SOCIEDADE BRASILEIRA DE ORTOPEDIA E TRAUMATOLOGIA

RBO REVISTA BRASILEIRA DE ORTOPEDIA

www.rbo.org.br

Update Article

Surgical treatment of neglected clubfoot using external fixator☆

Rodrigo Mota Pacheco Fernandes[a,*], *Maurilio Darcy dos Santos Mendes*[a], *Renato Amorim*[b], *Marcus Aurélio Preti*[c], *Marcelo Back Sternick*[d], *Guilherme Pelosini Gaiarsa*[e]

[a] *Hospital Estadual da Criança, Rio de Janeiro, RJ, Brazil*
[b] *Universidade Federal de Santa Catarina (UFSC), Departamento de Ortopedia, Florianópolis, SC, Brazil*
[c] *Hospital de Urgência e Emergência Metropolitano de Ananindeua, Ananindeua, PA, Brazil*
[d] *Hospital Felício Rocho, Belo Horizonte, MG, Brazil*
[e] *Universidade de São Paulo, Faculdade de Medicina, Hospital das Clínicas, Instituto de Ortopedia e Traumatologia, São Paulo, SP, Brazil*

ARTICLE INFO

Article history:
Received 6 October 2015
Accepted 8 October 2015
Available online 9 August 2016

Keywords:
Clubfoot
Congenital abnormalities
External fixators
Surgical procedures, operative
External fixation

ABSTRACT

The definition of neglected clubfoot (NC) includes a variable range of complex deformities of the foot that are refractory to conventional treatments or are treated inappropriately. Several etiologies may be related to this. The Ilizarov method has become established as a tool for treating these deformities. It minimizes soft-tissue damage through gradual correction of the deformity, with a high success rate in relation to achieving a plantigrade foot, with low incidence of recurrence. The indications for treatment include severe rigid deformities (Dimeglio III and IV), or adverse skin conditions. Careful clinical and radiological examination is fundamental for proper planning and installation of the external fixator. The techniques used include selection of external fixation assemblies, which can be closed when there is a connection between the leg, hindfoot and forefoot. This closed assembly may or may not be constricted, according to whether hinges are provided or whether use of the natural anatomical hinges during correction of the deformity is envisaged. An open assembly makes it possible to add flexibility to the foot through histogenesis, while allowing closed corrections of greater precision later on. Hexapod fixators are an innovation with high potential for accuracy in correcting deformities. Procedures associated with external fixation include soft-tissue release and bone procedures. These procedures enable corrections that are more anatomical, for different degrees of severity and stiffness of deformity. It can be concluded from analyzing this case series that treatment of neglected clubfoot using an external fixator has a high rate of good and excellent results, with low frequency of complications.

☆ Study conducted by the Sociedade Brasileira de Ortopedia e Traumatologia (SBOT), Comitê ASAMI – Fixadores Externos, São Paulo, SP, Brazil.

* *Corresponding author.*
E-mail: rodrigouff@gmail.com (R.M. Fernandes).

http://dx.doi.org/10.1016/j.rboe.2016.08.002

Tratamento cirúrgico do pé torto inveterado com fixador externo

Palavras-chave:
Pé torto
Anormalidades congênitas
Fixadores externos
Procedimentos cirúrgicos operatórios
Fixação externa

