

Visited on 09/18/2018

***Surgery in Africa - Monthly Review*****Treatment of  
Neglected Clubfoot**[Introduction](#)[Pathologic Anatomy](#)[Patterns of Anatomy](#)[General Considerations](#)[Correction of Neglected Clubfoot by the Ponseti Method](#)[Soft Tissue Release](#)[Lateral Column Shortening Osteotomies](#)[Corrective Midfoot Osteotomies](#)[Triple Arthrodesis](#)[Talectomy](#)[Dorsal Bunion](#)

Visited on 09/18/2018

<a href="#">Ilizarov Method</a>
<a href="#">Complications</a>
<a href="#">Knowledge Gaps</a>
<a href="#">Resources</a>
<a href="#">References</a>

**ABSTRACT:** The Neglected clubfoot deformity is a major disability for children and adults in low income countries. The bones and joints of the foot deform into fixed equines, adducts, cavus, and supination as the patient walk on the side or dorsum of the foot.

The Orthopaedic literature on clubfoot deformity focuses on early intervention in a resource-rich environment, with numerous surgical options outlined for both primary treatment and treatment of relapsed clubfoot. (1,2)

There is very little literature available on treatment of the neglected clubfoot with major texts providing little more than anecdotal reference to triple Arthrodesis as a salvage procedure.

Large numbers of children with neglected clubfoot deformities present to outpatient clinics and deciding how to manage and treat these children becomes a significant challenge.

The purpose of this article is to provide an insight of the surgical treatment methods available for neglected clubfoot.

## INTRODUCTION:

The Neglected clubfoot is one which there has never been initial treatment or perhaps very inadequate and incomplete treatment. The deformity is made worse by weight bearing on the lateral side or dorsum of the foot, exaggerating the abnormal shape and causing further deformation. The contracted soft tissues on the medial side of the foot are encouraged to contract further.

The bones are compressed unnaturally at a time when they are plastic and deform into abnormal shapes. Bone that normally support the arch of the midfoot now bear axial load. A thickened callous and large bursa develops over the weight bearing area often associated with deep fissures, vulnerable to breakdown and infection.

Visited on 09/18/2018

## PATHOLOGIC ANATOMY

The primary contractile forces of the soft tissues in clubfoot deformity results in progressive bony deformity. The primary soft tissue and bony deformities have been well described in the dissections of Ponseti. (3) and in the magnetic resonance imaging studies of Pirani. (4)

Early manipulation and cast treatment, in an infant before walking age, using the Ponseti technique shows cartilage remodeling back toward a normal anatomical appearance. (4) The neglected clubfoot, by contrast, has significant bony deformation and soft tissue release alone cannot fully restore bony anatomy. There is significant bony deformity in the neck and of the talus, shape of the navicular, subluxation of the cuboid, and dramatic obliquity of the calcaneocuboid joint.

## PATTERNS OF DEFORMITY

There is a spectrum of severity of clubfoot deformity right from birth. Although all the elements of equinus, rear foot varus, cavus, and forefoot adductus are present, each of these will contribute variably to the deformity; this results in numerous combinations and degrees of deformity and stiffness. Even after many years of neglected deformity, some feet retain a degree of flexibility.

A basic clinical classification can be used on physical examination:

1. Moderately flexible: The foot can be considerably corrected in some cases to neutral position.
2. Moderately stiff: There is some correctability, but not to neutral position and with moderately severe deformity persisting.
3. Rigid : There is almost no correction possible with severe deformity persisting.

These clinical features can be applied both to the midfoot and rearfoot. In young infants, the clinical classification systems of Dimeglio or Pirani are useful for this assessment (5) (6)

## GENERAL CONSIDERATIONS

The treatment of neglected clubfoot is largely surgical. The dilemma in the developing world is the large number of cases presenting with an extreme shortage of skilled surgeons.

There is no single surgical procedure that can resolve all clubfoot scenarios. A full armamentarium of procedures must be at the ready.

