Correction of persistent clubfoot deformities with the Ilizarov external fixator

Experience in 10 previously operated feet followed for 2–5 years

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We reviewed the outcome in 10 idiopathic clubfeet in 7 patients treated with the Ilizarov external fixator (IEF) for persistent foot deformities after previous surgery. After follow-up of a median of 40 (25–56) months, 6 patients/parents were satisfied with the results and most of them reported better walking capacity and fewer problems finding shoes that fit. Severe equinus deformity was seen in 9/10 feet prior to treatment in the IEF and in no foot at follow-up. However, persistent reduction of ankle joint motion , limited walking capacity and intermittent pain were commonly found.

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The management of persistent and relapsed clubfoot deformities after one or more surgical procedures is difficult. Repeat soft-tissue procedures will rarely align the deformities satisfactorily and different kinds of osteotomies or triple arthrodesis are often required (Hjelmstedt and Sahlstedt 1980, Lundberg 1980, Angus and Cowell 1986, Hall and Calvert 1987, Graham and Dent 1992).

The Ilizarov external fixator (IEF) has recently been reported to be a useful tool for correcting severe foot deformities (Grill and Franke 1987, Bianchi and Aronson 1991, Desgrippes et al. 1992, Paley 1993, Cantin et al. 1994). We reviewed our experience with the fixator for correction of persistent deformities in 10 clubfeet previously operated on one or several times.

Patients and methods

We reviewed 10 feet in 7 boys with idiopathic clubfeet, treated with the IEF for persistent foot deformities after previous surgery (Table 1). The IEF treatment took place during years 1990–92. The age of the patients when the IEF was applied ranged from 6 to 15 years. All patients were re-examined by one of the authors (HW), who had not been involved in the treatment of the patients.

The number of prior surgical procedures ranged from 1 to 7 (Table 1). 6 feet had been subjected only to soft tissue procedures and 4 had also had bony procedures (6 osteotomies in 1 foot). A total of 29 soft tissue releases or tendon transfers had been performed. At the first admission, the median time required for application of the fixator was 100 (75–135) minutes and the stay in the hospital was 6.5 (3–10) days. The total number of admissions ranged from 2 to 4 and the median total time on the ward was 10 (7–18) days. The median duration in the IEF was 10 (6–12) weeks and after removal of the fixator all feet were immobilized in a below-knee cast for 8 (8–14) weeks. The median follow-up period was 40 (25–56) months.

Initially, 1 ring was placed in the proximal tibial metaphysis and 1 in the distal, but we now prefer to mount the proximal ring in the mid-area of the shaft of the tibia. This seems to cause fewer complaints from the knee and the ring diameter can be kept smaller (Figure 1). The 2 crossed K-wires were tensioned to between 1000 and 1200 N. The 2 tibial rings were connected with 3 threaded rods. 1 half-ring or 5/8-ring was fixed to the calcaneus by 2 crossed K-wires. Another half-ring was fixed to the forefoot with 1 K-wire introduced from the lateral side of the foot transfixing the fifth to third metatarsal bones and 1 from the medial side transfixing the first to third metatarsal bones. The half-rings on the foot were connected with each other as well as with the distal tibial ring by threaded rods.

The hindfoot equinus and varus were corrected by distraction from the distal tibial ring to the calcaneal ring in a distal and slightly dorsal direction to avoid

