Journal of Pediatric Orthopaedics
17:490–495 © 1997 Lippincott–Raven Publishers, Philadelphia

Complete Subtalar Release in Resistant Clubfeet: A Critical Analysis of Results in 146 Cases

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Study conducted at Regional Children's Hospital, St. Petersburg, Russia

Summary: A series of 101 patients (146 feet) with resistant clubfoot corrected by complete subtalar release is presented. A detailed rating system was used to evaluate the results. Minimum follow-up was 2 years. Fourteen feet (9.6%) had undergone additional surgical procedures at the time of review, and 101 feet (69%) had excellent or good functional ratings at that time. The mean total ankle motion was 34.2° (range, 8–56°). The better results occurred in feet without previous surgery. Final ankle range of motion was increased by using a special flexed-knee cast with reserve space above the foot. Longer follow-up is needed to determine the optimal age for surgery.
Key Words: Clubfoot—Complete subtalar release—Rating system.

There are many treatment regimens for clubfoot. Some authors recommend manipulations with minimal multistaged surgery (2), whereas others recommend neonatal corrective surgery (7). It is impossible to compare objectively various treatment programs, because their authors use different criteria to evaluate results. Only a few investigators described long-term results of complete subtalar release (1,3,5,9). The number of feet in these published series ranged from 17 to 55.

A detailed functional rating system for clubfoot was used in this study. Positive and negative points were assigned, with major complications scoring most negatively. Priority in evaluation was given to clinical criteria. Range of ankle motion was documented by radiographs. The purpose of this study was the analysis of clubfeet corrected by complete subtalar release. The advantages and disadvantages of this surgical approach are presented.

MATERIALS AND METHODS

At Regional Children's Hospital (St. Petersburg, Russia), complete subtalar release (4) was first performed in 1989. Between that time and May 1993, 129 patients with 189 clubfeet underwent this procedure. Of these, 14 patients with 22 teratologic or neuromuscular clubfeet were excluded from review, leaving a group of 115 patients with 167 clubfeet. Of this group, 14 patients (21 feet) were lost to follow-up. This article presents results in 146 patients with idiopathic clubfeet who returned for examination.

All feet were initially treated by serial long-leg plaster of paris casts for a minimum of 5 months. Nonsurgical treatment was successful in 40% of cases (165 feet); 248 feet failed cast treatment and underwent surgery. The indications for complete subtalar release were the presence of hindfoot varus after previous treatment and uncorrected horizontal calcaneal rotation beneath the talus, which causes toeing-in.

The Cincinnati incision and soft-tissue releases were performed as described by McKay (4) and Simons (8) with the variations listed subsequently. In feet with rigid forefoot adduction after correction of the calcaneocuboid and talonavicular joints in which the calcaneal-second metatarsal angle was >30°, capsulotomies of the navicular–first cuneiform and first cuneiform–first metatarsal joints were added. The tendo Achilles was lengthened in the coronal plane. The interosseous talocalcaneal ligament was preserved when calcaneal rotation could be easily corrected. At wound closure, the lower skin margin was displaced medially in relation to the upper margin. One talonavicular and two talocalcaneal pins were inserted in all feet. The talonavicular pin was directed from posterior to anterior. One calcaneocuboid pin was used in cases with marked medial displacement of the cuboid. In feet with marked forefoot adduction, an additional pin was directed from the calcaneus into the first metatarsal to maintain correction of the forefoot. We supervised or performed all procedures.

At the end of the procedure, a long-leg, flexed-knee plaster cast was applied. The foot was positioned in ex-

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ternal rotation (thigh–foot angle, 10–15°) and neutral dorsiflexion or slight equinus. Extra space was created above the foot to provide early ankle motion. The cast application (with reserve space) was performed as follows (Fig. 1): a special elastic pad was placed on the dorsal aspect of the foot before the cast application and fixed with a cotton bandage. The plaster cast was applied. After the cast was set, the elastic pad was removed, leaving a reserve space on the dorsal aspect of the foot. The cast was changed after 24 h and again 2 weeks later. Foot displacement into dorsiflexion occurred spontaneously and also with manipulations. Manipulations into dorsiflexion were started after the swelling decreased, on about the fifth to seventh day after surgery. A thumb was positioned below the foot to provide passive dorsiflexion. This manipulation was done by the surgeon or parent several times a day. The patient also could actively dorsiflex the ankle.

