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Management of relapsed, residual and neglected clubfoot

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Abstract: The non-surgical Ponseti "conservative" approach to treating clubfoot has nearly reached global adoption in the last 20 years. Consequently, there has been a significant decline in the requirement for surgical treatment of clubfoot. Percutaneous tenotomy is necessary for at least 90% of feet, and tibialis anterior tendon transfer may be necessary for 15% to 40% of patients, according to Ponseti, who himself frequently used surgery for specific cases. Further surgical intervention may be required in rare cases due to the frequency of relapses. Relapses occur when foot abnormalities that were treated in the past return. Incompletely repaired foot abnormalities are known as residual malformations. Furthermore, ignored clubfoot remains a significant problem in many emerging regions. Ponseti principles can help heal many neglected foot issues, especially in younger children. On the other hand, surgical methods are more commonly required for older children and adults. Inadequate follow-up, not recommending a full course of bracing, not fully using the Ponseti principles, and not being able to stick to the foot abduction brace regimen are major factors for relapsed or persistent clubfoot. Due to inherent muscular imbalance, relapses might occur occasionally even with great treatment and strict adherence to the bracing procedures. Reinstituting Ponseti casting and "à la carte" surgical treatment are two of the solutions we outline. Alternatively, a hexapod external fixator can be an effective tool for situations that are especially difficult to treat. If you want to be a true expert in clubfoot care and not just a Ponseti practitioner, you need to be able to perform every possible adjunctive surgical procedure.

Keywords: *relapsed, residual and neglected clubfoot*

Introduction

Manipulation and strapping, later supplanted by casting, have been the first lines of defense against congenital idiopathic clubfoot since ancient times.1The treatment that was most commonly used in the second part of the twentieth century was prolonged casting followed by extensive soft-tissue releases.On the other hand, severe scarring, joint stiffness, and muscular weakening were reported in numerous feet that had significant soft-tissue release 1, 2.2-5Idiopathic clubfoot was only ever successfully treated with nonoperative methods for the mildest cases for a long time. The Ponseti method, which does not need surgery, saw a renaissance at the turn of the millennium. To make matters more ironic, Ponseti had been describing and using his method for close to

40 years prior to its real global proliferation. There was no need for significant surgical therapy because practically every foot that was treated utilizing the Ponseti method became functional, pain-free, normal-looking, and mobile.three to tenThe Ponseti treatment's efficacy was immediately apparent, and it quickly gained widespread acceptance. According to Ponseti's 1963 report, 71% of patients saw positive outcomes, while 28% had some residual deformity.3A success percentage of 85 to 90% was recorded in his subsequent works.96 percent of kids stayed away from open soft-tissue release, according to research by Herzenberg et al. After 30 years of following up with patients who received Ponseti treatment for idiopathic congenital clubfoot, Cooper and Dietz8 discovered that 78% of those patients had satisfactory or excellent functional and clinical results, compared to 85% of age-matched controls. Although the Ponseti method is commonly portrayed as "nonoperative" or "conservative," even the most staunch Ponseti supporter will concede that surgery is frequently necessary: tenotomy (around 90%), tibialis anterior tendon transfer (TATT) (around 15% to 40%), repeat tendo Achilles lengthening (TAL), and occasionally plantar fasciotomy for specific relapses. Nevertheless, the premise of this article is that the Ponseti working in the sector is not limited to the few operations mentioned. Problems with feet that have already been treated with Ponseti can be so difficult to resolve that a variety of surgical treatments may be necessary.

Relapses are still an issue, even if the great results are now evidently being replicated all over the world. When a foot deformity that has been treated before returns, it is called a relapse. The difference between this and a "residual" clubfoot is that the latter was never completely corrected but only partially. As a last point, we call the case of an elderly patient's untreated foot a "neglected" clubfoot.

For many causes, relapses might still happen even after Ponseti treatment. We classify all relapses nosologically as follows: early (six months to thirty months), older (thirty months to eight years), and teenage (nine years and up).

