Early intensive treatment of clubfoot.

75 feet followed for 6–11 years

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47 consecutive children with 28 bilateral and 19 unilateral clubfeet were treated during the neonatal period according to a strict protocol including physiotherapy and bracing from the first 2 weeks of life; further, in most of the children, an operation was performed at 3 (2–5) months of age. Physiotherapy was continued during the first year of life and bracing for 3 years. 27 feet had repeat operations. No peroperative or postoperative complications were seen.

At follow-up at aged 8 (6–11) years, the cosmetic result was good in 62 feet, acceptable in 12 feet, and poor in 1 foot, whereas the functional result was excellent in 51 feet, good in 21 feet, and fair in 3 feet. The radiographs showed a higher lateral talocalcaneal angle in the control feet than in the treated feet; but in other radiographic aspects, no differences were seen. The need of a secondary or even tertiary operation did not indicate a poor result.

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Treatment of clubfoot usually consists of a combination of bracing, casting, physiotherapy, and operation (Reimann 1967, McCauley 1972, Taylor et al. 1976, Turco and Spinella 1982). The trend during the last few decades has shifted towards early aggressive treatment including early operation (Reimann and Becker-Andersen 1974, Main et al. 1977, Ryöppy and Sairanen 1983). The evaluation of the result of clubfoot treatment is not easy, as there is no consensus on how to describe the outcome of treatment. Various subjective and objective methods have been described (Main and Crider 1978, Laaveg and Ponseti 1980, Sompi 1984, Lau et al. 1989). Most presentations in the literature contain a mixture of early cases and late referral cases, which makes it even more difficult to evaluate the effects of the treatment (Laaveg and Ponseti 1980, Somppi 1984, Lau et al 1989). Gait analysis does not seem to reflect the clinical outcome (Otis and Bohne 1986).

We report a consecutive population-based series of patients treated according to a strict protocol reflecting the trend of early active treatment. At follow-up, cosmetic, functional, and radiographic results have been studied a minimum of 6 years after initiating treatment.

Patients and methods

53 children were referred to our department for idiopathic nonteratogenic clubfoot during the first 2 weeks of life from 1979 to 1984 inclusive. 5 children had moved to other parts of the country and 1 child had died, which left 47 children (32 boys and 15 girls; Table 1). In 28 children the deformity was bilateral and in 19 unilateral, so totally 75 treated feet were followed up.

The treatment protocol included daily treatment by a physiotherapist with special interest and training; further, the parents were instructed to perform corrective manipulation at home twice daily. A plastic brace (Figure 1) was fitted to the foot and adjusted in accordance with the improved position of the foot. The orthopedic technician thus worked in close collaboration with the physiotherapist. After 2–5 (recently after 2) months of treatment, a decision was made concerning an operative soft-tissue release, which was performed in all the feet with residual deformity. In the event of an operation, the foot was immobilized in a plaster cast for 5 weeks, followed by a dynamic splint (Figure 2). If operative treatment was not instituted, the dynamic splint was applied earlier. During this period, the child was treated by the physiotherapist once a week and by the parents twice daily. At 6 months of age, the visits to the physiotherapist were reduced to one every second week, and after 1 year of age one visit every fourth to sixth week depending on the appearance of the foot. From 1 to 3 years of age, the dynamic splint was used only at night. The majority of patients wore antivarus shoes when walking. When the physiotherapist and/or the surgeon noted that the foot had deteriorated, a repeat operative correction was recommended. At 3 years of age, all the

