Does Short-term Application of an Ilizarov Frame with Transfixion Pins Correct Relapsed Clubfoot in Children?

Mohamed Ahmed Refai MD, Sang-Heon Song MD,
Hae-Ryong Song MD, PhD

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Abstract

Background Treatment of relapsed clubfoot after soft tissue release in children is difficult because of the high recurrence rate and related complications. Even though the Ilizarov method is used for soft tissue distraction, there is a high incidence of recurrence after removal of the Ilizarov frame owing to previous contracture of soft tissue and a skin scar.

Questions/Purposes We asked (1) whether transfixation of midfoot joints by temporary K wires during the consolidation stage after short-term application of an Ilizarov frame would maintain correction of the relapsed clubfoot

clinicoradiologically and (2) whether this method would reduce the rate of recurrence and related complications in patients with a skin scar from previous surgery.

Methods We retrospectively reviewed 18 patients (19 feet) with relapsed clubfeet who underwent correction by soft tissue distraction using an Ilizarov ring fixator, between March 2005 and June 2008. The mean age of the patients was 8 ± 2 years (range, 4–15 years). K wire fixation for the midfoot joints combined with a below-knee cast were used during the consolidation stage. The minimum followup was 2 years (mean, 4.5 years; range, 2–6 years).

Results The average duration of frame application was 5 weeks; the mean duration of treatment was 11 weeks. At last followup, 16 of 19 feet were painless and plantigrade and only three of 19 feet had recurrence. The mean preoperative clinical American Foot and Ankle Society (AOFAS) score had increased at last followup (57 versus 81). The values of the AP talocalcaneal, AP talo-first metatarsal, and lateral calcaneo-first metatarsal angles improved after treatment. The three recurrent clubfeet were treated by corrective osteotomies and Ilizarov frame application.

Conclusion This method could maintain the correction of relapsed clubfoot in children and reduce the recurrence rate and complications regardless of the presence of a skin scar owing to previous surgery.

Level of Evidence Level IV, case series. See the Guidelines for Authors for a complete description of levels of evidence.

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M. A. Refai, S.-H. Song, H.-R. Song (✉)
Department of Orthopaedic Surgery, Institute for Rare Diseases,
Guro Hospital, Korea University Medical College,
80 Guro-Dong, Guro-Gu, Seoul 152-703, Korea
e-mail: songhae@korea.ac.kr

Introduction

Recurrence in clubfoot is not uncommon [13]. El-Mowafi defined the feet with recurrences as those with multiplanar deformities, with or without shortening of the foot after

failure of previous management, which needed subsequent correction [6]. Recurrence occurs mainly in the hindfoot and is clinically evident by the development of equinus and varus deformities of the heel [4]. Midfoot deformities also may occur during recurrence [20]. Although Ponseti serial casting techniques reportedly achieve lasting correction in 62% to 98% of patients with a 10% relapse rate after initial successful treatment [22], patients with recurrent clubfoot require additional treatment [15]. The Ilizarov method is one of the options that can be used to treat recurrent clubfoot in patients as young as 4 or 5 years, and other methods including serial casting and soft tissue release are still effective.

From the age at which standing and walking begin, extensive peritalar or pantalar arthrolyses are required for complete anatomic correction of relapsed or neglected clubfeet [23]. However, these arthrolyses are successful only in patients between the ages of 8 and 10 years. Once skeletal ossification is completed in late childhood, anatomic correction by arthrolysis no longer is possible. Especially in severe cases, some authors are inclined to wait until after the child's 12th to 15th year of life, when skeletal maturity is reached, to improve the foot deformity by wedge osteotomies and subsequent triple arthrolysis [7]. This, however, causes additional shortening of the foot, which prompted us to look for a method of correcting severe clubfoot or talipes equinus deformities without bone resection or arthrodesis from the 8th year of life onward. We found a method attributed to Konjuchov and Abalmasova et al., as described by Franke et al. [7] and Grill and Franke [10], that uses the Ilizarov external fixator. With this method, it is possible to correct all components of the deformity simultaneously by continuous guided distraction. Paley described the Ilizarov external fixator as a tool for correction of clubfoot deformity [18]. The Ilizarov frame corrects the three-dimensional foot deformity simultaneously, without shortening the foot [6, 24]. Gradual lengthening of the blood vessels, nerves, muscles, connective tissues, and skin may reduce the risks of neurovascular damage, skin necrosis, and secondary infection [25].

