

Beth Meyers, CST/CFA, OTC

congenital



clubfoot

FUNDAMENTALS OF TREATMENT

Clubfoot is the most common congenital orthopedic deformity in the world. This is a condition in which the position of the foot is abnormal at birth. Approximately 5,000 babies each year are born with clubfoot in the United States. Incidence is higher in Polynesians and Africans. One out of 750-1000 babies are affected.⁶ About 50% of cases are bilateral, and 70% of cases occur in boys.²

At Gillette Children's Specialty Healthcare, three to five new patients with clubfoot are seen each month. Gillette Children's Specialty Health Care treated more than 120 new infants with clubfoot in 2002.

During the 1980s and 1990s, clubfoot treatment meant major reconstructive surgery to correct the deformity. The outcome has been a disappointment to parents, children and the physicians who treated them. The feet remained stiff,

painful, and not able to function normally, some requiring additional surgeries.

The past few years have shown a major trend in the acceptance of a treatment plan developed by Ignacio Ponseti, MD, 50 years ago. The treatment plan consists of five to seven weekly manipulations and casting, a percutaneous Achilles tenotomy (95% of cases) and wearing a foot abduction bar (FAB) with straight-last shoes (shoes that are nonspecific to the right or left foot) attached to maintain correction. Demand for this technique was generated mainly by a group of parents on an Internet discussion board.⁴

Ponseti states, "Parents of infants born with clubfoot may be assured that their baby if otherwise normal, when treated by expert hands, will have normal-looking feet with normal function for all practical purposes. The well-treated clubfoot is no handicap and is fully compatible with a normal life."³

Facts about clubfoot

Clubfoot (talipes equinovarus) is a complex deformity occurring as an isolated idiopathic condition in a normal child, or may be associated with major neuromuscular disorders, such as spina bifida, arthrogryposis, amniotic banding and many syndromes as well. Teratologic clubfeet are generally more stiff, resistant feet, which typically require some surgical intervention. There are four main components of clubfoot: equinus (foot pointed downward), heel varus (heel turned inward), cavus (high arch), and forefoot adductus (forefoot turned inward).

Etiology

Little is known about the true etiology of the clubfoot, many theories have been explored through the ages, including the following:

- *Packaging.* A very common explanation for clubfoot is intrauterine packaging, the belief that the baby for some reason was crowded in the uterus. This is truly the cause of the “positional clubfoot,” which can be brought to full correction the first time it is examined. As an explanation for true clubfoot, this is not likely, as the incidence is not increased in twins or large babies, and the deformity has been identified through the use of ultrasound as early as 14 weeks gestation.
- *Neuromuscular defect.* Due to the high incidence of clubfoot associated with many neuromuscular disorders, there is a theory that it has a neurogenic basis. Magnetic Resonance Imaging (MRI) can be useful in providing further information regarding possible neurogenic involvement.
- *Arrested fetal development.* This theory states that during the embryonic stage, some type of neurologic or vascular event interrupted the normal development below the knee. Frequent unilateral incidence weakens this theory.
- *Hereditary.* Once a family has a member born with clubfoot, we know there is a hereditary factor. The chance for a subsequent sibling to be born with clubfoot is 20-30 times the baseline incidence. It is difficult to explain to a family the possibility of future members

inheriting clubfoot when the anecdotal experiences clinically don't seem to follow percentages in the medical literature.

Peter Williams, MD, pediatric orthopedic surgeon from Melbourne, Australia, categorized congenital defects into two groups using industrial metaphors: packaging defects, simple defects due to intrauterine position; and manufacturing defects, defects with a probable embryogenic basis.²

Anatomy

The baby born with clubfoot actually has possible anatomical involvement from the hips down. The hip is the least involved, and the foot exhibits the worst of the deformity. A full examination of the baby should include examination of the back to check for hairy patches or unusual dimpling that would indicate a spinal cord abnormality. Hips should be examined for dislocation or subluxation. Upper limbs should be examined as well for any signs of joint stiffness or other anomalies. Finally, a full exam of the lower limbs and feet should be performed.

