Published in final edited form as:

ANZ J Surg. 2017 October ; 87(10): 815–819. doi:10.1111/ans.14123.

Ilizarov technique and limited surgical methods for correction of post-traumatic talipes equinovarus in children

Xiao Jian Wang, MD^{*,†}, Feng Chang, MM[†], Yunxing Su, MM[†], Bin Chen, MD[†], Jie-Fu Song, MM[†], Xiao-Chun Wei, MD^{*}, and Lei Wei, MD^{*}

^{*}Department of Orthopaedics, Second Hospital of Shanxi Medical University, Shanxi Key Laboratory of Bone and Soft Tissue Injury Repair, Taiyuan, China

[†]Department of Orthopaedics, Shanxi Provincial People's Hospital, Taiyuan, China

Abstract

Background: The objective of this study was to evaluate the efficacy and safety of using Ilizarov invasive distraction technique combined with limited surgical operations in the treatment of post-traumatic talipes equinovarus in children.

Methods: Eighteen cases of post-traumatic deformed feet in 15 patients who received the treatment of Ilizarov frame application, limited soft-tissue release or osteotomy were selected in this study. After removal of the frame, an ankle-foot orthosis was used continuously for another 6–12 months. Pre- and post-operatively, the International Clubfoot Study Group (ICFSG) score was employed to evaluate the gait and range of motion of the ankle joint. Radiographical assessment was also conducted.

Results: Patients were followed up for 22 (17–32) months. Ilizarov frame was applied for a mean duration of 5.5 (4–9) months. When it was removed, the gait was improved significantly in all the patients. The correction time was 6–8 weeks for patients who underwent soft-tissue release and 8–12 weeks for those with bone osteotomy. At the last follow-up assessment, the differences between pre- and post-operative plantar-flexion angle, dorsiflexion, motion of ankle joint and talocalcaneal angle were significant (all $P < 0.05$). The observed complications included wire-hole infection in one foot, toe contracture in one, residual deformity in three, recurrence of deformity in two and spastic ischaemia in one foot.

Conclusion: Our findings suggest that Ilizarov technique combined with limited surgical operation can be considered as an efficient and successful method for correction of post-traumatic talipes equinovarus in children.

Keywords

children; Ilizarov technique; post-traumatic talipes equinovarus; talocalcaneal angle

Correspondence Dr Lei Wei, Department of Orthopaedics, Second Hospital of Shanxi Medical University, No. 382 Wuyi Road, Taiyuan 030009, China. lei_wei@brown.edu.

Conflicts of interest
None declared.

Introduction

Post-traumatic talipes equinovarus is a kind of orthopaedic deformity resulting from high energy injury to the feet and usually requires surgical correction.¹ It is an abnormality of the bone and soft tissues after severe trauma, which presents as adduction, supination, varus and equinus deformity of the foot. Once the biomechanical environment at the foot and ankle joint was disturbed, talipes equinovarus may occur under the constant stimulation of load-bearing stress. It has been widely accepted that appropriate treatment of the deformity should be started as early as possible, otherwise the foot may present with disability, pain and discomfort later in life. However, choosing appropriate treatment is challenging. Ilizarov technique is an effective treatment for talipes equinovarus, especially for those with various complex foot deformities.^{2,3} But, the sole use of Ilizarov technique may be associated with complications. In addition, surgical methods alone often result in poor correction effect and a high relapse rate from 20% to 50% which requires further operations.^{4,5}

The objective of our study was to evaluate the result of managing post-traumatic talipes equinovarus in children by using Ilizarov technique with limited adjunctive surgeries.

Methods

Patients

Altogether, 18 feet in 15 patients (11 boys and four girls) with post-traumatic talipes equinovarus who presented to the orthopaedic department of our hospital between January 2010 and December 2012 were included in this study. They were treated by Ilizarov technique and limited soft-tissue release or bony operations. The mean age of patients at the time of operation was 9 ± 3 years (range 4–13 years). Ten feet involved the right side, two the left side and three were bilateral (Table 1).

Operative technique

All the children received general anaesthesia. Systemic antibiotics were given 1 h before operation and a tourniquet was used. The Ilizarov technique can be combined with moderate soft-tissue releases or osteotomies. The choice of adjunctive operations was determined by the type of foot deformity,⁶ that is (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 (V) forefoot deformities. Adjunctive soft-tissue operations were conducted in the situation of percutaneous plantar fasciotomy and tenotomy of the long toe flexors. Ilizarov frame has a flexible design that can adapt to any future plan of correction. A functional standard frame was applied to patients in this study 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; and (iii) the heel construct made of a half-ring was attached to the calcaneus by two wires. The three constructs were connected by appropriate hinges and motors.^{3,7,8} After application of the

frame, intraoperative anteroposterior and lateral radiograms were taken to evaluate the position of the wires and the frame. Antibiotics were given for 1 day after operation.

