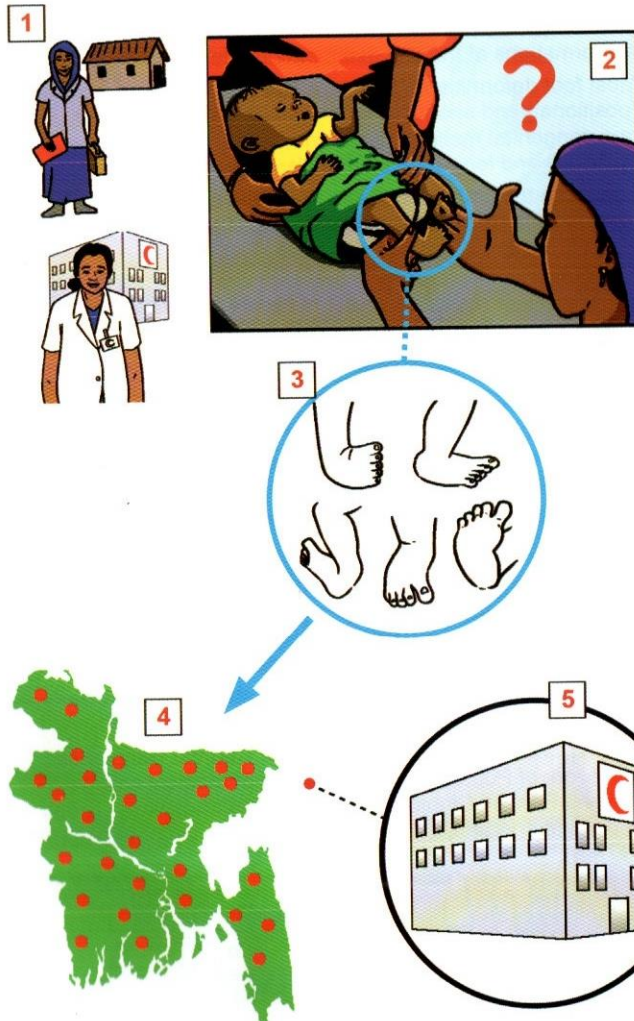
- The National Neonatal Health Strategy and Guidelines for Bangladesh (2009) call for health workers to screen for congenital malformations at the first examination after birth.
- Most foot deformities at birth are due to intrauterine crowding (positional) and spontaneously resolve. Some, however, are true congenital malformations and need treatment to prevent deformity and long-term painful disability.
- Therefore the first two steps in the pathway are screening for foot deformity at birth and referral if positive.

Screening for possible foot deformity

- [1] **Nurses, midwives, and CHW** at hospital and home births usually conduct the first examination after birth and screen for congenital malformations.
- [2] **Screening for possible foot deformities.** This is simple. It takes only a few moments to visually check the shape of the foot, and then to gently move the foot in different directions checking for restricted motion or stiffness. Infants' feet are very flexible, as bones are mostly soft cartilage.
- [3] **A possible foot deformity** is any foot that does not look normal, or does not move freely.

Refer all children with possible foot deformity

- [4] **Refer** all children with possibly foot deformity to a Ponseti Training Center or Ponseti Clubfoot Clinic for further assessment by an orthopaedic surgeon, diagnosis, and treatment if necessary. Counsel the parents to attend. Reassure that if a problem is found, early treatment is very successful.
- [6] **Ponseti Training Centers and Clubfoot Clinics.** Bangladesh has a network of Ponseti Training Centers at medical college hospital and Ponseti Clubfoot Clinics at district hospitals. These clinics provide specialized care for children with clubfoot deformity (pgs. 17-18).



Ponseti Clubfoot Care Pathway

2.4 Ponseti Clubfoot Clinic Network

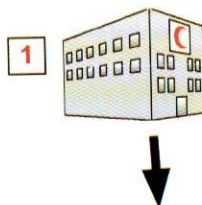
- ❑ Bangladesh has a **network of clubfoot clinics** at public medical college and district hospitals.
- ❑ The clubfoot clinic is the **focal point of care** for a child with a clubfoot in that clinic's catchment area.
- ❑ Clinics at medical college hospitals teaching healthcare students are called **Ponseti Training Centers**

Ponseti Clubfoot Clinics (PCC)

- [1] Every PCC** is headed by an orthopaedic surgeon specially trained in the Ponseti method. Skilled healthcare providers assist the surgeon in patient management.
- [2] Diagnosis.** The orthopaedic surgeon assesses the child. If the child is found to have a benign positional foot deformity, the surgeon reassures the parents that the condition will resolve without treatment (pgs. 19-20).
- [3] Counseling.** If the child is found to have a clubfoot deformity, the orthopaedic surgeon counsels parents about the condition, the treatment, and the good outcomes with treatment (pgs. 19-20).
- [4] Ponseti treatment.** The orthopaedic surgeon will manage the clubfoot with the Ponseti method. The deformity is corrected with serial casting at weekly intervals with a percutaneous Achilles tenotomy before the last cast if necessary. To prevent relapse, braces are worn until 4 years of age with regular follow-up at the clinic to ensure correct use and fit, and also to detect and manage relapse if present (pgs. 23-24).
- [5] Coordinate care.** Clinic staff liaise with CHW to help parents and caregivers manage problems in their homes, and to monitor for complications and adherence (pgs. 25-28).

Ponseti Training Centers (PTC)

- [6] Teaching.** PTCs are located at medical college hospitals and so also serve to educate medical students and orthopaedic surgeons in training about clubfoot and the Ponseti method.



Ponseti Clubfoot Care Pathway

2.5 Counseling

- Parents' worries about their child's foot can be overwhelming. Through counseling parents, the surgeon addresses fears, solves problems, and thereby promotes adherence to treatment which is very long.

Explain the diagnosis. Describe the treatment.

- Diagnosis.** Ensure parents understand that clubfoot is a common congenital abnormality, that its cause is unknown, and that it's not their fault or a curse.
- Treatment.** Explain this includes deformity correction, prevention of relapse and regular follow up till age 4 years.
 - The deformity is corrected by weekly manipulations and casts for about 4 to 8 weeks. In most cases an Achilles tenotomy is performed under local anaesthetic before the last cast.
 - Prevention of relapse is best accomplished by the use of a brace that holds the foot in correct alignment. **It is fitted the day the last cast is removed, and should be worn 23 hours a day for 2 months and then at night until 4 yrs of age.**
 - Routine follow-up visits to ensure correct brace use and fit, and to monitor for relapse.

Assess parents concerns

- Parents want to know.** What happened? Was it their fault? Is it a curse? Can be treated? What are the results? Will the child be disabled? How much does it cost. Will they be able to cope?

Fill information gaps & problem solve

- Counsel** based on parents' specific concerns and motivate parents to bring the child for treatment.

Reassure:

- Ponseti treatment works.
- With a complete course of treatment till age 4 years, children will walk, and run just like other children and experience a normal childhood.
- As adults, they will continue to enjoy freedom from pain, good function and can wear normal shoes.



Ponseti Clubfoot Care Pathway

2.6 Casting & Bracing Problems

- These can lead to serious complications and adverse outcomes.
- In Bangladesh CHWs may visit the home during treatment. They have a unique opportunity to problem solve, monitor clinic attendance, and promote adherence.

Casting problems requiring urgent removal of the cast

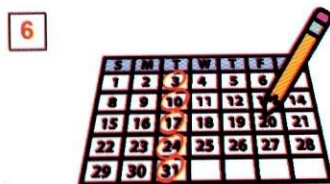
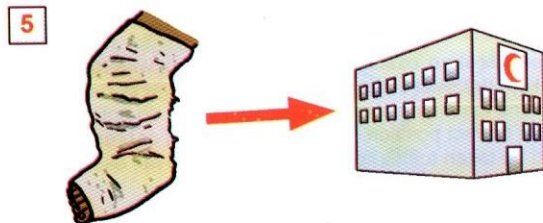
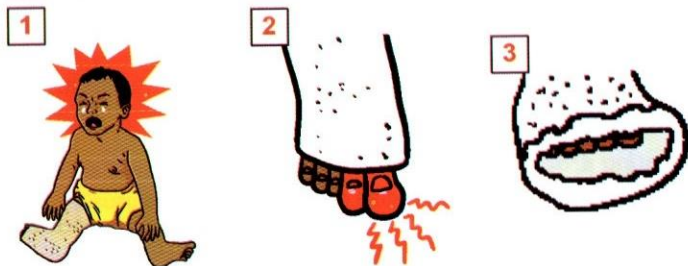
- [1] **Inconsolable crying.** Children cry frequently, but are usually easily comforted. Inconsolable crying may have a cast complication such as a compartment syndrome. The cast should be removed urgently if no other reason can be found for the pain.
- [2] **Swelling/dyscoloration of the toes.** Swollen/dyscolored toes are a sign of a cast complication. The cast should be removed urgently.
- [3] **Cast Slip.** Poorly molded loosely applied casts move and can slip distally on the leg and foot. The toes start to disappear. Ill fitting casts are ineffective in correcting deformity, and cause complications such as pressure sores. The cast should be removed urgently if the cast starts to slip.
- [4] **Cast removal.** The child should go to the hospital right away to have the cast removed. If this is not possible, the cast can be removed at home by soaking and peeling. Crying should stop as soon as offending cast is removed. The child should go to the clinic as soon as possible for review.

Casting problems – urgent hospital review

- [5] **Wet and broken casts.** Plaster casts are not waterproof and have to be kept dry. Wet casts soften and break. Wet skin does not dry. Sores and infections can occur. Broken casts do not maintain the foot in a correct position. If casts become wet or break, the child should be taken to the hospital soon for removal, assessment, and treatment.

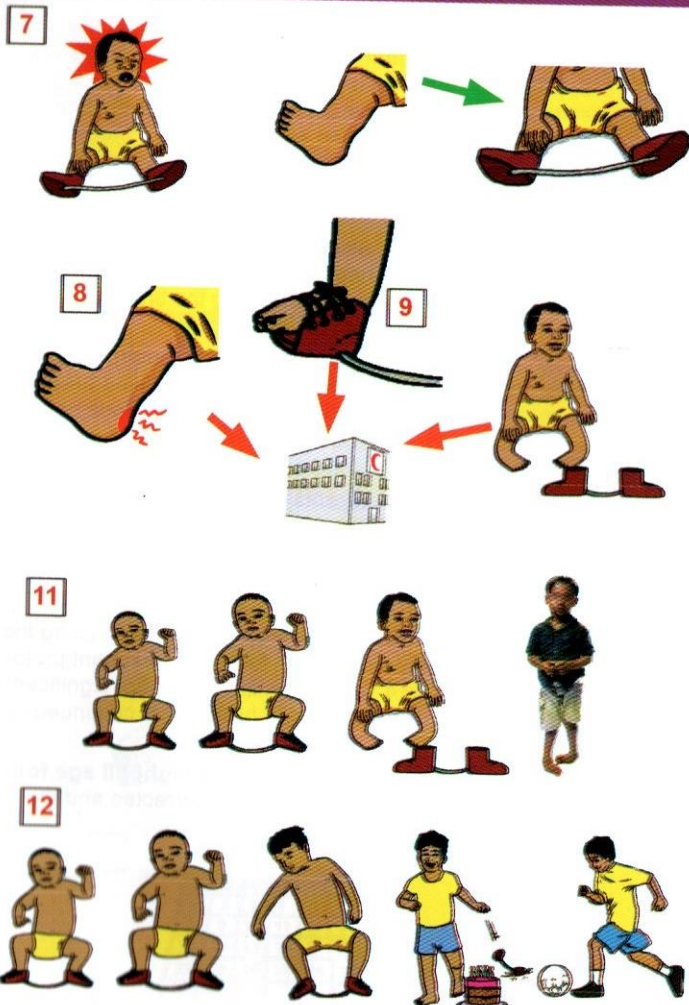
Adherence

- [6] CHWs should encourage attendance by reminding parents of casting and bracing appointment dates. They reassure parents that clubfoot is usually corrected by casts and bracing prevents relapse.



Common bracing problems and answers

- [7] **Crying baby – Child not used to brace.** Crying worries the household. If the foot looks normal, there are no sores or blisters, and the brace fits well, the child is probably crying because they are not used to wearing the brace. This is common for the first few nights in the brace at first application and inconsistent brace use. Encourage parents to use the brace regularly and as directed. Reassure that after a day or two the child becomes used to it and does not cry.
- [8] **Crying baby – Child in pain.** Skin sores, and swelling are painful. Typically, sores occur over the heel or on the top of the foot. Children cry when the brace is applied. Stop using the brace and refer the child to the clinic.
- [9] **Poor brace-fit.** Children's feet grow fast and can outgrow the supplied brace. The toes protrude from the front. Ill-fitting braces cause problems. They are difficult to put on. The foot does not stay in brace. Refer to clinic for a brace check.
- [10] **Inconsistent brace use.** Daily brace application is demanding. When the foot looks corrected parents think it is no longer needed. If the child cries, family and friends may think the brace is causing a problem. Parents become inconsistent in applying the brace. Remind parents of the brace's purpose - to stop clubfeet relapse. Refer to hospital if necessary.
- [11] **Premature stoppage of brace use.** Parents may stop using the brace after one or two years rather than following treatment protocol of night time use till age 4 years. Remind parents of significant risk of recurrence and lifelong disability if bracing not continued till age 4 yrs.
- [12] **Encourage parents to use the brace every night till age four** as the best way to ensure the deformity stays corrected and the child grow up free of pain and disability.



Fundamentals for Orthopaedic Surgeons

3.1 Terminology and Joint Motions

- Clubfoot is a **complex 3-dimensional deformity** of multiple tarsal joint misalignments and tarsal bone deformations.
- The understanding of normal joint motions, clubfoot patho-anatomy and the manipulation techniques requires a common terminology.
- 3 standard reference planes (sagittal, coronal, and transverse) and 3 axes of motion (perpendicular to each plane) are described. A clear understanding of these is vital.
- Tarsal bone and joint motions can then be described with reference to these planes and axes.

Three standard reference planes and three standard axes of rotation using calcaneus as an example

• Each standard reference plane and the axis of rotation perpendicular to it has the same colour. Curved arrows show rotation about axes of rotation. Red arrows indicate movement towards deformity. Green arrows show movement toward correction.

[1] Transverse plane (purple)

[2] Axis of rotation perpendicular to transverse plane (purple)

- Adduction (**red arrow**) is the movement of the distal end of the bone towards the medial body plane.
- Abduction (**green arrow**) is the opposite.

[3] Sagittal plane (yellow)

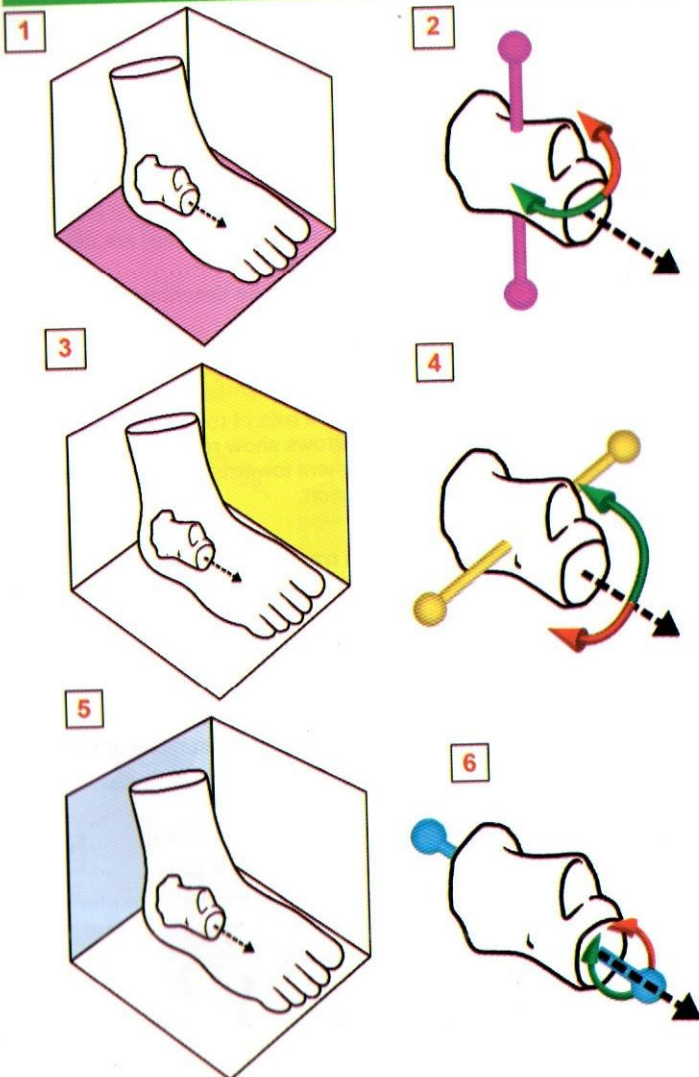
[4] Axis of rotation perpendicular to sagittal plane (yellow)

- Flexion (**red arrow**) is the movement of the distal end of the bone towards the plantar surface of the foot.
- Extension (**green arrow**) is the opposite.

[5] Frontal plane & perpendicular axis of rotation (blue)

[6] Axis of rotation perpendicular to frontal plane (blue)

- Inversion (**red arrow**) is the movement of the plantar surface of the bone towards the medial body plane.
- Eversion (**green arrow**) is the opposite.



Movements of the ankle and cuneiform-1st metatarsal (MT1) joints

- These joints move mainly by rotating around the axis of rotation perpendicular to the sagittal plane.

(7) Ankle (tibiotalar) joint.

- Ankle flexion describes movement of distal part of talus in planar direction (**red arrow**) with respect to the tibia.
- Ankle extension (**green arrow**) is the opposite.

(8) Cuneiform 1st Metatarsal joint (CMT1J).

- CMT1J flexion describes movement of distal part of 1st metatarsal in the planar direction (red arrow) with respect to medial cuneiform
- CMT1J extension (green arrow) is the opposite.

Movements of the subtalar joint (supination and pronation)

- Due to curvilinear joint surfaces, these movements involve rotation of calcaneus simultaneously around all three axes of rotation.

(9) Subtalar neutral. The calcaneus is immediately under the talus.

- (10) Subtalar supination. The calcaneus simultaneously adducts, inverts, and flexes (**curved red arrow**) under the talus. These motions occur together. Therefore, when the calcaneus adducts, it also has to flex and invert.

- (11) Subtalar pronation. The calcaneus simultaneously abducts, everts, and extends (**curved green arrow**) under the talus. These motions also occur together. Therefore, when the calcaneus abducts, it also has to extend and evert.

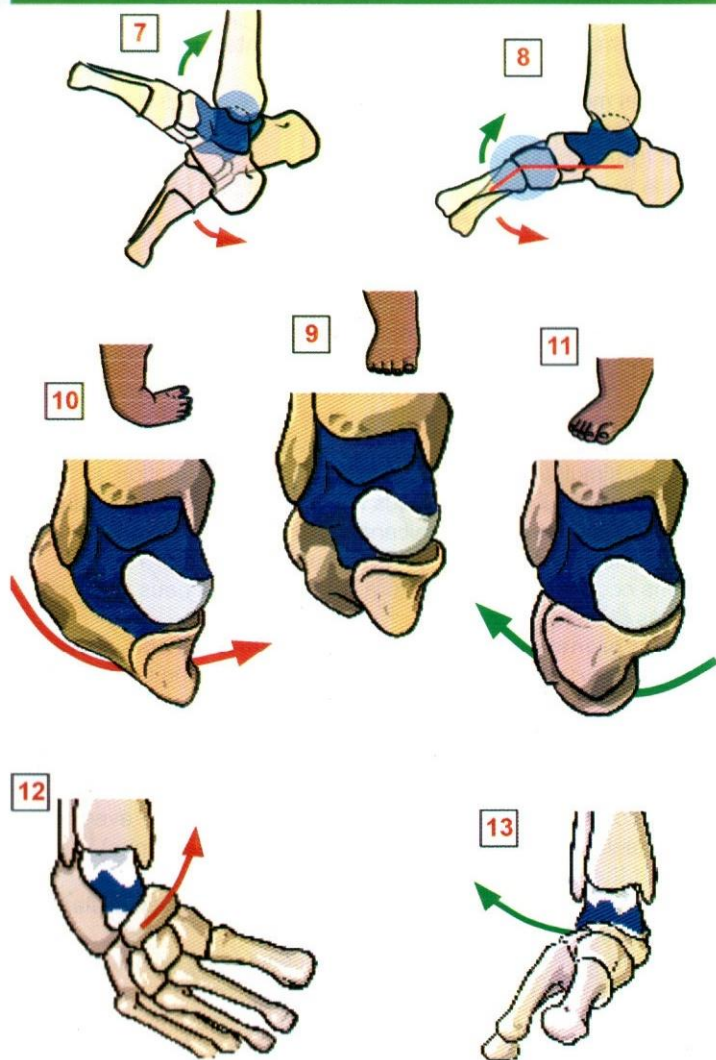
These coupled movements explain the importance of abduction of the foot around the fulcrum of the talar head (pgs. 55-56). As the foot abducts, the calcaneus also abducts, and at the same time everts (correcting heel varus) and extends (correcting part of equinus).