RESUMO

O pé torto inveterado (PTI) inclui em sua definição uma gama variável de deformidades complexas do pé refratário a tratamentos convencionais ou tratados de forma inadequada. Diversas etiologias podem estar relacionadas. O método de Ilizarov é consagrado como uma ferramenta de tratamento dessas deformidades, minimiza danos a partes moles, através de correção gradual da deformidade, com alto índice de sucesso em relação à obtenção de um pé plantígrado com incidência baixa de recidiva. As indicações do tratamento incluem deformidades graves e rígidas (Dimeglio III e IV) ou em condições de pele desfavoraveis. O exame clínico e radiológico criterioso é fundamental para um planejamento adequado e a montagem do fixador externo. As técnicas empregadas incluem a seleção das montagens do fixador externo, que pode ser fechada, quando há conexão entre perna, retro e antepé. Essa montagem fechada pode ser constrita ou não, quando se oferecem as dobradiças ou quando se espera usar dobradiças anatômicas naturais durante a correção da deformidade. A montagem aberta permite flexibilizar o pé através da histogênese, permite correções fechadas mais precisas posteriormente. Os fixadores hexapodais representam inovações com alto potencial de precisão na correção de deformidades. Os procedimentos associados à fixação externa incluem as liberações miotendíneas e os procedimentos ósseos. Esses procedimentos permitem correções mais anatômicas para graus diferentes de gravidade e rigidez de deformidade. Conclui-se, na análise das séries de casos, que o tratamento do pé torto inveterado com fixador externo apresenta um alto índice de bons e excelentes resultados, com baixa frequência de complicações.

Introduction

Neglected clubfoot (NC) can be interpreted in several ways. The English terms that define this condition (neglected, resistant, or relapsed clubfoot) include the likely related situations of no treatment; inadequate, insufficient, or discontinued treatment; resistant cases (most often syndromic or teratologic); or relapsed and refractory to traditional treatments, whether conservative or surgical.[1–3]

NC is a common problem in developing or underdeveloped countries. Approximately 80% of children with congenital clubfoot (CCF) are born in developing countries, many of those with limited and/or late access to the healthcare system and trained specialists for treatment.[1,3,4]

Treatment with external fixators is presented as an established option in several case series. The main advantages relate to the high success rate in detriment to the common complications in the treatment of these feet in sharp corrections. The most common complications are related to soft tissue, vascular and surgical wounds, and recurrence, as well as those that arise from the use of open techniques (arthrodesis and bone resections) in skeletally immature patients. This study presents the indications, technical variations, and innovations, through a review of case series.[2,3,5,6]

Indications

There is no consensus on when to consider a clubfoot as neglected, or not eligible for conservative treatments.[1,2] The criteria for indicating treatment with external fixation include adult patients or children older than 5 years, those with non-reducible feet after manipulation and serial casting, those who underwent over three unsuccessful surgical treatments, syndromic cases (arthrogryposis, sequelae from neuromuscular diseases, Freeman–Sheldon syndrome, Streeter syndrome, Marfan syndrome), patients who underwent complicated open surgical treatments with soft tissue necrosis, and recurrence.[2,3,5] However, some of these criteria are questionable and subjective, particularly those related to age, number of surgeries, and etiologies. Another selection criterion for treatment is the classification proposed by Dimeglio et al., in which those classified as grade III and IV would be eligible for treatment (Fig. 1).[6,7]

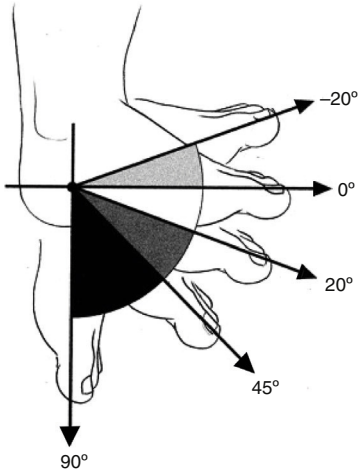
The indicated etiologies include sequelae (contractures) from burns, polio, refractory clubfoot (whether idiopathic or untreated), trauma sequelae, central or peripheral neurological damage sequelae, meningitis sequelae, and lower limb length discrepancy sequelae.[2,3,5,8]

Anatomopathology

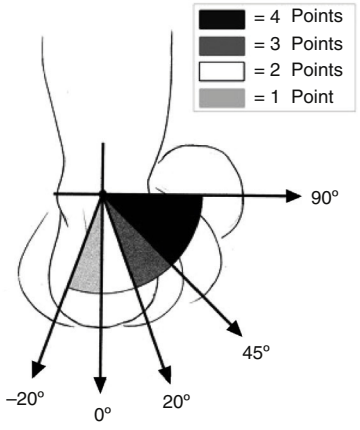
In NC, the anatomical deformities do not necessarily conform to those described in CCF, given that this entity covers a range of conditions (added for clarity) from classic CCF deformities to post-traumatic deformities and under- or overcorrections from previous treatments. Thus, a careful analysis of the deformities and joint mobility, from the clinical and radiological standpoint, is necessary for proper three-dimensional understanding of the deformity and subsequent preoperative