Presented here are approaches that have proved useful in the treatment of neglected clubfoot. The choice of surgery depends on the patients age as well as the, severity of the deformity and the degree of flexibility of the foot. There is a progression from manipulation and casting in young patients (under 4) to soft tissue surgery, soft tissue surgery combined with midfoot osteotomies to osteotomies alone and then arthrodesis in isolation. Arthrodesis remains a very common operation in low income countries for a painful rigid clubfoot in a skeletally mature individual.

Even if complete correction is not obtained or maintained with casting, the soft tissue stretching obtained by preoperative casting often reduces the extent of subsequent surgery and improves the anatomical results.

## Correction of neglected clubfoot by the Ponseti method.

## Visited on 09/18/2018

The Ponseti method of manipulation and casting to treat clubfoot has been shown to be effective in children up to two years of age. The results of the study of A.F.Lourenco et al (7) showed that neglected clubfeet can be successfully treated using the Ponseti method. They retrospectively reviewed 17 children (24 feet) with congenital idiopathic clubfeet presented after walking age and had undergone no previous treatment. All were treated by the method described by Ponseti, with minor modifications.

The mean age at presentation was 3.9 year (1.2-9.0) and the mean follow-up was 3.1 years (2.1-5.6). The mean time of immobilization in a cast was 3.9 months (1.5-6.0). A painless plantigrade foot was obtained in 16 feet without extensive soft-tissue release and/or bony procedure. Four patients (7 feet) had recurrent equinus which required a second tenotomy. Failure was observed in five patients (8 feet) who required posterior release for full correction of the equinus deformity. The sample size was small, and further studies are necessary to understand fully the limits of this method in neglected clubfeet. However, the results are encouraging for the treatment of this problem by a simple, effective, and inexpensive method in countries with limited resources for health care. A substantial challenge in applying Ponseti's method in low income countries has been in providing bracing and followup for several years, to prevent the recurrence of deformity with growth.

## Soft Tissue Release

This is the most common surgical procedure in younger children up to approximately 4 years of age. In children older than this, osteotomies are often required as well. Soft tissue releases follow established guidelines in standard orthopaedic publications and are well described. (1) The pathologic contracted connective tissues on the medial, posterior, and lateral sides of the foot and ankle are released or lengthened. Occasionally, with the use of preoperative serial casting, only posterior release is required in more flexible feet. Posterior release involves release of the posterior capsule of the ankle and subtalar joints as well as open Achilles tendon lengthening.

More resistant cases with midfoot adduction and cavus require medial lengthening as well. The initial landmarks for the dissection are the Achilles tendon posteriorly and the abductor hallucis anteriorly, with the neurovascular bundle between. The neurovascular bundle must be carefully exposed and protected through the dissection. This usually consists of complete release of the posterior and medial subtalar joint capsule (leaving the interosseous ligament intact), talonavicular joint capsulotomy (including the spring ligament and the bifurcate Y ligament), and medial calcaneocuboid joint capsulotomy, release of the knot of Henry, sectioning of the adductor, and lengthening of posterior tibial tendon. The flexor hallucis longus and flexor digitorum longus can usually be left because they stretch postoperatively, but occasionally these need lengthening as well. The lateral tether should be sectioned, releasing the lateral subtalar joint capsule, peroneal tendon sheath, and calcaneofibular ligament. The plantar fascia should be sectioned in the interval behind the lateral branch of the posterior tibial nerve to treat residual cavus.

This surgical procedure can be carried out through the Cincinnati incision or by a two incision technique. The Cincinnati incision is a single long incision parallel to the plane of the sole, extending from just anterior and distal to the fibula on the lateral side, posteriorly above the calcaneus, and ending medially near the distal part of the great toe metatarsal. It provides excellent exposure to all tissues involved in a comprehensive posterior, medial, and lateral release. In the more severely involved foot with significant equinus, the Cincinnati incision has its limitations in that closure of the posterior incision will not be possible, or if closed the foot has to be left in an uncorrected position and followed by remanipulation. It has been shown however, that clubfoot incisions left widely open do epithelialize successfully without the need for secondary wound closure or skin grafting. (8)

Lateral transfer of the tibialis anterior tendon is usually reserved for relapses after corrective cast management, usually after age 2 years once the lateral cuneiform has begun to ossify. (9) Because many

## Visited on 09/18/2018

children in poorer environments present for soft tissue release at an older age, consideration should be given to tibialis anterior tendon transfer at the index procedure. This helps control residual forefoot supination. It might also reduce the risk of relapse or dependency on lengthy postoperative abduction bracing protocols.

