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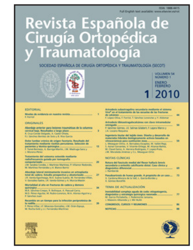

ORIGINAL ARTICLE

Varus deformity of the ankle in a child: correction using external fixation

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KEYWORDS
Ankle varus;
Angular deformity;
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Abstract
Introduction and objective: Varus deformity of the ankle during infancy is a not uncommon after effect after epiphysiolysis of the distal tibial or an infection in this area during childhood. The authors review the cases treated using external fixation.
Material and methods: A retrospective review was made of 14 cases of varus ankle clinically and radiologically studied using lower limb antero-posterior teleradiography in the standing position and treated using monolateral external fixation. The cause of the deformity, its magnitude, procedure employed, complications, and premature physeal closure after treatment.
Results: All cases of varus ankle were retrospectively reviewed, with the most frequent cause of the deformity in ankle varus during infancy being epiphysiolysis of the middle portion of the distal tibia (SH II, III or IV lesions), distal tibia infection or sepsis. There were two cases of epiphysiolysis type II, three of type III, and three of type IV. The methods of correction employed were, physeal distraction when the physis was open in four cases, and distal metaphyseal osteotomy and subsequent callus distraction in eight cases. In two cases correction was performed acutely combining another treatment method to correct a concomitant discrepancy. The callotasis was performed on all of them using fibular osteotomy, fixing it with a Kirschner wire, except in three cases. The most frequent complications were infections around the screws and ad-latum displacement.
Discussion and conclusions: Good results have been obtained in this series of varus deformity of the ankle in the child by means of physeal distraction, osteotomy and callotasis. Physeal distraction before reaching skeletal maturity may be the method of choice. If it is performed earlier the premature closure of the rest of the fertile physis is likely. If the treatment is hemicallotasis, besides the fibular osteotomy, intramedullary fixation with a Kirschner wire is also recommended.

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PALABRAS CLAVE
Tobillo varo;
Deformidad angular;
Fijación externa

Deformidad en varo del tobillo del niño: corrección mediante fijación externa

Resumen
Introducción y objetivo: La deformidad en varo del tobillo durante la infancia es una secuela no infrecuente tras una epifisiolisis de tibia distal o una infección de esta zona durante la infancia. Los autores revisan los casos tratados mediante fijación externa.
Material y métodos: Se revisaron de forma retrospectiva 14 casos de tobillo varo estudiados clínica y radiológicamente mediante telerradiografía anteroposterior de EEII en bipedestación y tratados mediante fijación externa monolateral. Se analizó la causa de la deformidad, su magnitud, procedimiento empleado, complicaciones y cierre precoz de fisis tras el tratamiento.
Resultados: Se revisaron retrospectivamente todos los casos de tobillo varo, siendo las causas más frecuentes de deformidad en varo del tobillo durante la infancia: las epifisiolisis de la porción medial de la tibia distal (lesiones SH II, III o IV), infección de tibia distal y sepsis. Hubo dos casos de epifisiolisis tipo II, tres de tipo III y tres de tipo IV. Los métodos de corrección empleados fueron en cuatro casos la distracción fisaria cuando había fisis abierta o la osteotomía metafisaria distal y callotasis posterior en ocho casos. En dos se realizó la corrección de forma aguda asociando otro método de tratamiento para corregir una discrepancia concomitante. En todas las callotasis se realizó osteotomía del peroné, fijándolo con aguja de Kirschner excepto en tres casos. Las complicaciones más frecuentes fueron infecciones alrededor de los tornillos y desplazamiento *ad-latum.*
Discusión y conclusiones: En esta serie se han obtenido buenos resultados en el tratamiento de la deformidad en varo del tobillo del niño mediante la condrodiastasis, la osteotomía y la callotasis. La distracción fisaria antes de alcanzar la madurez esquelética puede ser el método de elección. Si se realiza precozmente es presumible el cierre precoz del resto de fisis fértil. Si el tratamiento es hemicallotasis es recomendable además de la osteotomía del peroné su fijación intramedular con aguja de Kirschner.

Introduction

Varus deformity in the ankle during childhood is not uncommon after physeal fractures or generalised sepsis that originate a bone bridge in the growth plate cartilage of the distal tibia causing progressive angulation during the remaining growth period until the individual reaches bone maturity.[1] These angulations cause a biochemical imbalance, creating an overload in the middle portion of the joint and cause the appearance of degenerative joint phenomena accompanied by pain.[2,3] In childhood the decision to realign the joint is taken to prevent degenerative phenomena, before pain is the main symptom.

