

Ilizarov technique combined with limited adjunctive surgical procedures for correction of relapsed talipes equinovarus in children

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Abstract

Objective: To evaluate the efficacy and safety of using the Ilizarov invasive distraction technique combined with limited surgical operations in the treatment of relapsed talipes equinovarus in children.

Methods: This retrospective study analysed the outcomes of paediatric patients with relapsed talipes equinovarus who were treated with the Ilizarov technique with moderate open limited soft tissue or bony operations. The International Clubfoot Study Group (ICFSG) classification system score was used to evaluate the deformities before and after surgery.

Results: The study evaluated 16 feet in 14 patients (nine boys). The correction time ranged from 6 to 12 weeks. The mean duration of frame application was 5.9 months. The gait was improved significantly in all patients. At final follow-up, the mean ankle dorsiflexion and plantarflexion ranges were 8.3° and 34.6°, respectively. The talocalcaneal angle improved from 10.0° preoperatively to 28.3° postoperatively in the anteroposterior plane; and from 4.1° preoperatively to 42.1° postoperatively in the lateral plane. The differences in the angle of plantarflexion, dorsiflexion, range of motion of the ankle joint and talocalcaneal angles pre- and postoperation were significant.

Conclusions: These current findings suggest that the Ilizarov technique combined with limited surgery effectively corrects relapsed talipes equinovarus in children.

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Keywords

Relapsed talipes equinovarus, Ilizarov technique, talocalcaneal angle, children

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Introduction

Idiopathic talipes equinovarus is a term used to describe a group of deformities of the foot that are present at birth. They are complex foot deformities that consist of forefoot over adduction, equinus of the hindfoot, and varus of the hindfoot and heel. Using conventional extensive release surgery gives a satisfactory result for this foot deformity for most children, but a relapsed deformity that requires further treatment may occur in approximately 20%.¹ Ponseti's method is the most popular technique for the correction of the foot deformity, which Ponseti first described in 1980 and obtained good results in clinical practice. Although this method is not exclusively conservative as it often requires some minimally invasive procedures, such as percutaneous Achilles tendon lengthening, it would not be sufficient to treat complex foot deformities that need osteotomy.²⁻⁴ Because of the difficult treatment procedure and poor curative effect, there is no firm consensus about the optimal treatment strategy despite a wealth of experience. The Ilizarov technique is an effective treatment for talipes equinovarus, especially in those patients with complex foot deformities, but complications can arise when the Ilizarov technique is used alone.⁵ Furthermore, the conventional surgical method often results in low correction rates and high relapse rates, with only 20–50% of patients not requiring further operations.^{6,7}

The objective of this present study was to evaluate the result of managing relapsed talipes equinovarus in children by using the Ilizarov technique with limited adjunctive surgeries.

Patients and methods

Study population

This retrospective study analysed the outcomes of paediatric patients with relapsed talipes equinovarus who presented to the Department of Orthopaedics, Second Hospital of Shanxi Medical University, Shanxi Key Laboratory of Bone and Soft Tissue Injury Repair, Taiyuan, Shanxi Province, China and were treated with the Ilizarov technique with moderate open limited soft tissue or bony operations between January 2010 and December 2012. The study was approved by the local ethics committee of Shanxi Medical University and conducted in accordance with the World Medical Association Declaration of Helsinki. Verbal informed consent was provided by the parents/legal guardians of all patients included in this study.

Surgical technique

All children received routine general anaesthesia. Systemic antibiotics were given 1 h before surgery and a tourniquet was also used. The Ilizarov technique can be combined with moderate soft tissue releases or osteotomies. The choice of adjunctive surgical procedures was determined by the type of foot deformity:⁸ (I) subtalar arthrodesis was selected for the patient with hindfoot varus; (II) midtarsal osteotomy for forefoot over adduction; (III) three joint arthrodesis for combined forefoot and hindfoot three dimensional deformities; (IV) percutaneous Achilles tendon lengthening for Achilles tendon contracture and forefoot deformities; and (V) adjunctive soft tissue

operations were selected in the situation of a percutaneous plantar fasciotomy and tenotomy of the long toe flexors. The Ilizarov frame has a flexible design that can adapt to any future correction plans. A constrained standard frame was used for patients in this study that consisted of: (i) a preassembled tibial base construct formed from two rings was applied to the leg using small transfixion wires (1.5 or 2.0 mm in diameter); (ii) a forefoot construct formed from a half-ring was attached by wires inserted transversely through the metatarsal shafts according to the foot size; (iii) the heel construct made of a half-ring was attached to the calcaneus by two wires. The three constructs were connected by the appropriate hinges and motors as described previously.^{9,10} After application of the frame, anteroposterior and lateral radiograms were taken for all the studied patients. Antibiotics were given for 1 day after surgery.