In children, correction is achieved without the need for soft tissue release, tendon lengthening, or osteotomies [21]. The Ilizarov protocol consisted of correction of all elements of the deformity, followed by maintenance of the frame in the corrected position for 4 to 10 weeks, to achieve stabilization of the correction [3, 16]. Thus, the Ilizarov technique has been considered a time-consuming procedure, with the additional disadvantages of complicated frame arrangement, pin tract infection, and lack of patient and parent compliance [9]. The duration of frame application can be shortened by increasing the distraction rate or by using a method other than the Ilizarov frame to maintain the correction during the consolidation phase [14]. Increasing

the distraction rate has been associated with pain and severe swelling of the foot, skin sloughing, and neurovascular complications [17]. Therefore, another method of reducing the time while maintaining durable correction would be important.

We therefore asked (1) whether transfixation of midfoot joints by temporary K wires during the consolidation stage after short-term application of an Ilizarov frame would maintain correction of the relapsed clubfoot clinicoradiologically and (2) whether this method would reduce the rate of recurrence and related complications in patients with a skin scar from a previous surgery.

Patients and Methods

We retrospectively investigated patients who underwent gradual soft tissue distraction using an Ilizarov ring fixator for relapsed idiopathic clubfoot deformity between March 2005 and June 2008. We included 18 patients (19 feet) among the 32 who underwent foot deformity correction. We included patients with relapsed idiopathic congenital talipes equinovarus deformity who were older than 4 years at the time of surgery, and were treated by application of an Ilizarov frame for correction of the deformity through soft tissue distraction and transfixation of the midfoot joints during the consolidation phase. We excluded patients with syndromic or neurologic foot deformity, acquired foot deformity, inadequate followup, and patients requiring a bony procedure to attain correction of the deformity. The mean age of the remaining 18 patients at the time of surgery was 8 ± 2 years (range, 4–15 years). There were 12 boys and 6 girls. Nine feet had relapsed deformity after correction by the Ponseti method and 10 feet had been treated previously by posteromedial release (Table 1). The mean followup was 4.5 ± 1 year (range, 2–6 years). We did not recall any patients specifically for this study; all data were obtained from medical records and the angles were recorded from the patients' radiographs.

For all patients, we reviewed the preoperative functional grading scores and last followup scores using the AOFAS score [12], and the duration of frame application. We divided the cases into the nine feet previously treated by the Ponseti method (Group 1) and the 10 feet previously treated by posteromedial release (Group 2). We compared preoperative AOFAS clinical scores and the three foot angles between the two groups, and postoperative improvement of AOFAS scores and the values of the three angles.

The senior author (HRS) performed surgery on all patients. The Ilizarov ring fixator (U & I Co. Ltd, Seoul, Korea) was used for gradual deformity correction and the percutaneous abductor hallucis muscle and plantar fascia were released in all cases. First, the surgeon passed two

Table 1. Patient demographics

Patient	Age (years)	Sex	Site	Previous management	Preoperative AOFAS score	Postoperative AOFAS score at last followup	Time wearing fixator (days)	Duration of treatment (days)	Duration of followup (years)
1	4	Male	Right	Ponseti technique	71	84	30	60	6
2	6	Male	Left	Ponseti technique	54	91	26	56	4
3	5	Male	Right	Ponseti technique	68	84	40	95	6
4	5	Male	Left	Ponseti technique	54	84	30	60	5.5
5	11	Male	Right	Ponseti technique	61	64	35	65	3.5
6	6	Female	Right	Ponseti technique	51	91	45	90	4
7	5.5	Female	Left	Ponseti technique	48	90	28	58	6
8	6.5	Male	Left	Ponseti technique	54	90	37	67	2
9	4	Female	Right	Ponseti technique	71	80	35	80	2.5
10	8	Female	Left	Posteromedial release	71	91	38	68	5
11	13	Male	Right	Posteromedial release	51	91	56	111	6
12	8	Male	Left	Posteromedial release	64	87	45	95	4.5
13	10	Male	Right	Posteromedial release	58	91	55	100	3
14	12	Female	Right	Posteromedial release	54	87	50	95	4
15	7	Male	Right	Posteromedial release	64	91	37	67	6
16	10	Female	Left	Posteromedial release	58	91	41	71	3.5
17	15	Male	Bilateral	Posteromedial release	32	32	43	73	4
18	8	Male	Right	Posteromedial release	68	91	26	66	5.5

AOFAS = American Orthopaedic Foot and Ankle Society.

Fig. 1A–B (A) AP and (B) lateral view photographs show the frame during correction.