Movements of the talonavicular and calcaneocuboid joints

- These joints move mainly around the axis of rotation perpendicular to the transverse plane:

- (12) Adduction describes movement of the cuboid and navicular towards the medial body plane (**red arrow**).

- (13) Abduction (**green arrow**) is the opposite.



Fundamentals for Orthopedic Surgeons

3.2 Pathogenesis & Pathology

- The etiology is unknown. A current hypothesis is that an environmental stimulus triggers of a genetic predisposition which results in a focal posteromedial retracting fibrosis and gastrocsoleus contracture.
- These in turn lead to in tarsal joint misalignments and anlagen shape deformations, that give rise to the characteristic deformities of cavus, adductus, varus, and equinus seen in clubfoot.

Posteromedial retracting fibrosis

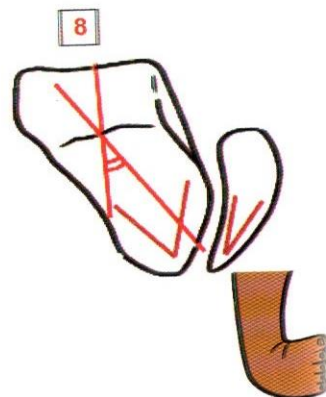
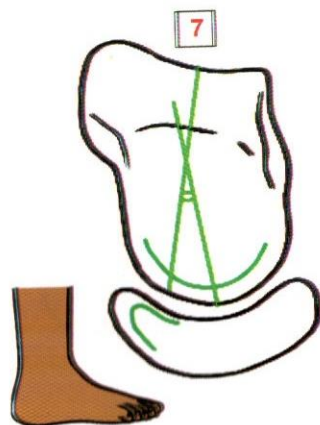
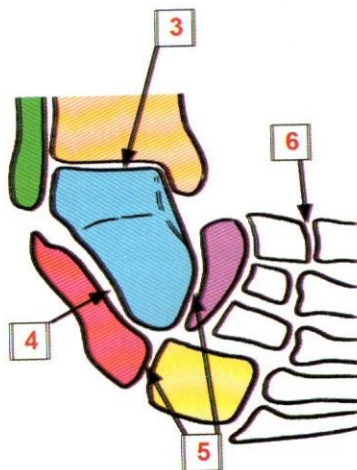
- (1) Focal retracting fibrosis of of capsular ligaments and tendon sheaths posteromedial to the ankle, subtalar, and talonavicular joints. (|||||).
- (2) Gastrocsoleus contracture. The muscle tendon unit is shorter and smaller than normal (red spring).

Tarsal joint misalignments

- (3) Tibiotalar joint is plantarflexed, contributing to equinus deformity.
- (4) Subtalar joint is supinated contributing to equinus and heel varus deformities.
- (5) Talonavicular joint (TNJ) & Calcaneocuboid joint (CCJ) are both adducted, contributing to mid-foot adduction deformity. The navicular approximates the medial malleolus.
- (6) Cuneiform first metatarsal joint is plantarflexed, contributing to cavus deformity.

Tarsal anlagen shape deformations

- (7) Normal.
 - Talar neck – slight medial inclination (green angle).
 - Head of talus – dome shape (green curve).
 - Lateral pole navicular – round shape (green curve).
 - (8) Clubfoot.
 - Talar neck – Increased medial inclination (red angle)
 - Head of talus – smaller and wedge shaped (red arrowhead)
 - Lateral pole Navicular – wedge shaped (red arrowhead)
- The anlagen of the calcaneus and cuboid are also misshapen (not shown).



Assessment Of Clubfoot

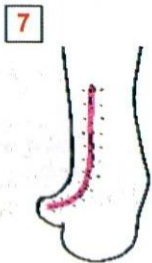
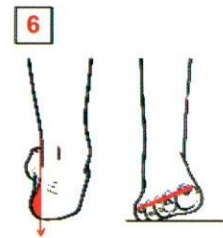
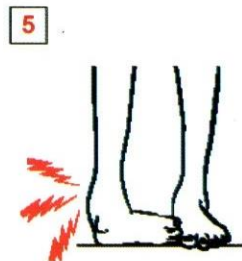
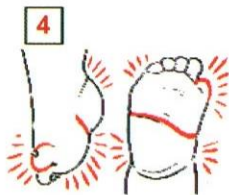
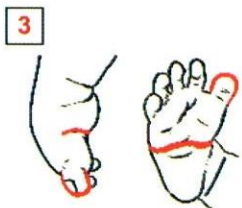
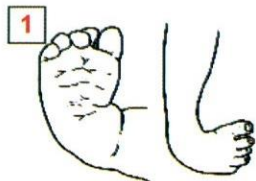
4.1 Clubfoot Types

- There are **many types of clubfoot**. (Ponseti International Association 2015). Each has its own clinical characteristics clinical treatment protocol, and prognosis.
- The first step in management after diagnosis of clubfoot is to establish its type.

Types of clubfoot

- [1] **Idiopathic clubfoot - patient not walking.** This is the most common type seen at birth. Other congenital abnormalities are absent.
- [2] **Syndromic Clubfoot.** This type is a rare, but important type usually diagnosable at birth. There are other congenital abnormalities or syndromes such as arthrogryposis and myelomeningocele.
- [3] **Atypical clubfoot.** This looks like [1], but has a deep complete plantar crease that extends all the way to the lateral border of the foot. The equinus can be severe. The 1st ray is foreshortened, the hallux is hyper-extended. Other congenital abnormalities are absent.
- [4] **Complex clubfoot.** This looks like [3], but has a history of multiple cast-slips and a short 1st ray and hyper-extended hallux. The whole foot may be inflamed (swollen, tender, and skin may be reddened). The heel may be flattened. This is usually an iatrogenic deformity.
- [5] **Idiopathic clubfoot - patient walking.** This is [1] left untreated until the child starts to walk. Weight bearing adds further deforming forces and causes pain.
- [6] **Persistent clubfoot.** One or more of cavus, adductus, varus, or equinus deformities are present following previous Ponseti treatment, or other nonsurgical treatments.
- [7] **Post-surgical clubfoot.** One or more of cavus, adductus, varus, or equinus deformities are present following previous joint invasive procedures (e.g. posteromedial release). Surgeries associated with the Ponseti method are not included in this category.
- [8] **Well-corrected clubfoot.** The absence of either cavus, adductus, varus, or equinus after previous Ponseti or other treatments.

● Replace 2 with 1.1.7



Assessment Of Clubfoot Pirani Score for Infants

- Use the Pirani Score at each visit to assess the severity of deformity in infants, to monitor progress and to guide decision making. (pgs. 47-8, 67-8, 75-8, 83-84, 99-100, 103-4, 107-8, 111-2, & 125-6).

The Pirani Score

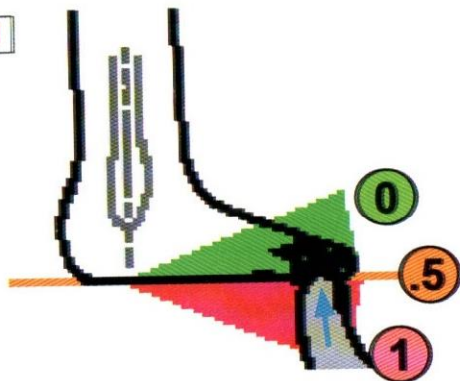
This score clinically assesses the severity of deformity in infants by measuring six clinical signs that change as the foot deformity improves. Each sign is scored **0 (normal)**, **0.5 (mild)**, or **1 (severe)**. Examine for signs with the baby relaxed on mother's lap:

- Hind Foot Score (HFS).** The summed scores of three signs form the HFS, and assess severity of equinus. Score ranges from 0 (normal) to 3 (severe).
- Mid-Foot Score (MFS).** The summed scores of three signs form the MFS, and assess severity of supination, adductus, and cavus. Score ranges from 0 (normal) to 3 (severe).
- Total Score (TS).** The sum of HFS & MFS assess severity of the club foot as a whole with a score range from 0 (normal) to 6 (severe).

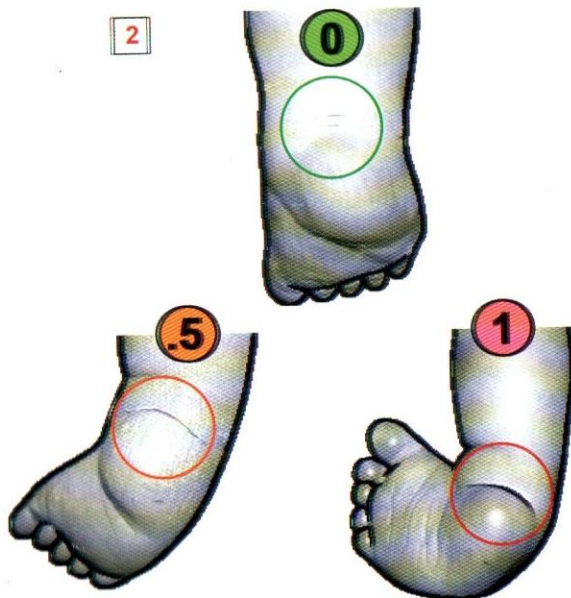
IFB signs assess equinus

- For each sign, first gently correct the deformity till resistance is felt, and then assess the score.
- (1) Rigid Equinus (RE).** As equinus increases, ankle dorsiflexion is increasingly limited. With the knee flexed 90°, examine extent of dorsiflexion with respect to neutral from the lateral side to avoid confounding effect of cavus:
 - Score 0 if dorsiflexion above neutral (normal).**
 - Score 0.5 if dorsiflexion only to neutral.**
 - Score 1 if dorsiflexion short of neutral.**
- (2) Posterior Crease (PC).** As equinus increases, posterior ankle skin creases deepen. Closely examine number and depth of posterior ankle crease(s):
 - Score 0 if multiple fine creases (normal).**
 - Score 0.5 if one or two non indenting shallow crease(s).**
 - Score 1 if single indenting crease.**

1



2



- (3) Empty Heel (EH). As equinus increases, the calcaneal tuberosity moves proximally and the heel pad feels increasingly soft or empty of bone. Palpate the calcaneal tuberosity through the fat pad at the corner of the heel:

- **Score 0 if tuberosity immediately palpable (normal).**
- **Score 0.5 if tuberosity felt only with deep palpation.**
- **Score 1 if tuberosity not palpable.**

MFS signs assess subtalar supination, midfoot adduction and cavus

- (4) Talar Head (TH). As supination and adduction increase, the navicular moves medially, uncovering the talar head laterally. Palpate the talar head laterally with a thumb about 2 cm anterior to the fibula tip in the newborn. Gently abduct the foot until resistance is felt. Assess how well the navicular reduces by determining how much talar head remains palpable:

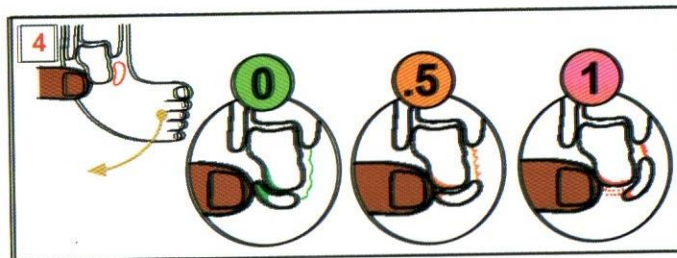
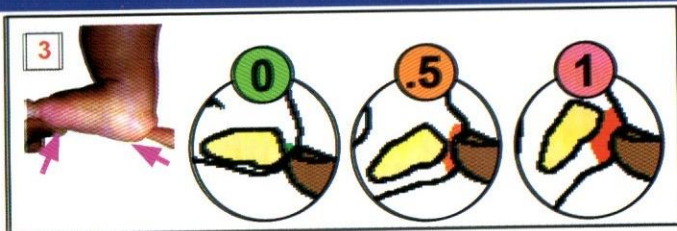
- **Score 0 if navicular slides between thumb and head of talus and talar head impalpable (normal).**
- **Score 0.5 if navicular reduces partially. Both talar head and navicular palpable.**
- **Score 1 if navicular does not reduce. Only talar head palpable.**

- (5) Curved Lateral Border (CLB). As adduction increases, the cuboid and navicular adduct and the lateral border of the foot curves. Assess the lateral border of the foot for curvature:

- **Score 0 if lateral border straight (normal).**
- **Score 0.5 if lateral border with a gentle curve.**
- **Score 1 if lateral border with 'boomerang' curve.**

- (6) Medial Crease (MC). As cavus increases, fine transverse creases in the arch of the foot deepen. Closely examine the number and depth of medial longitudinal arch crease(s):

- **Score 0 if multiple fine creases (normal).**
- **Score 0.5 if one or two non indenting shallow crease(s).**
- **Score 1 if single indenting crease.**



Assessment Of Clubfoot

4.3PBS Score for Walking Child

- Use the PBS Score at each visit at each visit to assess the severity of deformity in walking children, to monitor progress and to guide decision making. (pgs. 47-8, 83-4, 99-100, 103-4).

PBS Score

check page numbers

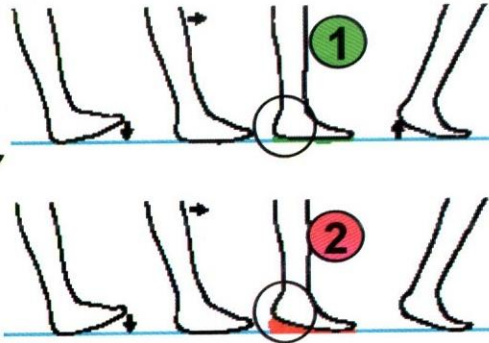
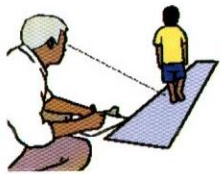
This Score clinically assesses the severity of deformity in walking children by measuring seven clinical signs that change as the foot deformity improves - two signs with child standing, two with child walking and three with child seated. Five signs are scored **1 (normal)** or **2 (abnormal)** and two signs as **1 (normal)** or **2, 3, or 4**. (**Mild, moderate** or **severely** abnormal).

- PBS Ankle Score (PBSA)**. Summed scores of three signs assess equinus from 3 (normal) to 8 (severe).
- PBS Subtalar Score (PBSS)**. Summed scores of four signs assess subtalar supination from 4 (normal) to 10 (severe).
- PBS Total Score (PBST)**. The sum of PBSA & PBSS assess severity of the clubfoot as a whole from 7 (normal) to 18 (severe).

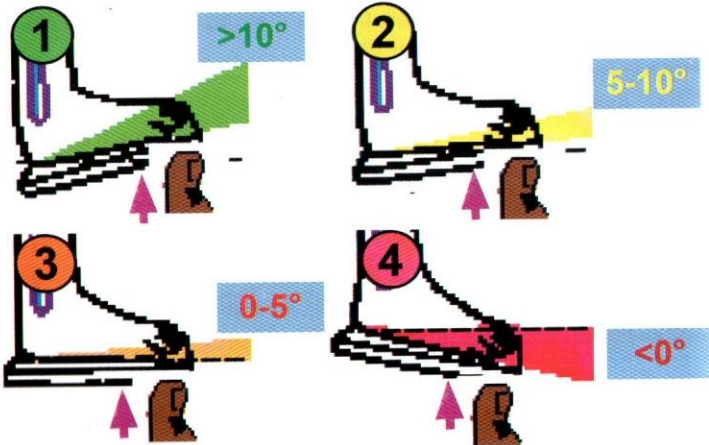
PBSA Score signs assess equinus

- Early Heel Rise (HR)**. As equinus increases there is premature heel rise (or absent heel strike). Observe the foot during stance phase with child walking on a firm surface. Determine if heel strike occurs, and if so, whether heel rise occurs before or after the ipsilateral tibia becomes perpendicular to the ground:
 - Score 1 if heel rises after tibia perpendicular (normal).**
 - Score 2 if heel strike absent, or heel rises before tibia perpendicular.**
- Passive Ankle Dorsiflexion (PAD)**. As equinus increases, ankle dorsiflexion becomes limited. Place child on parents lap with hip and knee flexed to 90°. Gently extend ankle until resistance felt. Determine the PAD angle between the sole of the foot and neutral (orthogonal to fibula line). Stabilize foot on a wood board if necessary.
 - Score 1 if PAD angle greater than 10°.**
 - Score 2 if PAD angle between 5 & 10°.**
 - Score 3 if PAD angle between 0 & 5°.**
 - Score 4 if PAD angle less than 0°.**

1



2



(3) Active Ankle Dorsiflexion (AAD) assesses ankle dorsiflexor strength, equinus permitting. Perform this assessment immediately after PAD. Dorsiflex the foot until resistance is felt. Now ask the child to hold the foot in that position. Assess AAD - the ability of child to hold the foot above neutral (orthogonal to line of fibula). Where the child does not cooperate, tickle the sole to provoke the child to actively dorsiflex the foot:

- **Score 1 if child hold/dorsiflex ankle above neutral**
- **Score 2 if cannot hold/dorsiflex ankle above neutral**

PBBS Score signs assess subtalar supination

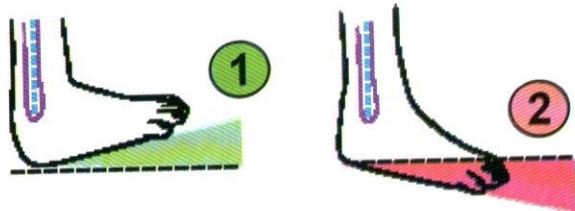
(4) Heel Varus (HV) As supination increases, the heel deforms into varus. Have the child stand on a low stool with feet equally weight bearing. Equalize leg lengths if necessary. Look at rear of weight bearing foot from a low angle. Determine midline of Achilles tendon. Determine position of heel (which normally reflects position of calcaneal tuberosity). Assess position of heel with respect to midline of Achilles tendon.

- **Score 1 if heel mostly lies directly below or lateral to midline of Achilles tendon**
- **Score 2 if heel mostly medial to midline of Achilles tendon.**

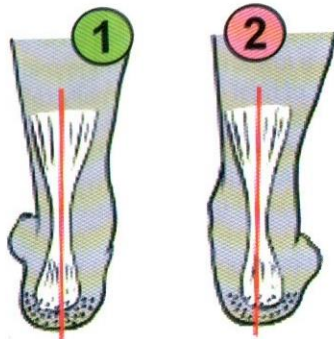
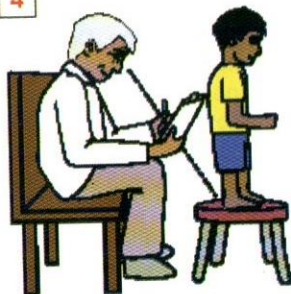
(5) Standing Supination (SS) With fixed subtalar supination, the forefoot may also appear supinated and the medial metatarsal heads do not weight-bear. Have the child stand on a low stool with feet equally weight bearing. Equalize leg lengths if necessary. Look at front of weight bearing foot from a low angle. Assess how many metatarsal heads are in contact with the ground.

- **Score 1 if metatarsal all heads in contact with weight bearing surface of stool (normal)**
- **Score 2 if metatarsal heads medially not in contact with weight bearing surface of stool.**

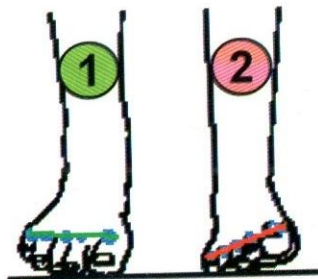
3



4



5



(6) Walking Supination (WS) With increasing subtalar supination from tibialis anterior over activity, the forefoot supinates during swing phase of gait. Have the child walk on a firm surface towards you. Observe feet from anterior perspective during swing phase from low viewing angle. Determine alignment of forefoot with respect to ground during latter part of swing phase. Repeat as necessary.