Classification

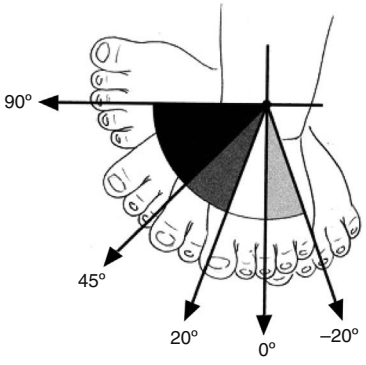
Grade	Type	Frequency, %	Score
I	Benign	20	(<5)
II	Moderate	23	(=5<10)
III	Severe	35	(=10<15)
IV	Very severe	12	(=15<20)



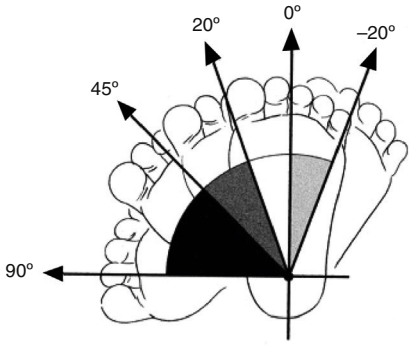
Equinus assessment in the sagittal plane



Varus assessment in the frontal plane



Derotation assessment of the calcaneal-foot block in the horizontal plane



Forefoot assessment in relation to the hindfoot in the horizontal plane

Congenital clubfoot assessment according to the severity scale

Features: Reproducibility	Points	Features: Other parameters	Points
90°–45°	4	Posterior fold	1
45°–20°	3	Medial fold	1
20°–0°	2	Cavus	1
<0° to –20°	1	Poor muscle condition	1

Fig. 1 – Dimeglio classification (Source: Tripathy et al.[12]).

planning. The classic anatomical alterations of CCF include bone, joint, and ligament deformities. The talus presents in equinus, with a reduced declination angle, as well as plantar and medial deviation of its neck. The cuboid, calcaneus, and navicular are diverted plantar and medially. The calcaneus presents in equinus and varus, among other factors, due to the contracture and more medial insertion of the sural triceps, and does not show significant changes in its anatomy. Medial joint contractures and shortening of the deltoid, tibionavicular, and plantar calcaneonavicular ligaments

are also observed. The shortening of the posterior tibial, flexor hallucis longus, and flexor digitorum longus tendons, as well as of the abductor muscles of the hallux and plantar fascia, is an important aspect of the pathological anatomy of clubfoot, aiding in the understanding of this deformity and its treatment.[1–3,9]

Clinical and radiographic examination

At clinical examination of the NC, the deformities and range of motion in degrees should be recorded. The main deformities and hinge insertion points should be determined. It is important to evaluate limb length discrepancy and associated rotational or angular deformities.[1,2]

Radiographic examination includes anteroposterior (AP) projections of the foot and profiles with and without load. Thus, osteo-articular deformities can be assessed and the important angles in operative planning, the apexes of the deformities, can be determined; furthermore, the flexibility can be analyzed and documented by comparing the tests with and without load. The radiological parameters most commonly used in this evaluation are the talocalcaneal angle in AP and lateral views (added for clarity) (Kite), talo-first metatarsal angle in AP, talo-first metatarsal angle in profile (Meary-Tomeno), and calcaneal pitch angle.[4,5,9] Fridman and Sodré[10] draw attention to the talonavicular joint in AP as a statistically significant predictor of good outcome in the postoperative analysis of flat foot correction. Multiplanar deformity often hinders a precise radiological evaluation of many of these deformities, requiring subsequent assessments during gradual correction. Other examinations, such as computed tomography or magnetic resonance imaging, may be useful in the diagnosis of ankylosis, coalitions, and structural deformities of the tarsal elements.[2,11]

Surgical technique

The surgical techniques related to the correction of NC with a circular external fixator can be divided into two sub-categories: mountings, through which gradual distraction histogenesis is performed, and associated procedures (osteotomies and soft tissue procedures).