Henry, Herold et al recommended two staged operation in older children and adults , with medial release, resection of the abductor hallucis, section of the posterior tibial tendon, and lengthening of the Achilles tendon as the first stage. The second stage comprised a bone procedure like triple Arthrodesis following correction of the foot by plaster casts. Supplemental operations like derotational osteotomy of tibia or metatarsal osteotomy may be indicated on an individual basis. (10)

## Forefoot supination

Persistent forefoot supination usually happens in association with calcaneal varus and is most prevalent in previously operated patients in whom the deformity can be rigid. The more flexible forefoot supination seen in neglected clubfeet that have had no surgery usually corrects adequately with soft tissue release and calcaneal shortening. Treatment of more flexible supination is lateral transfer of the tibialis anterior tendon to the lateral (third) cuneiform. This is a standard procedure for dynamic supination after successful cast treatment. (11)

## Lateral column shortening osteotomies

Revision procedures to correct adductus deformity in clubfeet increasingly require osteotomy as part of each subsequent procedure. (12)

The increasing frequency of osteotomy in revision clubfoot surgery is attributed to extensive scarring. Osteotomy has the advantage of correcting deformities of the tarsal bones, which undergo deformation during growth in idiopathic clubfeet. (13)

Soft tissue release alone may not fully correct residual adductus because of secondary bony deformity. The combination of soft tissue release with midfoot osteotomy is usually required in children between approximately 4 and 12 years of age with neglected clubfoot. (14)

The bony lateral column is longer than the medial column, resulting in midfoot adductus. Shortening osteotomy through the lateral column is required and should occur through the calcaneus or calcaneocuboid joint. The primary bone pathology is the obliquity of the calcaneocuboid joint and relative lengthening of the lateral portion of the anterior process of the calcaneus. Shortening should therefore occur through the distal calcaneus with an attempt to make the calcaneocuboid joint transverse. Alternatives include closing wedge osteotomy through the anterior process of the calcaneus leaving the articular surface intact, excision of the anterior process of the calcaneus (Lichtblau procedure), calcaneocuboid wedge resection (Dilwynn-Evans procedure). (15,16) In the young children, the Lichtblau procedure adequately shortens the lateral column and allows for pseudoarthrodesis to develop after remodeling. This allows for more subtalar joint and midfoot motion than a calcaneocuboid Arthrodesis.

In the older children, more correction can be achieved by doing a calcaneocuboid wedge resection, and the arthrodesis so performed may act as an epiphysiodesis to improve foot position with growth. Arthrodesis of this joint also potentially reduces the risk of relapse by providing a permanent solution but is associated with more potential stiffness of the subtalar and midfoot articulations.

Correction through the cuboid is not indicated because it does not address the primary pathology (14) Some surgeons advocate cuboid closing wedge osteotomies, or open wedge osteotomy of the medial

## Visited on 09/18/2018

cuneiform or both, depending on the clinically or radiographically determined site of the deformity and the age of the patient. ([17-20](#))

Combined cuboid/cuneiform osteotomy is a safe operation, which allows satisfactory correction of residual adduction deformity in previously treated idiopathic clubfeet.

Application of external fixator on the medial side of the foot before osteotomy to stretch the medial soft tissues is reported to be beneficial. ([21](#))

The combination of a shortening osteotomy of the cuboid and elongation of the cuneiform, as first described by McHale and Lenhart, has the potential to correct the deformity of the tarsal bones with minimal additional scarring. ([20](#))

Osteotomy of the first cuneiform as treatment of residual adduction of the fore part of the foot in clubfoot seemed the most logical approach because the deformity primarily affects the medial column. Only the first cuneiform must be osteotomised because the other, less involved sites of deformity appear to remodel with time after the medial column has been lengthened. The procedure is appropriate for children more than eight or nine years old because the operation requires a well ossified first cuneiform bone. The age of skeletal maturity (teen-age years) is the upper limit for this procedure; in adults the foot is not flexible enough to accommodate the change in alignment. ([17](#))