Gradual correction process

Correction was started on the second day after operation by 1 mm per day if only soft-tissue release was used or after a week if selective osteotomies were undertaken. All the deformities of the involved 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 of the frontal lateral hinges was used to correct the forefoot supination deformity. The hinges around the ankle joint were at the centre of ankle rotation.^{9,10} In the period of distraction, the tension over the soft tissues, the neurovascular status and presence of pain were monitored regularly.

Retention of Ilizarov frame

The Ilizarov frame was kept in a stable situation for 6 weeks until a prospective correction was achieved. Later, the frame was removed under general anaesthesia. During this period of stabilization, patients were encouraged to full weight bearing and improvement of the gait by 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) system was used to evaluate patients' outcomes, which included range of ankle motion, radiological assessment with anteroposterior, lateral and posterior films, orthoroentgenography in patients whose feet were lengthened and standing footprint measurement.

Statistical analysis

Data were expressed as mean $\pm$ standard deviation. Statistical computation of data was performed using the statistical package SPSS 22.0 (SPSS, Chicago, IL, USA). Differences between two groups were tested by independent samples *t*-test and the *P*-value <0.05 was considered statistical significant.

Results

The mean follow-up period was 22 (17–32) months. Averagely Ilizarov frame was applied for 5.5 (4–9) months. The correction time for deformed feet received bone osteotomy varied from 8 to 12 weeks and for those who received soft-tissue operations ranged from 6 to 8 weeks. When the frame was removed, the gait was improved significantly in all patients. At the last follow-up, the mean ankle joint motion was 38.7° ($27\text{--}48^\circ$) and the mean ankle dorsiflexion and plantarflexion was 8.8° ($7\text{--}13^\circ$) and 39.7° ($30\text{--}45^\circ$), respectively. Radiographs showed that the talocalcaneal angle improved from 7.1° ($1\text{--}11^\circ$) preoperatively to 26.4° ($17\text{--}36^\circ$) post-operatively in the anteroposterior plane, and from 3.8° ($1^\circ\text{--}10^\circ$) preoperatively to 41.7° ($31\text{--}47^\circ$) post-operatively in the lateral plane. The differences between pre- and post-operative indexes of plantarflexion ($P < 0.05$), dorsiflexion ($P < 0.05$), motion of ankle joint ($P < 0.05$) and talocalcaneal angle ($P < 0.05$) were all significant. The ICFSG score improved by an average of 23 points (2–36) per patient after correction; and

the score was excellent in seven feet, good in six, fair in four and poor in one foot. The rate of good–excellent outcome was 72% (Fig. 1; Tables 1,2). Figure 2 showed a 5-year-old girl with a deformed right foot caused by a scar contracture which resulted from a complicated trauma.

Several complications were observed in this study, including toe contracture in one foot, wire-hole infection in one foot, residual deformity in three feet and recurrence of deformity in two feet after removal of the frame. For the two cases of recurrent deformity after the first correction, further surgery was needed. The possible reasons may include elastic recoil of the soft tissues, joint incongruity or growth disturbance. Spastic ischaemia was developed in one patient who had a severe post-traumatic deformity, whose angiogram demonstrated an absent posterior tibial artery. This kind of symptom 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 for this patient was slowed down or even had to be reversed, after which the symptoms was improved.

Discussion

Post-traumatic talipes equinovarus, a common trauma sequel, is a challenge in orthopaedic surgery. The treatment aim is to ultimately achieve a fully corrected, functional, mobile, painless, plantigrade and normal-looking foot.¹¹ The patients should be able to wear normal shoes and walk comfortably. In the past decade, Ilizarov technique has made an outstanding contribution to solve complex clubfoot deformities in children. The Ilizarov's biological law has been the consequence of his revolutionary technique for treatment of orthopaedic problems.

The combination of soft-tissue release and gradual correction by Ilizarov method is a safe procedure and it has been proven to be a powerful salvage option for the treatment of severe clubfeet where conventional techniques are improper or have failed.¹² The Ilizarov technique allows gradual correction of the foot deformity and at the same time protects poor soft tissues. But, the speed of correction is really important: 1 mm per day is appropriate, which can retain an active and regenerative result, allowing reshaping of the bones and soft tissues. However, there are many disadvantages of Ilizarov technique such as long duration of frame use, patient discomfort, increased incidence of wire-hole infection and recurrence of deformities. In addition, it is recommended that children younger than 8 years can be treated successfully by Ilizarov technique alone, whereas those older than 8 years may be better treated with adjunctive foot osteotomies.