Gradual correction period

Correction was started on the second day after surgery at a rate of 1 mm per day if only soft tissue release was used or after 1 week if selective osteotomies were undertaken. All deformities of the treated foot were simultaneously corrected. Varus deformity of the heel was corrected through medial distraction and lateral compression through the two posterior calcaneal hinges. Forefoot over adduction deformity was corrected through distraction of the medial and compression of the lateral foot hinges. In contrast, lengthening the frontal lateral hinges was used to correct a forefoot supination deformity. The hinges around the ankle joint were at the centre of rotation of the ankle.^{11,12} During the period of distraction, the tension over the soft tissues, the neurovascular status, and the presence of pain, were monitored regularly.

Retention period

The frame was kept in a stable situation for 6 weeks once a prospective correction was achieved. During this stable time, until to the removal of the frame under general anaesthesia, the children were encouraged and allowed to bear full weight and improve their gait when undertaking walking exercise. Thereafter, an ankle-foot orthosis was routinely used in all the children for the following 6 months to 1 year. The International Clubfoot Study Group (ICFSG) classification system was used to evaluate patients' outcomes, which included range of ankle motion, radiological assessment with antero-posterior, lateral, and posterior films, orthoroentgenography in patients whose feet were lengthened, and standing footprint measurement.^{13,14} The ICFSG classification system is a global evaluation of all aspects of foot deformity, which is based on three main aspects consisting of a morphological evaluation (maximum score of 12), a functional evaluation (maximum score of 36) and a radiological evaluation (maximum score of 12). The total score range is from 0 (the perfect score) to 60 (the worst score). A total score of 0–5 is defined as excellent, 6–15 is good, 16–30 is fair and >30 is poor.

Statistical analyses

All statistical analyses were performed using the SPSS® statistical package, version 22.0 (SPSS Inc., Chicago, IL, USA) for Windows®. Data are expressed as mean ± SD. Differences between two groups were tested using independent samples *t*-test. A *P*-value < 0.05 was considered statistically significant.

Results

This retrospective study analysed outcome data for 16 feet from 14 patients (nine boys, five girls) with relapsed talipes equinovarus who were treated with the Ilizarov

technique in combination with moderate open limited soft tissue or bony operations. The mean \pm SD age at the time of the surgery was 7.4 ± 3.6 years (range 3.0–13.0 years). Nine patients had talipes equinovarus on the right side, three had deformities on the left side, and two patients had bilateral deformities.

The mean follow-up period was 20.1 months (range 16–24 months) (Table 1). The Ilizarov frame was applied for a mean of 5.9 months (range 4–9 months). The casting time for the deformed feet that received bone osteotomy ranged from 8 to 12 months; and for those who received soft tissue operations, it ranged from 6 to 8 months.

Plantigrade foot was achieved in all patients as the frame was removed and their gait was improved significantly. The ICFSG score was excellent in nine feet, good in four feet, and fair in three feet; giving a rate for good and excellent of 81% postoperation (Table 1; Figure 1). The improvement between the preoperative and postoperative ICFSG scores was significant ($P < 0.05$).

At the last follow-up appointment, the mean ankle dorsiflexion and plantarflexion ranges were 8.3° (range $6\text{--}13^\circ$) and 34.6° (range $30\text{--}46^\circ$), respectively (Table 2). There was improvement in the talocalcaneal index after correction in terms of radiography, which showed that the mean talocalcaneal angle improved from 10.0° (range $1\text{--}14^\circ$) preoperatively to 28.3° (range $18\text{--}36^\circ$) postoperatively in the anteroposterior plane; and from 4.1° (range $1\text{--}10^\circ$) preoperatively to 42.1° (range $31\text{--}47^\circ$) postoperatively in the lateral plane. The differences in the angle of plantarflexion, dorsiflexion, range of motion of the ankle joint and talocalcaneal angles pre- and postoperation were significant ($P < 0.05$ for all comparisons). Figure 2 shows representative images from a 5-year-old boy with a deformed right foot after several treatments. This boy underwent percutaneous Achilles tendon

lengthening and percutaneous plantar fasciotomy and deformity correction using an Ilizarov frame.