- **Score 1** if forefoot aligned parallel with respect to ground (normal).
- **Score 2** if forefoot raised medially with respect to ground

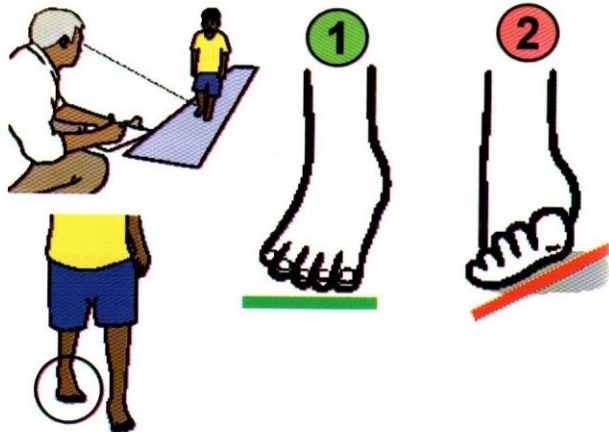
(7) Subtalar Abduction (SA). As posteromedial contracture increases, subtalar adduction and supination deformity becomes increasingly fixed. Assess for this deformity by determining the amount of passive subtalar abduction present.

- Look at the leg and foot from the front.
- Determine the line of anterior crest of tibia. Determine line of 2nd metatarsal. Stabilize the head of the talus with a thumb on its lateral aspect with one hand. With the other hand gently abduct the foot around the fulcrum of the talar head until resistance is felt.

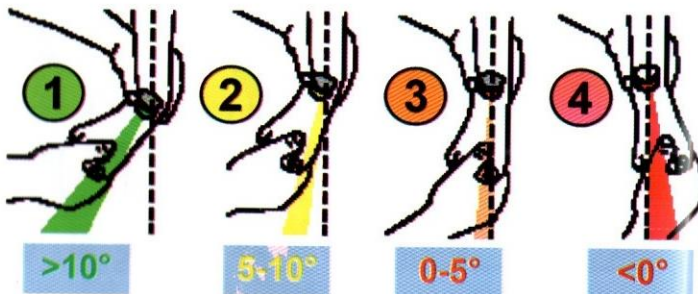
* Assess the angle between the line of the anterior crest of the tibia and the 2nd metatarsal intersect, usually directly over the center of the head of the talus. This is the PSA angle.

- **Score 1** if PSA angle greater than 10° .
- **Score 2** if PSA angle between 5° & 10° .
- **Score 3** if PSA angle between 0° & 5° .
- **Score 4** if PSA angle less than 0° .

6



7



Assessment Of Clubfoot

4.4 Recording

The Clubfoot Patient Record Form (CPRF)

[1] Use CPRF to:

- ☐ Record history, exam, clubfoot type and severity score at intake.
- ☐ Record scores, treatment, and outcomes at each visit.
- ☐ Guide treatment decisions. Pirani Score graph shows progress over time (see pgs xx).
- ☐ Inform DGHS DHIS clubfoot database.

Pirani Score (children not yet walking)

[2] Record all values of Pirani Score elements at each visit

- ☐ Each of CLB, MC, LHT, PC, RE & EH as 0, 0.5 or 1.
- ☐ MFS (CLB+MC+LHT) between 0 & 3.
- ☐ HFS (PC+RE+EH) between 0 & 3.
- ☐ TS (MFS+HFS) between 0 & 6.

PBS Score (walking children)

[3] Record all values of PBS Score elements at each visit:

- ☐ Each of HR, AAD, HV, SS, WS as 1 or 2.
- ☐ Each of PAD & SA as 1, 2, 3 or 4.
- ☐ PBSA (HR+PAD+AAD) between 3 & 8
- ☐ PBSS (HV+SS+WS+ SA) between 4 & 10.
- ☐ PBST (PBSA+PBSS) between 7 & 18.

Clinical Course

[4] Record treatment at each visit:

- ☐ P = Ponseti cast with a number for cast position; T = tenotomy; FAB = foot abduction brace; O = observation; R = referred for surgery; S = skin care for pressure area/sore; D = discharge.

[5] Record complications at each visit:

- ☐ P = pressure sore; I = infection; C = cast-slip; O = other; N = nil.

[6] Pirani Score graph shows progress with treatment - (see pgs xx)

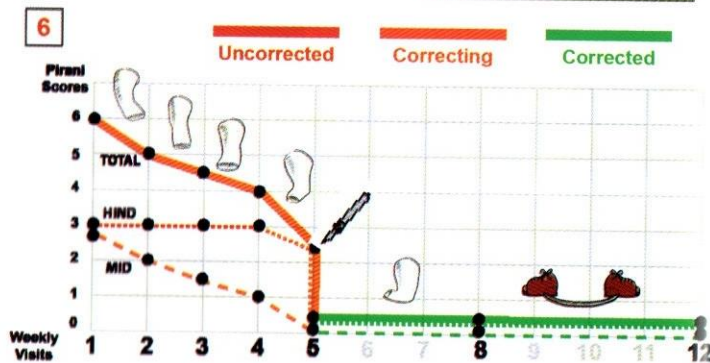
- ☐ Typical pattern where the deformity corrects in 5 weeks:
- ☐ Line colors indicate **uncorrected**, **correcting**, or **corrected**.
- ☐ Line style indicate MFS (-----): HFS (.....), TS (___)

Pirani Score	Visit →	1 st visit	
	Date →	05.01.2016	
	Foot →	L	R
	CLB	1	1
	MC	1	1
	LHT	1	1
	→ MFS	3	3
	PC	1	1
	RE	1	1
	EH	1	1
	→ MFS	3	3
	→ TS	6	6

PBS Score	HR			
	PAD			
	AAB			
	→PISA			
	HV			
	SS			
	WS			
	SA			
	→PBSS			
	→PBST			

Diagnosis	I	II
Treatment	P	P
Cast position	I	I
FAS Use	N/A	N/A
FAS Use		
FAS Size		
Complication	N	N

Diagnosis: I = Syndromic; 2 = Unilateral
 0 = Unaffected (of unilateral clubfoot)
 Treatment: P = Ponseti cast; T = Traction
 D = Discharge
 Complication: P = Pressure Sore; I = Infection



- This section describes physical setup, supplies necessary, care of the parent and child, cast removal technique and cast complications.

Teamwork, roles, & positioning for right clubfoot

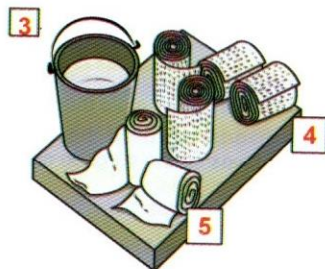
It takes a team to complete each manipulation and casting. The mother (usually) comforts the child. The doctor and assistant gently manipulate and cast the foot. All should be seated in a triangle pattern for maximum comfort. The exact positioning depends on the foot being treated. Below is the general setup for a right clubfoot. (Left foot setup and further details on pgs 63 - 64 & 69 - 72).

- [1] Mother and child.** Seat mother on a chair with a pillow transversely on her lap covered by a waterproof sheet. Place infants and young children on the pillow with the head next to the right breast. Older children do well with a sweet or snack, and may prefer to lie on a table most comfortable breast or bottle feeding on a parent's lap. (left breast for the left clubfoot). A shawl can be used for modesty.
- [2] Surgeon and assistant**
- The surgeon (**gray hair &**) sits facing the lateral side of the leg to manipulate the foot and later mold the cast.
 - The assistant (**black hair & gray hands**) sits distal the leg to apply padding and cast and then moves so the surgeon can move distal to mold.

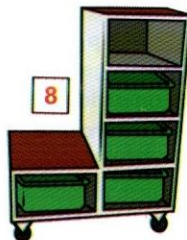
Prepare supplies

Prepare and set up supplies before the clinic starts. The clinic will run more smoothly. The supplies needed during manipulations and casting include:

- 1. **Bucket of water.**
- 2. **Plaster of Paris (POP) rolls** – 2", 3", and 4". Use larger sizes of POP for larger feet.
- 3. **Cotton padding.**
- 4. **Plastic apron.**
- 5. **Plaster knife** to score the cast.
- 6. **Mobile cast cart** holds all supplies and a low platform for a bucket of water. It is on wheels and can be moved as needed. Supplies can be easily reached throughout the casting procedure.



● add gloves



Care of the parent

[9] Counsel parents. Take the opportunity during and after casting to continue counseling the parents on the specific steps of pathway of management and with a kind and sensitive attitude. Reassuring and encouraging words help parents feel that the treatment will have a beneficial outcome. Inform parents of:

- **Visit schedule** and purpose of each visit:
 - Weekly for about 4-8 visits – serial manipulation and casting, with tenotomy at last weekly visit.
 - 3 weeks later – cast removed and brace fitted.
 - 2 weeks later – problem-solve around bracing.
 - 2 mos later – review and change bracing schedule.
 - Then every 3-6 mos until age 4 yrs, check for relapse and fit new braces if needed. Discharge at age 4 yrs if no relapse.
- **Good outcomes.**
 - Children grow up normally if the complete treatment protocol is followed
- **Cast care at home**
 - Prevent the cast from getting wet.
 - Seek immediate attention if toes swell or child cries inconsolably.

Care of the child

The surgeon and assistant should work in a relaxed unhurried manner. They should constantly observe child's face for signs of discomfort, and if present, loosen the hand grip and slows down until child relaxed again.

- [10] Relaxed child enables effective casting.** Comfort and distract the child to relax large leg muscles. Manipulations can be gentle and more effective. Casts can be more accurate (See pgs 59 - 60).
- [11] Struggling child increases risk for ineffective casting.** When the child struggles/cries, the natural reaction is to use more force to hold the leg and foot. This can hurt the child, who then only cries and struggles more. Casts are applied in a hurry and tend to be loose. Accurate molding is virtually impossible. Casting is ineffective (See pgs 59 - 60). There is increased risk of complications such as pressure-sores and cast-slip (See pgs 55 - 56)

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Cast removal

There are many ways to remove a cast. Avoid electrical cast saws, as they are noisy and scare children. NITOR recommends softening the cast with water, scratch the surface of the cast with a knife, find an edge, and unrolling.

Remove casts in the clinic on arrival, not the night before, as the foot loses correction overnight.

• Wet and soften cast

- [12] **Wet cast** – gently and slowly pour water on the cast. Child is on a waterproof sheet on mother's lap.
- [13] **Soften cast** by pressing on wet cast with thumbs.

• Score and unroll

- [14] **Score cast** with a knife until plaster edge found. Cut obliquely to reduce the risk of cutting too deeply.
- [15] **Unroll plaster** by finding an edge and pulling away.
- [16] **Continue wetting and softening cast.**
- [17] **Continue scoring cast, finding an edge, and unrolling until all plaster removed.**
- [18] **Remove padding** gently to expose the skin.



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Complications of Casting

Poor casting technique can result in loose casts where the foot slips, dents which can cause pressure sores, or tight casts which cause neurovascular compromise. Consequences can be devastating with delayed recognition or management. Look out for any sign of a complication. Take timely action as required.

[20] Signs

- ❑ **Inconsolable crying** without any other apparent cause (hunger, earache, etc) is a cardinal sign of pain and considered a complication unless proven otherwise. Worry about neurovascular compromise from a too tight cast. Look for:
- ❑ **Swollen/discolored toes** – these indicate a source of inflammation and swelling under the cast extending to the toes. Most commonly from pressure-sores from tight or ill-fitting casts.
- ❑ **Disappearing toes** are seen with too much padding, poorly molded, and loosely applied casts – **cast-slip**. The cast starts to slip, toes start to disappear, and ill-fitting casts may cause pressure-sores. They apply incorrect forces and predispose to iatrogenic complication of complex clubfoot deformity.
- ❑ **Wet casts** become weak, soften, and do not hold correction. Skin gets wet and macerated. Remove wet casts right away to prevent skin damage.

[21] Management - Remove casts right away and examine foot.

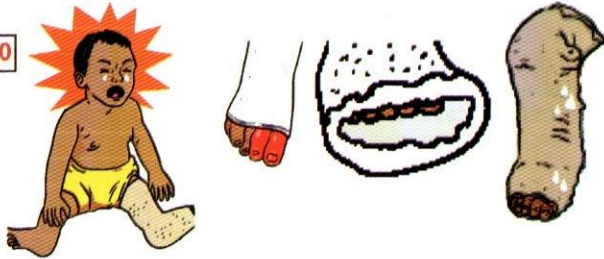
The child should stop crying almost immediately as pain from impending vascular compromise is relieved.

- [22] **Management minor pressure area.** These are commonly seen over the talar head laterally where the skin is thin or at the heel if the cast slips. If skin only reddened, clean, dress, and apply new carefully molded cast. If swollen, wait 1-2 days for the swelling to resolve before resuming casting.

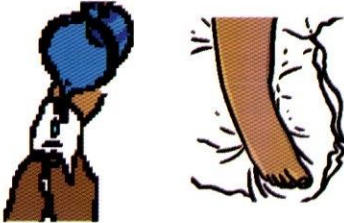
- [23] **If skin blistered, broken, or wet, clean and dress only** – wait a few days for sore to heal and then apply new carefully molded cast.

• **Cast-Slip** – apply a new well-molded cast. Use amended technique if complex clubfoot present (see pgs. 127 - 28).

20



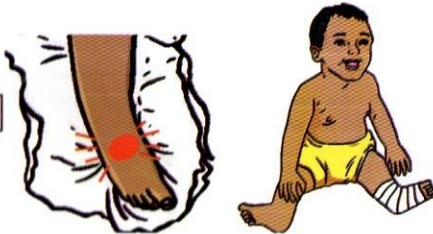
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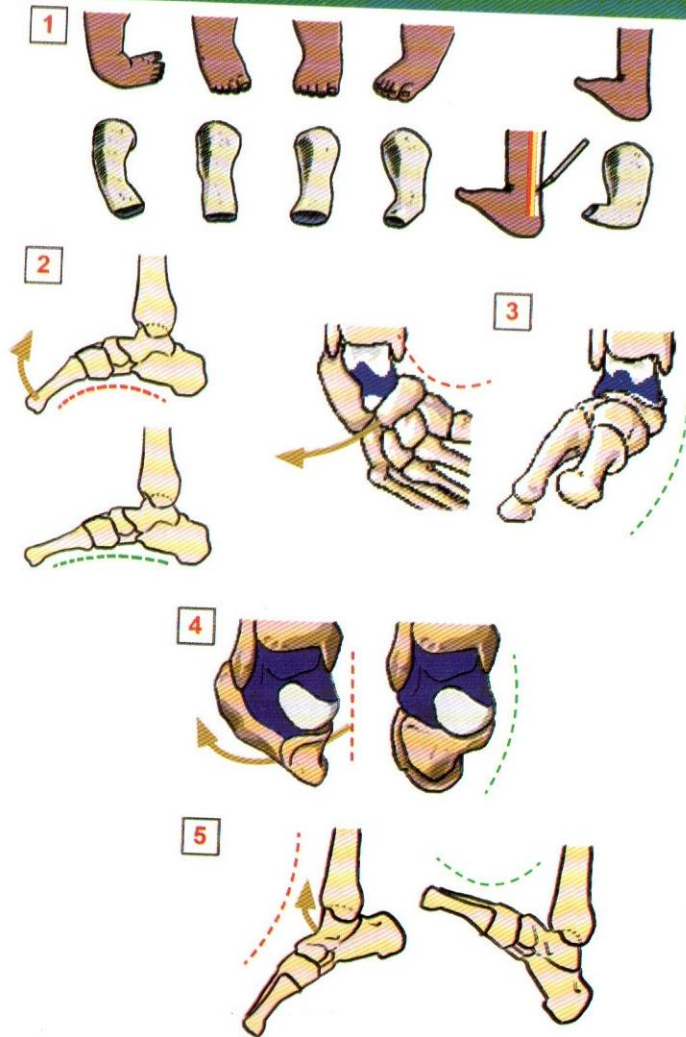
Manipulation & Casting

5.2 Mechanism of Correction

- Focal posteromedial retracting fibrosis and gastrocnemius contracture is thought to result in tarsal joint misalignments and anlagen shape deformations.
- Manipulation and casting apply low-load corrective forces on soft tissues and tarsal anlagen.
- Young connective tissues respond biologically to low load corrective forces with lengthening of contracted soft tissues and correction of tarsal anlagen deformities and misalignments.

Goals

- [1] A precise manipulative technique, accurate serial casting, and percutaneous Achilles tenotomy when indicated (before the last cast) usually corrects all deformities in about 5-6 casts.
- [2] **Correct cavus (red dashed line)** by dorsiflexing CMT1 (**yellow arrow**). Cavus usually corrects in the first cast (**green dashed line**).
- [3] **Correct TNJ & CCJ adductus (red dashed line)** by abducting navicular and cuboid on talus and calcaneus (**yellow arrow**). Adductus usually corrects slowly over 3-4 casts (**green dashed line**).
- [4] **Correct varus (red dashed line)** by abducting calcaneus under talus (**yellow arrow**). As the calcaneus abducts, it also everts, correcting varus, and extends, correcting some equinus. Varus usually corrects in 3-4 casts (**green dashed line**).
- [5] **Correct equinus (red dashed line)** by complete Achilles tenotomy and ankle dorsiflexion (**yellow arrow**). Do this after cavus adductus and varus are fully corrected (**green dashed line**).



How does Ponseti manipulation and casting work?

- Studies of serial MRI during treatment show misaligned tarsal anlagen gradually resume normal shape and alignment.
- The talonavicular joint is illustrated, but principles apply to all affected anlagen.

Effective manipulation and casting

[6] Be gentle. Encourage mothers to feed their babies.

- Relaxed babies move very little. Muscles stay soft. Contractures stretch
- Manipulations more effectively stretch contracted soft tissues.
- Easier to apply accurate casts that hold correction achieved
- Watch baby's face carefully - Loosen hands if discomfort noted.

[7] Untreated clubfoot. Contractures (**red springs**) displace navicular medially and deform soft cartilage of talar head and navicular (**solid red outlines**).

[8] 1st manipulation. Navicular abducted (**yellow arrow**) around the talar head fulcrum (thumb). Medial contractures stretched (**stretched red spring**). Cartilage deformity and joint misalignment improved (**dotted red outlines**).

[9] 1st cast. Accurately applied cast (**black lines**) holds correction achieved in first manipulation. Over time medial contractures lose tensile strength. Soft tissues and cartilage adapt to new resting lengths and shapes facilitating further corrections.

[10] 1st cast removed 1 wk later. Medial contractures at new resting length (**orange spring**). Talar head and navicular cartilage adapted to new resting shapes (**orange outlines**).

[11] 2nd manipulation. Navicular further abducted (**yellow arrow**) around the talar head fulcrum (thumb). Medial contractures further stretched (**stretched orange spring**). Cartilage deformity and joint misalignment improved (**dotted orange outlines**).

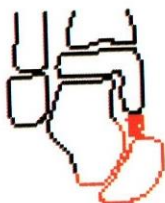
[12] 2nd cast - Accurately applied cast (**black lines**) holds correction achieved in second manipulation. Over time medial contractures lose tensile strength. Soft tissues and cartilage adapt to new resting lengths and shapes facilitating further corrections with subsequent casts

[13] 4th cast removed. Medial contractures stretched to correct resting length (**stretched out green spring**). Cartilage deformations and joint misalignments fully corrected (**green outlines**).

6



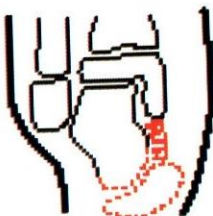
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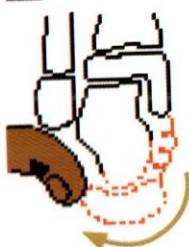
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Ineffective manipulation and casting - avoid

[14] Rough manipulations hurt

[15] Crying babies move

- Muscles contract and limbs move
- Manipulation and casting becomes very difficult

[16] 1st manipulation ineffective.