Developmental dysplasia of the hips (DDH) has a higher incidence in infants with clubfoot and great care should be taken to check the baby's hips at each visit. It is also considered prudent to order a hip ultrasound at three months of age, followed up with radiographs at six months to one year of age.²

Leg length can be affected on a limb with clubfoot as well. The leg length discrepancy is generally an issue that needs no more intervention than a possible shoe lift. The difference is most common in a unilateral clubfoot and can be .5 to 1.5 cm. The calf muscle on a leg with clubfoot will be smaller in circumference due to the composition of the muscle cells. It may be favorable to have bilateral clubfoot, as they tend to be similar and there is not a normal foot to compare to.

The foot bears the most significant features with the bones, muscles, tendons, ligaments and joint capsules all being involved. The position of a true clubfoot is forefoot adduction and supination, hind foot varus, mid foot cavus and fixed equinus.

All bones are in misalignment, the posterior/medial muscles and their tendons are shortened and tight, the plantar fascia is tight and the posterior/medial joint capsules are tight. There is contractile scar-like tissue, which is found in the medial portion of the foot. This fibrous tissue can increase the patient's chances for scarring after surgical procedures.

Upon first examination of clubfoot, observe the severity by feeling the stiffness/rigidity of the foot. If it can be brought to full correction the first time reduction is attempted, it is probably positional. If it is extremely stiff/rigid (like a rock), it is probably taratologic.

The foot presents with a deep posterior crease and fixed equinus, a curved lateral border, heel in varus, a deep medial crease and the lateral head of the talus can easily be palpated. This curly little foot may be flush with the medial tibia.

History of conservative treatment

Egyptian tomb paintings (hieroglyphics) depicted the treatment of clubfoot as early as 1,000 BCE. Hippocrates, circa 400 BCE, was the first to encourage that treatment begin as soon as possible after birth.

All clubfoot treatment programs begin with some form of manipulation and immobilization. In 1836, Guerin was the first to utilize plaster for the purpose of immobilization. In the 1930s, Hiram Kite promoted gentle manipulations and casting. Kite was the leading advocate of conservative treatment. With Ponseti's method, instead of using stretching casts in preparation for surgery, casting alone is used to correct the clubfoot.²

The works of doctors Robert Jones and Hiram Kite compelled Ponseti to perfect the conservative treatment for clubfoot. Jones wrote in 1923, "I never met with a case where treatment had been started in the first week where the deformity could not be completely rectified by manipulation and retention in two months."²

Because multiple surgeries had been required in the past to correct clubfoot, today's conservative (nonsurgical) methods stir up great controversy in the pediatric orthopedic



PHOTO: Anna Bitner/Gillette Children's Hospital

community. Some surgeons still find it difficult to believe that a condition that had formerly required such extensive surgical intervention, now requires none. The two most controversial methods are the Ponseti Method and the French physiotherapy method. French physiotherapy, also known as Functional Treatment, is performed by gently manipulating the feet daily, active physiotherapy and splinting. This process can take one year or longer. When the child is walking, he or she will be placed into ski splints for therapy. In a 10-year follow-up of 350 feet treated using this technique, 63% of the feet treated by well-trained physical therapists avoided surgery.¹

FIGURE 1
Bilateral clubfoot in baby M after five casts. The feet are correcting at different rates, which is not unusual.

Ponseti's studies of normal feet and clubfoot were the basis of the treatment he developed and refined in the late 1940s. By the late 1950s, after reviewing patients for a short-term follow-up article, Ponseti knew he had found the proper approach to clubfoot treatment. This method is used still today with superior results, with only 3% needing full corrective surgery.⁷

History of surgical management

“Significant experience is needed to produce a balanced foot that is neither in excess valgus nor in excess varus. The task of completely disassembling a foot, including cutting the “spring” ligament and then pinning it back together again

of a clubfoot corrective procedure that focused on medially rotating the laterally deviated talar head and neck. Practitioners ask themselves, “If Turco, Goldner, Carroll, McKay, and Lloyd-Roberts disagree, how can my patient have a good result?” Significant disagreement remains concerning the pathologic anatomy in clubfoot and how it should be corrected surgically.²

A procedure that was commonly used to correct the clubfoot is the “complete peritalar release”. Over time, doctors using this procedure have taken to a more conservative route by using an ala-carte approach. This method begins with a posterior release, proceeding to a medial release, lateral release and plantar fascia release as needed—a common statement from orthopedists which suggests their dissatisfaction with radical surgical treatments. In the minds of many doctors, there are two certain outcomes for surgically treated clubfoot: the overcorrected foot and undercorrected foot. The reality of surgery is the need for future surgeries to correct the overcorrected or undercorrected foot.