The foot was gradually brought into neutral position. The next cast change took place 4 weeks after surgery. At this point, pins and sutures were removed, and careful manipulation of the foot (especially into plantarflexion) was performed by the surgeon. Another long-leg, flexed-knee cast with reserve space was applied for 3 more weeks. Finally, the foot was positioned in a short-leg cast for 4–6 weeks.

A detailed rating system for functional results was used, with 150 points indicating a normal foot (Table 1).

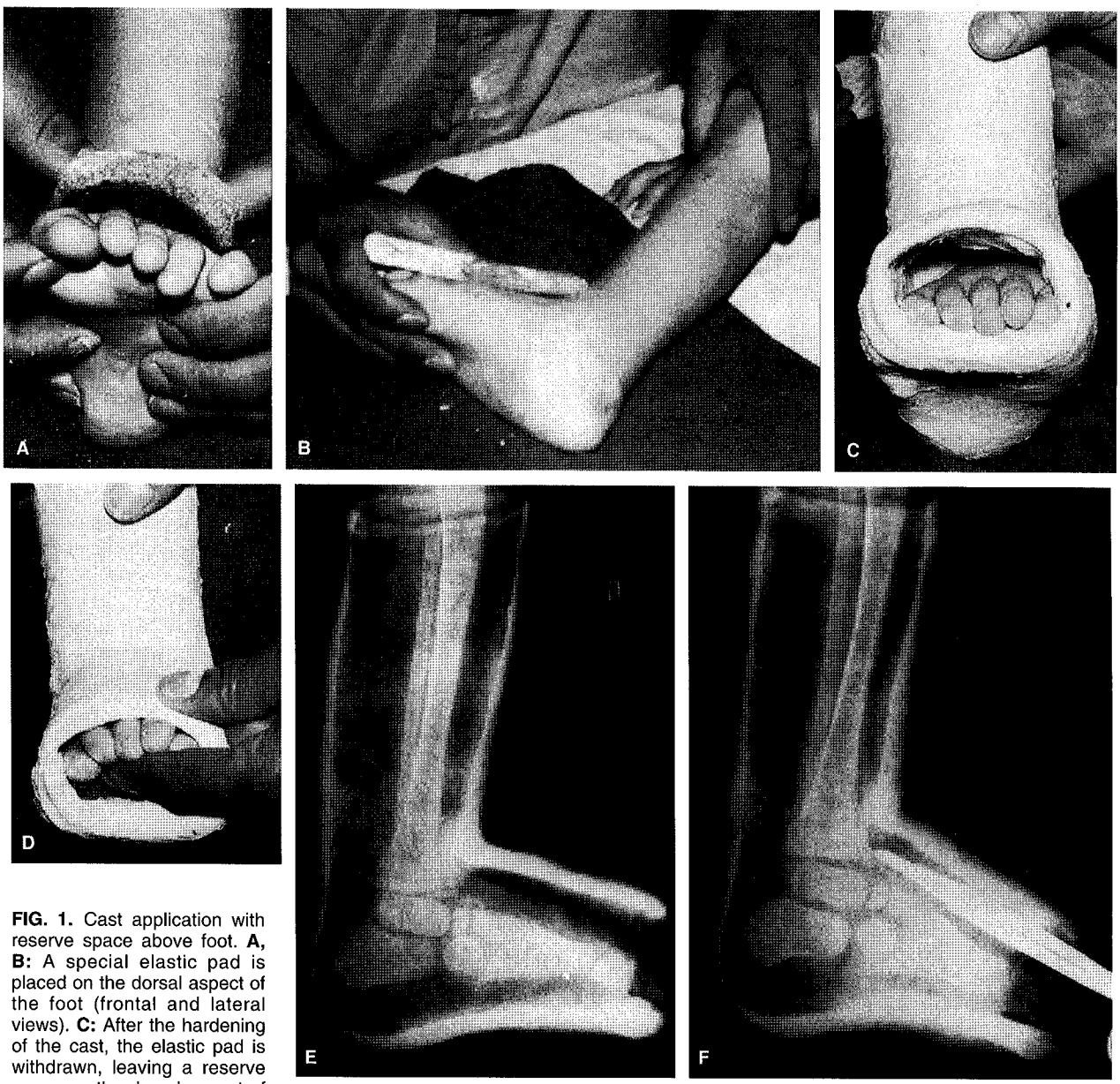

FIG. 1. Cast application with reserve space above foot. **A, B:** A special elastic pad is placed on the dorsal aspect of the foot (frontal and lateral views). **C:** After the hardening of the cast, the elastic pad is withdrawn, leaving a reserve space on the dorsal aspect of the foot. **D:** A thumb or index finger is positioned below the foot to provide passive dorsiflexion. **E:** Lateral radiograph, showing the reserve space above the foot. **F:** Scissors inserted in the reserve space.