## Corrective midfoot osteotomies

Corrective osteotomies about the midfoot are indicated for angular and rotational deformities. Midfoot osteotomies avoid extensive soft tissue exposure required for multiple joint Arthrodesis procedures. Typical indications for a midfoot osteotomy are rigid pes cavus, talipes equinovarus, rigid metatarsus adductus, malunion associated with midfoot or rearfoot arthrodesis, and neuro-osteoarthropathy midfoot deformities. ([22,23](#))

The goal of a midfoot osteotomy is to re-establish a plantargrade foot during stance. The position of the forefoot and hindfoot is paramount in planning for a midfoot osteotomy. Any concomitant procedures to the hindfoot, ankle, or tibia for deformity correction should be performed before the midfoot osteotomy, starting with the most proximal deformity and working distally. Any functional tendon transfers should be delayed until osteotomies have healed. Forefoot varus produces increased weight transfer to the lateral border of the foot and may cause a compensatory calcaneal valgus deformity. Conversely, forefoot valgus deformity produces increased weight transfer to the medial border of the foot and may cause a compensatory calcaneal varus deformity.

Deformities about the foot the forefoot can usually be corrected with midfoot osteotomies. Forefoot supination can be corrected through rotation of the fore foot segment following mid foot osteotomy. Sagittal and transverse plane forefoot deformities can be corrected with wedge-based mid foot osteotomies and translation, respectively. However, noncompensatory deformities and fixed compensatory deformities of the hindfoot, particularly the calcaneus and subtalar joint, cannot be corrected with a midfoot osteotomy alone. A calcaneal osteotomy or subtalar joint arthrodesis, in addition to a corrective midfoot osteotomy, is needed for rigid hindfoot deformities. ([23,24](#))

For rigid supination deformity, a complete midfoot osteotomy is performed after the lateral shortening procedure is completed. When the deformity is not severe and where the bones are of sufficient size, a plantar closing wedge osteotomy of the medial cuneiform is done. For more severe degrees of deformity, the osteotomy is carried transversely through all the cuneiforms freeing up the forefoot from the rear foot. The forefoot can be pronated on the rearfoot and fixed with pins. This is a difficult correction to achieve. These

## Visited on 09/18/2018

osteotomies may also be combined with transfer of the tibialis anterior tendon.

Sagittal plane deformities in the pes cavus foot are a frequent indication for mid foot osteotomy. The osteotomy is designed with a dorsally based wedge to Dorsiflex the forefoot and decrease the arch height. (25,26) At times, a wedge osteotomy has to be taken from the navicular-cuneiform joint extending into the cuboid to obtain adequate correction.

Procurvatum deformities and ankle equinus cannot be corrected with a midfoot osteotomy, and additional soft tissue or osseous procedures about the ankle are required. It is important to evaluate the ankle on a lateral weight-bearing radiograph for procurvatum and recurvatum deformities of the ankle. At times, dorsiflexion stress radiographs are indicated to ensure an anterior osseous impingement is not evident at the ankle and that sufficient ankle joint dorsiflexion remains when considering correction of an anterior equinus by way of a mid foot osteotomy. In addition, posterior osseous cavus deformity should be corrected with calcaneal osteotomies, as opposed to mid foot osteotomies

Corrective mid foot osteotomies represent an effective surgery to treat selected foot deformities. Knowledge of deformity, planning and normal anatomical relationships of the foot is important an attempt to re-establish a plantigrade foot.

## Triple Arthrodesis

Triple Arthrodesis is a versatile procedure used to correct major deformities in children. In the developed world, triple Arthrodesis is used primarily as a salvage procedure for pain after previous surgical correction. (27) In the developing world context, with reference to neglected clubfoot, the procedure has its versatility in correction of large degrees of deformity. In severe deformity, particularly with marked cavus when the foot is facing backwards, soft tissue release and osteotomy is unlikely to achieve full correction. In this case, triple Arthrodesis can be very useful. Conventional orthopaedic wisdom recommends triple arthrodesis not to be performed before advanced skeletal maturity, at age 10 to 12, to avoid growth retardation by removal of cartilage involved in enchondral ossification.