Ten feet experienced no complications during the study (Table 1). Six feet experienced complications during the study: (i) pin tract infection took place in one foot, which was treated by proper attentive pin care; (ii) toe contracture occurred in one foot and was treated with percutaneous tenotomy; (iii) residual deformity took place in two feet and occurrence of deformity in two feet after removal of the frame. Manipulation and casting under general anaesthesia was undertaken again and eventually achieved good foot appearance; (iv) spastic ischaemia took place in one foot, which is a symptom that is usually caused by an overly rapid distraction. Limiting the distraction rate to 1 mm per day will reduce the risk of spastic ischaemia. Therefore, the distraction rate for this patient was slowed down or even had to be reversed, after which the symptoms were improved.

Discussion

Despite advanced surgical treatment, many children with talipes equinovarus may experience residual deformity or recurrence of the foot deformity requiring further corrective treatment.¹⁵ It is regrettable that many surgical interventions will lead to a stiff, small and painful foot and in those patients treated with osteotomy, the foot can also become shortened.⁷ An alternative treatment method is needed to improve outcomes. The aim of treatment of relapsed talipes equinovarus is to achieve a fully corrected, mobile, painless, plantigrade, normal-looking foot.¹⁶ Following successful treatment, patients should be able to wear normal shoes and walk comfortably. In the past decade, the Ilizarov technique has made the most outstanding contribution to

Table 1. Demographic and clinical characteristics of paediatric patients with relapsed talipes equinovarus who were treated with the Ilizarov technique combined with moderate open limited soft tissue or bony operations ($n = 14$; 16 feet).

Patient	Age, years	Sex	Number of previous operations	Laterality	Operation type ^a	Frame application time, months	Casting time, months	Follow-up time, months	Complication	Preoperation ICFSG score	Postoperation ICFSG score
1	10	F	0	R	II+IV+V	5	8	18	N	18	2
2	7	F	0	R	IV+V	5	6	18	TC	28	4
3	3	M	0	R	IV	7	6	20	N	16	0
4	9	M	1	L	II+IV	9	8	18	N	28	7
5	9	M	1	L	I+IV+V	8	12	16	OC	36	14
6	4	M	0	R	IV+V	8	8	18	SI, RD	32	20
7	8	F	1	R	IV	4	6	24	N	14	0
8	6	M	0	L	IV	4	6	24	N	16	6
9	10	F	2	R	III+IV	6	10	24	PTI	30	4
10	5	F	0	R	IV	4	6	16	N	32	2
11	5	M	0	R	IV+V	4	6	18	N	24	0
12	9	M	1	R	III+IV	8	12	24	RD	40	26
13 ^b	7	M	1	R	IV	4	6	18	N	32	2
14 ^b	7	M	0	L	IV	4	6	18	OC	28	18
15 ^c	10	F	0	R	IV+V	6	8	24	N	18	3
16 ^c	10	F	0	L	II+III+IV+V	8	12	24	N	40	11

^aOperation type: (I) subtalar arthrodesis for hindfoot varus; (II) midtarsal osteotomy for forefoot over adduction; (III) three joint arthrodesis for combined forefoot and hindfoot three dimensional deformities; (IV) percutaneous Achilles tendon lengthening for Achilles tendon contracture and forefoot deformities; (V) adjunctive soft tissue operations for percutaneous plantar fasciotomy and tenotomy of the long toe flexors.

^{b,c}Patients with bilateral talipes equinovarus.

ICFSG, International Clubfoot Study Group classification system; F, female; R, right; N, none; TC, toe contracture; M, male; L, left; OC, occurrence of deformity; SI, spastic ischaemia; RD, residual deformity; PTI, pin tract infection.