TABLE 1. *Rating system for clubfoot surgery*

Criteria	Level	Points
Gait abnormality	Absent	10
	Only while running	0
	Constant	−10
Shoe type	Regular	10
	Regular + orthopedic	5
	Orthopedic only	0
Pain	Never	10
	With heavy activity	5
	With routine activity	0
Ankle dorsiflexion (passive motion)	15–25 over 90	20
	5–14 over 90	10
	0–4 over 90	0
	<90	−20
Position of heel when standing	0–5 valgus	10
	6–10 valgus	5
	11–20 valgus	−5
	>20 valgus	−25
	0–5 varus	−5
	>5 varus	−25
Appearance of forefoot	Neutral	10
	<5 ADD/ABD	5
	5–15 ADD/ABD	0
	>15 ADD/ABD	−10
Ankle motion by radiograph	>40	30
	31–40	20
	21–30	10
	11–20	0
	<11	−20
Calf atrophy	Absent	5
	Mild	3
	Severe	0
Cavus/planus	Absent	10
	Present	0
	Rocker-bottom or dorsal navicular subluxation	−10
Foot–knee realignment[a]	External rotation 0–15	10
	Neutral	0
	Internal rotation or external rotation >15	−10
Flexion of great toe	Present	5
	Absent	0
Strength of tricep surae	Weight supported on toes, one foot only	10
	Weight supported on toes, both feet	5
	Weight not supported on toes	0
Functional abilities	Can heel- and toe-walk	10
	Can heel- or toe-walk	5
	Cannot heel- and toe-walk	0

ADD, adduction; ABD, abduction.

[a] General foot position in relation to the knee joint and lower limb as a whole was assessed according to presence or absence of toe-in gait, foot-progression angle, and thigh–foot angle were also evaluated.

Marked residual or secondary deformities (e.g., heel valgus >20°) were assigned negative points. The results were assessed, according to the scores, as follows: excellent (Fig. 2), 111–150 points; good, 71–110 points; fair, 31–70 points; and poor, <31 points. Foot-progression axis, thigh–foot angle, and transmalleolar angle as described by Staheli et al. (10) also were documented.

Our radiographic assessment included an anteroposterior (AP) and two lateral radiographs, as described by Simons (9). Critical analysis was emphasized on radiographs of feet with residual or secondary deformities. Calcaneocuboid evaluation was made according to Thometz and Simons (12).

RESULTS

Of the 101 patients in this study, 54 (53.4%) were boys, and 47 (46.6%) were girls. Of the 146 clubfeet, 70 (48%) were right and 76 (52%) left feet. Forty-three patients (42.6%) had bilateral clubfeet.

Five patients had undergone six prior operative procedures (posterior release in two feet, posteromedial release in three feet, and medial release in one foot). The average age at operation was 13.2 months (range, 5–62). Average postoperative follow-up was 34.1 months (range, 24–62; SD, 8.8).

Seventy feet (47.9%) had external foot–knee rotation, 52 feet (35.6%) had central (neutral) rotation, and 24 feet (16.5%) had internal rotation.

Average range of ankle motion (by radiographs) was 34.2° (range, 8–56°).

At follow-up, equinus was present in 3.4% of feet, hindfoot varus in 2.7%, and heel valgus >10° in 8.9%. Additional findings were calcaneal gait in 10.9% of feet, cavus in 21.9%, forefoot supination in 12.3%, and residual forefoot adduction (averaging 11.2°) in 12.3%.

Calcaneocuboid relationships before surgery were classified, according to Thometz and Simons, as follows: grade 0, 39 feet; grade I, 93 feet; and grade II, 14 feet. Postoperatively, the classifications were as follows: grade 0, 117 feet; grade I, 27 feet; and grade II, 2 feet. Feet with minimal calcaneocuboid malalignment had a good clinical appearance, and an insignificant radiographic talonavicular overcorrection was frequently seen.

The mean rating at follow-up was 102.1 points (range, −22 to 148; SD, 28.5). The results were assessed as excellent in 22.2% of feet, good in 46.8%, fair in 27.3%, and poor in 3.7%. To compare our results with those of other authors, we used the Magone et al. rating system (3). Our average rating using this system was 83.3 points. Complete subtalar release in the series of Magone et al. yielded an average rating of 78.8 points.