Norgrove Penny reports to have used triple Arthrodesis in children as young as 6 years and did not observe any adverse growth characteristics. Moreover, discrepancy in the size of the feet in is seldom more than a cosmetic nuisance and in bilateral cases not relevant. (14)

A modification of the classic Lambrinudi triple Arthrodesis, originally described for polio equinus deformity, is necessary. (28) In general, resection through the talus should be minimized because of the tenuous blood supply and most of the correction made through the calcaneus. The calcaneus is rich in blood supply with ample bone allowing for large wedge excisions for correction.

A standard oblique ollier-type incision is made on the lateral side of the foot and the extensor digitorum brevis shelled out sharply from the sinus tarsi. The calcaneocuboid, subtalar, and talonavicular joints are thus exposed. The peroneal tendons are carefully mobilized around the calcaneocuboid joint. The correction is made principally through the anterior process of the calcaneus. The first cut is made transverse to the long axis of the calcaneus, removing a large laterally based wedge. The medial aspect of the cut should come out just behind the oblique edge of the calcaneocuboid joint. A conservative excision of the cuboid articular surface is done, parallel with the articulation. The talar cut involves excision of the head and a portion of the neck of talus. The line of resection extends from the articular margin of the head of the talus obliquely downward to the anterior articulation of the posterior facet of the subtalar joint. Bone resection will depend on the severity of the deformity.

Additional equinus correction can be achieved by percutaneous or open lengthening of the Achilles tendon. Plantar fasciotomy can also be added for cavus, performed through a short longitudinal incision in the

Visited on 09/18/2018

midfoot.

The decision for triple arthrodesis should be made before hand. An extensive medial release combined with triple arthrodesis can result in substantial swelling and skin breakdown and slough.

## Talectomy

Talectomy is described for treatment of equinovarus deformities in myelodysplasia and arthrogryposis, and has also been used for severe clubfeet. Talectomy, however, provides an incongruous joint, and often it is still difficult to obtain fully corrected foot position. Triple Arthrodesis is a preferable procedure since it is functionally and cosmetically superior to talectomy. (14)

Talectomy should be reserved for severe, untreated clubfoot , for previously treated clubfoot that is uncorrectable by any other surgical procedures, and principally for neuromuscular clubfoot.

## Dorsal bunion

Dorsal bunions that develop after clubfoot surgery have been attributed to muscle imbalance. McKay reported dorsal bunions in 11 children after posteromedial release for clubfoot and attributed the deformity to weakness of the triceps surae. The bunion develops as the patient tries to push off with toe flexors to compensate for the tricep's weakness. Another suggested factor is imbalance between the anterior tibialis muscle and an impaired peroneus longus muscle. Iatrogenic injury to the peroneus longus tendon in the sole of the foot may be the cause in some cases. Most authors recommend transfer of the flexor hallucis longus to the neck of the first metatarsal, combined with bony correction by plantar closing wedge osteotomy of the first metatarsal.

## Ilizarov Method

The Ilizarov method has been advocated as a means of avoiding some draw backs of osteotomy in the treatment of neglected clubfoot, particularly the risks of neurovascular injury, soft tissue injury, and shortening of the foot. The Ilizarov is an external fixator system with hinges and distractors, providing a powerful means of obtaining correction of severe foot deformities. (29) Progressive correction can be accomplished with safety regarding blood supply and skin.

Rings are fixed to the tibia connected to half rings for the calcaneus and the forefoot. Asymmetrical distraction corrects the various deformities. When bony deformity is not severe, an unconstrained frame (lacking fixed hinges) is used to take advantage of the existing articulations, much as with serial casting. For more severe deformities, distraction osteogenesis through osteotomies is accomplished using a more constrained frame with hinges.

Joshi has developed a simple frame based on Ilizarov concepts that has been used extensively in India and elsewhere with good results. (30)

The Joshi frame is less bulky than a similar Ilizarov frame, less expensive, and simpler to apply. Recent reports from India adapting Ilizarov correction to the Ponseti technique have also been encouraging. An olive wire is inserted into the neck of the talus and an unconstrained construct used to correct forefoot adduction and varus around the talus. (31) There is vulnerability to relapse in older children because of the osseous deformity, notably the obliquity of the calcaneocuboid articulation. combining Ilizarov corrections with osteotomy through the calcaneus is more likely to produce a lasting effect. (32) Use of Ilizarov instrumentation is limited in the developing world, but may be a procedure of choice in resource rich



## Visited on 09/18/2018

environments. Triple arthrodesis may be the procedure of choice in resource poor environments for the same spectrum of deformity.