Table 1. Data of 75 idiopathic nonteratogenic clubfeet in 47 children

Case	Sex	Side	A	B	C	D	E	F	G	H	I	J	K	L	M
1	M	R	10.6	12.0			1	0	0	2	36	21	22	43	0
2	F	L	7.9	2.3			1	0	0	1	40	9	27	36	10
3	M	R	10.8	3.9			1	0	0	3	35	5	18	23	0
		L	10.8	3.9	5.3		1	0	1	2	35	11	18	29	20
4	F	R	8.8	17.6			0	0	1	1	40	10	38	48	16
		L	8.8	17.6			0	0	1	1	40	10	30	40	9
5	F	R	8.8	2.2			1	0	0	1	40	13	28	41	0
6	M	R	6.9				0	0	0	2	35	16	28	44	5
		L	6.9				0	0	0	1	35	20	25	45	0
7	M	R	11.0	2.9			1	0	0	1	35	11	11	22	−4
		L	11.0	2.9			1	0	0	1	35	12	18	30	0
8	M	R	11.2	2.9			1	0	0	1	35	8	20	28	4
		L	11.2	2.9	2.6		1	0	1	1	35	19	20	39	0
9	M	R	7.9	2.6			1	0	0	1	36	17	36	53	8
		L	7.9	2.6			1	0	0	1	36	17	26	43	19
10	M	R	11.2	3.5			1	0	0	1	40	18	21	39	−9
		L	11.2	3.5	5.7		1	0	0	1	40	22	23	45	10
11	M	R	9. 2	2.9	0.2		1	0	0	1	40	17	32	49	0
12	M	R	9.8	5.1	7.8		1	1	0	2	37	14	28	42	6
		L	9.8	5. 1			1	0	0	2	37	16	20	36	12
13	M	R	6.2	2.0			1	0	0	1	35	13	16	29	14
		L	6.2	2.0			1	0	0	1	35	20	24	44	13
14	M	R	9.9				0	0	0	1	40	7	23	30	6
		L	9.9				0	0	0	1	40	10	32	42	−8
15	M	L	9.9	2.9	2.4		1	0	0	1	35	11	25	36	18
16	M	R	9.3	1.8	5.6	6.0	1	0	1	2	33	10	7	17	8
		L	9.3	1.8	3.9	5.6	1	0	1	2	33	9	15	24	11
17	M	R	8.9	2.9	6.3		1	0	1	1	37	8	26	34	12
		L	8.9	2.9	6.3		1	0	1	1	37	12	16	28	9
18	M	R	8.5	2.4			1	0	0	1	37	18	14	32	8
19	F	R	5.9	2.1	4.5		1	1	1	2	32	10	19	29	8
		L	5.9	2.1	4.5		1	1	1	2	30	11	15	26	0
20	F	R	5.8	1.7			1	0	0	1	40	15	21	36	0
		L	5.8	1.7			1	0	0	1	40	21	28	49	0
21	M	L	5.6	2.1			1	0	0	1	37	23	1.5	3.8	0
22	F	R	5.8				0	0	0	1	37	2	25	27	14
23	F	L	6.2	1.9	4.8		1	1	1	2	30	21	20	41	25
24	M	R	6.4	2.4			1	0	0	1	40	16	26	42	−5
		L	6.4	2.4			1	0	0	1	40	15	28	43	7
25	M	R	7.6	2.2	3. 1	6.4	1	1	0	2	30	8	8	16	8
26	M	R	8.0	2.2			1	0	0	1	32	14	37	51	0
27	M	R	8.0	2.2	2.4		1	0	0	1	40	20	31	51	0
		L	8.0	2.2	2.4		1	0	0	1	40	15	36	51	0
28	M	R	8.2	2.5			1	0	0	1	40	20	23	43	10
		L	8.2	2.5	6.1		1	1	0	1	35	21	37	58	0
29	F	R	6.8	2.1	6.4		1	1	0	1	35	12	23	35	11
		L	6.8	2.1	4.7		1	1	0	1	35	0	17	17	11
30	M	R	7.0	2.8			1	0	0	1	37	11	21	32	3
		L	7.0	2.8			1	0	0	1	37	10	15	25	15
31	F	L	7.3	2.6			1	0	0	1	40	13	26	39	0
32	M	R	10.1	2.4	6.2		1	0	1	1	40	14	18	32	0
		L	10.1	2.4	6.2	7.3	1	1	1	1	40	8	12	20	8
33	M	R	7.3	3.0			1	0	0	1	40	12	32	44	0
34	M	R	6.4	3.0			1	0	0	1	40	20	35	55	7
35	M	R	5.9	1.9			1	0	0	1	40	31	20	51	0
		L	5.9	1.9			1	0	0	2	35	18	19	37	16
36	F	R	7.4	4.0			1	0	0	1	37	13	25	38	7
		L	7.4	4.0			1	0	0	1	37	17	15	32	8
37	M	R	6.9				0	0	0	1	40	25	41	66	−10
		L	6.9				0	0	0	1	40	19	34	53	0
38	M	R	7.2	2.5			1	0	0	1	40	20	32	52	−9
		L	7.2	2.5	2.8		1	0	0	1	38	15	24	39	4
39	F	R	9.0	3.0			1	0	0	1	40	9	36	45	0
		L	9.0	3.0			1	0	0	1	40	16	34	50	0
40	F	R	5.9	2.2			1	0	0	1	40	25	19	44	12
41	M	R	9.0	2.2	5.0		1	0	0	1	40	15	18	33	1
		L	9.0	2.2			1	0	0	1	40	19	22	41	−10
42	F	R	7.0				0	0	0	1	40	22	33	55	7
43	M	R	10.2	4.6			1	0	0	1	40	10	14	24	0
		L	10.2	4.6			1	0	0	1	40	12	26	38	4
44	M	L	7.4	5.0			1	0	0	1	40	16	25	41	0
45	F	L	6.6	2.1			1	0	0	1	40	15	30	45	3
46	M	R	6.6	3.2	6.0		1	0	0	1	40	21	34	55	8
47	F	R	6.8	2.4			1	0	0	1	35	24	20	44	0
		L	6.8	2.4	4.8		1	0	1	1	35	14	15	29	4