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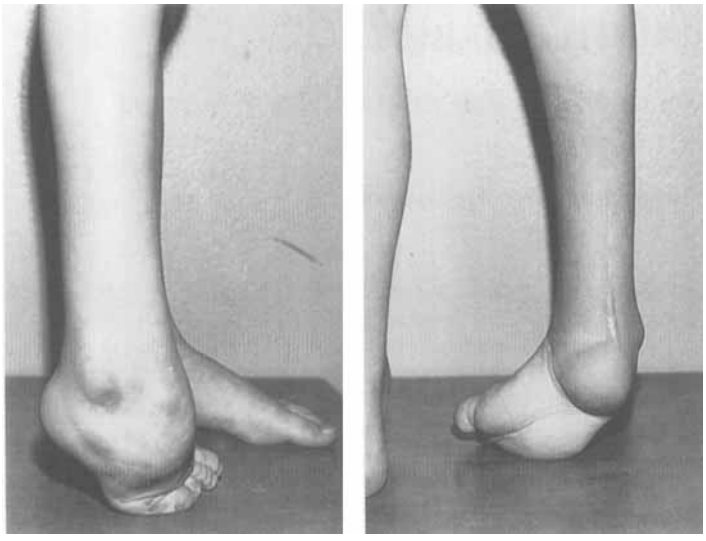
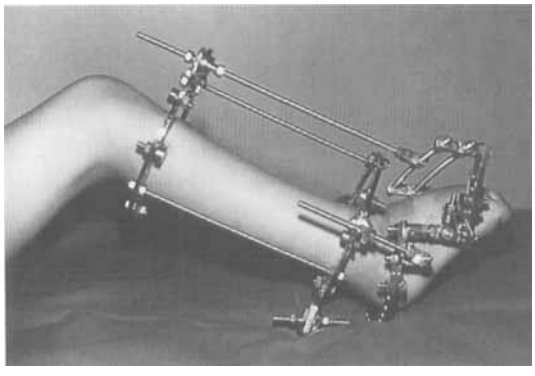
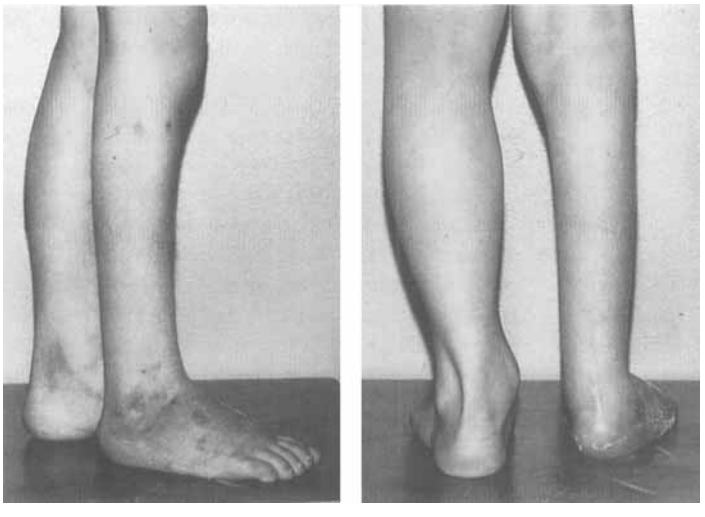
Figure 1. Case 1.



Persistent equinus and varus deformity of the hindfoot and supination and adduction deformity of the forefoot in a 6.5-year-old boy.



During treatment with the IEF.



At 34 months of follow-up. The foot is plantigrade and the deformity of both the hindfoot and forefoot has been corrected. Lehman score: fair.

ventral subluxation of the talus. In the first case, the equinus deformity was corrected by rotation at the ankle mortise through hinges. However, when using this technique we found, by radiographs during the distraction period, that the talus subluxed anteriorly. We therefore now use a design of the IEF, without hinges. As long as distraction of the hindfoot was going on, repeat radiographs of the ankle were obtained in order to recognize any physeal separation. When radiographs revealed about 0.5 cm axial distraction of the joint space between the talus and the tibia, the patients were taken back to the operating room and under general anesthesia the distraction rods were temporarily removed, while the equinus and varus deformity of the hindfoot were maximally corrected. This procedure was repeated until the deformity was considered to be maximally corrected. The forefoot adductus and cavus were corrected simultaneously with the hindfoot by medial distraction between the calcaneal and forefoot half-rings. The total rate of distraction per day was individualized, depending on the deformity and local complaints, and ranged from 1 to 2, mm with 4 increments.

The major part of the distraction was performed at home. The children were usually examined in the clinic every second week. Minor modifications of the frame could usually be performed without anesthesia. When the desired correction was achieved, the frame was removed under general anesthesia. The foot was afterwards protected in a below-knee cast for 2–3 months in the corrected position and full weight bearing was encouraged. In none of the 3 patients with bilateral foot deformities were both feet corrected simultaneously and the

Table 1. Data on 7 patients (10 feet) treated by correction of persistent clubfoot deformities with the Ilizarov external fixator