- Contracting muscles (**red arrow**) counter manipulation force

[17] Navicular fails to abduct

- Short arrow (**yellow**) around the talar head fulcrum.
- Medial contractures fail to stretch (**red springs unchanged**).
- Cartilage deformations and joint misalignment do not improve (**red outlines**).

[17] 1st cast inaccurate.

- Cast loose/poorly molded (**black line**) - Does not hold foot uncorrected.
- **Biologic response muted**. Correction is slow and limited.

[18] 1st cast removed

- 1 wk later
- Medial contractures remain the same (**red spring unchanged**).
- Cartilage deformations and joint misalignments remain the same (**red outlines**).

14



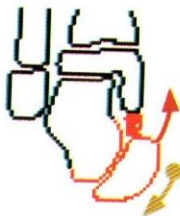
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Manipulation & Casting

5.3 Manipulation

- The standard technique for the manipulation and casting of the idiopathic clubfoot - patient not walking is described.
- Techniques for other types of clubfeet vary in some of their details and are described in the sections for other types of clubfeet. The surgeon needs an assistant. All should be seated for maximum comfort.

Positioning

- Surgeon & assistant with plastering skills (preferable):**
 - The surgeon (gray hair & blue hands) sits lateral to manipulate.
 - The assistant (black hair & gray hands) sits distal to apply padding and cast and then moves so the surgeon can move distal to mold.
- Surgeon & assistant without plastering skills:**
 - The assistant (black hair & gray hands) sits laterally to hold the foot.
 - The surgeon (gray hair & blue hands) manipulates, pads, casts, and molds sitting facing the clubfoot.

Identify clubfoot with both hands - Identify head of talus

For right clubfoot - left hand holds hind foot and identifies head of talus. Right hand holds forefoot. Reverse hand positions for a left club foot.

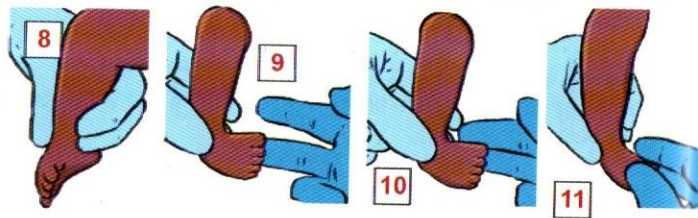
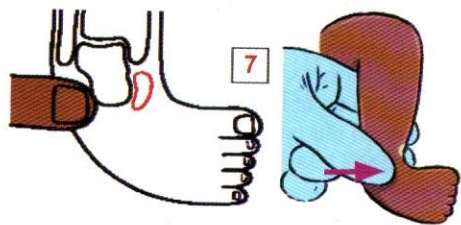
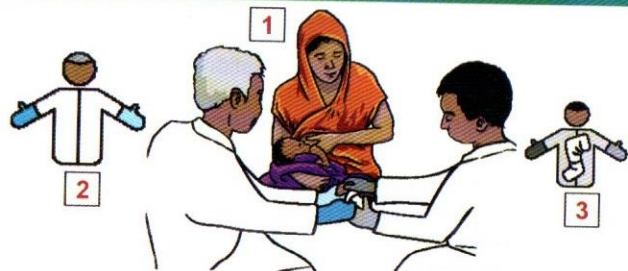
Left thumb - palpate for, and identify prominence, of talar head about 2cm anterior to tip of fibula (in newborn). Confirm by feeling the navicular move on the talar head with foot abduction. Press left thumb gently on lateral talar head during all manipulations so it acts as a fulcrum (pink arrow).

Left index/middle fingers - place on medial malleolus to stabilize distal tibia and ankle.

Right long finger - place on plantar forefoot in line with the 1st metatarsal.

Right index finger - place on medial forefoot in line with the 1st metatarsal.

Right thumb - place on dorsal 1st/2nd toes to stabilize the forefoot.



Principles

- At every manipulation first correct cavus. Then correct as much adductus as permitted by the suppleness of the foot. Varus corrects spontaneously as adductus corrects
- Resist the temptation to correct equinus until cavus, adductus, and varus are all fully corrected.

First manipulation and cast

(12) Goal

- Effective manipulation to supinate the forefoot to correct cavus, then abduct the entire foot under the talus to correct adductus and varus. Techniques for correction of cavus and adductus described separately for clarity.

- Effective cast application to hold correction.

(13) Correct cavus - supinate the forefoot

- Use hand holds (pgs 61 - 62) to apply gentle left thumb pressure on the talar head so it acts as fulcrum (red arrow).
- Cavus is caused by 1st metatarsal flexion (red dashed line) or pronation of the forefoot. It is supple in newborns and usually corrects in the first cast.
- Dorsiflex 1st ray with right long finger to supinate the forefoot. (yellow arrow), which corrects cavus (green dashed line). Only the long finger is shown for clarity.

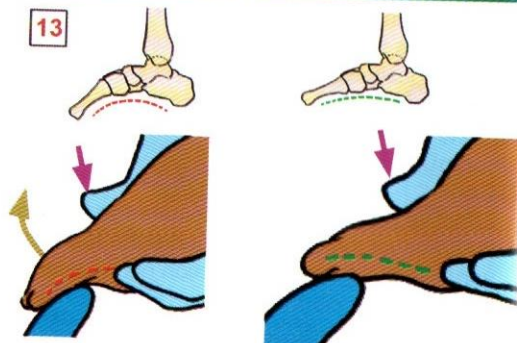
(14) Correct adductus & varus - abduct the supinated forefoot

- Immediately after supinating the forefoot, take advantage of remaining suppleness and abduct the foot as much as soft tissues allow.
- Use hand holds (pgs 61 - 62) to apply gentle left thumb pressure on the talar head so it acts as fulcrum (red arrow).
- Adductus arises from medially displaced talonavicular and calcaneocuboid joints (red dashed line). Varus arises from an adducted and inverted calcaneus under the talus.
- Abduct the supinated foot gently with the right hand the (yellow arrow) until resistance is felt. As plantar medial contractures stretch (green dashed line) adductus and varus improve.
- Apply well-molded cast to hold corrections achieved (pgs.67-72).

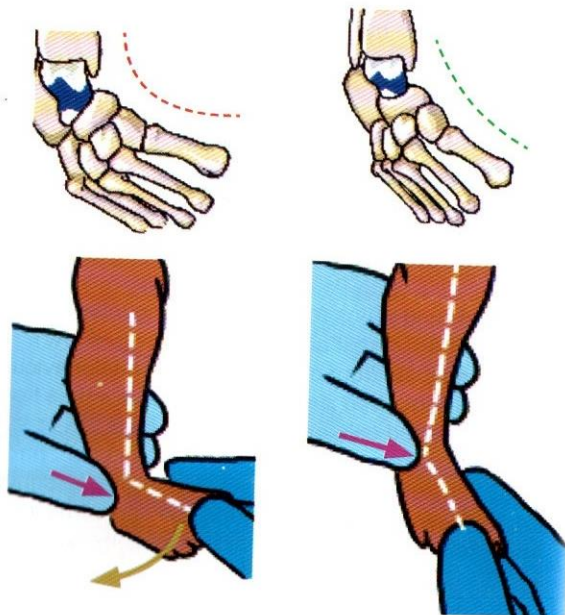
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Subsequent manipulations and casts

- These **target complete correction of remaining adductus** – heel varus will correct automatically.
- Some equinus (arising from the subtalar joint) will automatically correct. Resist the temptation to actively correct equinus until cavus, adductus, and varus are all fully corrected.

[15] Each week

- **Remove cast** applied at the last visit.
- **Check Pirani/PBS score** – to confirm that the deformity is correcting satisfactorily (pgs 45-46 & 73-76).
- Continue effective manipulations and cast applications until cavus adductus and varus are fully corrected – usually about 4-5 casts.
- Supinate the forefoot (pgs. 63-64)
- **Immediately** after supinating the forefoot, take advantage of remaining suppleness and abduct the foot as much as soft tissues allow (pgs. 63-64).
- **Apply well-molded casts each week** to hold foot in increasing abduction and plantar medial contractures stretched (pgs. 67-72).

Monitor progress

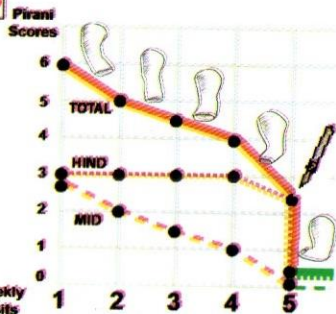
[16] Pirani Score graph of satisfactory progress with treatment - (see pgs xx)

- Line colors indicate **uncorrected**, **correcting**, or **corrected**.
- Typically cavus, adductus and varus corrects in 4 to 5 weeks:
- MFS (-----) starts dropping early reflecting correction of cavus and adductus.
- HFS (.....) drops only a little as correction of equinus is deferred till cavus adductus and varus are fully corrected.
- TS (___) reflects sum of MFS & HFS
- Pirani Score graph details and other patterns (pgs. XX-XX)

15



16



Uncorrected

Correcting

Corrected

67

Manipulation & Casting

5.4 Casting

- Accurate above knee cast holds correction achieved by effective manipulation. Apply below knee part. Mould. Let set. Then extend above knee.
- Two below knee techniques described for assistant with and without plastering skills.

Below knee cast – assistant with plastering skills

[1] Positioning:

- Surgeon sits laterally, manipulates and then hold the foot corrected (pgs. 61-66).
- Assistant with plastering skills sits distal and applies below knee cast.
- Surgeon molds cast whilst still malleable. Surgeon may wish to move distally (wheeled stool useful).

[2] Surgeon's role - maintain correction obtained as padding/plaster applied, then mould cast

- Left image. Corrected foot after efficient manipulation (pgs. 63 - 64). Left thumb (pink arrow 1) stabilizes talar head as fulcrum.
- Middle image. Right thumb replaces left thumb to maintain talar head fulcrum (yellow A to B). Then left thumb moves to knee (pink A to B).
- Right image. Left thumb pressure stabilizes proximal lateral leg (pink arrow 2). Right thumb moves back to the 1st and 2nd toes (yellow A to B) and provides unimpeded access to the foot and leg to apply padding and plaster. Right hand (pink arrow 3) gently abducts supinated foot to maintains correction.

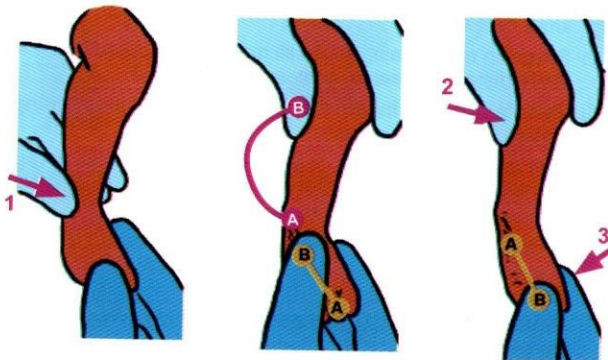
[3] Skilled assistant's role - apply padding and plaster

- Left image. Apply 2 overlapping snug wraps of 2" soft cotton around surgeon's finger and child's toes. Continue with 2/3rds overlap to give 3 layers over foot, heel, ankle, and leg.
- Right image. Apply 3 overlapping snug wraps wet plaster around surgeon's finger and child's toes. Use 2" rolls for infants and 3" rolls for ambulatory children. Continue with 2/3rds overlap to give 3 layers over foot, heel, ankle, and leg. Return to toes with 50% overlap, and leave a knot to help removal. Smooth cast to fuse layers and strengthen so cast does not have to be thick.

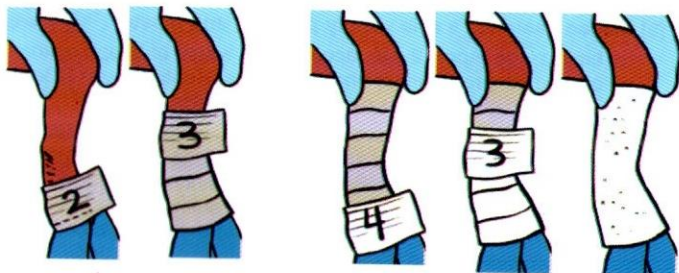
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Below knee cast – assistant without plastering skills

[4] Positioning:

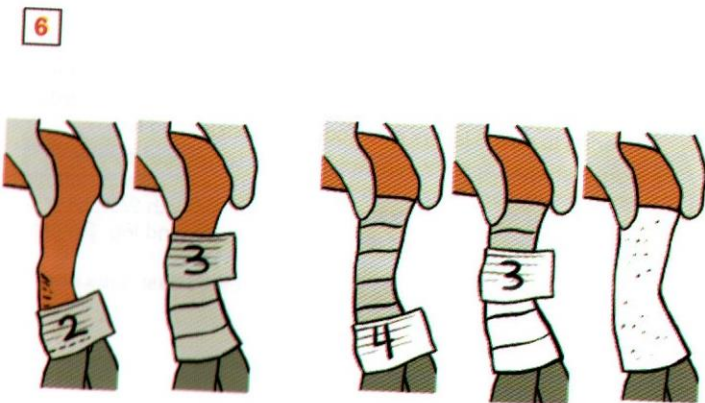
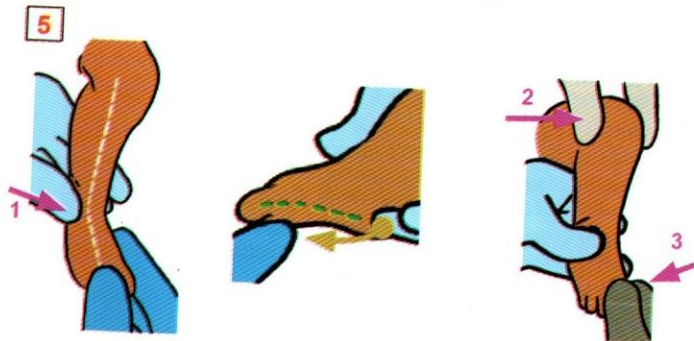
- Surgeon sits facing child to manipulate the foot, apply padding/cast and mould.
- Assistant without plastering skills sits laterally and holds the leg and foot as directed.

[5] Surgeon's role - direct assistant how to hold foot to maintain correction

- Left image. Corrected foot after efficient manipulation (pgs. 63 - 64). Left thumb (pink arrow 1) stabilizes talar head as fulcrum.
- Middle image. Surgeon's left long finger (yellow arrow 1) moves distally into longitudinal arch to maintain foot supinated and abducted with only left hand. Right hand then lets go.
- Right image. Surgeon maintains correction with left hand. Left thumb reians on talar head as fulcrum. Surgeon directs assistant (grey hands) to hold foot supinated and abducted. Assistant's left hand holds knee with gentle thumb pressure (pink arrow _). Assistant's right hand holds forefoot abducted and supinated (pink arrow 3) to maintain correction.

[6] Surgeon's role - apply padding/plaster and mould.

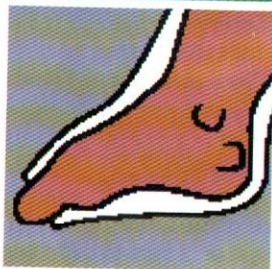
- Assistant (grey hands) holds foot corrected.
- Left image. Apply 2 overlapping snug wraps of 2" soft cotton around surgeon's finger and child's toes. Continue with 2/3rds overlap to give 3 layers over foot, heel, ankle, and leg.
- Right image. Apply 3 overlapping snug wraps wet plaster around surgeon's finger and child's toes. Use 2" rolls for infants and 3" rolls for ambulatory children. Continue with 2/3rds overlap to give 3 layers over foot, heel, ankle, and leg. Return to toes with 50% overlap, and leave a knot to help removal. Smooth cast to fuse layers and strengthen so cast does not have to be thick.



Moulding the cast

- Careful molding is critical to maintain correction, capture the heel and prevent cast-slip (pgs. 53-4).
- Stop moving fingers once cast starts to lose its sheen. Its starting to set, and movement causes cast to crack and weaken.
- [7] **Spaces** (white areas with **red dots**) that require attention.
 - Plantar medial to the 1st ray.
 - Dorsolaterally over the talar head.
 - Above the prominence of the heel.
- [8] **Carefully mold** the cast as it sets to eliminate dead spaces (**green lines**).
 - **Left image.** Left thumb applies constant gentle pressure to plantar medial 1st ray (**pink arrow**) to keep supinated forefoot abducted. Left index finger moves up and down applying gentle pressure over talar head laterally. (**double headed yellow arrow**). Avoid creating a dent.
 - **Right image.** Right index finger molds above the heel prominence and around the malleoli (**double headed yellow arrows**) to prevent the heel from rising and the cast slipping. the heel from rising, and the cast from slipping. **Do not touch the heel**
- Extend cast above knee and trim around toes**
 - Wait until the below knee section has set. Use 3" plaster rolls for children under 4 yrs, and 4" for children over 4 yrs:
- [9] **Extend above knee:**
 - **Flex knee 90°** – avoid the temptation to externally rotate the leg.
 - Wrap 3 layers of soft cotton up to the groin – **apply moistened plaster slab** anteriorly over the knee.
 - **Complete cast to high thigh** – leave knot to assist in removal.
 - **Smooth cast.**
- [10] **Trim cast over toes** dorsally (**red line**) to prevent toe-crowding, permit free toe extension, and to leave plantar platform to resist toe flexion.

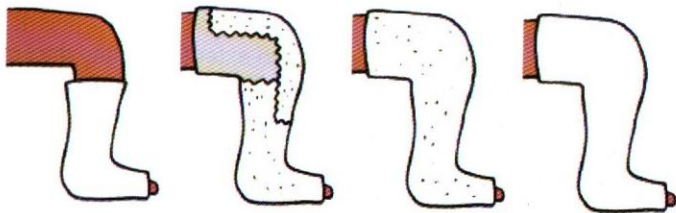
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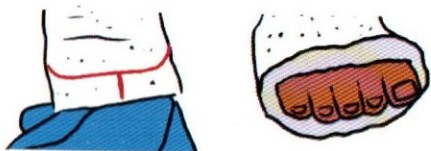
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Manipulation & Casting

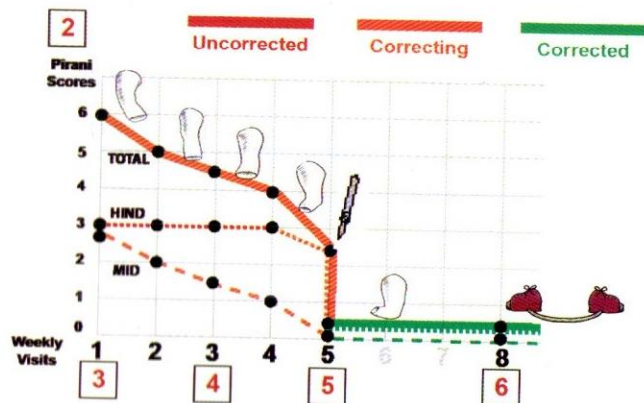
5.5 Assessing Progress (Not Ambulatory Child)

- The Clubfoot Patient Record Form (CPRF) and Pirani Score graphs can show whether deformity correction is satisfactory (or not), and indications for casting, tenotomy, and bracing.

CPRF and Pirani Score Graph - Satisfactory Correction

- The form and graph on pg 74 show the data for the same patient in different ways.
- (1) CPRF of weekly Pirani Scores, diagnosis and treatment of bilateral clubfeet. The deformities corrected with 5 casts. Achilles tenotomy was indicated before the last cast. Foot abduction braces were fitted on cast removal.
 - (2) Pirani Score graph of Typical pattern where the deformity corrects in 5 weeks:
 - Line colors indicate **uncorrected**, **correcting**, or **corrected**.
 - Line style indicate MFS (----): HFS (.....), TS (.....)
 - (3) 1st visit:
 - **MFS = 3; HFS = 3; TS = 6.**
 - Cast #1 applied.
 - (4) 2nd, 3rd, & 4th visits:
 - Scores improve. MFS improves before HFS. **HFS remains at 3; MFS improves to 1; TS = 4.**
 - Casts #2, #3, & #4 applied.
 - (5) 5th visit:
 - Scores continue to improve. Mid foot corrected, hind foot correcting. **MFS = 0; HFS = 2.5; TS = 2.5.**
 - Indications for tenotomy met; HFS > 1; MFS < 1 (pg. 81).
 - Tenotomy performed. Foot corrected. **MFS = 0; HFS = 0.5; TS = 0.5.**
 - Cast #5 applied.
 - (6) 6th visit – cast removed:
 - Foot remains corrected. Tendon healed. **MFS = 0; HFS = 0.5; TS = 0.5.**
 - Indications for bracing met; HFS < 1; MFS < 1 (pg. 97).
 - Foot Abduction brace (FAB) fitted.