A Age at follow-up (yr)
B Age at operation 1 (mo)
C Age at operation 2 (yr)
D Age at operation 3 (yr)
E Soft-tissue release: 1 yes, 0 no
F Tendon transfer: 1 yes, 0 no
G Osteotomy: 1 yes, 0 no
H Cosmetic result
1 good
2 acceptable
3 poor
I Functional result
36–40 excellent
32–35 good
28–31 fair
< 28 failure
J Talocalcaneal angle AP (degrees)
K Talocalcaneal angle lateral (degrees)
L Talocalcaneal index J + K
M Talometatarsal I angle AP (degrees)

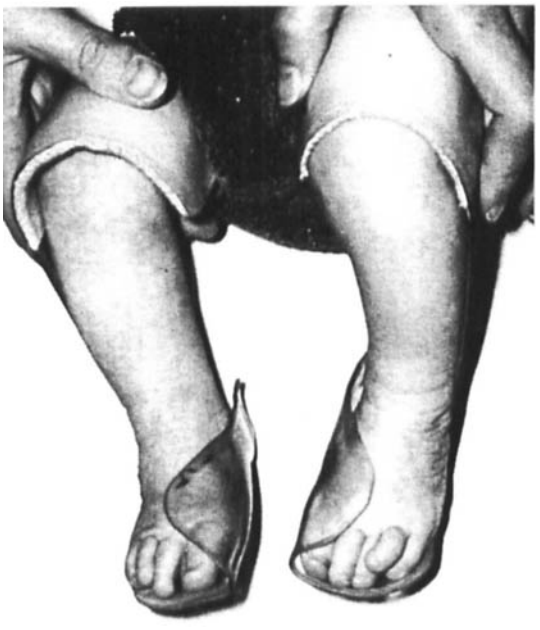

Figure 1. Plastic brace worn during the first few months of life. The brace is adjusted as the deformity decreases.

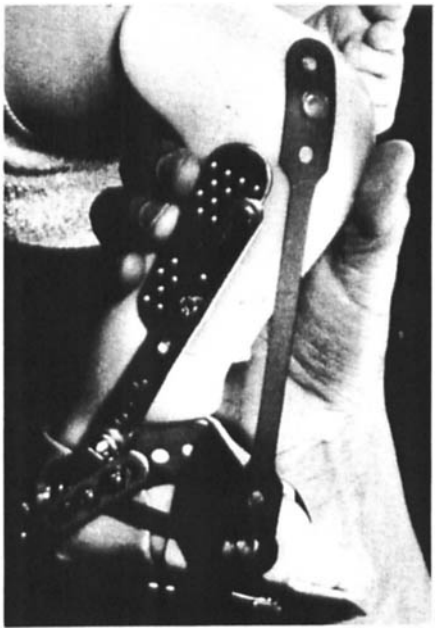

Figure 2. Dynamic brace, worn 24 hours a day until the child starts walking, thereafter only nightly.

active treatment was discontinued, and only a clinical follow-up examination, once or twice a year, was carried out until the age of 7 years.

At a mean age of 8 (6–11) years, the patients were invited to a clinical and radiographic follow-up examination. This follow-up examination was carried out in accordance with that described by Lau et al. (1989), i.e., cosmetic, functional, and radiographic evaluation. When assessing the cosmetic result, calf atrophy, a short foot, and a decreased leg length were disregarded, because they were considered to be part of the natural history of clubfoot. A good cosmetic result described a foot with all the components of the clubfoot corrected, a plantigrade position, and absence of forefoot adduction. An acceptable cosmetic result required a plantigrade foot, but with mild residual deformities. A poor cosmetic result contained significant residual deformity or overcorrection.