Ilizarov wires horizontally through the lower third of the tibia and fixed them under tension to a ring. Similar wires were placed transversely through the posterior part of the calcaneus and the distal part of the metatarsals, and each wire was fixed to a semicircular ring, without transfixation

of the toes. The tibial and calcaneal rings were attached to each other by two bars, and the calcaneal and metatarsal rings were connected by links, allowing dorsiflexion at the ankle (Fig. 1). Correction started 2 or 3 days after application of the device. After achievement of correction,

the frame was removed with the patient under general anesthesia. External rotation of the foot on the talus was achieved by moving the forefoot and calcaneus laterally, while the talar head was pushed medially. The surgeon inserted two K wires that transfixated the talonavicular and calcaneocuboid joints using image intensifier guidance along the longitudinal axis of the talus and calcaneus, in the posteroanterior direction of this valgus/external rotation overcorrection position. If present, toe contractures were managed at this step by percutaneous release, without wire fixation of the metatarsophalangeal joint, and toe extension was maintained by the cast. The cast maintained the ankle in dorsiflexion for 4 to 6 weeks. After this period, the cast and K wires were removed and the patient then wore a foot/ankle orthosis for 6 months.

Postoperatively, all patients used crutches with initial nonweightbearing, then weightbearing as tolerated after 3 days after frame application. Physiotherapy was recommended two or three times per week, in an outpatient facility, to prevent development of either knee or toe contractures by using passive and active knee flexion and extension exercises, with passive dorsiflexion of the toes. After frame removal, partial weightbearing was permitted using crutches, with the patient doing knee flexion and extension exercises while wearing a short-leg cast. After cast removal 4 to 6 weeks after application, an ankle/foot orthosis was used day and night for 6 months. The patients used special clubfoot shoes with a high straight lateral border and forefoot abduction for 1 year.

We followed patients monthly for 1 year after surgery, every 6 months during the second year, and yearly thereafter. At every visit, we clinically evaluated pain, walking distance, difficulties with ordinary activities and sports, ability to wear conventional shoes, foot alignment, and ankle and subtalar ROM. We recorded the detailed postoperative score twice during the second year of followup and once yearly thereafter. We classified the complications into minor and major according to Paley's classification [17]. The major complications interfered with the original goals of treatment and the minor did not.

The preoperative, immediate postoperative, and last followup standing AP and lateral radiographs were reviewed. Two observers (MAR and SHS) independently measured three angles. These same observers measured the angles again 1 month later to check for intraobserver and interobserver reliabilities. The talocalcaneal angle (TCA) and the talo-first metatarsal angle (TMT1) on the AP radiographs and the calcaneo-first metatarsal angle on the lateral (CMT1-LAT) standing radiographs were measured [2, 11] (Fig. 2). We determined the intraobserver and interobserver reliabilities of foot angle measurements using kappa coefficients. The kappa coefficients value of the

TCA-AP was 0.87, the TMT1-AP was 0.89, and the CMT1-LAT was 0.92.

We used Student's paired t-test to: determine the differences in AOFAS scores between the preoperative and last followup values; compare the TCA-AP measured on the preoperative and last followup radiographs; determine differences in TMT1-AP and CMT1-LAT angles between the preoperative and last followup radiographs; compare the means of preoperative clinical scores between Groups 1 and 2; determine differences between means of postoperative clinical scores between Groups 1 and 2; compare the means of preoperative values of foot angles between the two groups; and compare the differences between the mean postoperative values between the two groups. The data were tested using the Kolmogorov-Smirnov test and the data were normally distributed, therefore it met the assumptions of the parametric tests used. We performed the statistical analysis using SPSS[®] software, version 16.0 (SPSS[®], Chicago, IL, USA).

Results

After short-term Ilizarov soft tissue distraction followed by midfoot joint transfixation by temporary K wires during the consolidation stage, 16 of 19 (18 patients) feet were plantigrade and pain free at last followup (Fig. 2). At last followup, the mean of the overall AOFAS score increased ($p < 0.001$). The mean of the overall standing TCA-AP angle values increased ($p < 0.001$). The mean of the overall TMT1-AP angle values decreased ($p < 0.001$). The mean of the overall CMT1-LAT angle values increased (Table 2). The mean total duration of treatment was 10 ± 2 weeks (range, 8–12.5 weeks). We observed no difference between the two groups in mean preoperative scores and preoperative TCA-AP and CMT1-LAT angles, although the mean value of the TMT1-AP was higher in Group 2. We also found no difference in the mean postoperative scores between the two groups (84 versus 83). At the last followup, the mean TCA-AP, TMT1-AP, and CMT1-LAT angles showed no differences in deformity correction between the two groups (Table 3).