There are currently many different techniques described to treat these deformities, such as open or arthroscopic epiphysiodesis, percutaneous osteotomy, physeal distraction, osteotomy and callotasis, among others. All these techniques use different posterior osteosynthesis materials such as cannulated screws, Kirschner wire, plates or external fixation devices.[4-6]

Radiological analysis of the deformity indicates where to carry out the osteotomy (generally near the physis) to correct it. Those recommended are open surgery increment and synthesis with a screwed on plate or external fixation devices.

External fixation is a useful tool in treating angular deformities in the long bones. They allow external control of the osteotomy to be maintained until bone consolidation is achieved, acting in the area of deformity and achieving lengthening and adjustment of angular correction during treatment. The most commonly-used procedures are: asymmetric physeal distraction, when we act on a growth cartilage level. This procedure is indicated in cases of angular deformities in patients nearing skeletal maturity, or asymmetric callotasis, when a metaphyseal osteotomy is carried out together with acute or gradual correction, applicable to varus deformities of the ankle in patients who have reached skeletal maturity.[7-9]

The aim of this study was to undertake a review of our clinical experience in varus deformities of the ankle in children treated with external fixation.

Material and methods

A retrospective study was carried out on 12 patients (2 had bilateral affectation), 6 males and 6 females, with a mean age of 11.2 years (range: 9-16 years) at the time of surgical intervention.

In the majority of cases studied with varus deformity (greater than 10º), the x-rays showed that there was a bone bridge in the distal tibial physis. In one case, the deformity was caused by an improper union through secondary displacement of an open fracture of the distal metaphyseal tibia (table 1).

Table 1 Study case data

Case	Age (years)	Gender	Side	Aetiology	Deformity in the varus and apex	Dysmetria (cm)	Physeal bridge subtotal
1	9	F	R	Septic arthritis	12º physis	0	40%
	10	F	L	Septic arthritis	22º physis	0	50%
2	12	M	R	Traumatic	26º physis	2.5	50%
3	11	M	R	Septic arthritis	25º- physis	5	70%
4	14	F	R	Traumatic	24º metaphysis	3	0
5	14	F	L	Meningococcal Sepsis	14º physis	0	100%
	14	F	R	Meningococcal Sepsis	28º metaphysis	5.5	100%
6	14	M	L	Traumatic	23º physis	0	35%
7	15	F	R	Traumatic	12º varus distal tibial physis + proximal tibia recurvatum	4	30%
8	12	M	L	Traumatic	16º physis	0	10%
9	15	M	L	Osteomyelitis	30º metaphysis	5 (tibia)	100%
10	16	M	L	Traumatic	15º physis	2	20%
11	12	F	L	Traumatic	20º physis	1	35%
12	12	F	R	Traumatic	15º physis	1	20%

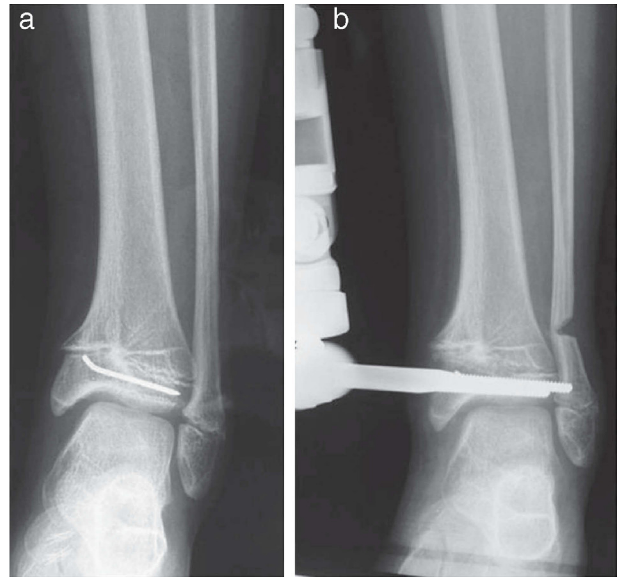

Figure 1 a) 12-year-old female who had a SH type IV epiphysiolysis at the age of 10 years old. We see a 35%physeal bridge in the central area of the ankle. b) Asymmetric distraction of the physis and wedge subtraction osteotomy of the fibula.