Visit→	1 st Visit		2 nd Visit		3 rd Visit		4 th Visit		5 th Visit		6 th Visit	
Date→	05.01.2016		12.01.2016		19.01.2016		26.01.2016		02.02.2016		09.02.2016	
Foot→	L	R	L	R	L	R	L	R	L	R	L	R
CLB	1	1	5	5	0	0	0	0	0	0	0	0
MC	1	1	5	5	5	5	5	5	0	0	0	0
LHT	1	1	1	1	1	1	5	5	0	0	0	0
→MFS	3	3	2	2	1.5	1.5	1	1	0	0	0	0
PC	2	2	1	1	1	1	2	2	1	1	5	5
RE	1	1	1	1	5	5	1	1	0.5	0.5	0	0
EH	1	1	1	1	1	1	1	1	2	2	0	0
→HFS	3	3	3	3	3	3	3	3	2.5	2.5	5	5
→TS	6	6	5	5	4.5	4.5	4	4	2.5	2.5	5	5
Diagnosis (L/R)	3		3		3		3		3		3	
Treatment (M/FAS/TS/TS)	P		P		P		P		P		T	
Cast position (M/F)	1		2		3		4		5		FAB	
FAB Use (Y/N/NA)	NA		NA		NA		NA		NA		Y	
FAB Size (M/L)											2.3	
Complication (P/L/C/O/N)	N		N		N		N		N		N	



Pirani Score Graphs - Other Patterns

[7] Pattern of Syndromic clubfoot:

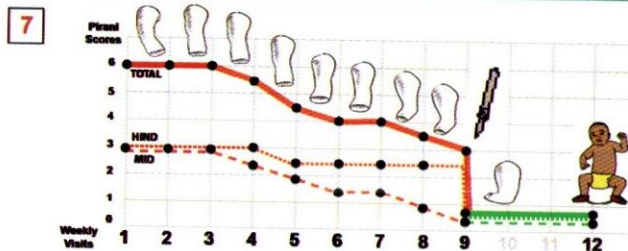
- All scores improve slowly with weekly manipulations and casts.
- Deformity correction can take longer – sometimes even up to 10-12 casts.
- The pattern of correction remains the same with MFS coming down first
- Indications for tenotomy and bracing remain the same.

[8] Poorly applied 3rd cast:

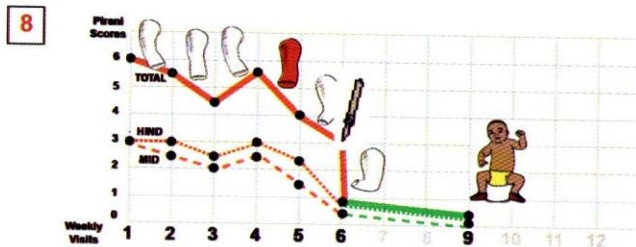
- The 1st and 2nd manipulations and casts were effective. Pirani scores improved.
- 3rd manipulation and cast ineffective. Foot abduction in cast 3 less than cast 2. Pirani scores worsen. Likely the baby was moving and the surgeon was unable to apply the cast with contractures maximally stretched.
- 4th and subsequent manipulations and casts efficient. Satisfactory improvement in Pirani Scores each week.
- Indications for tenotomy met at 6th week. Correction took six casts
- Indications for FAB remain the same.

[9] Recurrence of deformity:

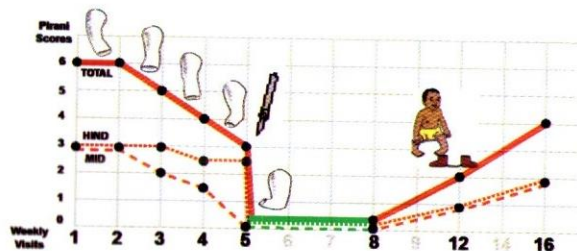
- All manipulations, casts and tenotomy satisfactory.
- Deformity corrected in 5 weeks.
- FAB not used.
- Deformity recurs – Pirani scores worsen.



change 3rd cast to red, 4th cast to white



9



Manipulation & Casting

5.6 Common Errors

- Knowing **common errors** and how to avoid them improves results.
- Usually they are due to an incomplete understanding of pathoanatomy and subtalar joint motion that often lead to errors in technique and consequent failure of correction or even compounding of deformity.

Pronating the forefoot to correct cavus

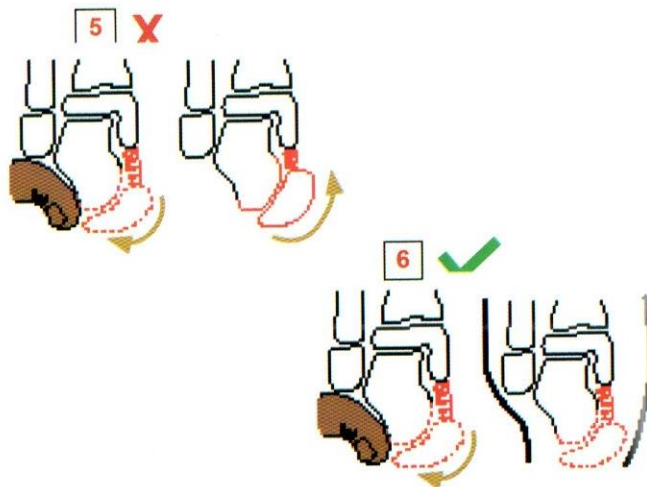
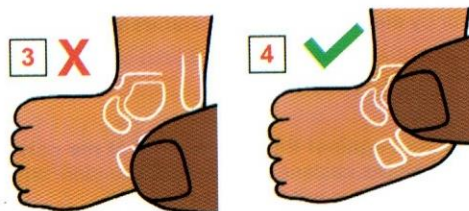
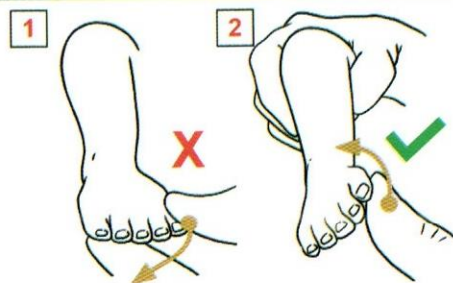
- [1] **Pronating the forefoot** is an error. It makes the deformity worse by increasing the cavus.
- [2] Avoid this error by **elevating the 1st metatarsal** which corrects cavus.

Putting the thumb on calcaneocuboid joint when abducting the foot

- [3] **Abducting the foot against thumb pressure at the calcaneocuboid joint** blocks calcaneal abduction, eversion, and extension is an error. Heel varus will not correct.
- [4] Avoid this error by **accurately identifying the talar head**:
 - **Talar head** lies about 2 cm anterior to the fibula tip in the newborn – more in older children.
 - **Thumb palpates tip of fibula** and then moves 2 cm distally to locate talar head (**yellow arrow**). Confirm by gently abducting/adducting the foot with the other hand and feeling the navicular moving on the talar head.
 - **Abduct the foot against thumb pressure on talar head** allows foot to abduct under the talus. The calcaneus everts and heel varus corrects.

Manipulating without holding correction

- [5] **Frequent manipulations not followed by immobilization** is an error. Posteromedial contractures are stretched, but not held stretched. Contractures do not soften. Further stretching is impeded. Deformity persists.
- [6] Avoid this error by **immobilizing the foot in a cast** with the contracted ligaments at the maximum stretch obtained after each manipulation. Keeping ligaments stretched over several days loosens them sufficiently to facilitate further stretching.



Applying below Knee Casts

- [8] **Below knee casts** are an error. They do not hold the foot in abduction under the talus, and do not prevent the ankle and talus from rotating. The correction obtained by manipulation is lost. Cast tends to slip more often.
- [9] Avoid this error by **applying toe to groin casts with the knee bent to 90°**.

Dorsiflexing the ankle before correcting subtalar supination

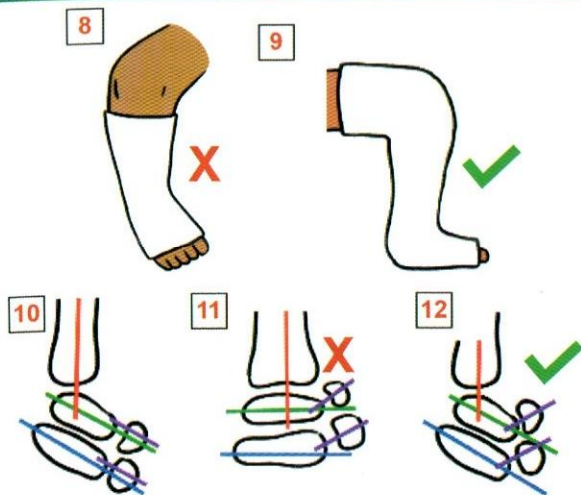
- [10] Equinus arises both from tibiotalar plantarflexion and talocalcaneal plantarflexion.
- [11] **Premature ankle dorsiflexion** is an error. Attempts to correct equinus before the calcaneus is fully abducted and therefore fully extended causes a mid-foot break with spurious dorsiflexion at the mid-tarsal joint.
- [12] Avoid this error by **avoiding dorsiflexion of the ankle until the subtalar joint is fully abducted and subtalar equinus corrected**. Dorsiflexion then can correct any residual equinus without compression and flattening of the soft talar dome and without causing a mid-foot break.

Manipulating and casting without assistance

- [13] **Manipulating and casting by yourself** is an error. Accurate and effective Ponseti casting requires two people – one to hold the correction and another to apply the cast.
- [14] Avoid this error – always **arrange for assistance** before starting to manipulate and cast the foot.

Manipulating and casting a crying baby/child

- [15] **Manipulating and casting with a crying baby** is an error. Unhappy crying babies move. Powerful leg muscles contract. Gentle manipulations are not effective in stretching contractures. Casts weaken.
- [16] Avoid this error by **comforting the child before starting**. Place the baby on mother's lap, feed (by breast if possible), and avoid any maneuvers that cause discomfort. Muscles stay relaxed. Manipulations are more effective in stretching contractures. Casts can be light and accurately molded.



Achilles Tenotomy & Final Cast

6.1 Purpose & Indications

- Manipulations and casts correct cavus, adductus, and varus.
- About 90% of clubfeet require Achilles tenotomy as there is often insufficient dorsiflexion when cavus, adductus, and varus are fully corrected.

Purpose

- Achilles tenotomy facilitates the correction of any remaining equinus before application of the last cast.
- Tenotomy is complete, percutaneous and creates a gap in the tendon. The ankle dorsiflexes immediately.
- After three weeks, the gap heals with the tendon a lengthened.

Decision making - is Achilles tenotomy indicated?

- The indication for Achilles tenotomy is Insufficient ankle dorsiflexion after full correction of cavus, adductus and varus.

(1) Non ambulatory child - measure Pirani Score (pg. 35-38) each visit.

- If **MFS = 1 or more**, supination, adductus, and cavus remain uncorrected. Continue manipulation and casting. tenotomy not indicated.
- When **MFS = 0.5**, supination, adductus, and cavus should be fully corrected. Tenotomy may be indicated. Measure the HFS.
- **[2] If HFS 1 or more**, Achilles tenotomy is indicated.
- **[3] If HFS less than 1**, Achilles tenotomy unnecessary.

(4) Ambulatory child - measure **SA & PAD** (pg. 43-44) each visit

- If **SA more more than 1**, supination, adductus, and cavus remain uncorrected. Continue manipulation and casting.
- When **SA = 1**, supination, adductus, and cavus should be fully corrected. Tenotomy may be indicated. Measure the PAD.
- If **PAD > 1**, Achilles tenotomy is indicated. In children 4 years and older, use open Tendo Achilles lengthening
- If **PAD = 1**, Achilles tenotomy unnecessary.

Tenotomy & Final Cast

6.2 Technique

- Achilles tenotomy is a **straightforward** procedure.
- **Prepare** family, and equipment.
- Understand the **anatomy** to avoid complications.
- Know the steps.

Prepare the family

(1) At the start of treatment, explain:

- That Achilles tenotomy is necessary in about 90% of cases.
- It is a safe minor procedure performed in the outpatient clinic under local anaesthesia.
- The child can go home soon after. Some acetaminophen can be given in rare situations when there is any discomfort.

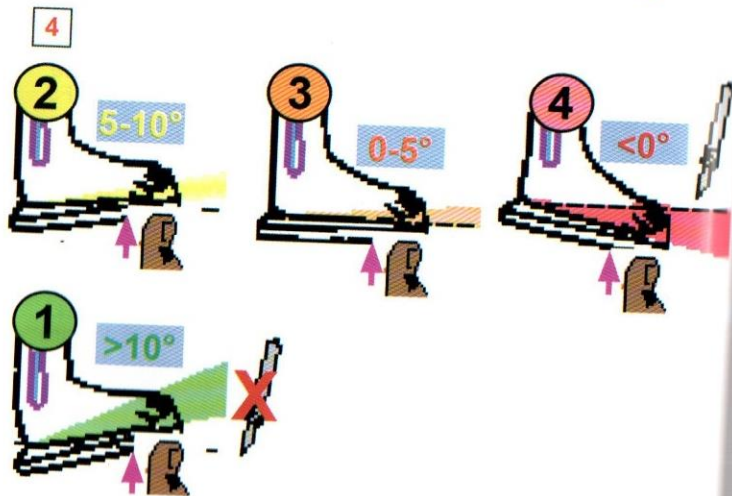
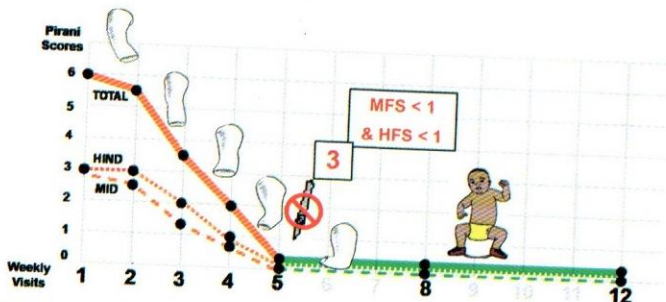
Prepare equipment

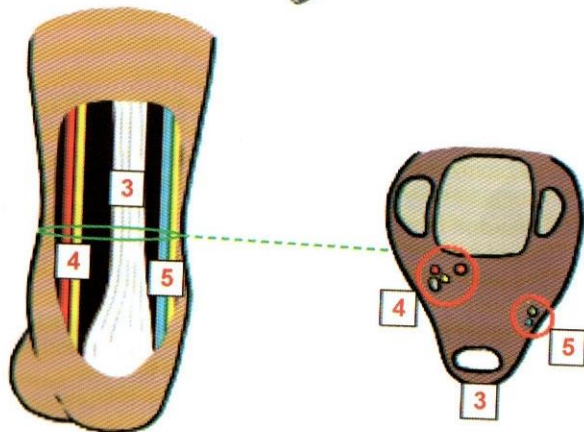
(2) These supplies should be **readily available** in every clubfoot clinic:

- Sterile gloves.
- Insulin or Tb syringe with 25 gauge needle.
- Scalpel handle with #15 blade.
- Prep solution.
- Local anaesthetic.
- Gauze.

Surgical Anatomy

- The tenotomy is a percutaneous procedure. Know the anatomy of the tendon and nearby structures vulnerable to injury.
- **Achilles tendon** broadens as it approaches insertion on posterior surface of calcaneal apophysis. Avoid apophyseal injury by transecting tendon 1-1.5 cm proximal to its insertion. The tendon is narrower. Tenotomy is easier.
- **Posterior tibial neurovascular bundle** lies anteromedial to the tendon. Avoid bundle injury by staying close to the tendon with the blade. Never turn sharp side of blade towards bundle.
- **Sural neurovascular bundle** lies anterolateral to the tendon. Avoid bundle injury by not penetrating too deep with the blade.



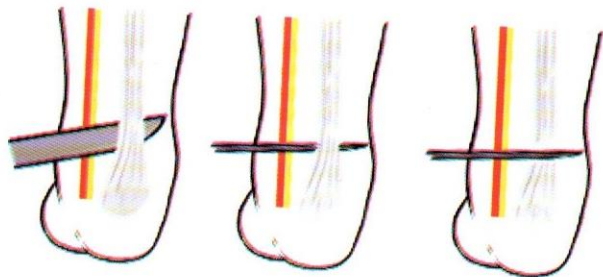
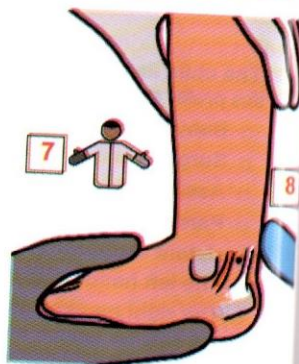
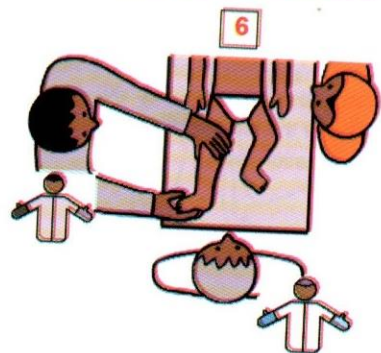


Positioning – described for right foot

- [6] **The child lies supine** at the end of the examination table. Some clinics prefer to have a parent next to and comforting the child:
 - Baby is supine – feet at the end of the examination table.
 - Surgeon at the foot of the examination table.
 - Assistant holds ipsilateral leg.
 - Parent comforts the child.
- [7] **Assistant stabilizes leg:**
 - The left hand holds the knee extended.
 - The right hand holds the forefoot, dorsiflexes the ankle, places the Achilles tendon on stretch, and externally rotates the leg to expose the right posterior ankle. This makes it easier for the surgeon to palpate and locate the tendon.

Tenotomy

- [8] **Palpate** the tendon and its calcaneal insertion. Identify the proposed tenotomy site about 1-1.5 cm above its insertion. The tendon is narrower and easier to transect. There is less risk for damage to the apophysis.
- [9] **Prep, drape, and infiltrate local anesthetic** just medial to the proposed tenotomy site. Use only 0.25 cc – any more obscures the tendon making palpation and tenotomy more complicated.
- [10] **Insert** the tip of #15 scalpel blade a few mm medial to the tendon, directing it immediately anterior to the tendon. Keep flat part of the blade parallel to the tendon.
- [11] **Rotate the blade** so the sharp edge points posteriorly toward the tendon.
- [12] **Move the blade towards the tendon and transect it:**
 - A distinct "pop" or "snap" and sudden ankle dorsiflexion are the signs of successful tenotomy as the two ends of the tendon move apart 1 cm or more. **Remove the blade** and apply clean gauze on the incision. It should be only 2 or 3 mm long. Sutures are unnecessary. A small amount of bleeding is normal. Hold dressing in place for 1-2 min until bleeding stops.
 - In young infants, the ankle should then **easily dorsiflex** more than 10° above neutral. The foot looks fully corrected.



Post-tenotomy cast

[13] Young infants:

- Apply an above knee cast as described on pg. 67 with foot in the fully corrected position – **abduction 60-70° and extension at least 10°.**
- The baby and mother may go home after you confirm intact distal neurovascular function. Usually no analgesic is necessary.

[14] **Remove after 3 weeks** – the tendon is healed. The scar is minimal. Confirm that ankle extension is at least 15°. The foot is then ready for bracing.

[15] Tenotomy in older infants and children:

- **Dorsiflexion may be limited** to less than 10° even after successful tenotomy ("pop"/sudden extension) from posterior ankle capsular contracture.
- **Look for this** – if present, change casts weekly. Gently increase ankle extension until greater than 10°. Capsular contractures stretch allowing about 5° improvement each week.