Severe, unacceptable overcorrected flatfoot deformity is increasingly being recognized as a complication of aggressive surgical treatment of clubfoot.¹ Clinically, these feet are described as having a contracted tibialis anterior tendon, limited plantar flexion, severe flatfoot with heel valgus, concavity of the sinus tarsi, and hallux flexors with a dorsiflexed first ray. Patients may also have a dorsal bunion. These feet are functionally and cosmetically worse than undercorrected feet.²

With time and follow-up, physicians have recognized the unpredictable results of surgical correction and, in the late 1990s, their disappointment has opened their practices to learning the more conservative, predictable Ponseti Method so as to “First, do no harm.”

Evidence of more open acceptance of this method is somewhat anecdotal, but shows an increasing trend. The Ponseti Method is being taught at orthopedic meetings around the world in one form or another. Physicians are presenting their positive experiences and results, indicating that, once properly trained, physi-

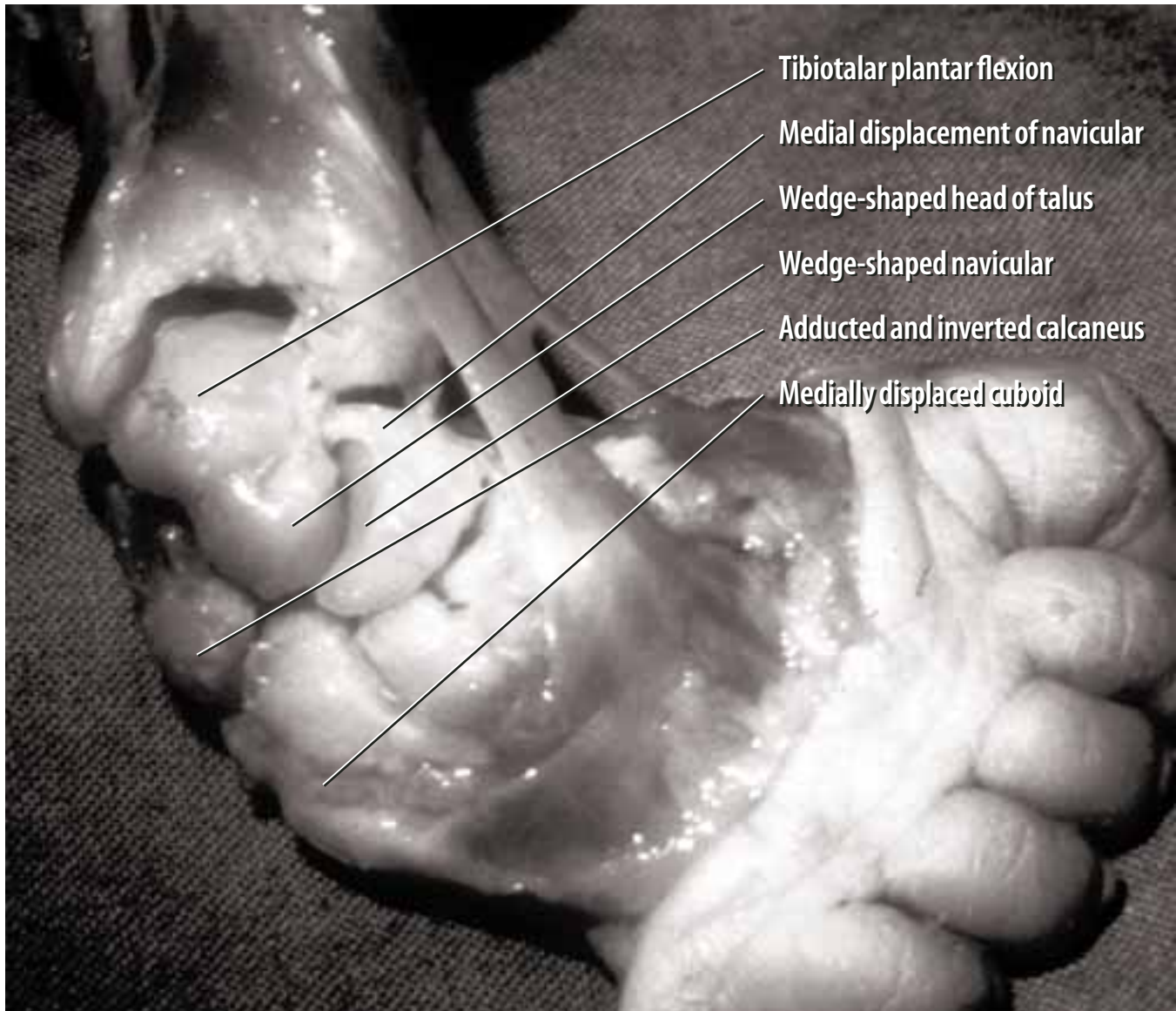
FIGURE 2

A 17-week-old fetus with bilateral clubfoot.



with hope for predictable balance and function, proves a daunting task.”²

Surgical correction for clubfoot became the norm in the 1970s. There were many views on the procedures to perform, the incisions to use, and at which age surgery should take place. GC Lloyd-Roberts (1910-1988) helped develop the theory that most patients with clubfoot have external tibial torsion. Leonard Goldner began