COMPLICATIONS AND SUBSEQUENT SURGERY (Table 2)

Serious wound problems occurred in three feet. Wound dehiscence developed on the posteromedial aspect of the foot medial to the Achilles tendon. Usually it was seen on postoperative days 7–10. The distance between skin margins did not exceed 12 mm. These cases were managed as follows: the talonavicular pin was immediately removed. A long-leg, flexed-knee cast with the foot in external rotation was applied with the "window" over the wound. Antibiotic therapy and laser ra-

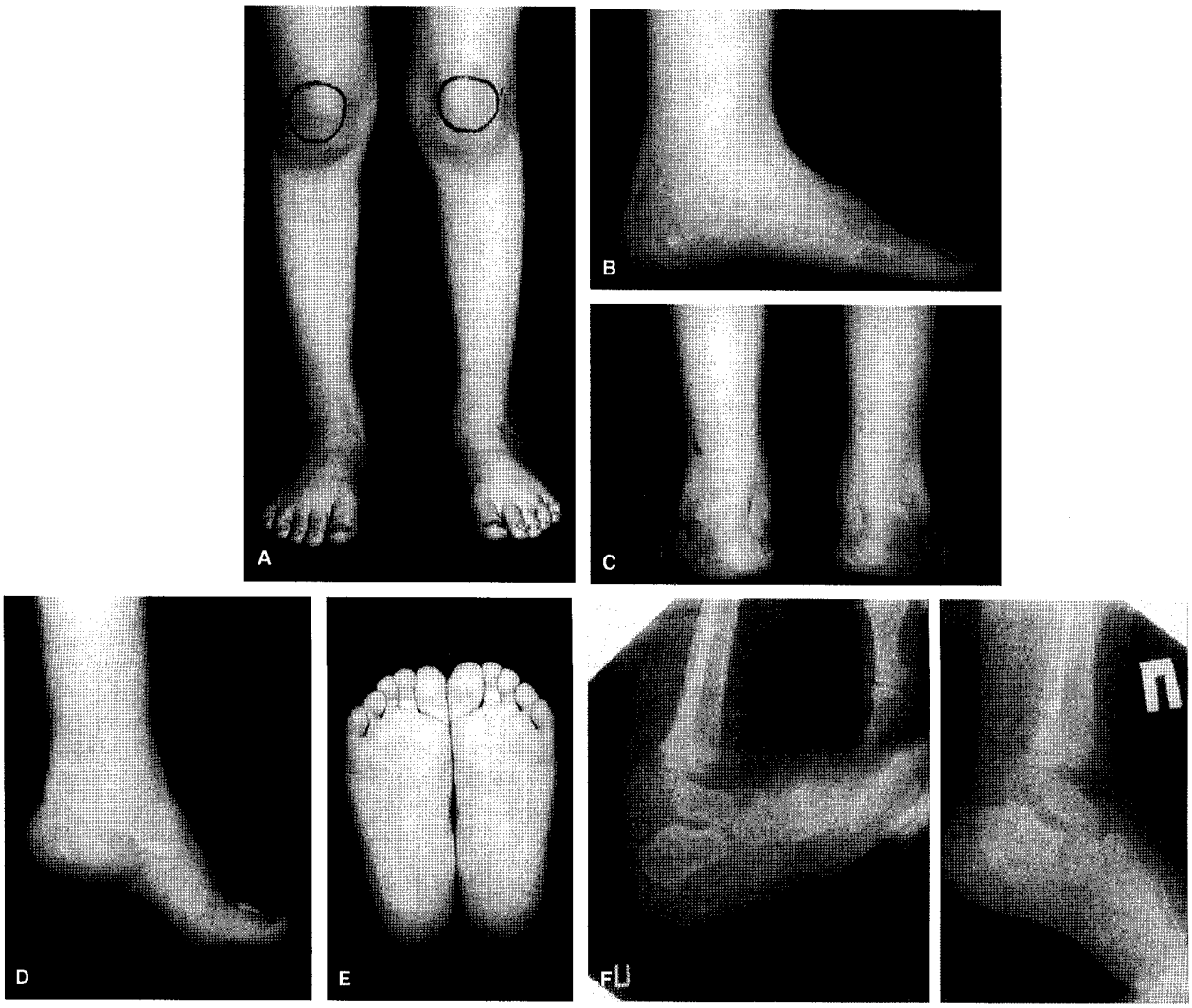

FIG. 2. A 5-year-old boy with excellent result of surgical treatment (rating, 138 points). **A:** External foot rotation in relation to the knee joint is 10°. **B:** Lateral view with normal appearance of longitudinal arch (absence of cavus or planus deformities). **C:** Position of heel when standing is 0°. **D:** Weight supported on toes, one foot only. **E:** Neutral position of the forefoot. **F:** Ankle motion by radiographs is 32°.