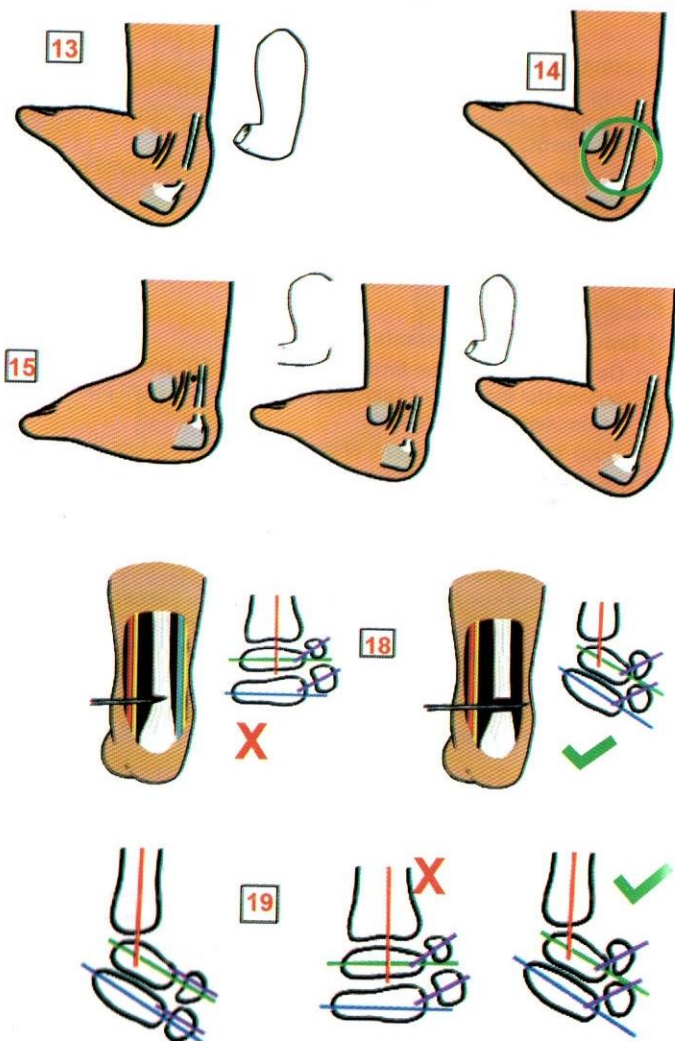
Common tenotomy errors

[18] Incomplete tenotomy is an error:

- Absence of "pop" or sudden ankle extension indicates incomplete tenotomy. The tendon will not lengthen. Attempts to extend ankle create a mid-foot break and may deform talar dome.
- Avoid this error by repeating the tenotomy maneuver. Look for a "pop" or "snap". Ankle will then extend without mid-foot break.

[19] Premature tenotomy is an error:

- Equinus arises both from tibiotalar plantarflexion and talocalcaneal flexion. Tenotomy and attempted ankle extension before calcaneus is fully abducted and extended will create mid-foot break with spurious dorsiflexion at the mid-tarsal joint.
- Avoid this error by **performing tenotomy only after the calcaneus is fully abducted**. Residual equinus corrects easily without risk of compression and flattening of the soft talar dome and mid-foot break.



Bracing To Prevent Relapse

7.1 Rationale/Brace Design

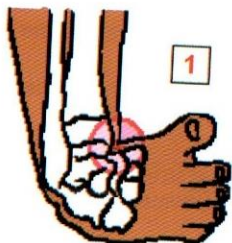
- Bracing is **demanding** of both parents and children and is the most **problematic** part of Ponseti treatment.
- The **most common cause of relapse** is failure of adherence to bracing protocols.

Rationale

- [1] **Clubfoot has a stubborn tendency to recur**, likely from persisting posteromedial retracting fibrosis aggravated by muscle imbalance:
- Without diligent bracing, contractures recur in more than 80% of cases.
 - Tendency to recurrence reduces with growth to about 10% at age four yrs.
- [2] **A well-fitted brace prevents recurrence:**
- The brace is fitted the same day as the last cast is removed and holds the corrected foot in the same position as obtained in the last cast. Posteromedial soft tissues remain stretched, and the tarsal bone deformations and misalignments remain corrected.
 - Regular brace use as prescribed reduced recurrence rates to less than 10%.

The Only Effective Brace

- [3] Many brace designs have been tried. The only brace type that is effective in preventing recurrence is the Foot Abduction Brace (FAB).
- The FAB is **two open toe shoes connected by a bar** made locally from simple, easily available materials (pg. 91)
 - It works because it **controls for both foot abduction and extension** without the need for knee flexion. Bracing with the knee flexed fails to stretch the gastrocnemius and increases risk of recurrence of equinus. As the knees free to move, when the child kicks the gastrocnemius is stretched
 - The FAB is provided to clinics **ready made in 9 standard sizes**. Each size has fixed bar length and shoe size. Most children will fit a standard size.



2



3

	21.5	7.0
	23.0	8.0
	24.0	9.5
	25.5	10.5
	26.5	11.5
	28.0	12.5
	29.5	13.5
	30.5	14.5
	32.0	15.5

Shoe design

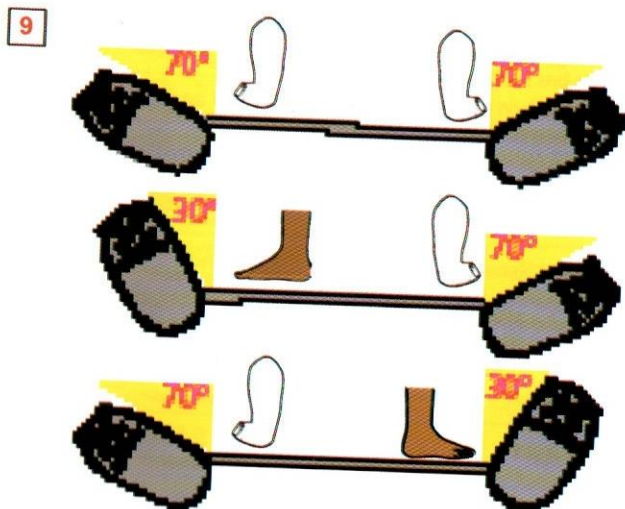
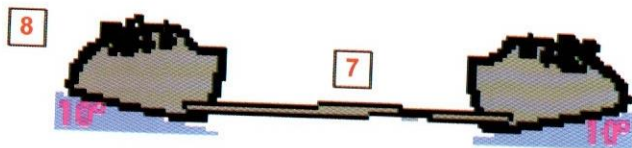
- [4] The shoes are leather, open-toed, and with lace-closures.
- [5] A deep heel cup (**green curve line**) prevents the heel from riding up and promotes it to develop a normal shape.
- [6] A medial "peep-hole" allows one to see if the heel is riding up (**red arrow**).

Bar design

- [7] A 6 or 7 mm **malleable round iron bar** connects the shoes.
 - The bar can be bent to hold the shoes at differing angles of abduction (shoe out angle) and extension (shoe up angle).
 - A bendable bar avoids the need for any moving parts. Bend the bar as close to the shoe bar joint as possible.
 - Ensure that SUA and SOA angles are correctly set as below.

Shoe angles

- [8] **Shoe Up Angle (SUA)** – the angle between the sole of the shoe and the bar in the coronal plane.
 - This should be 10° for corrected clubfeet and for the normal foot in a unilateral case.
- [9] **Shoe Out Angle (SOA)** – the angle between the longitudinal axis of the shoe and the bar in the transverse plane. This should be 70° for corrected clubfeet and 30° for the normal foot in a unilateral case.
 - **Top - bilateral clubfeet.** Both SOA's should be 70°.
 - **Middle - unilateral left clubfoot.** Left SOA should be 70°. Right SOA should be 30°.
 - **Bottom - unilateral right clubfoot** Right SOA should be 70°. Left SOA should be 30°.



Bracing To Prevent Relapse

7.2 How To Apply The FAB

- There are two methods of applying the FAB.

Standard method

- Use this method until child and parent used to the brace.
- It provides more control to get the heel down and back into the heel cup.
- Always fit the more difficult foot first.

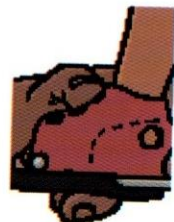
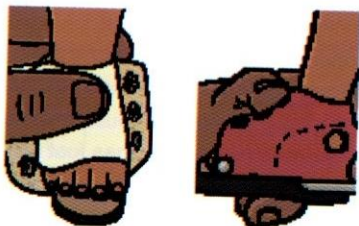
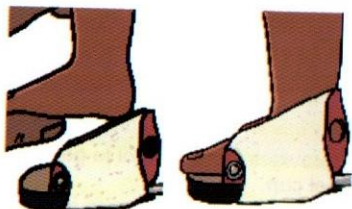
Standard - place foot in the FAB shoe

- Proper placement of foot into lace up shoe requires some practice:
 - Remove lace** – open the shoe leather.
 - Gently extend foot** – push heel down and back into heel cup.
 - Thumb pressure** pushes foot fully down and back into shoe.
 - Close leather tongue** – replace the thumb.
 - Thumb** holds heel in place – apply **counter-pressure** by index and long fingers.

Standard - apply & secure laces – check heel stays down

- Applying and tying laces without losing foot position becomes easier with practice:
 - Apply lace from proximal to distal** – thumb pressure keeps foot in the brace.
 - Pass lace across** from one top hole to the other.
 - Then **pass lace ends to immediately below and across**.
 - Continue** until bottom holes reached.
 - With thumb pressure still holding foot down, hold 2 lace ends with other hand and **pull to remove laxity** in laces.
 - Tie a bow** distally.
 - After tying, pull leg upwards and **check "peep-hole" to ensure the heel remains down**. If heel rises up, redo with attention to maintaining thumb pressure and tightening laces.
- Proceed to applying FAB to second foot once you are sure the first shoe is on tightly and the heel is not riding up.

1



2



95

Alternate Method

- This method saves time.
- Show parents both the standard and alternate method.
- Explain that it should be used only when the foot is well-corrected and supple.
- Do not use when the baby is fussy or crying. First apply the lace, then insert the foot, snug, and tie the laces.

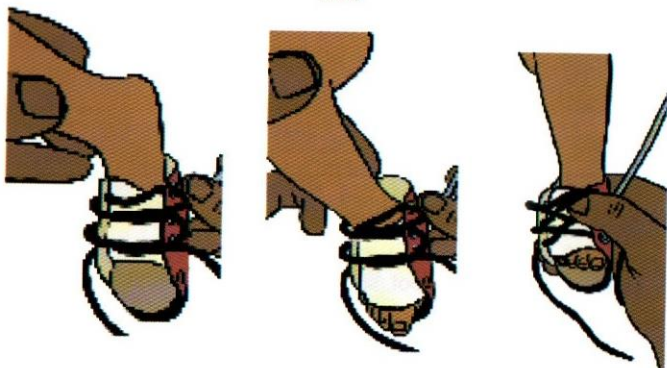
Alternate - place foot in the FAB shoe

- [3] Take care to make sure the heel is down and back in the heel cup:
- **Loosen laces** – insert foot toes first from the top of the shoe.
 - **Ensure foot is in the shoe** – toes should be seen protruding below the leather tongue.
 - **Use thumb pressure** to push heel down and back into heel cup. Apply **counter-pressure** by index and long fingers.

Alternate - secure laces – check heel stays down

- [4] Use the same technique to secure laces:
- **Use thumb pressure** to push heel down and back into heel cup. Apply **counter-pressure** by index and long fingers.
 - Hold two lace ends with other hand and **pull to remove laxity** in laces.
 - **Tie a bow** distally.
 - After tying, pull leg upwards and **check "peep-hole"** to ensure the heel remains down. If heel rises up – redo with attention to maintaining thumb pressure and tightening laces.
 - **Proceed to applying FAB to second foot** once you are sure the first shoe is on tightly and the heel is not riding up.

3



4



97

Bracing To Prevent Recurrence

7.3 First Bracing Visit

- Bracing marks **transition** from deformity correction to prevention of recurrence, and a more active role for parents.
- **Prepare** the parent, foot and FAB. Teach parents its use.
- **Ensure parents understand** FAB rationale, application, wearing schedule, and high risk of relapse if not applied.

Prepare parents and check feet

[1] Counsel parents and confirm understanding:

- **FAB Use** prescribed is crucial to prevent recurrence.
- **FAB application** (pg. 93-94).
- **FAB wearing protocol** – 23 hrs a day for 2 mos. Then only at night when sleeping to 4yrs of age.
- **Barriers they may face** (cultural/social/family) that impair their ability to follow FAB wearing protocol, and how to overcome them (pg. 11-12 & pg. 19-20).

[2] Explain follow-up schedule and purpose of visits:

- **2 weeks** after fitting – to check FAB fit/use and problem-solve.
- **2 months** after fitting – to check FAB fit & use. Check for recurrence of deformity. Reduce FAB use to when sleeping at night, providing there is no recurrence.
- **Then every 3-6 mos** until age 4 yrs – FAB fit/FAB use/recurrence check. Problem-solve.
- **Age 4 yrs** – stop FAB. Discharge if no relapse after 6 mos.

[3] Examine skin for pressure areas. Postpone starting FAB till sore is healed. Apply a dressing and continue casting cast foot in corrected position. Unless infected sores usually heal with 1 or 2 weeks of further casting.

[4] Confirm deformity corrected before stating FAB

- **Non ambulatory child** (Pirani Score). MFS & HFS should each be less than 1
- **Ambulatory child** (PBS). SA and PAD should each be 1
- Continue casting if either MFS or HFS > 0.5.
- Continue casting if either SA or PAD > 1.



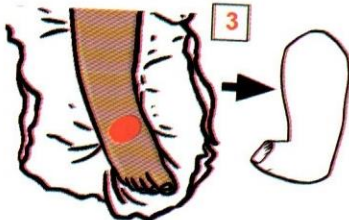
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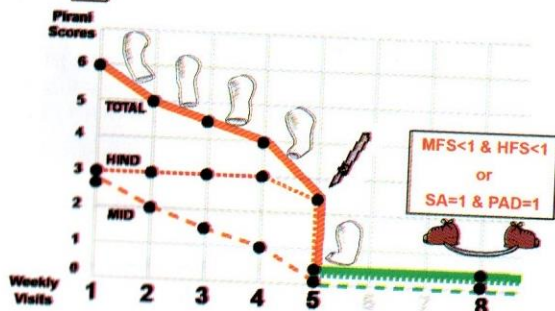
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4



Select and prepare brace

- [5] Measure affected foot length (tip of longest toe to back of heel) with a tape-measure in cm to determine the brace size to use;
- Foot length determines FAB size – use the FAB chart to select the appropriate brace size.

[6] Set FAB SUA:

- All shoes – 10°.

[7] Set FAB SOA:

- Unilateral right clubfoot – R = 70°, L = 30°.
- Unilateral left clubfoot – R = 30°, L = 70°.
- Bilateral clubfeet – R = 70°, L = 70°.

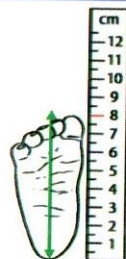
[8] Check FAB bar long enough:

- Each FAB size has predetermined bar and shoe lengths.
- Bar length okay – usually foot length should provide a bar length that is long enough that it should be sufficient for the shoulders to fit between the backs of the shoes. The feet will be as far apart as the shoulders and the child will be comfortable.
- Bar length short – a bar that is any shorter holds the feet too close to each other for the child's comfort, and the child may cry. Use a brace one size larger if the bar is too short.

Apply the brace

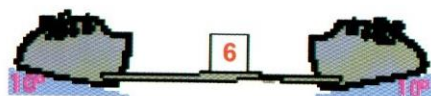
[9] Demonstrate how to apply the FAB:

- Ask parents to put it on and confirm technique satisfactory.
- Explain the FAB is well-tolerated.
- It helps to teach baby to kick legs together, as baby may feel uncomfortable at first when it alternately tries to kick its legs.

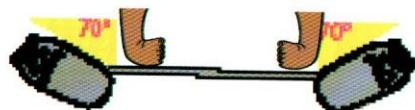


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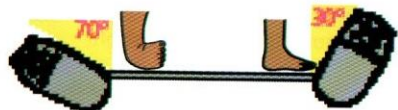
6	21.5	7.0
7	23.0	8.0
8	24.0	9.5



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7



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Bracing To Prevent Relapse

7.4 Subsequent Clinic Visits & When To Stop FAB

- Ponseti clubfoot treatment is long and **demanding**.
- Most common cause of **relapse** is failure to adhere to FAB.
- Regular clinic follow-up promotes satisfactory FAB **adherence**.
- Regular clinic follow-up allows proper fit and alignment of the FAB, monitoring for brace complications, recurrence, and problem-solving.
- At every visit:

Check parents are applying the FAB

(1) Parents stop the brace for many reasons:

- Feet look **normal** to the parents.
- **Child cries** – family members think the brace is damaging the child. There may be relapse.
- **Skin sores** – parents may not be applying it correctly.
- **Brace too small**.

Check FAB fit, wear, and alignment

- ##### (2) Ensure the child has a well-fitting and properly adjusted brace – examine the brace. It should look well used. Check brace for sufficient bar and shoe length. Check the angle of abduction and dorsiflexion – parents sometimes bend the bar into an ineffective angle. Fit larger brace if needed.

Examine the foot for recurrence

- Pirani scores MFS > 0.5 and/or HFS > 0.5 indicate recurrence
- PBS scores SA > 1 and/or PAD > 1 indicate recurrence
- Manage if found (pgs. 107 - 120).

Problem-solve

- ##### (3) Problem-solve
- Understand and help resolve the specific barriers parents face in order for them to be able to maintain the bracing protocol. Ask parents to apply brace. Confirm technique satisfactory. Ensure the parents have another follow-up appointment.

When to stop bracing

- At age 4 yrs if foot fully corrected. See again after another 3 mos. Monitor for relapse. Manage if present. Discharge from clinic if foot normal.

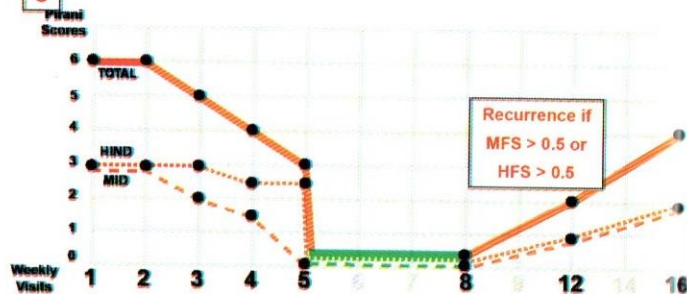
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Bracing To Prevent Relapse

7.5 Common Bracing Errors & Problems

- Bracing errors and problems are common.
- Parents get discouraged and stop applying a brace.
- Children face increased risk of relapse.

Not using FAB

- Use of any brace type other than a FAB is an error – other braces fail because they either do not control for foot abduction or do so at the expense of knee extension. The former predisposes to recurrence of varus, the latter to gastrocnemius contracture and equinus.
- Avoid this error – always prescribe a FAB.

FAB Sizing errors

- Using a brace with bar or shoes that are too short is an error. The child will find the FAB uncomfortable, and cry. Parents worry something is wrong, and do not use the brace. Risk of recurrence increases.
- Avoid this error by always checking that FAB bar is long enough so that the shoulders fit between the shoes that fit well.

FAB Angle errors

- Incorrect FAB SOA and/or SUA are an error:
 - SOA other 70°, and SUA other 10° fail to fully counteract tendency for recurrence of posteromedial contractures. Tarsal deformations and misalignments can recur.
- Avoid this error - ensuring correct angles.
 - SUA - All shoes – 10°.
 - SOA - Unilateral right clubfoot – R = 70°, L = 30°.
 - SOA - Unilateral left clubfoot – R = 30°, L = 70°.
 - SOA - Bilateral clubfeet – R = 70°, L = 70°.