The functional assessment was made on a 40-point scale (Table 2). Thirty-six to 40 points was considered to be an excellent result, 32–35 points a good result, 28–31 points a fair result, and less than 28 points a failure. The radiographic investigation included an anteroposterior (AP) view of the whole foot and a lateral view in forced dorsal flexion (Figure 3). The AP and lateral talocalcaneal angles, and the AP talometatarsal I angle were determined; and the talocalcaneal index (sum of AP and lateral talocalcanear angles) was calculated. Other deformities in the foot, such as,

Table 2. Functional rating system (Lau et al. 1989)

Parameters	Points
Activities (10 points)	
No limitation	10
Occasionally limits vigorous activities	6
Usually limits activities	4
Limits walking	2
Pain (12 points)	
Never painful	12
Occasional mild pain during vigorous activities	10
Usually painful after vigorous activities	8
Occasionally painful during routine activities	6
Painful during walking	4
Heel Position (5 points)	
Neutral/mild valgus	5
Severe valgus (10°)	0
Varus	0
Ankle Motion (5 points)	
Dorsiflexion more than 10°	5
Neutral to 10° dorsiflexion	2
Fixed equinus	0
Subtalar motion (2 points)	
Satisfactory	2
Unsatisfactory	0
Gait (6 points)	
Normal	4
Can heel walk	+1
Can toe walk	+1
No push-off	−1
No heel-strike	−1
Total	40

Excellent 36–40; good 32–35; fair 28–31; and failure < 28.

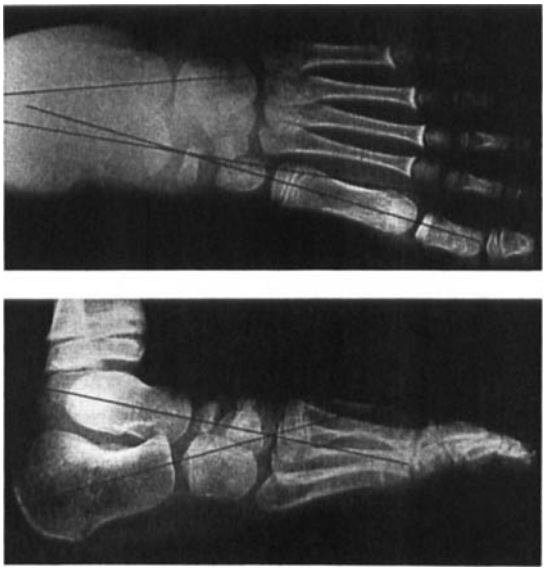

Figure 3. Radiographic examination at follow-up: AP view and lateral view in forced dorsal extension.

Table 3. Operative procedures

	Op 1	Op 2	Op 3	Op 4
No. of operations	67	25	4	1
Age at operation	0.2–1.5	2.5–8	5–7	6
Soft-tissue release	65	17	1	–
Tendon transfer	–	7	2	–
Osteotomy	2	11	3	1
Complications	–	–	–	–

Table 4. Cosmetic result

	Total	Operated on	Not operated on
Good	62	55	7
Acceptable	12	11	1
Poor	1	1	–

talonavicular subluxation and necrosis of the talar head or trochlea, were sought (Simons 1978). The contralateral foot of the 19 patients with a unilateral clubfoot was used as a control foot in the radiographic evaluation.

Using regression analysis, the cosmetic, functional, and radiographic results of the 75 treated feet were compared with each other.

Operations

Of the 75 feet, 67 were operated on (Table 3). This operation included lengthening of the achilles tendon, the TP (tibialis posterior) tendon, the FDL (flexor digitorum longus) tendon, and the FHL (flexor hallucis longus) tendon in almost all the cases. A posterior talocrural capsulotomy was carried out in the vast majority, and in 7 cases the talocalcaneal joint was opened posteriorly. In one third of the cases, also a capsulotomy of the talonavicular joint and a division of the plantaris fascia were performed. One child with bilateral clubfeet had a derotation osteotomy of the lower legs as his first and only operation at 1.5 year of age. In all the other children except 1, the first operation was carried out between 2 and 5 months of age. A second operation was performed on 25 feet at a patient age of 4 (2.5–8) years (Table 3). In a little less than half of these patients, this second operation was solely a soft-tissue release, whereas in 7 cases the anterior tibial tendon was transferred to the lateral side of the foot. In addition, one derotation osteotomy, eight Dwyer osteotomies, and two midtarsal osteotomies were performed. A third operation was performed on four feet in 4 patients aged 5, 6, 6, and 7 years (Table 3). Two midtarsal osteotomies, one Dwyer osteotomy, and two transfers of the anterior tibial tendon were carried out. Finally, 1 boy underwent a fourth operation at 6 years of age, a midtarsal osteotomy (Table 3). In none of the operations were peroperative or postoperative complications recorded. The operations were performed by 6 surgeons.

Results

Cosmetics

At the follow-up, 62 feet were classified as good, 12 as acceptable, and one as poor (Tables 1 and 4). No differences were seen between operated on and non-operated on feet.