The combination of soft-tissue release and gradual correction by Ilizarov method is a safe procedure in cases where closed reduction alone is hard to be successful, especially for those with poor skin conditions or who underwent failed surgical interventions. Anyway different types of deformities require diverse operation choices, such as Achilles tendon lengthening for ankle equinus, posterior release for ankle hindfoot equinus, etc. Medial releases can aid the correction of varus malalignment of the hindfoot and adduction of the midfoot. Besides, plantar fascia release will allow for reduction of the forefoot cavus deformity. A correction of the deformities by soft-tissue distraction may be a temporary solution until the child is old

enough for subsequent bony surgery. Our study yield satisfactory results by using Ilizarov technique and limited surgical operations in the treatment of post-traumatic clubfoot, which is consistent with other studies as well.^{13–15}

There are several systems available to evaluate the correction results of foot deformity, traditionally based on clinical and radiological aspects. ICFSG advised an evaluation system for the deformity of feet and the outcome of surgical interventions.^{16,17} The ICFSG score is a comprehensive index for foot deformity assessment, mainly from three aspects consisted of morphological evaluation, functional evaluation and radiological evaluation. The maximum score is 12 in morphological assessment, 36 in functional and 12 in radiological evaluations. The range is from 0 for a perfect score to 60 for the poorest. A total score of 0–5 is defined excellent, 6–15 good, 16–30 fair and over 30 poor. In this study, according to the ICFSG system, the result was excellent in seven feet, good in six, fair and poor in five feet. We have utilized the ICFSG system preoperatively and post-operatively in order to present a current and objective evaluation that can be used for future comparisons with other studies using the same system.

This study still has several limitations. First, our patients suffered from post-traumatic clubfoot conditions, and therefore our data have little relevance to patients with other types of foot deformities. Second, our study only included a small group of patients. Third, the follow-up time is relatively short. All in all, this method of treatment avoids time-consuming open surgeries, reduces some complications and is efficient in radiographical anomalies' correction and functional recovery.

Conclusion

Conservative open operation brings large trauma and poor results in treatment of post-traumatic talipes equinovarus in children, while Ilizarov invasive distraction technique is probable to offset those weak points. Our findings suggest that the Ilizarov technique combined with limited surgical operation is efficient for correction of post-traumatic talipes equinovarus in children.

Acknowledgements

This work was supported by grants from the National Natural Science Foundation of China (No. 81572098) and the Natural Science Foundation of Shanxi Province, China (No. 2008011012–3).

References

1. Thordarson DB. Fusion in posttraumatic foot and ankle reconstruction. *J. Am. Acad. Orthop. Surg* 2004; 5: 322–33.
2. McKay SD, Dolan LA, Morcuende JA. Treatment results of late relapsing idiopathic clubfoot previously treated with the Ponseti method. *J. Pediatr. Orthop* 2012; 4: 406–11.
3. Makhdoom A, Qureshi PA, Jokhio MF, Siddiqui KA. Resistant clubfoot deformities managed by the Ilizarov distraction histogenesis. *Indian J. Orthop* 2012; 3: 326–32.
4. El-Sayed M Ilizarov external fixation for management of severe relapsed clubfeet in older children. *Foot Ankle Surg* 2013; 3: 177–81.

5. Zions LE, Sangiorgio SN, Ebrahimzadeh E, Morcuende JA. The current management of idiopathic clubfoot revisited: results of a survey of the POSNA membership. *J. Pediatr. Orthop* 2012; 5: 515–20.
6. Vitale MG, Choe JC, Vitale MA, Lee FY, Hyman JE, Roye DP. Patient-based outcomes following clubfoot surgery. A 16-year follow-up study. *J. Pediatr. Orthop* 2005; 25: 533–8. [PubMed: 15958910]
7. El-Sayed MM, Seleem OA. Hind-foot correction and stabilization by pins in plaster after surgical release of talipes equinovarus feet in older children. *J. Orthop. Surg. Res* 2010; 42: 2–8.
8. Kocaoglu M, Erarp L, Atalar A, Bilen FE. Correction of complex foot deformities using the Ilizarov external fixator. *J. Foot Ankle Surg* 2002; 1: 30–9.
9. Moraitis T Relapsed clubfoot correction with soft-tissue release and selective application of Ilizarov technique. *Strategies Trauma Limb Reconstr* 2008; 3: 109–17. [PubMed: 19057984]
10. Utukuri MM, Ramachandran M, Hartley J, Hill RA. Patient-based outcomes after Ilizarov surgery in resistant clubfeet. *J. Pediatr. Orthop. B* 2006; 15: 278–84. [PubMed: 16751738]
11. Devadoss A, Devadoss S, Kapoor A. Differential distraction for relapsed clubfoot deformity in children. *J. Orthop. Surg (Hong Kong)* 2010; 18: 342–5.
12. El Barbary H, Abdel Ghani H, Hegazy M. Correction of relapsed or neglected clubfoot using a simple Ilizarov frame. *Int. Orthop* 2004; 28: 183–6. [PubMed: 14762694]
13. Prem H, Zenios M, Farrell R, Day JB. Soft tissue Ilizarov correction of congenital talipes equinovarus – 5 to 10 years postsurgery. *J. Pediatr. Orthop* 2007; 27: 220–4. [PubMed: 17314650]
14. Freedman JA, Watts H, Otsuka NY. The Ilizarov method for the treatment of resistant clubfoot: is it an effective solution. *J. Pediatr. Orthop* 2006; 26: 432–7. [PubMed: 16791057]
15. Hosny GA. Correction of foot deformities by the Ilizarov method without corrective osteotomies or soft tissue release. *J. Pediatr. Orthop. B* 2002; 11: 121–8. [PubMed: 11943985]
16. Bensahel H, Kuo K, Duhaime M, The International Clubfoot Study Group. Outcome evaluation of the treatment of clubfoot: the international language of clubfoot. *J. Pediatr. Orthop. B* 2003; 12: 269–71. [PubMed: 12821844]
17. Yoshino A, Takao M, Innami K, Matsushita T. Equinus deformity during tibial lengthening with ankle orthoses for equalization of leg-length discrepancies. *J. Orthop. Sci* 2011; 6: 756–9.