Patients were radiologically studied using antero-posterior teleradiography of the lower limbs in the standing position with a 5º internal rotation of the ankle to observe the tibio-fibular-talar mortise in its entirety and avoid pre- and postoperative false negatives as to skeletal maturity.[10] In addition, the size of the physeal bridge was measured in the teleradiography.

Clinically we assessed pain, aetiology and degree of deformity, as well as the range of pre- and postoperative mobility.

In the 14 cases studied, 12 cases were treated with an Orthofix monolateral external fixation. The remaining two had open osteotomy and synthesis with Kirschner wire.

Patients with limb shortening associated to the deformity had bone elongation procedures to compensate for limb length at the same time as the osteotomy or by a second proximal osteotomy as well as correction.

With regards to cases treated with external fixation (12 cases), these had an osteotomy and an acute correction of the deformity in 3 cases, osteotomy and gradual correction (hemicallotasis) in 5 cases and gradual correction at growth cartilage level (hemicondrodiatasis) in the remaining 4 (fig. 1).

A wedge subtraction osteotomy of the fibula associated to the previous techniques was carried out on the entire study group (except for one case) to adapt to the gradual correction of the varus, avoiding the impingement of the external aspect of the tibio-fibular-talar mortise. Fibular intramedullary fixation with Kirschner wire was undertaken in 4 cases to prevent *ad-latum* deformity during the correction observed in the first cases treated just with osteotomy.

The trigonometry ratio to calculate the necessary lengthening for angular correction used was tg α = opposite

Table 2 Surgical procedures and results of each case

Case	E.F.[a]	Treatment	C.I[b]	Complications	CAC[c]	Sequelae
1	Orthofix	Asymmetric distraction of the callus	3	*Ad-latum*	Yes	No
	Orthofix	Asymmetric distraction of the callus	3	No	Yes	No
2	Orthofix	Increase osteotomy followed by tibial callotasis(4cm)	–	No	Yes	No
3	Orthofix	Physeal bridge osteotomy and gradual correction Asymmetric distraction of the proximal tibial physis	2.5	No	Yes	No
4	Orthofix	Acute corrective osteotomy and gradual tibial callotasis	5	No	Yes	No
5	Orthofix	Asymmetric distraction of the callus	4	*Ad-latum* tibia	Yes	No
	Orthofix	Acute corrective osteotomy and gradual tibial callotasis	8	Post-trauma break of the fixation screw	Yes	No
6	Orthofix	Asymmetric distraction of the callus	3.5	*Ad-latum* 1 cm	Yes	No
7	Orthofix	Acute corrective osteotomy of the recurvatum	4	No	Yes	Dysmetria
4 cm						
8	Orthofix	Asymmetric distraction of the physis	3	No	Yes	Dysmetria 1.5 cm
9	Ilizarov	Acute corrective osteotomy and proximal tibial lengthening with Ilizarov	–	No	Yes	Dysmetria
1 cm						
10	Orthofix	Asymmetric distraction of the callus and tibial lengthening at the same time	4	No	Yes	No
11	Orthofix	Asymmetric distraction of the physis	3	No	Yes	Dysmetria
1 cm						
12	Orthofix	Asymmetric distraction of the physis	3	Discharge screws	Yes	Dysmetria 0.5 cm

[a] External fixator.
[b] "Modified" cure index (number of external fixation days/degree of correction).
[c] Complete angular correction.

leg/adjacent leg, where α is the deformity angle (its value was obtained on a scientific calculator), adjacent leg was given by the screw length and opposite leg was the magnitude of elongation. This way we know how many mm have to be lengthened in the external fixator. However, we also have to take into account that the bone should not be lengthened more than 1mm per day; for this reason, the same formula was applied although on this occasion the fixed leg was the metaphyseal tibia width.

Finally if the mm the fixator must be diverted are divided by the mm that have to be lengthened in the osteotomy site, we obtain the mm that have to be diverted in the device so that the bone grows 1 mm/day. For that reason, the method was modified, dividing the degrees of deformity between the number of external fixation treatment days, obtaining the number of days required for a degree of correction.

Clinical and radiological progress was assessed periodically in all patients during the post-operative weeks. During the treatment period, each patient actively collaborated in the care and handling of the external fixation device and dressings of the cutaneous holes. They also performed ankle movements in partial discharge during the gradual correction phase.

The external fixator was removed on an out-patient basis, except for the cases using hydroxyapatite screws, which were removed in the operating theatre after the patient was sedated. The patients walked with the help of crutches during the following month and these were gradually removed. After the third month, they were allowed to do all types of physical activities. The patients have been reviewed yearly.