Relapse prevention group

The initial phase of the Ponseti protocol includes casting the foot once a week for four to eight weeks, depending on the foot's response rate. Then, after three weeks of casting and an Achilles tenotomy, the foot is placed in the foot abduction brace (FAB) protocol full-time for three months. Nighttime and nap bracing continue until the child is four to six years old. Parents are liable for their children's therapy up until the last cast is removed and FAB is started, which is usually around nine to twelve weeks of age. One symptom of relapse, which occurs when the FAB is not followed, is the gradual loss of dorsiflexion, which causes the foot to slide out of the FAB. So, after the last cast removal and all subsequent visits, the clinician must measure and record dorsiflexion.

The education of the parents is vital for the treatment to be successful. Regular follow-ups are as crucial. Relapses are directly associated with not following the FAB, and parents need to know this. Eleven percent of subjects experienced relapses in 2004, according to Morcuende et al. #9. The failure to adhere to the FAB treatment plan led to relapses in the majority of patients. If dorsiflexion is lost too soon, it is best to cast again for a brief time to get it back, and then put the FAB back in. In most cases, the proper alignment of the foot can be restored with repeated casting. The necessity of the FAB must be emphasized once again to the parents. The doctor has a responsibility to inquire as to whether or not the parent is experiencing any difficulties in making use of the FAB. Physicians and physician extenders should devote more time to educating families, identifying obstacles to adherence, and proposing solutions for these patients who experience early relapses.

Recurrent Achilles tenotomy should be considered in exceptional cases if relapses are detected after 12 months and casting attempts to achieve greater than 10° of dorsiflexion have failed. Repeat tenotomies in a clinical setting are not something we endorse. Due to the scarred tendon's near proximity to the posterior tibial neurovascular bundle and the fact that it may require a mini-open surgery under general anesthesia, a repeat tenotomy is best performed in the operating room. It is true that too forceful percutaneous tenotomies can cause neuromas in continuity, specifically on the posterior tibial nerve. The proximity of the posterior tibial neurovascular bundle to a previously tenotomized Achilles tendon can be a disturbing sight to behold.

When you look at equinus, you might notice that it has a TAL and maybe even a forefoot equinus (cavus). Forced dorsiflexion will cause the plantar fascia to feel tight in such circumstances. There will be an elevated Meary

angle, which is typically 0°, when looking at the foot in a stressed lateral dorsiflexion or standing perspective. The so-called Ponseti II maneuver, which involves pushing upward on the metatarsal heads while counter-pressing on the dorsum of the neck of the talus, followed by serial casting after a plantar fasciotomy, can be helpful in this case. An incision along the arch of the foot's superficial plantar fascia is sufficient for less severe instances. For more serious cases, Steindler stripping, which involves transection of the whole origin of the short flexors of the foot off the calcaneus, can help reduce the cavus.

Equinus, combined with hindfoot varus and supination caused by over-activity of the tibialis anterior tendon, might be indications of recurrence in children of walking age.10Most relapsing feet (those younger than 2.5 years) can typically have their correction restored with a simple recasting following Ponseti principles. The purpose of recasting is to obtain maximum dorsiflexion and return the thigh-foot angle to the 60° to 70° range that was reached during the first treatment. Reinstituting a robust FAB program is crucial to sustain the correction that has been achieved. Remember that relapses are opportunities to educate your parents the value of FAB.

Cases of late relapse

Relapses in children between the ages of 2.5 and 8 are distinct from those in the early relapse group. Figure 1 shows that many of the children in this cohort either stopped using FABs, developed atypical clubfoot, or were never found. This group experiences a wide spectrum of relapses, from minor dynamic forefoot supination during walking to severe clubfoot deformity involving many components, including cavus, adductus, varus, and equinus. For children older than 2.5 years, Ponseti suggested TATT, which involves transferring the tendon to the third (lateral) cuneiform. No preoperative casting is necessary if the foot is pliable and passively correctable. Nevertheless, most children in this age range who experience relapses have immovable feet that cannot be completely passively treated. To get them back into alignment before surgery, Ponseti serial casting is necessary, preferably with long-leg casts. A non-passively correctible foot cannot be remedied with a tendon transplant. Tendon transfers are limited to just corrective maintenance. As a result, the plan is to use casting to get the injury fixed, and then the tendon transplant to keep it that way. Casting should be done first on all children with rigid abnormalities (Fig. 1). In addition to TATT, most of these patients also require TAL or gastrocsoleus recession due to loss of dorsiflexion. We think the FAB should be supported following TATT, but there is no unanimity on whether or not to employ it. A "biologic brace" is how some surgeons describe the TATT. Following a tendon transfer, the majority of youngsters will likely not utilize the FAB. If a passively correctable foot cannot be achieved with preoperative casting, then alternative procedures such as open release, osteotomy, or progressive distraction with an external fixator may be considered. There is a plenty of literature detailing TATT for relapsing foot.