operating on clubfoot in 1950. The surgical technique that he developed includes Z-lengthening the deep deltoid ligament medially and not opening the subtalar joint, which directly contradicts the theories of Turco and Carroll. Norris Carroll's keen observations and anatomic studies led to development



cians are showing they can reproduce the same results as those from Ponseti's group in Iowa City. This noninvasive method is now being used in 27 countries around the world.

Prenatal diagnosis

Better ultrasound technology and more experienced technologists have made it more common to find clubfoot prenatally. Ultrasounds are generally performed at 20 weeks gestation, but clubfoot has been discovered as early as 14 weeks. This early discovery can lead to parental counseling by the orthopedic surgeon.

During prenatal ultrasound of 14,013 patients, 61 were found to have clubfoot for a per-

centage of 0.43%. Associated anomalies were found in 67% of these patients, while 33% had isolated clubfoot. The false-positive rate for isolated clubfoot was 40%, all diagnosed in the third trimester of pregnancy. Higher level ultrasound may be ordered to further evaluate the baby's condition.¹

Parents benefit from the prenatal diagnosis, giving them time to seek knowledge from the Internet regarding treatment methods. The Internet is the main information source, which has brought the Ponseti Method to the public. Parents must be warned that not all information available on the Internet is accurate, and should be reminded that the definitive diagnosis will be