Results

The mean follow-up time was 4.7 years (range [r]: 2-10), until all patients reached skeletal maturity. The mean external fixation time was 4.2 months (r: 3-8). The mean size for the physeal bridge subtotal observed in the radiographic image tests was 46% (r: 10-100). The mean varus deformity angle of the ankle was 20º (r: 12-30) (table 2).

Complete correction of angular deformity (0º) was achieved in all cases studied. Seven patients with shortening associated to angular deformity had a mean preoperative discrepancy of 2cm (r: 0-5.5). This was resolved in all cases except for two2, which had a residual discrepancy of 0.6 and 1.5cm.

Reported complications were: infection around the screws in two cases, *ad-latum* epiphyseal displacement in two cases (which required fixator handling to reposition it in the out-patient department), post-traumatic breakage of the external fixator screw in one case and a deformity in the ankle valgus that required the source to be approached under anaesthetic for reduction and new synthesis, with a residual length discrepancy of 1.5cm in one case.

Clinically there were no differences in mobility with respect to the contralateral ankle or pain in any case during the last revision performed.

Finally, after corrective treatment, there was complete premature closure of the operated physis with respect to the contralateral side in all patients. This did not cause a loss of angular correction (fig. 2).

Figure 2 Antero-posterior and lateral x-rays of the same patient; we can see the angular correction maintained three years after carrying out physeal distraction.

Discussion

Varus deformity of the ankle can signify an important functional problem in paediatric patients. Gait disturbance, discrepancies in length, difficulties in finding shoes and cutaneous problems are some of the most common consequences.

Different techniques to correct this deformity have been described in the literature,[7,11-13] with external fixation being a useful tool. This deformity is first treated with epiphysiodesis resection when possible (asymmetric distraction at physis level).[14,15] If this is not possible, it is treated with corrective osteotomy by carrying out asymmetric and gradual distraction (hemicallotasis) or with acute correction.

Corrections carried out at the same time or those performed gradually seek the same objectives: to solve the deformity through an increment procedure, and if possible, prevent recurrence by resolving its causal problems. When corrective osteotomy is performed, it is important to act on the deformity apex to obtain good results without creating secondary deformities.[3,16]

The scarcity of cases where three different surgical techniques have been used does not allow us to statistically assess the results. When the correction is carried out at physis level, the modified curing time (number of days for the fixator per angular correction degree) is best. In our case studies, this was three days/angular correction degree.

The advantages of external fixation are that it allows external correction control to be maintained until bone consolidation, acting on the point of deformity (even at a physeal level), and allows angular corrections and corrections of length discrepancies to be performed during the treatment period. The surgical technique is not very invasive. Even in cases where the correction is carried out at a physeal level, this does not need osteotomy (except for that of the fibula). This is because the distractor forces provided by the external fixator allow the bone bridge to be broken and the physis distracted. This technique did not need a graft or patient allograft.[17,18]

Although a rare complication in this study, bone infection due to the external fixator screws is a commonly-described problem. In some severe cases, it can lead to interruption of treatment or having the implant withdrawn.

Fibular wedge subtraction osteotomy and its fixation with an intramedullary wire should be performed to avoid external impingement of the tibio-fibular-talar mortise and *ad-latum* displacement of the distal tibial epiphysis during correction in cases of osteotomy and posterior callotasis.

The use of external fixation is a useful procedure in the hands of experts who know how an external monolateral fixation device works mechanically, have basic knowledge of ankle physio-anatomy in children and adolescents and have basic understandings of trigonometry. We know that hemicondrodiatasis is a stable procedure as such and does not need tibial osteotomy, although fibular osteotomy is necessary. Given that the procedure is stable, it does not need stabilising with a Kirschner wire. Acute correction in a young adult would be the best choice when the angular deformity is small; fibular osteotomy is also needed in this case, although stabilisation would not be necessary except if bone lengthening procedures were performed and there was a risk of altering the tibio-fibular-talar mortise. Osteotomy and posterior callotasis is the procedure that has most risk of having *ad-latum* distal tibia; due to this, in these cases we recommend that as well as having a fibular osteotomy they should be stabilised with a Kirschner wire.

We can conclude that the results obtained in our series were satisfactory. That is why we recommend the use of external fixation to correct varus deformity of the ankle. However, a longer-term follow-up is needed to observe clinical and radiological changes of joint degeneration.

Evidence level

Evidence level IV.

Conflict of interest

The authors declare no conflict of interest.

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