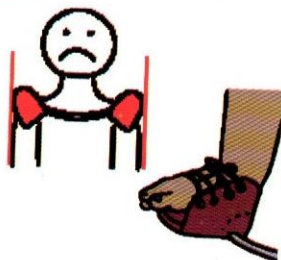
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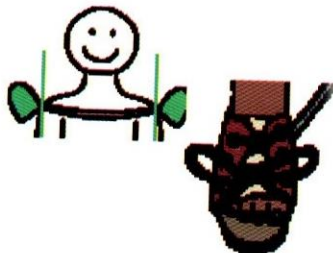
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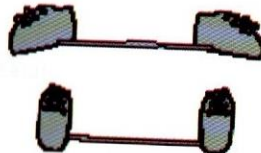
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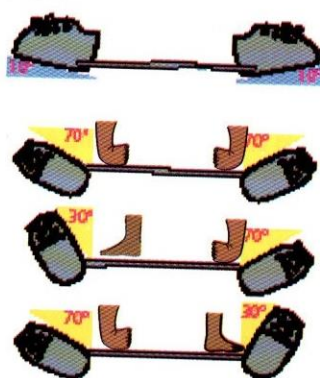
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Barriers to regular FAB use

[7] **Parents often face barriers** they cannot overcome in tolerating FAB use protocol:

- **Parents fail to apply the FAB** every day for the prescribed number of hrs.
- **Deforming forces** from retracting fibrosis are not counteracted sufficiently. Deformity recurs.
- The most common cause of recurrence is insufficient daily FAB use.

[8] **Counsel parents – determine nature of potential/actual barriers and problem-solve at every opportunity** so parents understand and can manage the bracing protocol – 23 hrs per day for 2 mos and then when sleeping at night until age 4 yrs.

Confirm that parents:

- Know how to apply the brace.
- Understand the need to brace.
- Understand the bracing protocol.
- Know that the most common cause of relapse is inadequate bracing.

Delayed recognition of recurrence

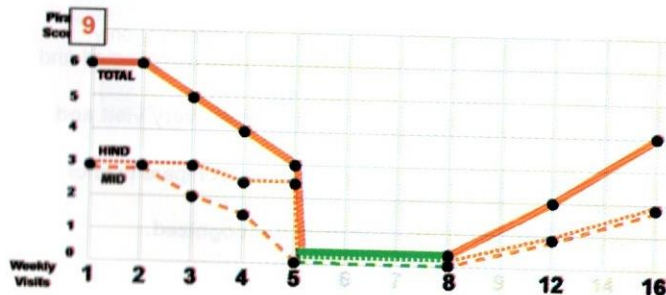
[9] **Failure to assess for presence of deformity at every follow-up visit is an error:**

- **Delayed recognition of recurrence.** The deformity only worsens with time. Treatment becomes more complicated and prolonged.
- Avoid this error – **assess every clubfoot at every visit and determine the Pirani/PBS scores.**
- Record deformity scores in the CPRF and compare to prior values.
- **Manage recurrence as soon as it is recognized.**

7 X



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Persistent Clubfoot

8.1 Etiology and Clinical Features

- [1] **Persistent clubfoot** – one or more of cavus, adductus, varus, or equinus deformities following previous Ponseti (including percutaneous Achilles lengthening, open lengthening of the Achilles tendon, and tibialis anterior transfer) or other nonsurgical treatments.
- Look for **persistent clubfoot** at every visit and treat right away. Treatment is easier and outcomes are better.

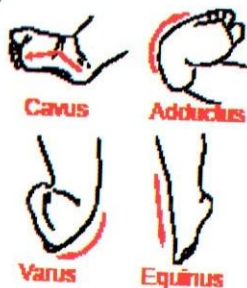
Clinical Features

- Non ambulatory child.** MFS > 0.5 and/or HFS > 0.5
- [2] **Ambulatory child.** Look for **WS** as a sign of muscle imbalance. PAD > 1 and/or SA > 1
- Recurrent deformity (prior full correction)**
 - CPRF** – deformity fully corrected with prior treatment.
 - Early recurrence** characterized by progressive loss of ankle dorsiflexion. HFS > 0.5 & MFS < 1; Pad > 1 & SA 1)
 - Later** there is also heel varus and adductus. Cavus is rare. (Both HFS & MFS > 1; Both PAD and SA > 1).
- Residual deformity (deformity never fully corrected)**
 - CPRF** – deformity never fully corrected with prior treatment.
 - Any Pirani/PBS subcomponent scores may be increased
 - Pathology may be complicated by prior inaccurate manipulation and casting. Outcomes may be compromised.

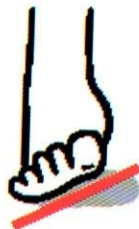
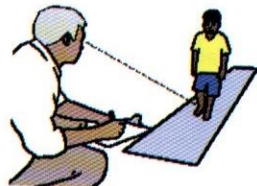
Etiology

- Non adherence to FAB use.** Clubfoot has a **stubborn tendency to recur**, likely from persisting posteromedial retracting fibrosis aggravated by muscle imbalance:
- [3] **Without diligent bracing**, recurrence rates approach 80%.
- [4] **With diligent bracing**, recurrence rates can be less than 5%.
- Other risk factors:**
 - Younger age** associated with increased risk. Recurrence common < 3 yrs; unusual = 3–5 yrs; rare > 5 yrs; very rare > 7 yrs.
 - Social factors.** Increased travel distance to clinic, poverty, and lesser education level of parents all increase risk
 - Risk of recurrence** unrelated to initial severity, age at start of treatment, or number of casts needed to correct.

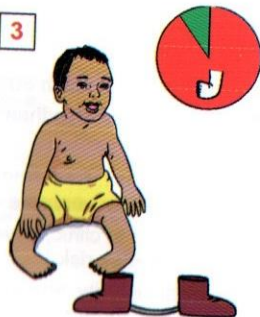
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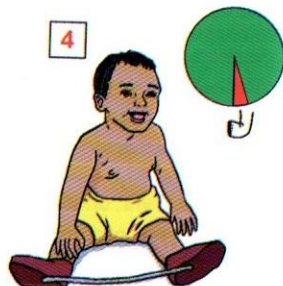
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Persistent Clubfoot

8.2 Overview of Management

- Do not ignore persistent deformity – it does not go away.
- **Remanipulate/cast to correct deformity.** Correct equinus if present with achilles tenotomy or open lengthening. Prevent recurrence by bracing or transfer of Tibialis Anterior to lateral cuneiform.
- **Problem solve** around bracing adherence (pgs. 97-98; pgs. 105-106).
- **Presence of Lateral Cuneiform ossific nucleus (LCON)** important for determining type of treatment.

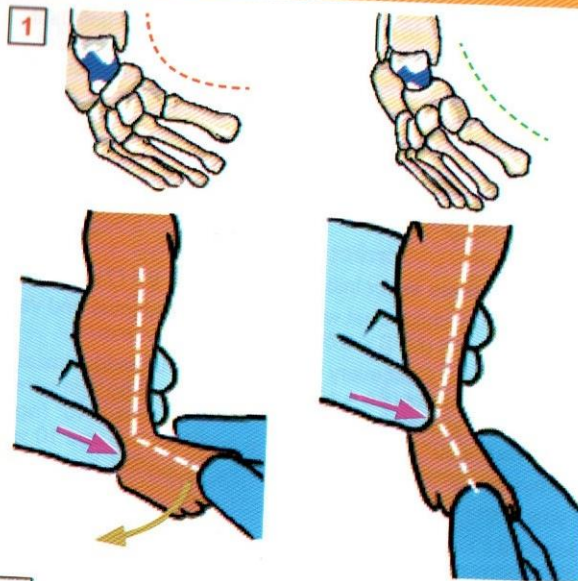
Manipulate and cast to correct cavus, adductus and varus

[1] Use same technique as for initial treatment (pg. 61-72).

- Non ambulatory child. Cast weekly. Cavus, adductus and varus usually correct (MFS < 0.5) in about 2 or 3 weeks.
- Ambulatory child. Cast every two weeks. Cavus, adductus and varus usually correct (SA = 1) in 4 to 6 weeks. Note that normal foot abduction lessens with growth. Aim to achieve > 40° (age under 6 yrs), > 30° (ages 6-10 yrs), & > 20° (above age 10 yrs).
- Obtain x-rays if:
 - > 2 years old (? ossification center of lateral cuneiform)
 - Older child's foot not responding to casting (? tarsal coalitions or other bony deformities)
- **Proceed with Step 2 when cavus, adductus & varus corrected**

Correct equinus and prevent recurrence

- **Age less than 2 yrs or LCON absent**
 - Counsel to problem-solve FAB adherence.
 - Repeat Achilles tenotomy (pgs. 81-88) if HFS > 1 or PAD > 1.
 - Resume bracing with FAB (pgs. 89-106). Continue follow-up.
- [2] **LCON present**
 - Correct residual equinus (PAD > 1) with Achilles tenotomy (pgs. 81 - 88) if under 4 years old, or open lengthening if older (pgs. 119-120)
 - Perform transfer of the tibialis anterior tendon to lateral cuneiform (pgs. 111-118) to prevent recurrence.
 - Follow up as needed. Further treatment not usually necessary.



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Persistent Clubfoot

8.3 Surgery – Tibialis Anterior Transfer

Rationale, indication and surgical goal

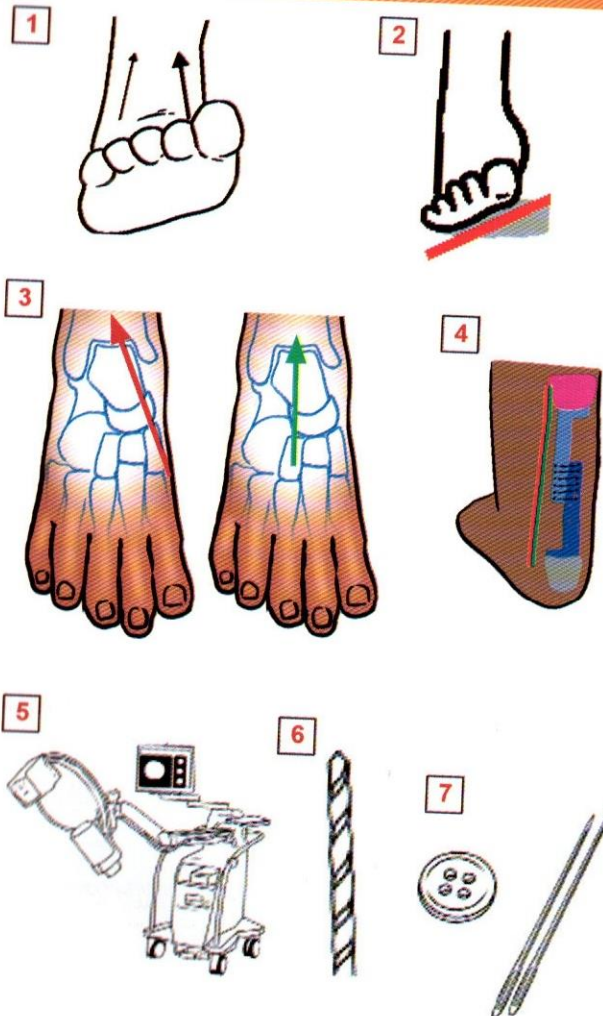
- [1] **Rationale.** Tibialis anterior supinates the foot as it dorsiflexes the ankle. The supinating force (**bold black arrow**) can act as a deforming force if the evertors are weak (**thin black arrow**). The rationale for the procedure is to redirect this deforming force, if present, thereby preventing recurrence of deformity.
- [2] **Indication.** Swing phase foot supination is the hallmark of this deforming force, and is the indication for transfer of the Tibialis Anterior provided the lateral cuneiform ossific nucleus is present.
- [3] **Surgical Goal.** To redirect the deforming action of the tibialis anterior (**red arrow**), its tendon detached from its insertion on the medial side of the CMT1 joint and transferred subcutaneously into lateral cuneiform. Its deforming supinating action is eliminated, whereas its dorsiflexion action is preserved (**green arrow**). The risk for relapse is markedly reduced.
- [4] **Correct residual equinus if present** with Achilles tenotomy (pgs. 81-88) or open lengthening (pgs. 119-120).

Equipment

- [5] **Mini C-arm** helps locate the lateral cuneiform ossific nucleus, but is not essential.
- [6] **3.2 & 4.5 mm drill bits** & manual or electric drill
- [7] **Two straight needles and button.**

Anaesthesia and positioning

- General anaesthesia. Supplement with long-acting local anesthetic to reduce immediate postoperative pain.
- Routine prep, drape, and high-thigh tourniquet.
- Patient is placed supine with feet at end of the operating table.
- The surgeon sits at the end of the table, and the assistant sits at the side of the involved foot.
- Mini C-arm, if available can be brought in between surgeon and assistant
- Slightly external rotate the limb when working medially and posteriorly.



Expose and harvest Tibialis Anterior tendon insertion

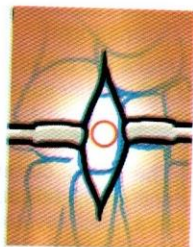
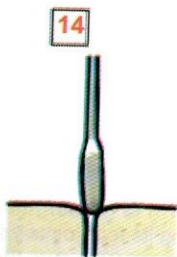
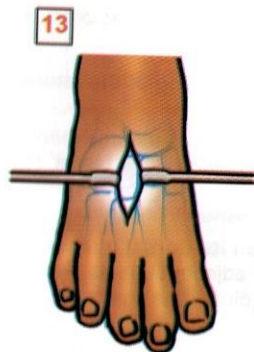
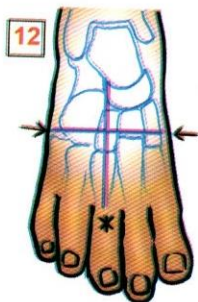
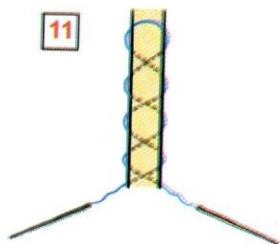
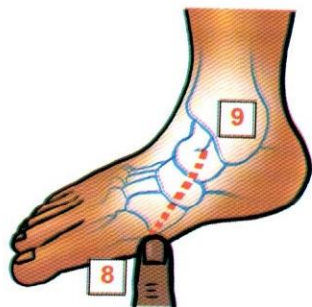
The tibialis anterior tendon passes anterior to the medial malleolus and inserts on the inferomedial CMT1 joint:

- [8] **Identify the CMT1 joint** – palpate for joint movement as you move the 1st metatarsal.
- [9] **Make a 4 cm skin incision directly over** the distal tibialis anterior tendon and insertion. Deepen through subcutaneous tissue and tendon sheath from just distal to extensor retinaculum to insertion to expose the tendon.
- [10] **Mobilize the tendon** – retract skin distally to expose and then sharply elevate its insertion off the medial capsule and cartilages of the CMT1 joint. Use a scalpel with blade parallel to the tendon to avoid accidental injury to joint and cartilage.
- [11] **Place Bunnell stitch** using 2-0 absorbable suture such as vicryl. Leave the stitch long and cut off the needles. The distal end of the tendon broadens immediately before its insertion. Trim tendon at its sides distally if necessary to ease passage of the tendon end into the drill hole in the lateral cuneiform.

Expose and prepare lateral cuneiform

The lateral cuneiform lies deep to the long toe extensors and the extensor digitorum brevis muscle belly. Use Mini-C arm to identify its surface making.

- [12] **If Mini-C arm not available**, identify surface marking of the lateral cuneiform by draw two lines connecting:
 - Head of the 3rd metatarsal to the lateral edge of head of talus.
 - Base of the 5th metatarsal to CMT1 joint.
 - The intersection of lines is the **surface marking of the lateral cuneiform**.
- [13] **Make a 3 cm longitudinal incision** centered on surface marking of lateral cuneiform. Deepen the incision by incising the fascia. Retract the long extensor tendons and the extensor digitorum brevis muscle to **expose the underlying tarsal bones**.
- [14] **The lateral cuneiform is rectangular on its dorsal surface**. Identify it by delineating its four joints with adjacent tarsals. Probe with a freer elevator for grooves over the joints. The ossific nucleus lies at the center of the bone.



- [15] Select a drill bit that is slightly larger than the width of the tendon at its distal end.
- [16] Make a drill hole through the center of the lateral cuneiform from its dorsal to plantar surface. Do not plunge. Safest drill angles through lateral cuneiform are
- **Coronal plane** - Angle drill about 20° lateral to a line orthogonal to the plantar surface of foot
 - **Sagittal plane** - Angle drill about 5° anterior to a line orthogonal to the plantar surface of foot
 - This give maximum distance between the drill exit from the plantar surface of the bone and and the main lateral and medial plantar nerves, and avoids violating any of the adjacent joints and tarsals.
 - Smooth edges of hole dorsally by removing overhanging periosteum with small rongeur. This helps prevent the tendon from bunching up at it enters the hole.

Transfer tendon

[16] Create subcutaneous tunnel

- The goal is to to allow the tendon a direct course from where it passes distal to the extensor retinaculum to the lateral cuneiform.
- Insert dissecting scissors or long haemostat with blades closed from proximal part of the medial incision to dorsal surgical incision.
- Open the blades half way and pull scissors/haemostat back creating a tunnel. Repeat as necessary till the motion is smooth.

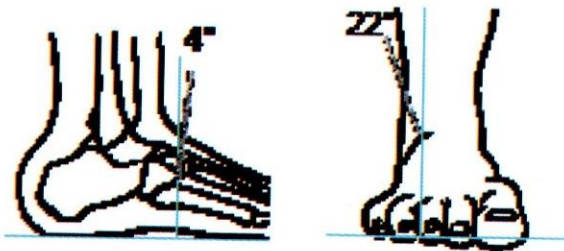
[18] Deliver tendon into dorsal incision

- Pass a hemostat from the dorsal to the medial incisions through the subcutaneous tunnel.
- Grasp the end of the suture holding the tendon
- Gently pull it and tendon into dorsal incision.

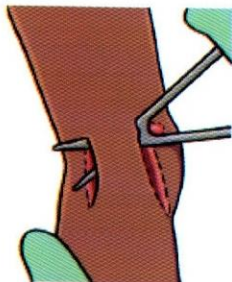
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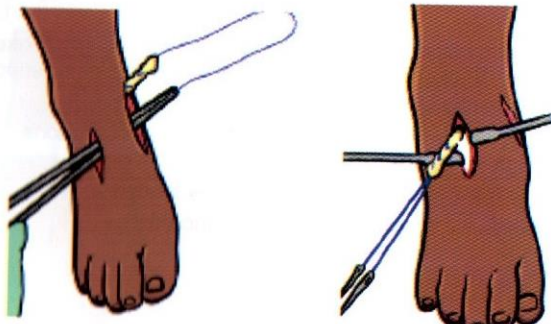
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Correct residual equinus

[19] Assess for equinus (PAD ≥ 1). If present correct with Achilles tenotomy (pgs. 81 - 88) if under 4 years old, or open lengthening if older (pgs. 119-120)

Secure tendon attachment and close

[20] Thread two suture ends through two separate straight needles.
 □ Pass threaded needles one at a time through, in order, the hole, the skin of the sole, a small gauze pad, and separate holes of a button.

Secure tendon attachment

- [21] With foot in 10° dorsiflexion, gently pull on the suture ends to draw the tendon into the drill hole.
- [22] Visually ensure > 0.5 cm of tendon is in bone tunnel
- [23] Tie the fixation suture over the button with multiple knots.
- Close incisions with foot held in corrected position to avoid tension on attachment.

Long leg cast

[24] Cover the incisions with sterile dressings. Apply a long leg cast (groin to toes) to keep the foot in 10° dorsiflexion and maximum available abduction. The knee should be flexed to 90°.

Postoperative care

Mobilize non-weight-bearing. Remove the cast and button at 6 weeks. No bracing is necessary after the procedure. Weight-bear as tolerated. See the child again in 3 mos to assess the effect of the transfer. With contraction, the transferred tendon is easily visible and palpable in its new position and the ankle dorsiflexes without any supination.

Outcomes

Reported long-term outcomes are excellent. Most patients have grade 4+-5 strength in the transferred tendon, and relapses are rare.

Preparation

In younger children who can be carried by parents, do bilateral at same sitting, providing indications are met for both feet. In children who are too heavy to be carried, consider doing sequentially so they may ambulate independently non-weight-bearing on surgical leg.

Persistent Clubfoot

8.4 Surgery – Open Lengthening Of Achilles Tendon

Surgical Goal

The surgical goal is to lengthen the tendon by Z-plasty such that ankle dorsiflexion with the knee flexed is greater than 10° .

Equipment, preparation, and positioning

As for tibialis anterior transfer (pg 117). Externally rotate the limb.

Expose Tendon

- [1] Make longitudinal skin incision medial to Achilles tendon** – start at its insertion and extend proximally for 5 cm. Avoid direct posterior incisions. They become irritable with shoes. **Incise the tendon sheath** directly deep to and for the entire length of the skin incision and expose the tendon from its muscle tendon junction to its insertion. Look for the plantaris tendon, and divide distally if present.