diation of the wound were used. Laser treatment was given for 5 min a day for 10–14 days. Technical specifications for our laser therapeutic apparatus "Atoll" are as follows: He-Ne laser, radiation wavelength, 0.6328 μm; average radiation power, 20 mW; density of stream, 0.002 W/mm (square). During the healing period (3–8 weeks), the cast was not removed. At follow-up, these wounds were healed without scarring. We believe that these complications were the result not of infection, but of lack of vascularity. All three feet were rated as good at final follow-up.

Residual equinus was present in five feet. In these cases, postoperative casting had failed to bring the foot into dorsiflexion. AP radiographs showed normal bony relationships, but lateral dorsiflexion radiographs demonstrated decreased talocalcaneal and tibiocalcaneal angles. All these feet underwent posterior release combined with Ilizarov distraction. The Ilizarov apparatus provided gradual correction of resistant equinus deformity over 2–3 weeks. The corrected position of the foot was maintained in the apparatus for 6–8 weeks. Ages at surgery were 19, 26, 29, 37, and 54 months. Three of these feet had good and two had fair results. The mean range of ankle motion in this group was 17.6%, with mean dorsiflexion of 9.3°.

Clinically marked cavus was associated with dorsal navicular subluxation in three feet. Surgical correction in these cases included extensive talonavicular and navicular–cuneiform capsulotomies, plantar dissection, and gradual navicular depression using the olive-wire technique with the Ilizarov distractor. This was combined with elongation of the medial column of the foot. Good results were obtained in all three feet (mean rating, 99.7 points).

Calcaneal gait caused by overlengthening of the Achilles tendon occurred in 16 feet. The mean foot dorsiflexion in this group was 33°, and patients were not able to toe-walk. None of these feet has required additional surgery to date for this complication.

TABLE 2. *Subsequent surgery: clinical summary*

Case	Foot	Age at CSTR (yr/mo)	Residual deformity	Rating after CSTR	Subsequent surgery	Age at subsequent operation (yr/mo)	Final rating	Follow-up (mo)
1	R[a]	4/4	EQ,CA,FA	8	ID	4/6	33	28
2	R	0/9	EQ,CA	18	PR + ID	1/7	90	37
3	R	0/9	EQ,FA,SUP	43	PMR + ID	2/5	73	18
	L	1/1	EQ,CA,FA,VR	−22	PMR + ID	2/2	68	21
4	R	1/3	EQ,CA,FA	43	PMR + Pl.Rel. + ID	3/1	73	26
5	R	1/4	CA′,FA,SUP	63	PMR + Pl.Rel. + ID	4/4	108	24
6	R[a]	2/6	CA′,FA,SUP	48	MR + LR + Pl.Rel. + ID	4/3	93	19
7	R	1/1	CA′,FA	73	MR + Pl.Rel. + ID	4/4	98	25
8	R	0/8	CA,FA,SUP	43	MR + LR + ID	3/10	88	29
9	R	0/5	CA,FA,SUP	68	MR + LR + Pl.Rel. + ID	2/3	93	23
10	L	0/11	CA,FA,SUP	58	MR + Pl.Rel. + ID	1/11	98	27
11	L[a]	1/6	CA,FA,SUP	55	MR + LR + Pl.Rel. + ID	3/7	93	20
12	L	1/3	FA,SUP,VR	18	MR + LR + ID	1/11	78	22
13	R	0/10	CA,FA,SUP	43	MR + LR + ID	2/9	83	30

EQ, equinus; CA, cavus; CA′, cavus associated with dorsal navicular subluxation; FA, forefoot adductus; SUP, forefoot supination; VR, varus; CSTR, complete subtalar release; PR, posterior release; PMR, posteromedial release; Pl.Rel., plantar release; LR, lateral release; MR, medial release; ID, Ilizarov distractor.

[a] Foot had previous operations.