FIGURE 3
Cadaver
club foot

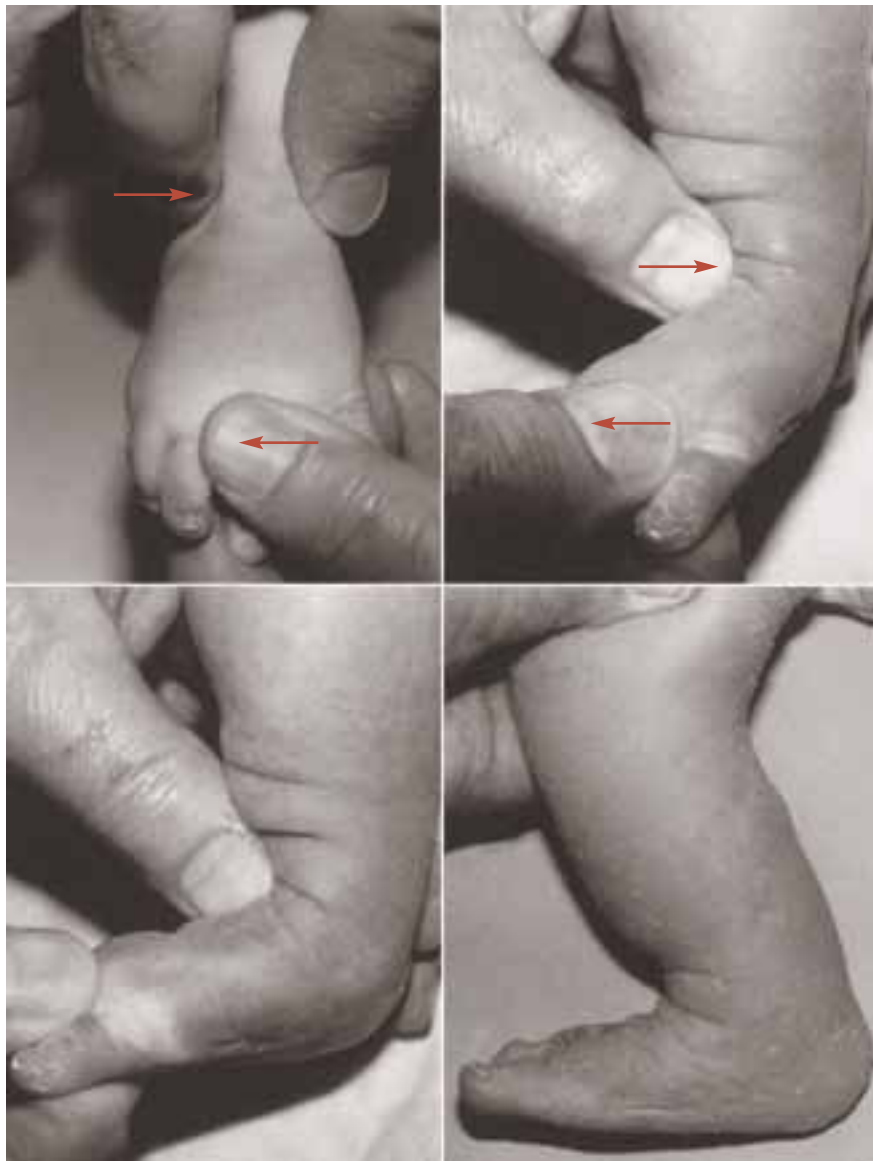


FIGURE 4

Manipulations
prior to casting, and
the corrected foot
after tenotomy.

made at birth, after the baby is fully examined by a physician.

Outcome

“Because in the real world most [radiographic] films are not taken in a standardized reproducible manner (child cries, foot twists, holders fingers slip), X-rays for clubfoot are often used to define patterns rather than clarify details.”²

X-ray is a common tool used to evaluate clubfoot and corrective progress, especially in the surgical treatment plans. Problems with early X-rays are with the tarsal bones, which are primarily cartilaginous, making angle measurements inaccurate. A forced dorsiflexion lateral X-ray

can clarify parallelism between the talus and calcaneus, confirming the diagnosis of clubfoot.

With the Ponseti Method, no X-rays are needed, as the clinical assessment determines the stages of correction. An X-ray showing a well-corrected foot after surgery may clinically exhibit as a stiff, painful foot. The desired outcome for the clubfoot is a flexible, painless, plantigrade, functional foot; this outcome is not determined by radiograph.

Functional outcome results of clubfoot treatment necessitate follow-up into adult life. Results of follow-up studies before adolescence are not very meaningful, because most children with defective feet do not complain. Their endurance and activity are boundless. Joint stiffness and muscle weakness are not as limiting in children as in adults. Clinical results should not be considered before age five when relapse is less likely. What has been achieved in correction at age five is permanent correction in the patient’s adult foot.

Classification/evaluation

A single standardized system to grade the severity of clubfoot has not been accepted. However, two grading systems, those of Pirani and associates and Dimeglio and associates have recently been proposed. Shafique Pirani, MD, from Vancouver, BC, has developed a grading system which directly correlates with the Ponseti Method. It is a six point grading system where each feature is given scores of 1.0-0.5-0.0: 1.0 being the worst and 0.0 meaning no deformity. The features that are evaluated in the hind foot are posterior crease, empty heel and rigid equinus. Features evaluated in the forefoot are medial crease, curvature of the lateral border and lateral head of the talus. It is a “look-feel-move” method of evaluating the clubfoot correction at each cast change.

The Ponseti Method

The Ponseti Method begins with five to seven weekly sessions of manipulations and cast applications. The initial manipulations are to correct abnormalities in the cavus and adductus. The thumb is used to palpate the lateral head of the talus with gentle pressure, while supinating the forefoot with the index finger of the other hand at the first metatarsal. This motion reduces the talonavicular joint. The calcaneus is never manipulated. Reduction of the talonavicular joint is achieved with the first or second cast.

Once this reduction is achieved, the forefoot is brought into less supination and into abduction. As the new casts are applied, the foot remains in some supination, as pronation would increase cavus, and attention is given to gentle molding over the lateral head of the talus in each cast. There is no attempt made to correct the equinus, until the forefoot is fully corrected. A toe-to-groin plaster cast, with the knee flexed to 90 degrees, follows each manipulation, and the external rotation of the foot will be increased weekly in the casts up to 70 degrees.