Amin Abdel-Razek managed relapsed clubfoot using this method and reported excellent and good results (72%) which was considered satisfactory, and while fair and poor results (27.8%) as unsatisfactory. (32)

## COMPLICATIONS

Skin Necrosis/breakdown, neurovascular insults, infections, non unions, recurrency and pain remain major complications in neglected clubfoot surgery. A surgeon should only take on major foot reconstructions once (s)he is comfortable diagnosing and managing the attendant complications.

Ponseti casting can lead to incomplete correction or creation of secondary deformity if the manipulations are not performed in the prescribed sequence. Recurrence following casting is more common if bracing is not used – Ponseti recommended three months of full time bracing, followed by night bracing until the third or fourth birthday.

Correction of substantial stiff equinus places the posterior tibial artery and nerve under stretch in the tarsal tunnel. The foot may not tolerate an immediate correction of a major deformity. If the toes or a portion of the foot have inadequate circulation in the fully corrected position then splitting the cast, relaxing part of the correction, and removing pins if present will often restore the circulation. Correction can be regained or maximized by serial manipulation and casting, under anaesthetic if necessary, in the early weeks following surgery.

Tight skin at incision lines can be dealt with in a similar manner – relaxing the correction and serially casting the foot. An alternative in the infant, with a Cincinnati incision, is to allow the posterior part of the incision to close by secondary intention.

Nonunion of osteotomies is probably common and may be minimally symptomatic and not constitute a clinical or functional problem. A painful nonunion, or one with recurrent collapse or deformity, can be treated by revision, bone grafting, and internal fixation.

Infection is often associated with poor circulation to skin incision edges and can be prevented by careful attention to detail in postoperative casting and manipulation. Treatment of established infection follows standard principles of drainage or debridement, antibiotic treatment, and wound management.

## KNOWLEDGE GAPS

Despite the high prevalence of clubfoot and its substantial importance to patients with the condition, there remain substantial gaps in knowledge regarding the optimal management. The orthopaedic literature concentrates on a plantigrade, stable, painfree foot as a goal of care and, in general, this is a suitable clinical objective. Important questions to be answered include:

1. What is the best way of delivering manipulation and casting to a newborn or young population?
2. What is the best strategy for bracing to prevent recurrence after manipulation and casting?
3. What are the functional outcomes and longterm implications of various clubfoot treatments?
4. Can Ilizarov frame type treatment of clubfeet be adapted for African settings?
5. What are the best treatment strategies for different types of neglected clubfeet?
6. How does corrected clubfoot anatomy relate to foot function in the community?

Visited on 09/18/2018

## RESOURCES

Among the references listed, the reader is directed in particular toward the Global-HELP materials on clubfoot available for free download at <http://www.global-help.org/> which include guides for clinicians on Ponseti casting and, as well as information for parents . Details of operative management most relevant to the African setting are found in Norgrove Penny's 2005 article from Techniques in Orthopaedics, which is available online at the U of T library for Ptolemy users.

Francis Nyiiro, MD, CURE Hospital, Addis Ababa, Ethiopia



Figure 1b – A triple arthrodesis being performed through a lateral Ollier incision. The osteotome is revising the cuts from the subtalar joint to correct heel varus. Forefoot adduction and cavus have been corrected by resecting the calcaneocuboid and talonavicular joints.



## Visited on 09/18/2018

Figure 1c – The foot, healed after a triple arthrodesis and plantigrade in an AFO. The patient walks on the sole of the foot and the dorsolateral skin callus is resolved.



Figure 1a: A neglected clubfoot in a teenager. Note the large, fissured dorsolateral callus which is where the patient bears weight. This foot is moderately flexible and has had no prior treatment. It is shown in the maximum position to which it can be corrected prior to surgery.

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