Ten feet (6.8%) had marked forefoot adduction >10°. This complication caused an in-toeing gait even when correction of subtalar calcaneal rotation was achieved. Of these feet, seven had significant medial displacement at the calcaneocuboid joint, as well as medial navicular translation on the talar head from one quarter to one half. In this group, medial release with extensive calcaneocuboid capsulotomy was performed through a lateral incision, and the Ilizarov distractor was applied. Two feet underwent simple medial release, and one foot underwent medial release together with application of the Ilizarov apparatus. At final follow-up, seven feet in this group showed good results, and three feet showed fair results.

Valgus angulation of the hind part of the foot >10° occurred in 13 feet (8.9%). All these feet had normal talocalcaneal angles on the AP radiographs, but talocalcaneal divergence was increased to +3 and +4 (according to Simons' scheme). Eight of these feet had lateral navicular subluxation from one quarter to one half on the talar head. The other five feet showed no significant lateral navicular translation. In our opinion, the valgus heel is a result of lateral displacement of the calcaneus beneath the talus. The total release of all talocalcaneal ligaments (including the interosseous ligament) and inaccurate talocalcaneal pinning cause this complication. Five of seven children with a valgus heel had hyperlaxity of their joints. All these feet may require a Grice procedure in the future.

DISCUSSION

Many have analyzed the results of clubfoot correction, but authors use different criteria to evaluate results. It is therefore difficult to compare objectively various treatment programs and surgical procedures.

Measurement of total ankle range of motion is important in the assessment of corrected feet. Only a few authors (3,5,6,9) verified these data by radiographs. Quantitative evaluation differs in various investigations. Simons (9) indicated that ankle range of motion of at least 25° must be present for a satisfactory result. McKay (5) defined range of motion <35° as an unsatisfactory result. Magone et al. (3) assigned decreasing points for motion from 40° to 0. Stauffer et al. (11) reported that during the stance phase of gait, the average total ankle range of motion was 24.4°, with average dorsiflexion of 10.2° and average plantarflexion of 14.2°. Therefore a normal foot must be plantigrade and should dorsiflex. It is crucial to evaluate not only total range of motion but its components as well, as emphasized by McKay (5) and Brougham and Nicol (1).

The mean ankle motion in our series was 34.2°. We believe that postoperative manipulation of the foot at the time of cast change produces increased ankle range of motion. In our opinion, positioning the foot in an above-the-knee plaster cast in mild equinus at the end of the procedure produces a plantigrade foot in the future. In our experience, casting in maximum dorsiflexion causes postoperative scarring of the anterior ankle capsule, resulting in anterior ankle contracture. A cast with reserve space above the foot also increases the total ankle range of motion.

From our point of view, clubfoot surgery is based on (a) soft-tissue releases of the bones, (b) correction of bony malposition, (c) accurate pin fixation, and (d) restoration of muscle balance if necessary.

The circumferential Cincinnati incision provides the surgeon with the best exposure for soft-tissue release and bony repositioning.

Like Porter (6), we believe that failure of clubfoot correction rests more in the surgeon's hand than in the child's foot. For example, incomplete subtalar release does not allow the surgeon to correct calcaneal rotation beneath the talus. The normalization of the talonavicular

and calcaneocuboid joints requires a complete release of these joints. Otherwise, the forefoot adduction will persist. Full bone repositioning is possible only with bilateral or circumferential surgical approaches.

The type of bony repositioning depends on the surgeon's clubfoot philosophy. Marked medial displacement of the cuboid required surgery in 14 feet in our series. Posteromedial release would not be successful in treatment of these feet.

In the cases of accurate pinning, the previous bony incongruity resolves because of the remodeling potential of bone and cartilage. Failures in bone fixation lead to overcorrection or secondary foot deformities. For example, inaccurate talonavicular pinning may be manifested as a cavus foot with dorsal navicular subluxation or as a planovalgus foot with lateral navicular translation. Inaccurate talocalcaneal pinning when the calcaneus is displaced laterally beneath the talus causes severe valgus deformity.

All the components of clubfoot surgery are interconnected. If the joint releases are incomplete, the surgeon's options for bone repositioning are limited. On the other hand, incomplete joint release may also prevent overcorrection.

We believe that overcorrection and secondary multiplanar foot deformities are the main problems with extensive clubfoot surgery. Therefore, treatment of these complications is of special interest for clubfoot surgeons.

Acknowledgment: We thank Drs. L. Suvorova and Carol Mowery for help in translation and manuscript preparation.

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