Fig 1: (A) Four-year-old boy with relapsed clubfoot, lost to follow-up and noncompliant with foot abduction brace (printed with permission); (b) foot after four Ponseti casts and before tibialis anterior transfer.

For relapses in this age range (2.5–8 years), many kids won't notice a difference in their equinus after a TAL. Thus, prior to and following the open 'Z' cut in the Achilles tendon, the authors suggest intraoperative stress lateral dorsiflexion images of the foot and ankle. A formal open ankle and/or subtalar arthrotomy should be considered by the surgeon as soon as possible if no improvement is shown. The peroneals, flexor hallucis longus (FHL), neurovascular bundle, and flexor digitorum longus (FDL) must be identified sequentially during meticulous anatomical dissection performed under tourniquet control and loupe magnification. The posterior capsulotomy can be performed once these structures have been exposed and retracted. The release of capsular capsules starts at the deep peroneal tendon sheath and posterolateral corner, travels medially to the deltoid, and ends at the FDL tendon sheath. After releasing it from the posterolateral corner, the subtalar joint is transferred to the FHL tendon sheath, if necessary.

Performing a TATT with a posterior arthrotomy in the same session may not be the best course of action. Reason being, open posterior arthrotomy patients should be able to move around after three weeks to avoid stiffness, however TATT patients must remain immobile for six weeks. This is why, if required, you should begin with the TAL, then move on to the posterior ankle release, and put off the TATT until another session. A TATT can be performed concurrently with an appropriate TAL if no capsulotomy is necessary. When the foot is immobilized for less than one month and physiotherapy is started early, the range of motion (ROM) attained by the ankle following a capsulotomy can be preserved.11

Relapses that are more severe may necessitate a complete, traditional posteromedial soft-tissue release. Deep scarring, weak muscles, and chronic foot stiffness are potential complications of significant soft tissue release, which is why we avoid it whenever possible. In the case of the first extremely rigid arthrogrypotic foot, where general stiffness is typical, this may not be the case. A hexapod external fixator may be considered for soft-tissue distraction in the correction of rigid abnormalities if preoperative casting, TATT, and gastrocsoleus lengthening do not work or are not a possibility. Patients requiring external fixation typically exhibit a combination of advanced age and foot rigidity. Nonepidiopathic clubfoot affects the majority of these

individuals. Children under the age of eight should have soft-tissue distraction performed according to Ilizarov principles of pediatric foot correction, while children eight and up should undergo a series of hindfoot, tarsal, and supramalleolar osteotomies that gradually address abnormalities.12-14

For soft-tissue distraction or changes, several writers have turned to classic circular Ilizarov style frames, including the Joshi fixator. Our preferred method of hexapod adjustment is computer-guided. We came up with the name "Ponse-Taylor method" to honor both Dr. Taylor (fixator) and Dr. Ponseti (sequential method of clubfoot correction) (Figs 2 to 4). The original hexapod frame that was widely available in the US and Europe was the Taylor Spatial Frame (TSF) (Smith & Nephew, Memphis, Tennessee).