				Inital data						Follow-up examination								
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	r	6	1	Eq; var; add	12		14	34	P	31°	0°	25°	25°	23	Yes	No	Sl.	61
2	l	7	4	Eq; add	8		8	51	Eq	45°	−10°	0°	0°	15	Yes	Occ.	Sl.	44
2	r	8	2	Eq	12	(1)	8	44	Eq	45°	−10°	15°	10°	20	Yes	Occ.	No	44
3	r	9	3	Eq; add	12		8	43	Eq	22°	−12°	33°	10°	20	Yes	No	Sl.	47
4	l	10	4	Eq; add	7		8	25	P	26°	6°	0°	27°	10	Yes	No	Sl.	69
5	r	11	2	Eq; add	9		8	33	P	20°	−3°	15°	20°	18	Yes	No	Sl.	57
6	r	11	2	Eq; add	11		14	56	P	25°	10°	8°	7°	10	Yes	No	Sl.	63
6	l	12	2	var; add	12		12	42	P	10°	10°	30°	5°	17	Yes	Occ.	Sl.	51
7	l	15	7	Eq; var	6	(2)	8	37	Eq	25°	−20°	40°	0°	4	No	Occ.	Sl.	52
7	r	15	2	Eq; var; add	7		8	29	Eq	15°	−10°	35°	15°	11	No	Occ.	Sl.	47

A Pat No.
B Side
C Age, yr
D Previous surgical procedures, No.
E Clinical appearance prior to surgery
  Eq. severe equinus
  var varus
  add adductus
F Time in the IEF, wk
G Complications
  (1) anterior subluxation of talus
  (2) separation of distal medial epiphysis
H Immobilization in cast, wk
I Follow-up, mo
Clinical assessment
J Foot in standing position
  P plantigrade
  Eq mild equinus
K Ankle joint motion, plantar flexion
L dorsiflexion
Radiological assessment
M TC lateral
N TC anteroposterior
O T-MT-1
Patients' own assessment
P Satisfied
Q Pain
  Occ. occasionally
R Walking restricted
  Sl. slightly
S Score, Lehman

time interval between applications of the IEF ranged from 7 to 14 months.

Data about the severity of the equinus deformity prior to surgery were collected from the medical records. When the patients were reviewed, both clinical and radiographical results were assessed. At the clinical follow-up examination, the equinus deformity was measured with the patients in the standing position, using a goniometer (Heck et al. 1965). The equinus deformity was classified as mild (5–20°), moderate (21°–29°) or severe (≥ 30°). The foot with a measured equinus deformity less than 5° when standing was classified as plantigrade. The range of ankle joint motion (both dorsiflexion and plantar flexion) was measured according to Lindsjö (1981). At the final radiographic follow-up examination, anteroposterior and lateral radiographs of the feet were obtained in a standardized manner, as described by Simons (1978). These 2 views were used to measure the "talocalcaneal index" (the sum of the talocalcaneal angle on the lateral and the AP views). The result was classified as acceptable, when the index was 40° or more, and as poor when less than 40° (Lehman et al. 1990). On the AP view, the tarsometatarsal-1 angle was also measured.

Furthermore, the clinical and radiographic findings at follow-up, as well as the results obtained from a questionnaire, were also used to assess the overall "functional results" by the rating system of Lehman et al. (1990). This includes measurement or assessment of: 1) ankle dorsiflexion, 2) subtalar motion, 3) the position of the heel when standing, 4) forefoot appearance, 5) gait, 6) the radiographic talocalcaneal (both AP and lateral views) and tarsometatarsal-1 angles, 7) whether the patients had difficulty in finding shoes that fit, 8) function, 9) pain and 10) the patients' and parents' satisfaction with the correction of the deformity. Each of the 10 measurements/assessments was scored with a maximum of 5–15 points. A total score of 100 points indicates a normal foot, 99–85 points an excellent result, 84–70 points a good result, 69–60 points a fair result and a score less than 60 a poor result.

Results

In one patient, the talus subluxed anteriorly during the distraction phase and impingement occurred between the trochlea tali and the tibia. The subluxation was corrected by changing the position of the distraction rods. In another patient, 15 years of age, partial separation of the distal tibia epiphysis on the medial side was revealed at routine radiography. As the growth plate was expected to start fusing in the near future, no action was taken. Superficial pin tract infection, which resolved on oral antibiotics, was seen in several cases. No neurovascular complications or osteomy-

elitis occurred. During the correction of the equinus deformity, progressive flexion position of the toes was seen in our first cases. These contractures were later successfully prevented from occurring by the use of rubber bands around the toes, connected to the IEF which applied forces to the toes in a dorsal direction.

The equinus deformity prior to application of the IEF was severe (≥ 30°) in 9/10 feet and 1 foot was plantigrade in standing position. At the follow-up examination, mild (5°–20°) equinus deformity was found in 5 feet and 5 feet were plantigrade. The median ankle joint motion measured 25.5° (5°–35)° and was 20° or less in 4 out of 10 feet.