At the final casting, 95% of the patients need a percutaneous Achilles tenotomy to complete the correction of the equinus. This is accomplished as an outpatient procedure in the clinic with EMLA cream (2.5% lidocaine and 2.5% prilocaine) and/or local anesthetic. The foot is prepped and draped in sterile fashion, and the physician uses a tiny cataract blade to divide the Achilles approximately 2 cm above its insertion on the calcaneus. This should bring the foot into 10-15 degrees of dorsiflexion. The final cast with or without the tenotomy will be maintained for three weeks.

When the final cast is removed, the foot should be in an easily maintained overcorrected state. A pair of straight-last shoes, attached by an adjustable foot abduction bar, will maintain the overcorrected position. If the deformity is unilateral, the shoe of the clubfoot will be externally rotated to 70 degrees and the normal shoe externally rotated to 45 degrees. The bar width between the closest point of the heels will be equal to the width of the baby's shoulders.



FIGURE 5

A series of casts corrects the adductus and varus.

FIGURE 6

A tenotomy is performed approximately 2 cm above the calcaneus to allow an additional 10-15 degrees of dorsiflexion.



The strap keeps the heel anchored in the shoe, and it is important to keep it strapped tightly. If the child's feet are slipping out of the shoes, the feet should first be evaluated for loss of correction. The shoes or the FAB may need adjusting along with re-educating the parents. This brace system will be worn 23 out of 24 hours per day for three to four months, then reduced to sleeping time only until the child reaches four or five years of age.

Relapse

Unless splinting is instituted, relapse is certain and swift in premature infants, and more slowly later on. Relapse is rare after five years of age and

extremely rare after the age of seven. About one half of the recurrences are observed two to four months after the shoes/FAB are discarded; usually on the family's own initiative, after the parents see that the foot looks normal and yield to the child's resistance to continuing to wear the apparatus.

Even with the best attempts at consistency, about 6% of children can have a relapse.⁸ In most cases, the relapse happens in the hind foot equinus and varus. Slight adduction and supination

may also occur. A clubfoot, which has presented with a relapse, will have casting reinitiated. This will be a series of weekly manipulations with casting and, in some cases, a second Achilles tenotomy may be required. If the forefoot adductus and supination remain, the anterior tibial tendon may be transferred from its original insertion to the third cuneiform after 2.5-3 years of age.

About the author

Elizabeth Meyers, CST/CFA, OTC, has been an orthopedic technologist at Gillette Childrens Specialty Health Care, in St Paul, Minnesota, for two years. She had previously worked at the Shriners Hospital-Twin Cities and as a private assistant in general orthopedics. She began working with clubfoot in 1992. Meyers learned the Ponseti Method in 2000 from Ignacio Ponseti, MD, in Iowa City, Iowa. She has personally been involved in casting and caring for more than 200 babies with clubfoot.

Acknowledgments

Ignacio Ponseti, MD, has been a constant support and resource to me since 2000. The Ponseti Method has become a passion of

FIGURE 7

After the last cast is removed, straight last shoes attached to a bar help hold the correction in place.



mine since learning it in September 2000 along with Richard Aadalen, MD, in Iowa City. Aadalen and James Johanson, MD, are a few of the club-foot masters in Minnesota. I am forever grateful to these two fine orthopedic surgeons for the knowledge they shared with me and their respect and support. Other wonderful physicians I have worked with who have switched to using the Ponseti Method include: Keith Gabriel, MD, Steven Koop, MD, Deborah Quanbeck, MD, David Spiegel, MD, Stephen Sundberg, MD, and Kevin Walker, MD. These physicians have had a great influence in my life as well.

Editor's Note: For additional information about the life and contributions of Ignacio Ponseti, MD, please refer to the History of Surgery published in the July 2003 issue of The Surgical Technologist.

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- Dr Ponseti's web site www.vh.org/pediatric/patient/orthopaedics/clubfeet/index.html
- Clubfoot Support Group health.groups.yahoo.com/group/clubfoot
- Gillette Children's Hospital www.gillettechildrens.org

Images used courtesy of IV Ponseti.

FIGURE 8

Before and after the Ponseti Method. Clubfoot at 2-1/2 weeks, and 3 months.