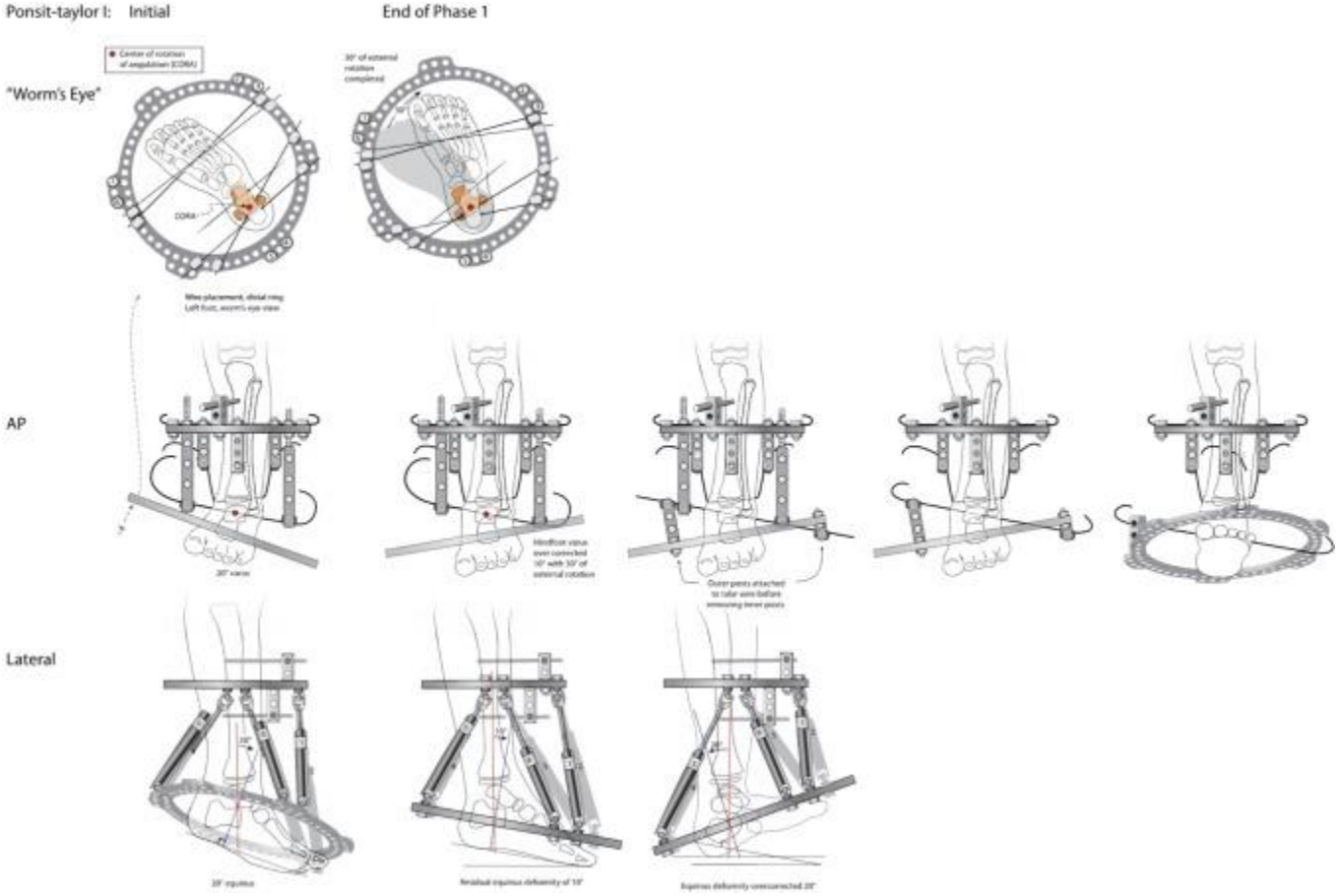

Figure 2: The 'Ponse-Taylor' hexapod strategy to correct residual/relapsed clubfoot (used with permission, Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore). Worm's eye view: before and after derotation to correct the internal spin through the subtalar joint. Anteroposterior (AP) view: during the initial varus to valgus correction and derotation, the talar neck wire is attached to the tibial ring with step down plates, to focus the correction through the subtalar joint. Next the talar neck wire is transferred to the foot ring, and then the equinus correction is focused on the ankle joint. Lateral view: the gradual correction of the equinus to neutral, and then additional over correction into approximately 20° dorsiflexion, anticipating some rebound.