Mounts

The Ilizarov external fixator allows for a wide range of mountings and techniques. All proposed mountings are formed by modules or blocks that serve as parts of the external fixator. The modules are the leg and foot. The latter can be divided into separate modules for hindfoot, midfoot, and forefoot. The first important point is the definition of correction points by identifying the apexes of the deformities, to determine how the modules will interact in deformity correction. The system can be set up and established strictly for these correction points or in a freer manner. Therefore, the mountings can be classified as open or closed; the latter can be subdivided into constrained or unconstrained (Fig. 2).[2,3,5,8]

Open mounting

In this mounting, the leg module is positioned as a fixed element, exercising independent distraction on the modules on the hindfoot and on the forefoot, which are not connected. In this open system, distraction works to "open" or "expand" the foot, acting on soft tissue or osteotomies made in the calcaneus, midfoot, and ankle. As this technique does not to determine the correction points, corrections may be made on points that are not necessarily suitable. This technique is correctly used in cases where the goal is not to achieve an anatomical correction of the deformity, but rather to obtain a plantigrade foot, even with functional impairment of the joint. It is also adopted in cases with serious and multiplanar deformities, which, after partial correction through an open technique, may be converted into a closed mount, with better-defined apices. Since this is a less stable mounting, it is adequate for NC corrections in patients with sensitivity disorders, such as those with myelomeningocele sequelae (Fig. 3).[2,5]

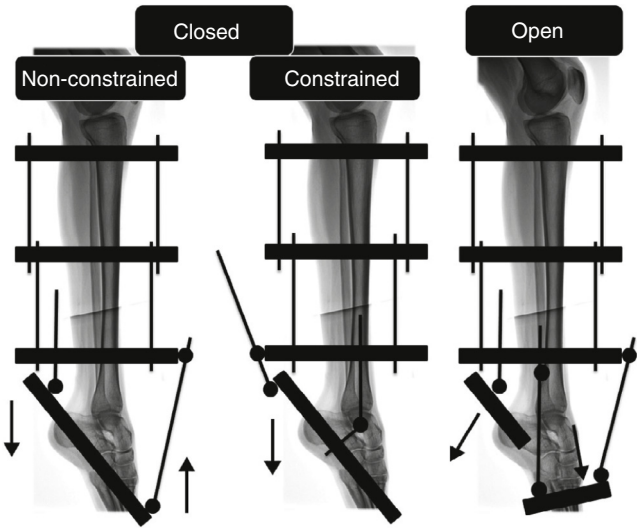


Fig. 2 – Mounting types.

Non-constrained closed mounting

In this mounting, the modules of the hindfoot and forefoot are connected. The correction between the components is performed by "motors" (threaded bars that exert gradual distraction between the modules). However, the exact hinge point (apex of the deformity) is not defined. The correction is made through probable natural hinges. For example, the correction of the deformity in equinus is made by further distraction between the leg module and hindfoot module, without defining the hinge in the ankle joint. This type of mount leads to a high risk of non-anatomical corrections. In the aforementioned example regarding equinus, this mounting allow for corrections that can lead to talus subluxation or improper equinus correction in the midfoot, which creates a rocker-bottom deformity (Fig. 4).[2,5]

Constrained closed mounting

In this mounting, the correction points are defined by the apexes of the deformities. The hinges are carefully positioned, seeking an anatomical correction. This mounting is more complex than those previously mentioned, but presents better prognosis with regard to function, as the surgeon can set

Fig. 3 – Correction with open system – pre- and post-correction and conversion to closed system.