Function

51 feet scored an excellent result, 21 a good result, and 3 a fair result (Tables 1 and 5). No functional failures were seen. Half of the patients achieved the maximum

Table 5. Functional result

	Control feet	Club feet	
		Operated on	Not operated on
Excellent[a]	19	45 (12)	6
Good	–	19 (10)	2
Fair	–	3 (3)	–
Failure	–	–	–
Total	19	67 (25)	8

[a]See Table 2. Figures within parentheses denote feet operated on more than once.

40 points in the functional evaluation; and even with repeated operative treatment, the functional outcome was favorable. There was a correlation between cosmetic and functional result ($k = 0.57$, $r^2 = 0.32$).

Radiography

The median AP talocalcaneal (T–C) angle was practically the same in the treated feet (15°) and the control feet (16°; Table 6). The lateral talocalcaneal angle was smaller in the group with treated feet (24°) than in the control feet (35°), and the talocalcaneal index was lower (39/51). However, there was a considerable overlap between the treated feet and the control feet. No difference was seen as regards the AP talometatarsal I (T–MTI) angle (4.9/1.3°). No complications, such as necrosis of the trochlea tali, and no signs of residual deformity, such as talonavicular subluxation, were seen radiographically. No correlation between radiographic result and cosmetic or functional result was found.

Discussion

The treatment protocol described is strenuous for the parents, and requires an acceptable distance from the home to the hospital, and also highly skilled physiotherapists and orthopedic technicians. If these prerequisites are satisfied, very good cosmetic and functional results can be obtained. It should also be noted that neither peroperative or postoperative complications nor radiographic complications occurred, which is unusual in the literature. No case of talonavicular subluxation as a sign of insufficient correction of forefoot adduction was seen.

The radiographic evaluation is of limited value as has been noted previously (Beatson and Pearson 1966, Main and Crider 1978, Simons 1978, Lau et al. 1989). This is emphasized by the great overlap between the control feet and the treated feet in our study. We did not find the correlation between the radiographic and the functional score denoted by Yamamoto and Furuya (1988). The decrease in the lateral talocalcaneal angle in the treated feet probably represents a still highly located calcaneus, although this was not apparent clinically. Translocation of the hindfoot as an effect of overcorrection is not unusual, and seems to be related to subtalar release in young infants. Although 64 operations were performed during the first 6 months of life, no case of overcorrection was seen, which is in contrast to the results of Goldner (1979) and Lau et al. (1989). This may partly be explained by the low rate, of navicular/subtalar release (22/65) and partly by the fact that our navicular release, when performed, was not extensive. A complete subtalar release is probably not indicated at the first operation (Yngve et al. 1990), possibly not even capsulotomy of the talocalcaneal joint.

The functional score, adopted from Lau et al. (1989), focuses on activity, pain, heel position, ankle mobility, subtalar mobility, and walking pattern. The two factors that reduced the scores in the majority of

Table 6. Radiographic result

	Functional score	T-C angle AP	T-C angle lateral	T-C index	T-MT1 angle AP
Club feet (n 75)					
Median	37	15	24	39	4.9
SD	*2.9*	*5.6*	*7.7*	*11*	*7.2*
Range	30–40	0–31	7–41	16–66	–10–25
Control feet (n 19)					
Median	40	16	35	51	1.3
SD	*0*	*6.0*	*6.6*	*9.4*	*7.0*
Range	40	0–27	21–45	33–65	–13–15

our patients with less than 40 points were the ankle and the subtalar mobility. This is probably of minor importance, as it did not affect the walking pattern, the activity, or the heel position in the majority of the cases.

As regards the operative therapy, it seems surprising that repeat operations were not prognostically negative factors, which has been claimed by other authors previously (Evans 1961, Somppi 1984, Lau et al. 1989), although the functional result tended to be somewhat inferior. However, it is advantageous to avoid osteotomies in this group of growing children (Björnnes 1975, Goldner 1979, Turco 1979). Possibly, a more aggressive treatment of recurrent deformity with tendon transfer could replace some of the osteotomies, for example, transfer of half of the anterior tibial tendon (Hoffer et al. 1974). Another development is soft-tissue corrections of the foot by means of the external fixator of Ilizarov, which probably can be of help in the future in children with residual bone deformities and in late cases (Grill and Franke 1987).

We are well aware that our treatment program is not universally applicable in all of its aspects. Additional studies should subsequently determine whether or not in the future similar results can be achieved exclusively by casting or by a less surgically oriented approach. Today, the scoring system described by Lau et al. (1989) is probably superior to other scoring systems for evaluating clubfeet. Further, this evaluation system makes possible comparisons of the various methods of treatment.

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