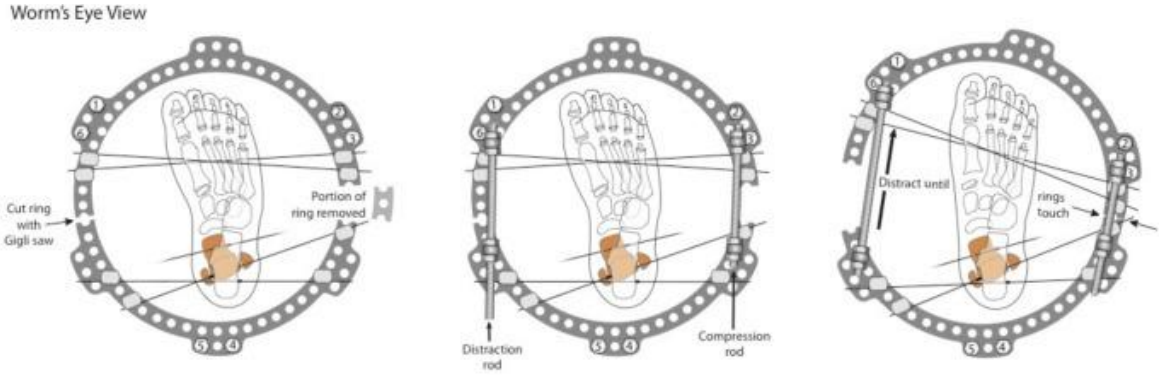

Figure 3: Ponse-Taylor II: used for cases in which there is also a forefoot adductus or cavus (used with permission, Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore). This is the last step, after the internal rotation, varus and hindfoot equinus have been corrected. The foot ring is cut on both sides, removing a segment from the lateral side in order to allow the cut ends to shorten. Threaded rods are applied over one-hole posts to act as a distractor on the medial side, and to allow compression (neutralization) on the lateral side, to correct adductus. For pure cavus, both sides may be distracted.