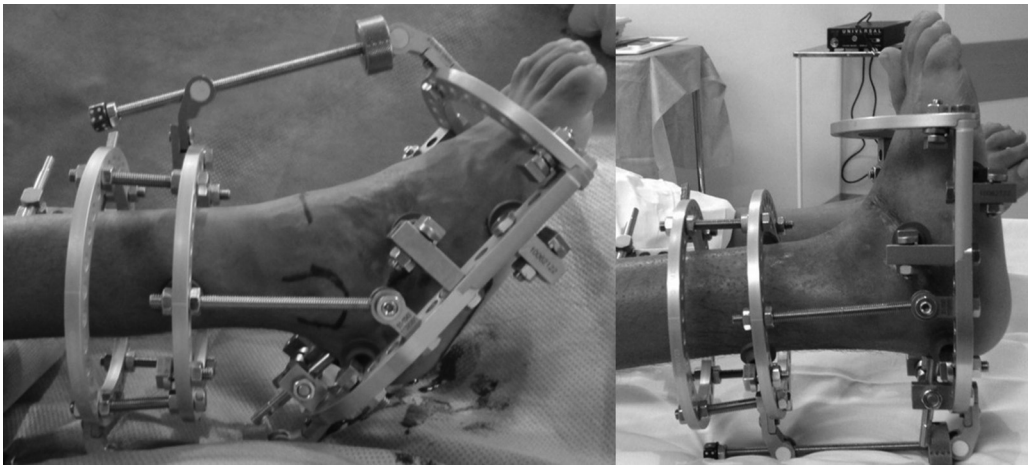


Fig. 4 – Mounting with non-constrained closed system.

Fig. 5 – Correction of equinus deformity with closed system.

Fig. 6 – Correction of deformity with hinges positioned on the ankle and midfoot, with midtarsal navicular-cuboid osteotomy.

mountings that lead to corrections, prevent subluxations, and promote associated arthrodiastasis (Figs. 5 and 6).[2,3,5]

Software-guided fixators (hexapodal)

The software-guided fixators offer great precision in correcting deformities; they can be classified as a non-constrained closed system, in which the correction is made by six bars (hexapodal) that have a great potential to correct complex deformities.[2]

Techniques and associated procedures

Distraction histogenesis. Distraction can be conducted at several points simultaneously. Again, it is necessary to list priorities, the severity of the deformity, and type of mounting. The pace and frequency of distraction processes are classically described as 0.25 mm every six hours.[2,3,5] However, in angular corrections, it is important to note the distance between the hinge, the elements upon which distraction should be performed (*e.g.*, the focus of osteotomy), and possible structures at risk due to the distraction (such as the skin or the tibial nerve in equinovarus corrections).[5] Frequency is important to minimize the damage created by the distraction and prevent soft tissue injuries.[2–5,8] Tripathy et al.[12] presented a series of 15 cases in which the correction of NC was made according to the deformity correction sequence, following the principles established by Ponseti for the treatment of CCF. The deformities were corrected in the following sequence: cavus, adductus, varus, and equinus. Despite the small sample size, these authors observed good clinical and functional results, with a reduction of 11.7 in the Dimeglio score and final Laaveg and Ponseti score of 75.47 (Figs. 7 and 8).

Tenotomies and myotendinous release

The best moment to perform a myotendinous release is controversial in the literature. The severity of the deformity and the degree of rigidity appear to be fundamental elements for its indication. However, the limits of severity and rigidity that guide closed arthrodiastasis, the association with tenotomies, and the use of osteotomies are still subjects of discussion.[2,3,5,8] In skeletally immature patients, up to 10 or 12 years, there are advantages to this approach, which minimizes damage related to the development and growth of the bones of the tarsus and metatarsus.[5,13] The soft tissue procedures on feet with severe deformities (Dimeglio III and IV) and in recurrent cases after previous treatments, associated with neurological injuries or neuromuscular diseases and arthrogryposis, appear to have better results, with less overload on the system or even lower incidence of complications, residual deformities, and relapses, in addition to the reduced correction time when compared with the closed treatment.[2,5,7,8] Myotendinous releases are indicated as needed, according to what is perceived upon physical examination. The indications typically include Achilles tenotomy, which can be open or percutaneous (Hoke or White techniques), and plantar fasciotomy. Other tenotomies include tenotomy of the flexor hallucis longus, fingers, and posterior tibial, which can likewise be performed using percutaneous or minimally invasive, complete, or Z-shaped techniques. The percutaneous tenotomy of the flexors of the fingers and hallux is usually made through the interphalangeal joint of the fingers, with a No. 15 scalpel blade.[2–5,7,8,14,15]