The median lateral talocalcaneal (TC) angle was 20° (0°–40°) and the median AP TC angle was 10° (0°–27°) (Table 1). The median tarsometatarsal-1 angle was 16° (4°–23°). The TC-index was 40° or more (acceptable) in 4 of 10 feet and less than 40° (poor) in the remaining 6 feet.

6 of 7 patients and parents were satisfied with the correction (Table 1) and all except one reported better walking ability. In the patient who was not satisfied and who had had both feet corrected with the IEF, the total range of ankle joint motion measured only 5° on both sides, compared to 10°–35° in the remaining patients. For 8 feet they reported fewer problems in finding shoes that fit and for 4 feet less stiffness. 6 felt that their feet looked better after treatment. No patient reported increased stiffness of the ankle joint. Walking distance, however, was slightly limited in all patients except one, and pain was occasionally experienced in 6 of 10 feet.

The overall functional results, according to the classification by Lehman et al. (1990), was fair in 3 feet (60–69 points) and poor in the remaining 7 feet (59 points or less) (Table 1).

Discussion

An ideal rating system for assessing the overall results of treatment of clubfoot deformities is not yet available (Cummings et al. 1994). We primarily reviewed the patients' and parents' own assessment of the results and found that 6 of 7 were satisfied. The reported benefit of the treatment included better walking capacity, better appearance of the foot, less stiffness and fewer problems in finding shoes that fit. We also used the functional rating system of Lehman et al. (1990), which takes into account both clinical and radiographic results as well as the patients' own assessment. Using this rating system, the results were considerably less successful: in 3 feet the results were fair and in 7 feet poor (Table 1). Whether the high number of poor results was due to the fact that this rating system does not assess the results correctly or to poor selection of patients suitable for this procedure, it was not possible to evaluate.

Desgrippes et al. (1992) believed that many of the multioperated clubfeet treated with an IEF for recurrent deformities would ultimately require arthrodesis. On the other hand, they maintained that by using the IEF it was possible to correct the equinus deformity and realign the hindfoot, which is in agreement with our findings. Thus, in our patients, severe equinus of the hindfoot was seen in 9 of 10 feet prior to the application of the IEF. 4 of these 9 feet were plantigrade in the standing position at follow-up. For the remaining 5 feet, with residual mild equinus deformity, we believe that, by prolonged distraction in the IEF, it would probably have been possible to achieve a plantigrade position.

We found that ankle joint motion remained considerably reduced in 5 (20° or less) of 10 feet. As no patient or parent reported increased stiffness of the ankle joint after treatment in the IEF we feel that the reduced ankle joint motion was caused by the previous failed soft tissue procedures rather than by the distraction treatment.

In a previous review of our patients, the follow-up period was less than 2 years for 5 patients (8 feet). With the aim of increasing the follow-up period to at least 2 years, these 5 patients were re-examined. At the last examination, the Lehman score was found to have declined in 3 of these 8 feet. We thus feel that at least 2 years' follow-up is needed, especially in growing children, before one can reliably assess the outcome in clubfeet treated with the IEF.

Whether a constrained (i.e., with hinges) or an unconstrained model of the IEF should be used has previously been discussed by Paley (1993). We agree with his conclusion that the unconstrained model allows better tolerance when choosing the center of rotation. It also seems necessary to use an unconstrained model when treatment focuses on correcting deformities simultaneously at more than one joint.

Several complications have been reported using the IEF when correcting foot deformities, e.g., pin tract infection, dysesthesia, pain etc. (Grill and Franke 1987, Cantin et al. 1994). In our patients, two serious complications occurred: anterior subluxation of the talus and partial separation of the distal tibial physis. At review, both these patients were doing as well clinically as the others. Superficial pin tract infection was frequently seen, but resolved on using oral antibiotics. Neurovascular problems or pain necessitating readmission to the ward were not seen.

We are still at the beginning of the learning curve when using the IEF for correction of residual foot deformities in the multioperated clubfoot. This technique makes it possible to correct severe equinus deformities. However, persistent reduction of ankle joint motion remains a problem. We therefore believe that, when assessing the treatment of the multioperated clubfoot, a rating system which is focused on function (gait) more than on position of the foot when standing should be used. Furthermore, successful IEF treatment necessitates co-operation with the patients. Careful selection of children who are mentally stable and extensive information about the procedure to the child and parents prior to the application of the fixator are essential. Larger series and a longer follow-up are needed before we can decide at what age and for what deformities this procedure is most appropriate.

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