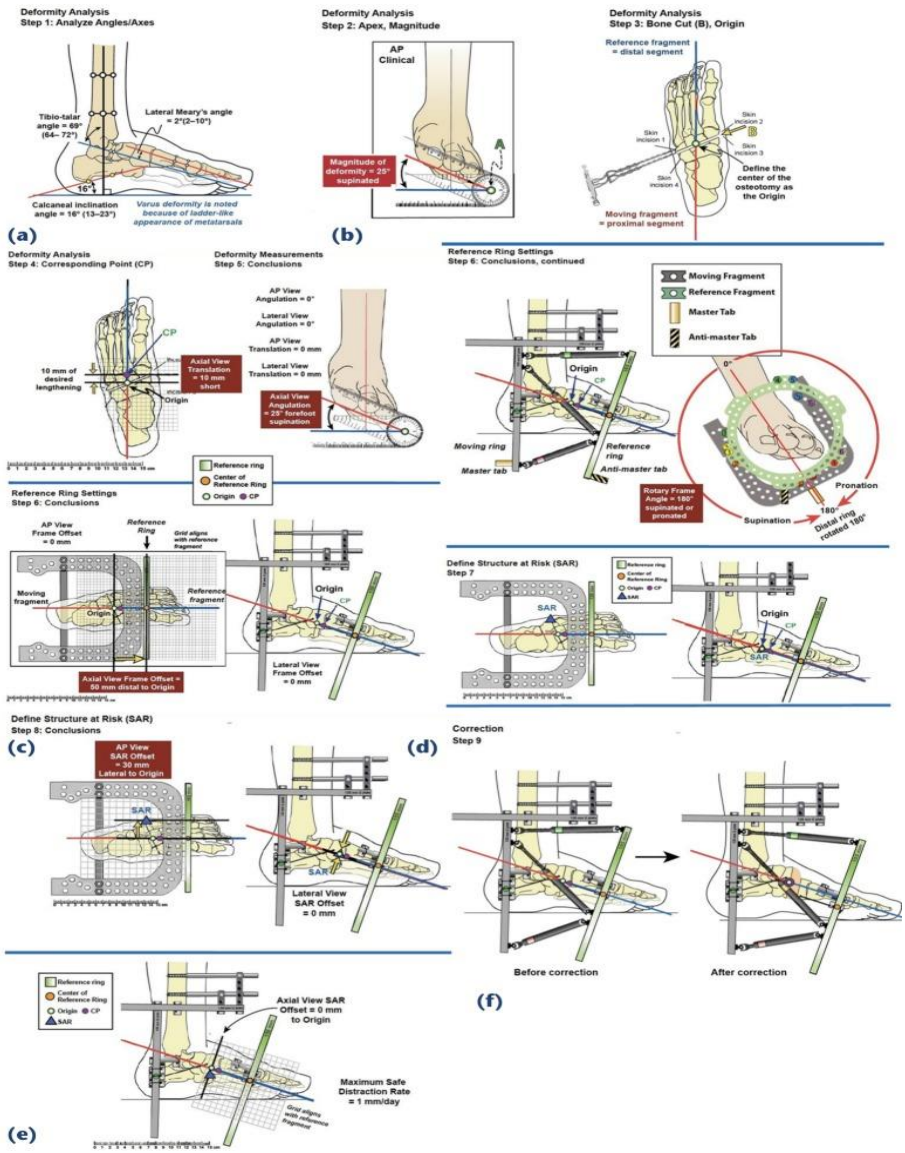

Figure 4: Hexapod 'Butt' frame to correct residual forefoot supinatus/adductus. This assumes that the hindfoot is well aligned (neutral) (used with permission, Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore): (a) lateral view of foot showing normal hindfoot orientation, but supinatus of the forefoot; (b) anteroposterior (AP) view of foot demonstrates forefoot supinatus. Percutaneous Gigli saw cut through the cuneiforms and cuboid; (c) the forefoot is designated as the reference segment, and the (green) ring applied perpendicular to that segment but rotated to reflect the supinatus (25°). The designated origin and corresponding point which are about 10 mm apart to permit disengagement of the osteotomy, to make it easier to rotate, can correct the deformity; (d) the forefoot is the reference segment, so it is depicted parallel to the floor, and the rest of foot (the proximal portion) is offset in an angular fashion. The structure at risk (SAR) is shown as the lateral edge of the osteotomy which is the farthest point from the centre of rotation (middle of the foot); (e) the offsets of the SAR are shown measured on the different views; (f) lateral view of the foot before and after correction. The foot is initially supinated, and then flat.

One approach to soft-tissue distraction that aims to recreate the two-stage Ponseti method is the Ponse-Taylor method of correction. Fixing the hindfoot's varus and internal torsion is the first step. To facilitate derotation of the foot, a talar olive wire is currently fastened to the proximal ring. To keep the joints from getting too involved, it's crucial to program in some lengthening. The second step can be initiated after the subtalar joint

has been used to derotate the foot. Stage 2 involves re-creating the Ponseti 'tenotomy' in order to achieve dorsiflexion. The talar wire needs to be removed from the tibial ring and then tensioned onto the foot ring. This will allow the talus and the entire foot to dorsiflex simultaneously. Normally, this frame manipulation is done under anesthesia in the operating room. However, in cases when the foot is insensate, such as in myelodysplasia, it can be done in the clinic. Programming dorsiflexion beyond the neutral position is the following step. To prevent rebound equinus, it is advised to go at least 20° above neutral. To avoid joint compression, add 5 mm to the program four or six weeks of keeping the foot in its new position, the frame is removed and splints are put on. It is advised to undergo postoperative physical therapy and wear a cast. Thirdly, a medially cut and lateral segment removal of the foot ring can be performed for feet with forefoot adductus or cavus For adductus, threaded rods suspended from one-hole posts bridge the ring's rips; for cavus, they distract on both sides; and for medially, they compress laterally.

Teenage cohort

This category includes many individuals who were treated using other ways in the past, dating back to the 'pre-Ponseti' era. Rigid abnormalities are common in these animals.

Relapses in this age range are now infrequent due to the global adoption of the Ponseti technique. The overactivity of the tibialis anterior causes residual supination and loss of dorsiflexion in the majority of these patients. Similar to the younger group, these patients may undergo recasting, tibialis anterior transfer, and gastrocsoleus complex or Achilles tendon lengthening as part of their treatment. But, all the symptoms of severe clubfoot can be present in patients who returned after a period of no follow-up.