Tendon transfers are used to etiologically analyze deformities, as well as arthrodesis, when a muscular imbalance that can lead to a relapse after the removal of the external fixator is observed.[2,5]

Dermal and subcutaneous retractions can be addressed in advance with skin expanders or, during surgery, with zetaplasty, and are subjected to further histogenesis with an external fixator in the same manner as other tissues.[5]

Bone procedures and osteotomy

Foot osteotomies are mainly indicated in skeletally mature patients (over 10–12 years) with severe deformities (Dimeglio III and IV), and extremely rigid feet.[5,13]

Osteotomies can be classified as (1) calcaneal (of the posterior tuberosity or below the subtalar joint); (2) talo-calcaneal (anterior talo-calcaneal, V-shaped, Y-shaped, or dome-shaped); (3) midfoot (navicular-cuboid or cuboid-cuneiform); and (4) forefoot (metatarsal or phalangeal). The related osteotomies combinations are listed. They can be percutaneous (with pre-burring or with a Gigli saw) or open (Fig. 6).[2,4,5,8,14,16]

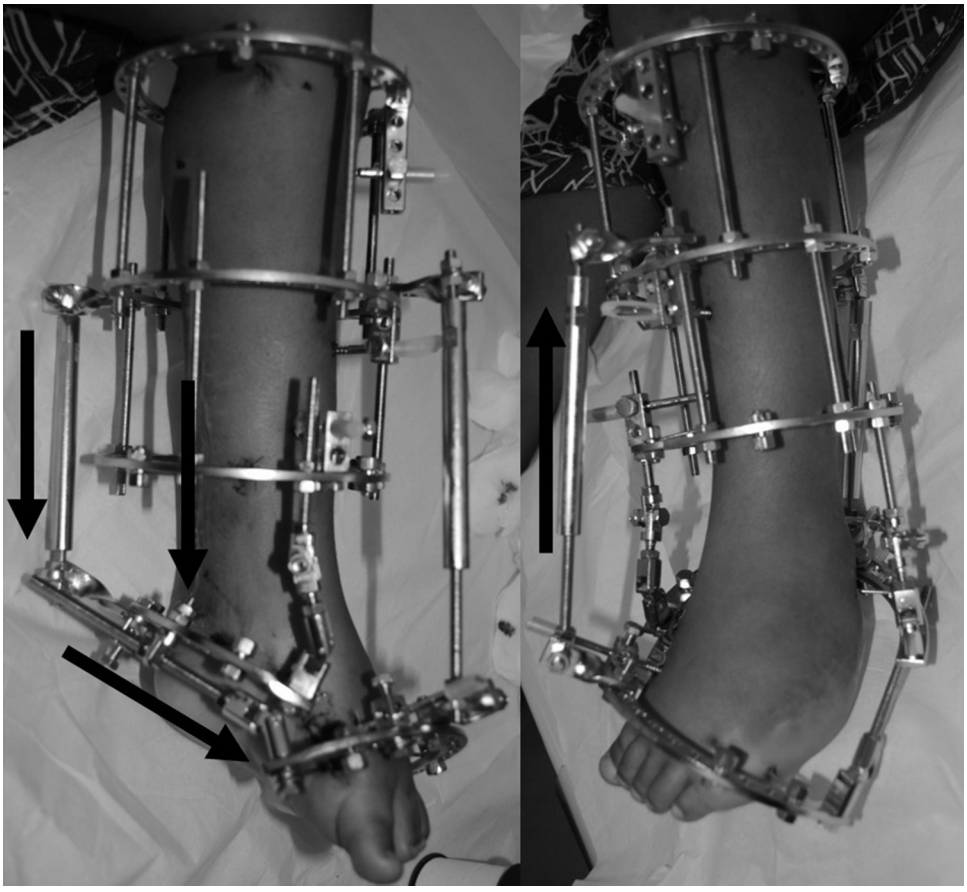


Fig. 7 – Simultaneous correction of deformities (varus, adductus, supination, and equinus).