Fig. 1. Relevant pre- and post-operative data of deformed feet. (a) The graph showed that the International Clubfoot Study Group (ICFSG) score improved significantly after operation (●, preoperation; ○, post-operation). (b–f) Graphs showed the significant improvement of ankle plantar flexion, TCP-AP and TCP-LP after treatment (all $P < 0.05$) (▨, preoperation; ▩, post-operation). All the relevant data were shown in Tables 1 and 2. TCA-AP, talocalcaneal angle in the anteroposterior plane; TCA-LP, talocalcaneal angle in the lateral plane. * $P < 0.05$.

Fig. 2.

The image of treatment process showed a 5-year-old girl with a deformed right foot caused by a scar contracture which resulted from a complicated trauma. (a) The preoperative photograph showed serious talipes equinovarus; the patient stood and walked on the dorsum of the foot. (b) An external fixator combining with surgical operation was used to correct the deformity. (c) The photograph showed that the plantigrade foot was achieved and the appearance and function of the foot had been improved obviously after removing the frame. (d,e) Anteroposterior plane and lateral plane radiograph showed that the deformity had been corrected and the foot bones regained normal arrangement.

Table 1

Patient demographics

Case	Age	Sex	Number of previous operations	Laterality	Operation type	Fixator time (month)	Retention time (month)	Follow-up time (month)	Complication	Preoperative ICFSG	Post-operative ICFSG
1	12	M	1	R	III + IV + V	4	6	24	N	22	8
2	6	M	0	R	IV + V	5	6	24	N	18	4
3	11	M	0	L	IV	6	8	20	RD	45	16
4	9	F	0	L	II + IV	9	10	16	SI	20	2
5	8	M	1	R	I + IV + V	7	12	17	N	36	3
6	5	F	1	R	IV + V	7	12	18	OC	34	32
7	9	F	0	R	IV	8	12	18	WHI	28	0
8	7	M	0	R	IV	7	6	24	N	26	0
9	15	M	2	R	II + III + IV	6	6	30	N	40	7
10	6	M	1	R	IV	4	6	16	N	32	12
11	7	M	0	R	IV	4	12	18	N	34	11
12	8	M	1	R	II + III + IV	4	12	24	RD	40	28
13	9	F	1	R	IV	5	8	30	N	38	2
14	9	F	0	L	IV	5	8	30	OC	36	18
15	10	M	0	R	IV	4	12	18	N	38	3
16	10	M	1	L	II + III + IV + V	4	12	18	TC	40	12
17	8	M	0	R	IV	5	12	24	RD	28	22
18 [†]	8	M	1	L	IV + V	5	12	24	N	36	4

[†]One patient. ICFSG, International Clubfoot Study Group; N, none; OC, occurrence of deformity; RD, residual deformity; SI, spastic ischaemia; TC, toe contracture; WHI, wire-hole infection.

Table 2

Comparison of the relevant data pre- and post-operatively

Parameters	Preoperation (°)	Final follow-up (°)	<i>t</i>	<i>P</i> [†]
Ankle joint motion	9.1 ± 4.3	38.7 ± 11.3	4.124	0.000
Ankle dorsiflexion	-38.0 ± 9.4	8.8 ± 4.3	3.265	0.002
Ankle plantarflexion	58.4 ± 22.8	39.7 ± 14.9	6.758	0.000
TCA-AP	7.1 ± 3.6	26.4 ± 11.6	5.677	0.000
TCA-LP	3.8 ± 2.8	41.7 ± 17.3	3.576	0.001

[†]Significant difference. TCA-AP, talocalcaneal angle in the anteroposterior plane; TCA-LP, talocalcaneal angle in the lateral plane.