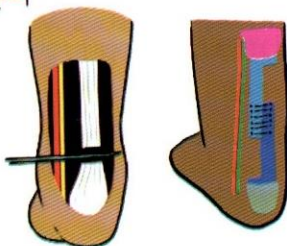
Z-lengthening

- [2] Split the Achilles tendon longitudinally** – insert a #15 scalpel with blade in sagittal plane into the middle of the tendon from posterior to anterior just below its musculotendinous junction. Incise and divide the tendon in the sagittal plane to its insertion into the calcaneus. Take care not to injure the calcaneal apophysis. **Release Achilles medially distally** – now rotate blade 90° so its sharp side faces medial. The blade will now be in the transverse plane. Incise the medial half of the tendon just above its insertion. **Release Achilles laterally proximally** – now move blade proximally to the top of the split. Rotate the blade so its sharp side faces lateral and transect the lateral limb of the split proximally.

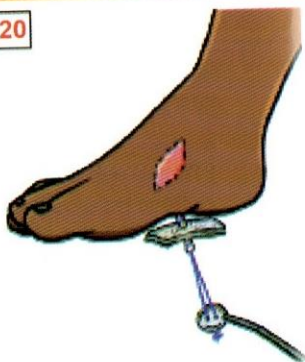
Repair

- [3] Repair Achilles at new length** – dorsiflex the ankle to 10° above neutral with the knee bent, and perform a side-to-side repair of the tendon with multiple simple or figure of 8 stitches using absorbable suture such as vicryl.

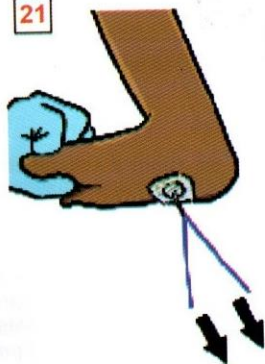
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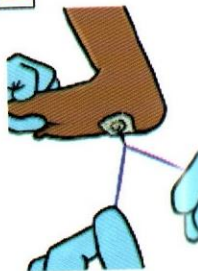
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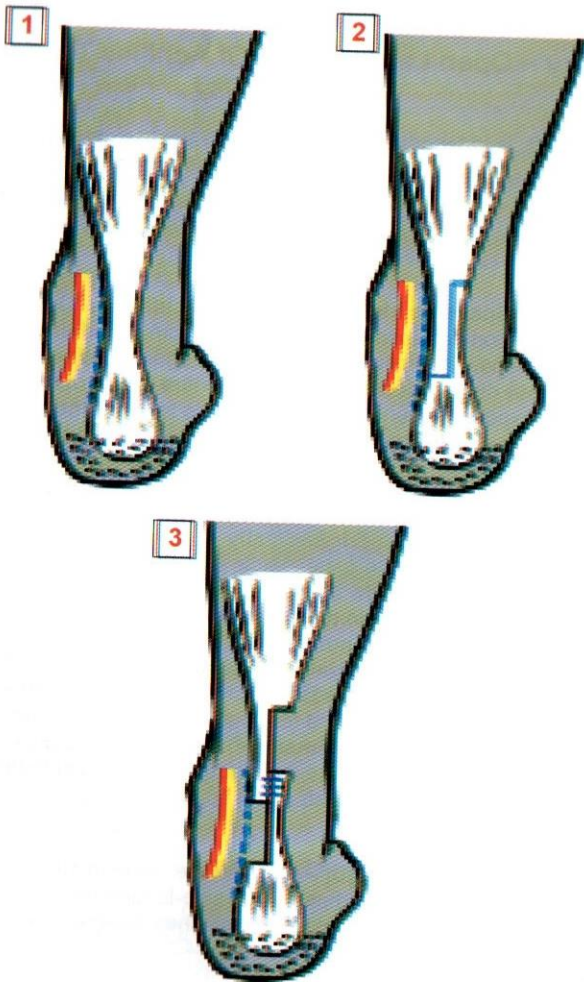


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Difficult Clubfeet

9.1 Idiopathic Clubfoot - Patient Walking

- [1] Left untreated till the child starts to walk, the idiopathic clubfoot - patient not walking becomes an **Idiopathic clubfoot - patient walking**, which bears weight on its dorsolateral surface and is subject to nonphysiologic deforming forces. Weightbearing skin develops painful callosities.

Management

- The principles of management remain the same.
- [2] **Correct cavus, adductus and varus** with serial manipulations and casts. Use techniques as described previously until PSA = 1. Deformity correction can take longer sometimes upto ten casts.
- [3] **Correct equinus if PAD > 1**. **Achilles** tenotomy safe and effective upto age 4 years. Occasionally, even after successful tenotomy ("pop"/sudden extension) the ankle does not dorsiflex immediately above 10° due to posterior ankle capsular contracture. **Change casts weekly till dorsiflexion > 10°**. Capsular contractures stretch allowing about 5° improvement each week.
- [4] In older children, perform open Tendo Achilles lengthening.
- [5] **Prevent relapse before LCON present with FAB.**
- [6] **Prevent relapse after LCON present with TAT** performed simultaneously with the open tendo achilles lengthening.

Outcomes

- Ponseti method is effective in correcting deformity, especially under age 6 years.
- **Nepal experience age 1 to 6 years** (Spiegel).
 - 94% achieved plantigrade foot and dorsiflexion 10 degrees with average 7 casts and achilles enotomy (78%), open lengthening (3%) or posterior release (8%).
- **Nepal experience age 5 to 10 years** (Banskota).
 - 49% achieved plantigrade foot and dorsiflexion 9 degrees with average 9 casts and achilles enotomy or open lengthening. Relapse seen in 16%.

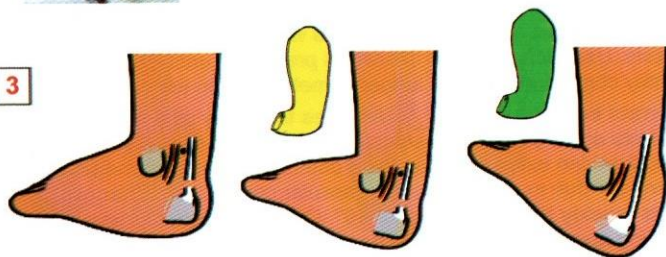
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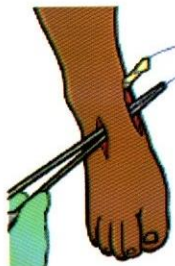
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Difficult Clubfeet

9.2 Syndromic Clubfeet

- Clubfeet are associated with more than 20 syndromes. They are an important group to identify early, as there may be differences in management, response to treatment and prognosis.

Most common syndromes

- Arthrogryposis.** Two types of multiple joint contractures can be seen with clubfeet at birth.
 - Amyoplasia** involves all 4 extremities. Shoulders are internally rotated, hips may be dislocated, knees and wrists are flexed and elbows extended.
 - Periheral.** Major joints are spared. MCP joints are ulnar deviated, digit IP joints are flexed and thumbs adducted.
- Spina bifida.** In more serious types a meningeal sac protrudes in the midline. Sensorymotor function may be impaired.
- Amniotic band syndrome.** Amniotic sac strands entangle limbs and digits that amputate or leave constriction bands.

Management

- Refer to pediatrics for general assessment.** When medically stable, treat unstable hips first (unless bilateral and teratogenic) and then the clubfeet. Altered sensation increases risk for pressure sores/infections and cast complications.
- Once stable** manipulate, cast, perform achilles tenotomy and brace using same techniques described previously.
- Syndromic clubfoot Pirani Score graph.** Deformity correction takes longer - sometimes upto ten casts. Continue manipulation and casting so long as there is improvement with each cast.
- Tenotomy/bracing indications** remain unchanged (pgs. 81-82).

Outcomes

- A successful outcome is a shoeable plantigrade foot, a neutral or valgus heel and ankle dorsiflexion of ten degrees.
- 90% correct with Ponseti method. 10 % need surgical release
- Recurrence rate is 50%. Treatment is with the standard technique (pg. 33-34). Expect about half the recurrences to be resistant and require surgical release.

Difficult Clubfoot

9.3 Complex & Atypical Clubfoot

- Calf muscle and posterior ankle ligaments contractures extend into the plantar foot intrinsics and ligaments and plantarflex all metatarsals. Timely recognition is important as management needs some modifications.

Distinguishing clinical features

- Both types share many features: severe equinus, deep posterior crease deep plantar crease that extends across the foot to its lateral border, 1st ray appears short, & hyperextended hallux.

[1] **Atypical clubfoot** - seen at birth (no prior treatment)

[2] **Complex clubfoot** - history of prior unsuccessful casting & cast slips. The foot is swollen and heel contour is flattened. There may be dorsal skin sores.

Management

- **Manipulation**

[3] **Foot abduction.** Carefully identify talar head. Stabilize hindfoot with index finger behind fibula and thumb on talar head. Supinate and abduct foot till lateral border straight. Normally 30° suffices. Do not abduct any more even if heel is not in valgus, for fear of causing hyperabduction midfoot break at the tarsometatarsal joints.

[4] **Foot dorsiflexion.** Once the lateral border is straight, stabilize the foot with both hands (thumbs on 1st & 5th metatarsal heads, index fingers anterior to ankle), and forcefully dorsiflex foot to simultaneously correct metatarsals plantarflexion & equinus.

• **Casts should be well moulded** above heel prominence & around the malleoli and the knee flexed to 110° to prevent the heel from rising and the from cast slipping.

• **Tenotomy** is usually required. Perform once metatarsal plantarflexion is corrected (plantar crease improved), 1.5 cm above posterior crease to avoid damage to calcaneal apophysis. If necessary change casts weekly till dorsiflexion $> 10^\circ$.

[5] **Bracing protocol** remains same except SOA = 30° to match abduction required to make lateral border straight.

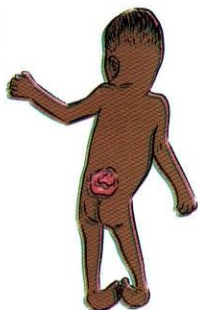
Outcomes

- Almost all deformities correct in 5 to 8 casts. Relapse rate is 20%.

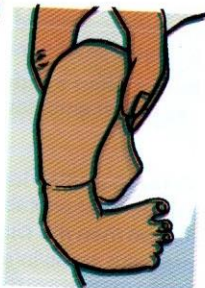
1



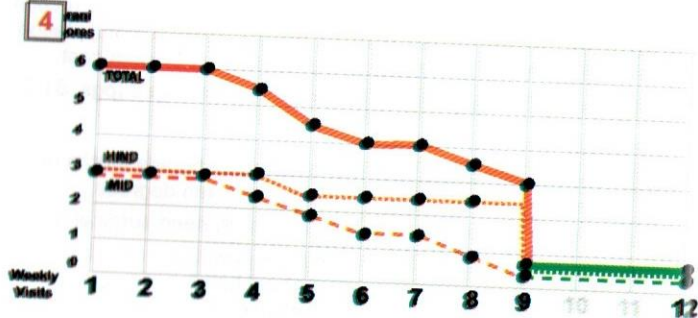
2



3



4



1



2



3

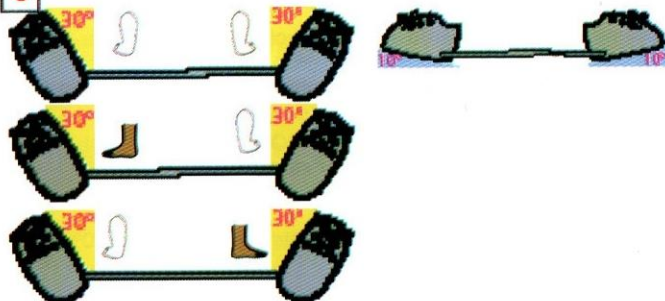
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4



5



127

Difficult Clubfoot

9.4 Postsurgical Clubfoot

[1] Surgery that violates joint capsules causes scarring, joint incongruity, and stiffness. Recurrence of deformity post invasive surgery remains an unsolved problem. The pathology is variable and may include tarsal bone deformations and misalignments, tarsal joint incongruities, widespread scarring, dysvascularity and damage to tarsal growth centers.

- Repeat invasive surgery is associated with poor outcomes.
- However, Ponseti treatment has been shown to be of benefit in well selected cases.

Management

- Differentiate between good and poor candidates
- Good candidates - those with cave
- Poor candidates - those with:

[2] Dorsal bunion or heel valgus

[3] Radiographic talar collapse (**Red Line**) or dorsal subluxation of navicular (**Yellow Arrow**)

- The principles of management remain the same.

[4] **Correct cavus, adductus and varus** with serial manipulations and casts. Use techniques as described previously. Deformity correction can take longer sometimes upto ten casts.

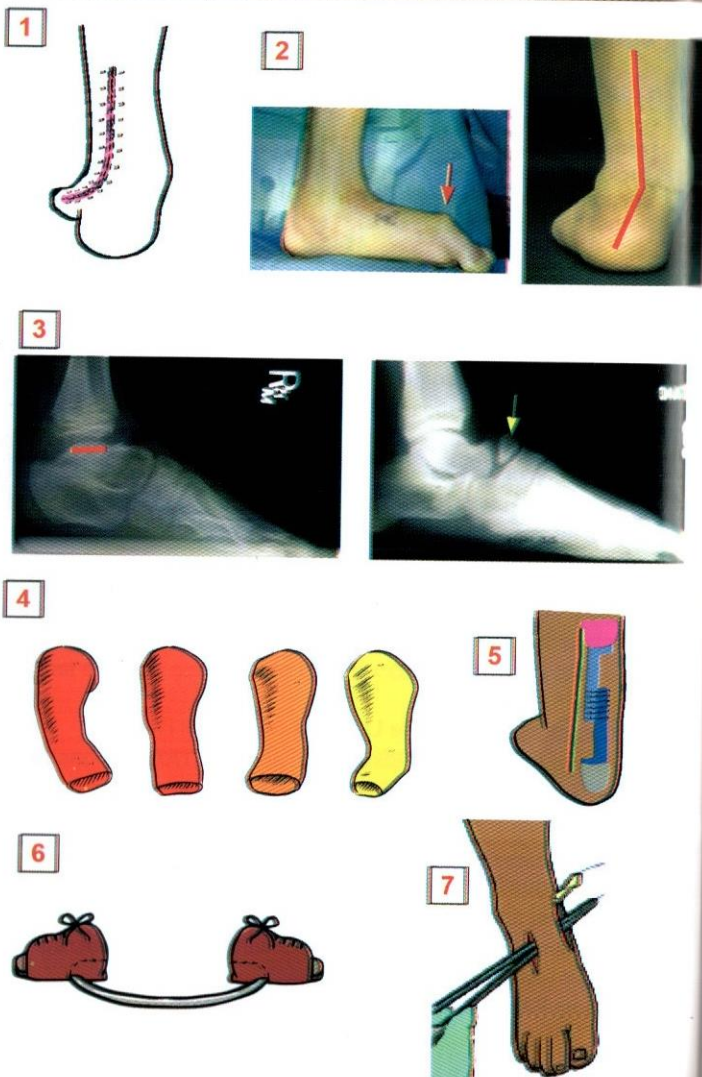
[5] **Correct equinus if PAD > 1 with open tendo achilles lengthening.**

[6] **Prevent relapse before LCON present with FAB.**

[7] **Prevent relapse after LCON present with TAT performed simultaneously with the open tendo achilles lengthening.**

Outcomes

- A successful outcome is a shoeable plantigrade foot, a neutral or valgus heel and ankle dorsiflexion of ten degrees.
- Cavus, adductus and varus correct in 90%
- Equinus corrects in some with casting, but most feet require open tendo achilles lengthening.
- Both FAB and TAT are effective in reducing rate of recurrence.



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The PBS Score - A Clinical Tool for Assessing Deformity in Ponseti Treated Ambulatory Children

3rd Annual International Clubfoot Symposium

Barcelona June 2014

Bonseti Training Center- Clubfoot Patient Record Form

Patient Detail				Clinic Detail	
Patient ID				201.	BTC/PCC name
Name of Child				202.	BTC/PCC ID
Date of Birth	Actual			203.	BTC/PCC Incharge Name
	Assumption				
Sex	Male	1		204.	Contact number of BTC/PCC Incharge
	Female	2			Mobile : _____
	Others	33			Mobile : _____
Date of 1st visit				Referral Status	
Place of Birth	Hospital Delivery	1			
	Home Delivery	2			
	Others	33			
Name of Mother				205.	Referred by CHW
Name of Father				206.	Name of Referrer
Village/Town				207.	Contact Number of Referrer
Union/Ward				208.	Name of the supervisor of CHW
Upazila				209.	Contact Number of the supervisor of CHW
District					
Contact number	Mobile : _____				Mobile : _____
	Mobile : _____				Mobile : _____
	Land line : _____				Mobile : _____

History of presentation				Last Visit		Consent	
302.				Yes = 1		No = 2	
Does the child have clubfoot?				Preterm (<37 weeks)		1	
303.				Term (38-40 weeks)		2	
Gestational age at birth				Post term (>41 weeks)		3	
304.				Normal Vaginal Delivery		1	
Birth Order of the child				Assisted Delivery		2	
305.				C- Section		3	
Type of delivery				Yes		1	
306.				No		2-307	
Any family history of Clubfoot among first blood relatives				Grand parents		A.	
307.				Parents		B.	
What is the relationship of this child with the affected person?				Uncle/Aunt		C.	
(Consider multiple answer)				Sibling		D.	
308.				Cousins		E.	
Other medical problem/treatment history:				History of Pre-Eclampsia or Eclampsia		A.	
(Consider multiple answer)				Others		X.	
I. Before delivery				Obstructed /delayed labor		A.	
Yes = 1				Mal/Breach presentation of the baby		B.	
No = 2				Any birth injury		A.	
II. During delivery				Congenital deformity of spine		B.	
Yes = 1				Developmental Dysplasia of Hip (DDH)		C.	
No = 2				Upper Extremity malformation		D.	
III. After delivery				Lower Extremity malformation		E.	
Yes = 1				Congenital heart diseases		F.	
No = 2				Others		X.	
309.				Yes		1	
Prior treatment for clubfoot?				No		2-316	
From where?				SCCB PTC Name:		SCCB ID: _____	
SCCB PTC				1			
Other				8			
310.				Name:			
Since when (the start of the treatment)?							
311.				Prior Casting		Yes	
312.				Prior Tenotomy		Yes	
313.				Prior Surgery (except tenotomy)		Yes	
314.				Prior Brace		Yes	
315.				Traditional Treatment		Yes	
316.				Is the child walking on its own on the day of first visit?		Yes	

Clubfoot Patient Record Form- Treatment Detail

Clubfoot Patient Record Form- Treatment Detail																			
		1 st Visit		2 nd Visit		3 rd Visit		4 th Visit		5 th Visit		6 th Visit		7 th Visit		8 th Visit		9 th Visit	
Visit→ Date→																			
Child Not Walking Pirani Score	Foot→	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
	CLB																		
	MC																		
	LHT																		
	→MFS																		
	PC																		
	RE																		
	EH																		
	→HFS																		
	→TS																		
Child Walking PBS Score	HR																		
	PAD																		
	AAD																		
	→PBSA																		
	HV																		
	SS																		
	WS																		
	SA																		
	→PBSS																		
	→PBST																		
Follow Up	Diagnosis (1-9)	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
	Treatment (P,T,FAB,O,R,S,D)																		
	Cast position (#1-5)																		
	SFAB Use (Y/N/NA)																		
	SFAB Use (hours/day)																		
	SFAB Size(# 3-14)																		
	Complication (P, I, C, O, N)																		
	Disagnosis: 1 = Syndromic; 2 = Untreated Walking; 3 = Untreated not walking; 4 = Atypical; 5 = Post-surgical; 6 = Complex; 7 = Persistent; 8 = Well corrected Unaffected (of unilateral clubfoot) =																		
	Treatment: P = Ponseti cast; T = Tenotomy; FAB = Foot Abduction Brace; O = Observation; R = Referred for surgery; S = Skin care for pressure area/infection; D = Discharge																		
	Complication: P = Pressure Sore; I = Infection; C = Cast Slip; O = Other; N = None																		



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