Arthrodesis, whether or not associated with wedge resections, and even bone resection, such as the frequently used cuboidectomy and talectomy, are increasingly restricted associated procedures when opting for treatments with an external fixator. These procedures are presented as options to treatment with external fixation.[2,5] Cuboidectomy associated with soft tissue procedures presented good results in the series published by Faldini et al.[17]

Other associated osseous procedures that can and should be indirectly considered in relation to foot deformity correction and maintenance are limb length discrepancy correction through bone lengthening (connected directly to the recurrence of equinus) and derotational osteotomy.[3–5,8]

Postoperative period and complications

A plaster cast immobilization is used for six weeks, followed by orthosis for three to six months.[15,18]

The time of external fixator use, considering these series, ranged from two to 14 months, with means ranging between five and nine months.[3,4,8,15,16,18] Refai et al.[11] presented a series of 19 cases of legs treated with Ilizarov fixator, used for five weeks, and subsequent use of cast immobilization, including midfoot wires during the consolidation phase. The authors reported good results in 16 cases, with a low rate of complications and relapses.[11]

The described complications are infection in pin pathway, surgical wound complications, digit contractures and deformities (claw), distal tibia fracture, vascular complications, metatarsophalangeal subluxation, premature consolidation of osteotomies, spontaneous ankylosis, symptomatic arthrosis, rigidity, recurrence, and residual deformity.[15]

The rate of positive results (excellent or good) observed in the comparison between the pre- and post-operative Dimeglio scores is 88%, according to El-Sayed.[6] Makhdoom et al.[18] observed good results in 74% of patients, using the scale proposed by Renkerand and Carpenter (apud Makhdoom et al.[18]). Refai et al.,[11] using the AOFAS score as a reference, identified 84% good results. Good results were also observed by Ahmed et al.[14] (72%), Franke et al.[13] (100%), Devadoss et al.[7] (72%), Kocaöglu et al.[8] (90%), de la Huerta[4] (100%), and Ferreira et al.[15] (78.9%). Although the number of good results were high, the diversity of cases and lack of prospective protocols limits the comparison among the series, as well as prospective evaluation with better statistical value and consequent significance.[19] The scores proposed and used are also quite varied in the literature. Saghieh et al. emphasized this limitation and suggested the use of the International Clubfoot Study Group scoring system (ICFSG) as a proposal for prospective evaluation.[19]

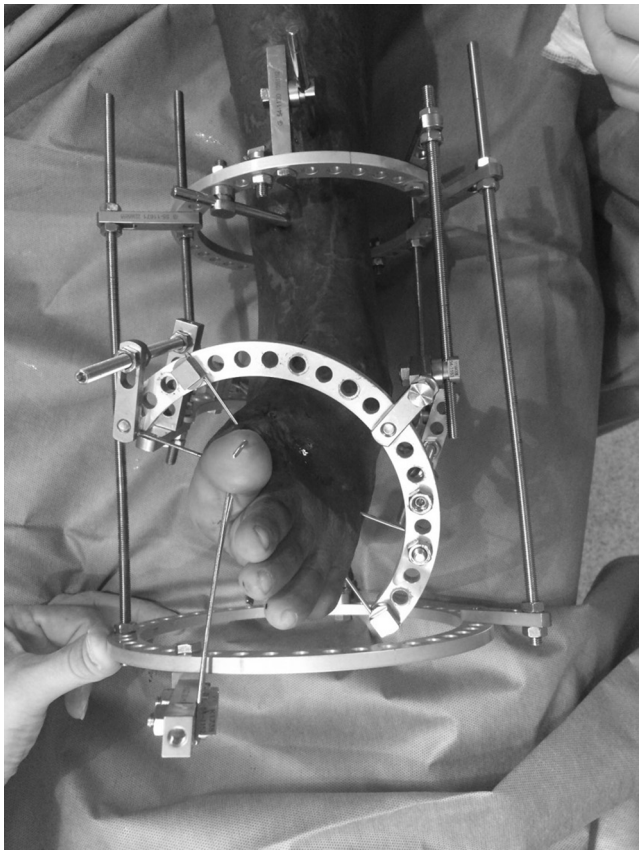


Fig. 8 – Complex foot deformity. Sequelae from compartmental syndrome.