Our preferred method of treating severe, inflexible abnormalities in older children and teenagers is with osteotomies followed by progressive hexapod frame repair. Since the majority of these patients had already undergone a soft-tissue release, the prospect of further improvement from this procedure is dim.the number ofStill widely used and effective today, the original Ilizarov frame for clubfoot deformity correction17 calls for constant fine-tuning of the frame, the construction of numerous hinges to achieve multiplanar treatment, and a great deal of practice to become proficient in.15, 17, 18The TSF is the hexapod that we favor.18A virtual hinge in the TSF's circular frame permits simultaneous rectification of six-axis abnormalities.

These days, you may get a wide selection of TSF foot frames to fix all sorts of foot abnormalities. Our two primary frame kinds are:

Two rings joined by six struts form the standard frame arrangement.

When employing external fixation to treat midfoot abnormalities, the Gigli saw is perfect; however, the osteotomy should be finished before the frame is applied, since it is far easier to complete the osteotomy without the interference of the frame. Osteotomy support during frame application is provided by the surrounding ligaments. Supination, cavus, and forefoot adduction are all efficiently remedied with the use of a butt frame. You can apply this frame with relative ease. One drawback of this frame is that it can't fix both equinus and varus problems at the same time. When a hindfoot varus is present, a calcaneal shift osteotomy (Dwyer) can be performed either concurrently or as an additional treatment.15

We will use cast immobilization for six weeks after correction is complete, and then ankle-foot orthosis (AFO) bracing. To check for recurrences, follow-up appointments are necessary frequently.

Overlooked foot condition

Adults, adolescents, and older children who suffer from untreated equino-cavo-adducto-varus are considered to have neglected clubfoot Nowadays, only a small number of migrants from low- and middle-income countries (LMIC) suffer from untreated severe clubfoot in industrialized nations. Half or more of the world's clubfoot patients do not receive treatment because they live in low- and middle-income nations (LMICs) that lack adequate access to contemporary medical facilities.19As a result of the foot's unusual pronation, midfoot adduction, hindfoot varus/inversion, and ankle fixed extreme plantar flexion (equinus), the foot appears strange. Adolescents and younger children have functional issues and can't wear regular shoes. Although many of these untreated feet can be unexpectedly soft, a typical Ponseti protocol can still be used as an initial step in treating youngsters under the age of 10. Although this form of late casting has shown some promise, surgical

intervention will be necessary for the vast majority of patients in this category. Age at the start of treatment has a negative correlation with treatment success.20Regardless of age or severity, a casting course should be the initial line of treatment.21An effective remedy to clubfoot abnormalities could be external fixation utilizing a hexapod Miter frame, which can correct all components at once.

Soft tissue adjuvant procedures

Adjunctive operations can be categorized as either bone or soft-tissue procedures. Performing a TAL with or without a posterior ankle capsulotomy is possible, as mentioned above. Although hindfoot equinus is the most common reason to enable dorsiflexion, it's worth noting that hindfoot varus is frequently treated at the same time. The ankle and subtalar complex typically shift from a "down and in" position (equinus and varus) to a "up and out" position (dorsiflexion and valgus) due to the interconnected nature of these motions.

In clinical settings, a downward-pointing foot posture is referred to as equinus. The equinus muscles of the hindfoot and the forefoot can exist independently or in tandem. Forefoot equinus, often known as a "cavus," is characterized by a bent or flexed first metatarsal. Stress dorsiflexion lateral radiographs of the foot make it easier to differentiate between forefoot and hindfoot equinus. Indicators of forefoot equinus include a Meary angle larger than 0 degrees. Plantar fasciotomy can help with this. Both superficial and deep plantar fasciotomies are possible. It is possible to perform a deep release on only the plantar origins of the short flexor muscles (Steindler) or on the entire foot, including the ligaments of the talonavicular and calcaneocuoid joints. To achieve additional correction and avoid rescarring to the preoperative state, it is recommended to consider postoperative stretching serial casting in all patients.