There were 36 minor and three major complications. A good result was defined as the patient having no major complications that would require additional major surgery. Minor complications were 19 pin tract infections, four flat-topped talus, four temporary foot stiffness, and eight toe contractures. All patients had pin tract infections controlled by frequent dressing and oral antibiotics. Toe flexion contracture occurred in eight of the 19 feet and was treated by percutaneous flexor tenotomy without transfixation of the metatarsophalangeal joint. Toe contracture was treated

Fig. 2A–I A 5-year-old boy had right-sided relapsed clubfoot after posteromedial release. His preoperative AP radiographs show (A) the talocalcaneal angle (TCA) at 6° and (B) talo-first metatarsal (TMT1) angle at 31° . (C) The preoperative lateral radiograph shows the calcaneo-first metatarsal (CMT1) angle at 123° . The postoperative AP radiographs show two K wires transfixing the talonavicular and calcaneocuboid joints after Ilizarov frame removal with the (D) TCA at 30° and (E) TMT1 angle at 13° . (F) The postoperative lateral radiograph shows two K wires transfixing the talonavicular and calcaneocuboid joints with the CMT1 angle at 148° . AP radiographs of the right foot at 3.5 years followup show the (G) TCA at 30° and (H) TMT1 angle at 10° . (I) A lateral radiograph of the right foot obtained at 3.5 years followup shows the CMT1 angle at 161° .

with frame removal and transfixation of the midfoot joints. Three major complications in two patients (12 years old [Fig. 3], and 15 years old) were recurrence of the foot deformity. They had varus deformity of the hindfoot with a mean of 15° (range, 10° – 20°) and cavovarus deformity of

the forefoot with a mean of 20° (range, 15° – 30°) after removal of the K wire. The calcaneal sliding osteotomy and the transverse osteotomy at the midtarsal joint were performed for correction of the recurrent deformity (Table 4).

Table 2. Preoperative and postoperative mean and SD of AOFAS scores and foot angles

Clinical score and foot angles	Preoperative			Postoperative			p value
	Mean	SD	Range	Mean	SD	Range	
AOFAS score	57	11	32–71	81	18	32–91	p < 0.001
TCA AP	5°	11°	−9° to −36°	30°	13°	10°–49°	p < 0.001
TMT1 AP	32°	7.5°	21°–51°	9.5°	6°	1°–30°	p < 0.001
CMT1 LAT	111°	8°	97°–125°	136°	15°	113°–150°	p < 0.001

AOFAS = American Orthopaedic Foot and Ankle Society; TCA AP = talocalcaneal AP angle; TMT1 AP = talo-first metatarsal AP angle; CMT1 LAT = calcaneus-first metatarsal lateral angle.

Table 3. Variables between groups

Variable	Group 1	Group 2	p value
Average age (years)	6	10	0.001
Average fixator time (days)	34	43	0.06
Average preoperative AOFAS score	59	57	0.7
Average postoperative AOFAS score	84	83	0.9
Average preoperative TCA	1	8	0.4
Average preoperative TMT1	28	36	0.01
Average preoperative CMT1	114	109	0.02
Average last followup TCA	25	34	0.14
Average last followup TMT1	10	9	0.76
Average last followup CMT1	140	132	0.07

AOFAS = American Orthopaedic Foot and Ankle Society; TCA = talocalcaneal angle; TMT1 = talo-first metatarsal angle; CMT1 = calcaneo-first metatarsal angle.

Discussion

The Ilizarov frame can correct relapsed clubfoot in children, but its disadvantages are long duration of frame use, patient discomfort, and increased incidence of pin tract infection [9]. The key maneuver for correcting most clubfoot deformities is lateral displacement of the calcaneus, cuboid, and navicular bones [19]. The talus is the fulcrum around which the entire foot couples kinematically [19]. Previous studies reported recurrence of foot deformity after removal of the Ilizarov frame even though the Ilizarov frame was maintained for several weeks after full correction of initial foot deformity and a below-knee cast or orthosis also was applied [1, 5, 8, 21, 25]. Prem et al. [21] reported that 18 of 19 feet with relapsed congenital clubfoot were plantigrade after correction with the Ilizarov frame, but their patients wore the frame for 16 weeks. El Barbary et al. [5] reported that 41 idiopathic clubfeet treated by soft tissue distraction had painless plantigrade feet at the last followup. Their patients wore the frame an additional 4 to 6 weeks after correction. However, other studies reported high recurrence rates after removal of the frame. Freedman et al. [8], reported 11 of 21 relapsed