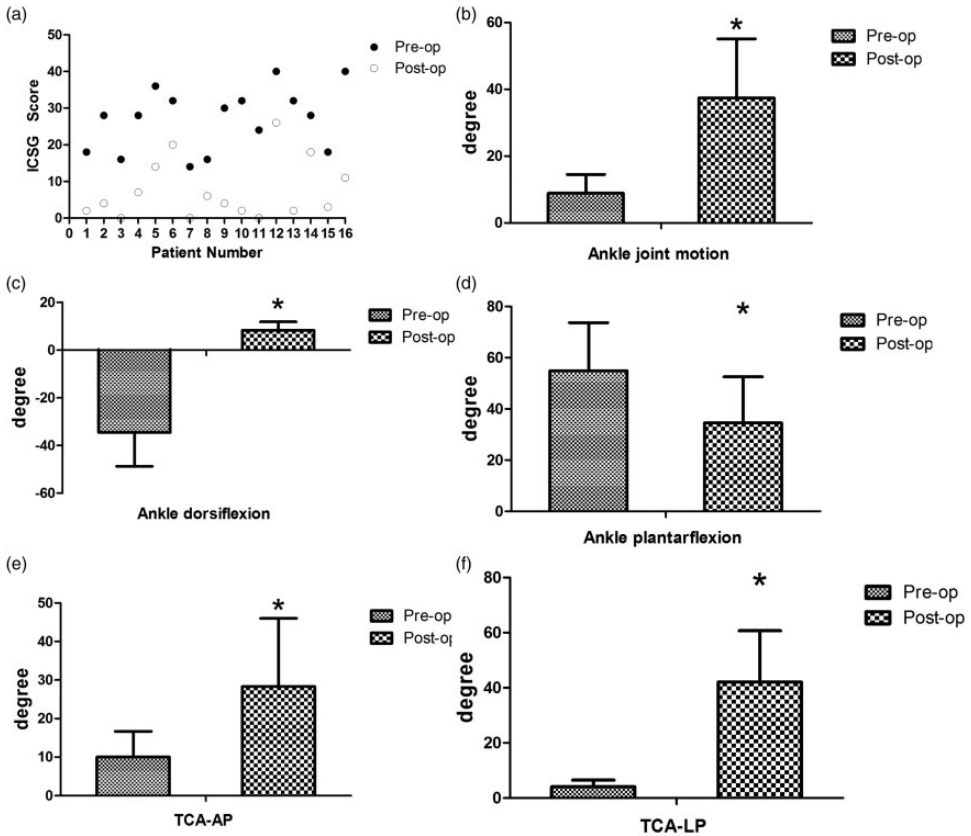


Figure 1. The International Clubfoot Study Group (ICFSG) classification system scores pre- and post-operation of paediatric patients with relapsed talipes equinovarus who were treated with the Ilizarov technique combined with moderate open limited soft tissue or bony operations ($n = 14$; 16 feet).

correcting the most complex foot deformities in children.^{1,5,6}

Using a combination of soft tissue release and gradual correction with the Ilizarov technique has been proven to be a useful salvage option for the treatment of severe deformities resulting from talipes equinovarus where conventional techniques are inappropriate or have failed.¹⁷ The Ilizarov technique allows the gradual correction of the foot deformity while protecting the soft tissues. Tissues corrected at a rate of 1 mm per day become active and regenerative, allowing reshaping of both the bone and soft tissue.^{1,6} There are several

disadvantages associated with using the Ilizarov technique, including the long duration of frame use, patient discomfort, increased incidence of pin tract infection and recurrence of deformity.^{1,5,6,12,13} In addition, it has been suggested that children younger than 8 years of age can be treated successfully using the Ilizarov technique alone, whereas those older than 8 might be better off with adjunctive foot osteotomies.⁶

The combination of soft tissue release and gradual correction by the Ilizarov method is a safe procedure in cases where closed reduction alone cannot be successful;

Table 2. The outcomes of paediatric patients with relapsed talipes equinovarus who were treated with the Ilizarov technique combined with moderate open limited soft tissue or bony operations ($n = 14$; 16 feet).

Parameters	Preoperation	Final follow-up	Statistical significance ^a
Ankle joint motion	8.9 ± 5.6	37.4 ± 17.7	$P < 0.001$
Ankle dorsiflexion	-34.6 ± 14.2	8.3 ± 3.5	$P < 0.001$
Ankle plantarflexion	54.9 ± 18.8	34.6 ± 18.0	$P < 0.001$
TCA-AP	10.0 ± 6.7	28.3 ± 17.7	$P < 0.001$
TCA-LP	4.1 ± 2.4	42.1 ± 18.6	$P = 0.001$

Data presented as mean \pm SD.

^aCompared with preoperation; independent samples t-test.

TCA-AP, talocalcaneal angle in the anteroposterior plane; TCA-LP, talocalcaneal angle in the lateral plane.