Release of the abductor hallucis tendon distally in an intramuscular slide manner can be performed alongside the plantar fascia to reduce forefoot adductus deformity. Performing a traditional open medial release of the talo-navicular joint is a more drastic approach to treating the adductus. There are many who think the calcaneocuboid release should be a part of a full midfoot release. A way to free the calcaneocuboid joint from the medial plantar approach has been detailed by Carroll.23

Both Garceau24 and Ponseti4 have done a good job of describing the TATT. The transfer of the peroneus longus tendon to the peroneus brevis tendon is an additional procedure that is occasionally performed alongside the TATT. The signs point to a cavus foot where a TATT would be most effective. The reasoning behind this is that when the tibialis anterior tendon is severed from the first metatarsal, the peroneus longus tendon pulls unopposed, which in turn causes the first ray to plantarflex even more, which in turn increases the cavus and causes the first metatarsal head to protrude excessively from the foot's plantar surface. To do the Pulvertaft-style peroneus longus to brevis transfer, a small incision can be made laterally, above the lateral malleolus. The peroneus longus is then detached and woven into the peroneus brevis.

The toes may seem tightly curled in the neutral or dorsiflexed posture after undergoing a combination of the aforementioned soft-tissue treatments to correct a clubfoot. Even though the FHL and FDL were openly Z-lengthened, this may still be the case. When this occurs, a 64-blade Beaver scalpel is used to provide a straightforward percutaneous release of the long flexors at the plantar-digital creases.

Joint distraction with external fixation, as mentioned before, is the last step in soft-tissue procedures. Overcorrecting and maintaining the overcorrected position for four to six weeks is crucial when using external fixation to distract joints. This is because the myofibroblasts in the collagen tissue have a "memory" that can cause quick relapses. Also, you should wear a cast for the long haul.

Additional operations for the bone

If the patient experiences persistent or recurrent symptoms following Ponseti treatment, there is a wide variety of bone surgical treatments available in the orthopaedic literature. These should only be used when simpler processes (TAL, TATT) and repeat casting fail. Patients are more prone to require bone operations as they age. To cure heel varus, a translational closure wedge can be used. Osteotomy performed by Dwyer is fastened internally. A combination of the medial cuneiform (medial opening wedge) and cuboid (lateral closing wedge) can be used to treat adductus, as explained by McHale and Lenhart.25In cases with cavoadductus that are more

severe and in children older than seven years old, a naviculectomy in conjunction with lateral calcaneocuboid shortening can effectively soften up a stiff foot and enable correct posture, as described by Mubarak and Dimeglio 26.

Because the modifications made by supramalleolar osteotomy can be "undone" by physeal remodelling in a growing child, guided growth is a better option for treating ankle equinus in school-aged children than this surgical procedure.27

Various combinations of varus, valgus, equinus, and supinatus can be corrected in the Ilizarov world through several osteotomies.28It would be too lengthy for this review piece to provide a detailed explanation of all of these. A midfoot Gigli osteotomy with TSF butt frame-assisted progressive correction is shown for demonstration reasons

Although long-term outcomes are inconsistent, talectomy in conjunction with lateral column shortening and fusion is an effective technique for arthrogrypotic feet as a last resort salvage operation.29

Summary

Over the last twenty years, the Ponseti technique has completely transformed the way clubfoot abnormalities are treated. However, relapses do occur; however, they are typically caused by following the wrong treatment plan or failing to adhere to the FAB. Most relapses can be better targeted with the use of an algorithm that takes age into account. Although the Ponseti principles can still be used to cure neglected clubfoot, more drastic measures may be necessary for elderly patients with significant abnormalities. There will inevitably be a decline in the need for expertise in older, more intrusive surgical treatments as the Ponseti method gains widespread use. Classic Ponseti principles will not work for all patients, though; many adults and children still deal with residuals and relapses, as well as untreated natural history foot. Thus, it is critical for the clubfoot specialist surgeon to be up-to-date with all of the classical surgical methods that have been successfully used by orthopaedic surgeons for treating difficult cases of clubfoot. It is our duty to maintain an organized surgical toolbox and to use our classical abilities prudently when necessary, as not all foot conditions can be adequately treated with plaster and a tenotomy.

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