clubfeet subsequently recurred. They concluded the Ilizarov method for treatment of resistant clubfoot deformities was associated with residual or recurrent deformity, and often required revision surgery. Similarly, Wallander et al. [25] reported recurrence in seven of 10 feet treated with the Ilizarov frame. In these two studies, a below-knee cast was used to maintain the correction during the consolidation stage. We similarly found a cast alone is not sufficient to maintain correction (Table 5). Therefore, we transfixed the midfoot joint with K wires to reduce the maintenance period of the Ilizarov frame and to avoid recurrence of foot deformity after removal of the frame. We therefore asked (1) whether transfixation of midfoot joints by temporary K wires during the consolidation stage after short-term application of an Ilizarov frame would maintain correction of the relapsed clubfoot clinicoradiologically and (2) whether this method would reduce the rate of recurrence and related complications in patients with a skin scar from a previous surgery.

Our study did have several limitations. First, our patients had relapsed idiopathic congenital clubfoot, and our data may not be relevant to patients with other causes of recurrence such as paralytic and syndromic relapsed clubfoot. Second, our patients were young, with faster healing capacity. The rates of complications and/or recurrence might have increased if we had used this technique for older age groups. Third, we could not determine whether results would be similar if other foot joints (subtalar joints) were used to maintain the correction. Fourth, our study included a small group of patients which limits the questions we can address and the types of statistical analyses.

We observed recurrence in three feet (two patients) of 19. The patients were 12 and 15 years old, both had undergone previous posteromedial release. These results suggested that patients older than 10 years with soft tissue contracture could have a high risk of recurrence even though our method is effective for prevention of recurrence. Therefore, foot osteotomy and distraction callotaxis might be better than only soft tissue distraction for obtaining good results after removal of the frame. In our study, there was a fixed period of

Fig. 3A–I The radiographs of a 12-year-old girl with right-sided relapsed clubfoot after posteromedial release and broken talonavicular wire are shown. The preoperative AP radiographs show (A) the talocalcaneal angle (TCA) at 9° and (B) talo-first metatarsal (TMT1) angle at 28° . (C) The preoperative lateral radiograph shows the calcaneo-first metatarsal (CMT1) angle at 119° . These AP radiographs show two K wires transfixing the calcaneocuboid joint after Ilizarov frame removal. (D) The TCA is 27° and the (E) TMT1 angle is 4° . (F) The preoperative lateral radiograph shows the CMT1 angle at 150° . AP radiographs of the right foot at 5 years followup show the (G) TCA at 5° and (H) TMT1 angle at 20° . (I) A lateral radiograph of the right foot obtained at 5 years followup shows the CMT1 angle at 120° and recurrence.

Table 4. Complications

Complications	Group 1	Group 2	Treatment
Minor			
Pin tract infection	9	10	Oral antibiotics and frequent dressing
Flat-topped talus	1	3	Results were not affected, no treatment was needed
Stiffness	1	4	Physiotherapy
Toe contracture	3	5	Percutaneous tenotomy with frame removal
Major			
Recurrence	1	2	Additional bony procedures were needed

transfixation of midfoot joints in both groups with different previous treatment (Ponseti method and posteromedial release), and we did not find any differences in the postoperative clinical scores or foot angle values even when the patients had scar contracture owing to previous posteromedial release. El Barbary et al. [5] also reported that eight of 41 feet with relapsed clubfeet had no previous surgery and there was no difference in correction or recurrence between the different treatment groups. Our patients with soft tissue scars from previous posteromedial release wore the frame for a longer time (mean, 43 versus 34 days) compared with patients who had the Ponseti method. These patients required a reduced distraction rate owing to pain and swelling of the foot during the distraction stage.

Table 5. Complications reported in similar studies

Study	Number of feet	Mean age of patients (years)	Mean time of correction (weeks)	Mean time wearing frame (weeks)	Length of followup (years)	Complications		
						Pin tract infection	Toe contracture	Recurrence
Bradish and Noor [1]	17	7.8	4.5	10.5	2.5	17	1	4
Prem et al. [21]	19	5	NR	16	6.9	19	NR	1
El Barbary et al. [5]	66	8.5	5.4	10.5	3.3	66	5	0
Wallander et al. [25]	10	9.4	10	10	3.3	8	3	5
Freedman et al. [8]	21	5.7	3.67	3.67	6.64	2	NR	11
Current study	19	8	5.5	5.5	4.47	19	8	3

NR = not reported.

We believe Ilizarov frame application is not essential for the consolidation stage in relapsed idiopathic clubfeet in patients in this particular age group. Transfixion of the midfoot joints with K wires is a simple way to maintain correction. This technique can be used in the presence of a soft tissue scar from previous surgical release.

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