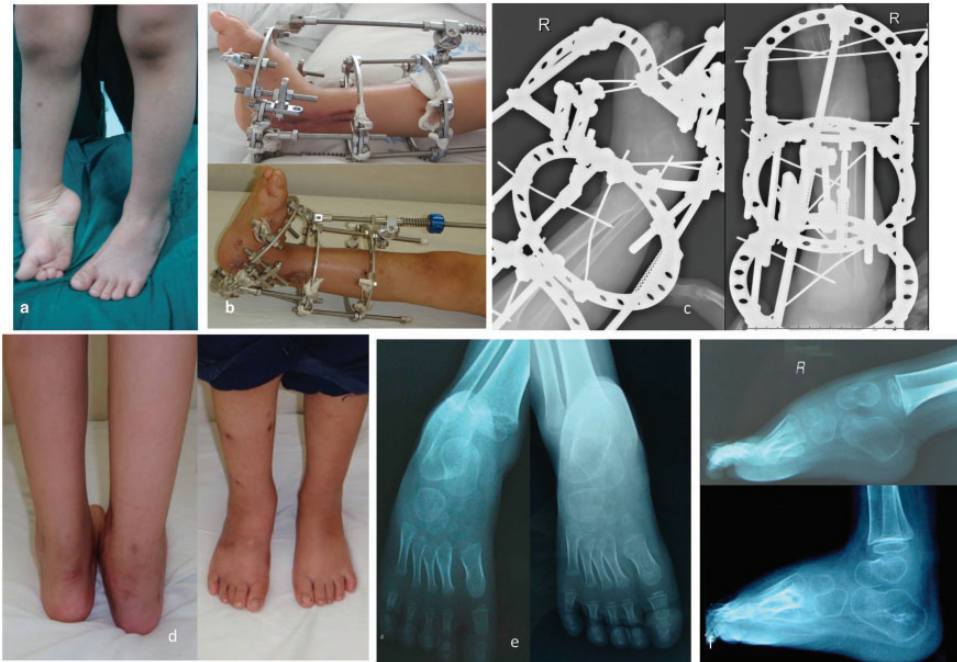


Figure 2. Representative images of a 5-year-old boy with a deformed right foot who had received several treatments for talipes equinovarus. A preoperative photograph of the child standing showed severe talipes equinovarus remained on the right side after previous treatment (a). An external fixator was used to correct the deformity (b). The postoperative radiograph showed the pin positioning in the midtarsal and metatarsal region (c). The photograph shows that a plantigrade foot was achieved and the appearance and function of the right foot had been improved significantly after removing the frame (d). The postoperative anteroposterior plane radiograph showed that the deformity had been corrected and the foot bones had returned to a normal arrangement (e). The postoperative lateral plane radiograph showed that the deformity had been corrected and the foot bones had returned to a normal arrangement (f).

for example in patients with poor skin conditions and in those children who have experienced failed surgical interventions for relapsed talipes equinovarus that need an exact operational choice for a different deformity, such as Achilles tendon lengthening for ankle equinus.^{4,8,10} A posterior release is used to correct ankle hindfoot equinus. Medial releases can aid correction of varus malalignment of the hindfoot and adduction of the midfoot. Finally, plantar fascia release will reduce forefoot cavus deformity. A correction of the deformity by soft tissue distraction may be a temporary solution until the child is old enough for later bony surgery.^{8,10}

There are several systems available to evaluate the results of correcting foot deformities. The evaluation of treatment success is traditionally based on clinical and radiological assessments. The ICFSG devised an evaluation system for defining foot deformities and to measure the outcomes of surgical interventions.¹⁸ The present study utilized the ICFSG system preoperatively and postoperatively to present an objective evaluation that can be used for future comparison against studies using the same system. In this present study, according to the ICFSG scoring system, the postoperative result was excellent in nine feet, good in four feet, and fair in three feet; giving a rate of good and excellent of 81%. This result was statistically significant, as it was in other studies.¹⁹⁻²¹ The ICFSG score improved by a mean of 20 points (range 10-30) per patient after correction.

Patients in this current study experienced several complications during treatment. Two patients had a recurrence of the deformity after the first correction and needed further surgery. The possible reasons for the recurrence of the deformity include elastic recoil of the soft tissues, joint incongruity, or growth disturbance. Spastic ischaemia occurred in one foot, which is a

symptom that is usually caused by too rapid a rate of distraction. Limiting the distraction rate to 1 mm per day usually reduces the risk of this complication. This symptom occurred in one patient who had a severe deformity, with an angiogram demonstrating an absent posterior tibial artery. The distraction was slowed down and even had to be reversed, which resulted in symptom improvement. Pin tract infection occurred in one foot and this was successfully treated with oral antibiotics. Toe contracture occurred on one foot and the patient was managed by adding a foot plate and elastic toe suspenders during the treatment phase. These contractures resolved after gentle manipulation under anaesthesia and bracing at the time of removal of the frame.

This study had several limitations. First, it only included a small group of patients. Secondly, the follow-up period was relatively short.

In conclusion, the Ilizarov technique can be used to treat foot deformities in children with relapsed talipes equinovarus as it avoids the need for an extended open surgical wound, it reduces some foot complications, it corrects the radiological anomalies as well as improving the function of the foot.

Declaration of conflicting interests

The authors declare that there are no conflicts of interest.

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