Conflicts of interest

The authors declare no conflicts of interest.

REFERENCES

1. Penny JN. The neglected clubfoot. Techn Orthop. 2005;20(2):153–66.
2. Ganger R, Radler C, Handlbauer A, Grill F. External fixation in clubfoot treatment – a review of the literature. J Pediatr Orthop B. 2012;21(1):52–8.
3. Ferreira RC, Stefani KC, Fonseca Filho FF, Santin RA. Correção do pé torto congênito inveterado e recidivado pelo método de Ilizarov. Rev Bras Ortop. 1999;34(9/10):505–12.
4. de la Huerta F. Correction of the neglected clubfoot by the Ilizarov method. Clin Orthop Relat Res. 1994;(301):89–93.
5. Kirienko A, Villa A, Calhoun JH. Ilizarov technique for complex foot and ankle deformities. Philadelphia, PA: Taylor & Francis; 2004.
6. El-Sayed M. Ilizarov external fixation for management of severe relapsed clubfeet in older children. Foot Ankle Surg. 2013;19(3):177–81.
7. Devadoss A, Devadoss S, Kapoor A. Differential distraction for relapsed clubfoot deformity in children. J Orthop Surg (Hong Kong). 2010;18(3):342–5.
8. Kocaoğlu M, Eralp L, Atalar AC, Bilen FE. Correction of complex foot deformities using the Ilizarov external fixator. J Foot Ankle Surg. 2002;41(1):30–9.
9. Santin RAL, Hungria Filho JS. Pé torto congênito. Rev Bras Ortop. 1977;12(1):1–15.
10. Fridman MW, Sodré H. Estudo radiográfico da região mediotársica e sua relação com a avaliação funcional do pé torto congênito idiopático tratado cirurgicamente. Rev Bras Ortop. 2002;37(1/2):13–22.
11. Refai MA, Song SH, Song HR. Does short-term application of an Ilizarov frame with transfixion pins correct relapsed clubfoot in children? Clin Orthop Relat Res. 2012;470(7):1992–9.
12. Tripathy SK, Saini R, Sudes P, Dhillon MS, Gill SS, Sen RK, et al. Application of the Ponseti principle for deformity correction in neglected and relapsed clubfoot using the Ilizarov fixator. J Pediatr Orthop B. 2011;20(1):26–32.
13. Franke J, Grill F, Hein G, Simon M. Correction of clubfoot relapse using Ilizarov's apparatus in children 8-15 years old. Arch Orthop Trauma Surg. 1990;110(1):33–7.
14. Ahmed AA. The use of the Ilizarov method in management of relapsed club foot. Orthopedics. 2010;33(12):881.
15. Ferreira RC, Costo MT, Frizzo GG, da Fonseca Filho FF. Correction of neglected clubfoot using the Ilizarov external fixator. Foot Ankle Int. 2006;27(4):266–73.
16. El-Mowafi H. Assessment of percutaneous V osteotomy of the calcaneus with Ilizarov application for correction of complex foot deformities. Acta Orthop Belg. 2004;70(6):586–90.
17. Faldini C, Traina F, Di Martino A, Nanni M, Acri F. Can selective soft tissue release and cuboid osteotomy correct neglected clubfoot? Clin Orthop Relat Res. 2013;471(8):2658–65.
18. Makhdoom A, Qureshi PA, Jokhio MF, Siddiqui KA. Resistant clubfoot deformities managed by Ilizarov distraction histogenesis. Indian J Orthop. 2012;46(3):326–32.
19. Saghieh S, Bashoura A, Berjawi G, Afeiche N, Elkattah R. The correction of the relapsed club foot by closed distraction. Strategies Trauma Limb Reconstr. 2010;5(3):127–35.