Midterm results following revision surgery in clubfeet

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Abstract Relapse rates of surgically treated clubfeet are about 25%. We reviewed 43 patients (57 feet) treated for relapsed clubfoot deformity between 1992 and 2001 in our department. The average age of the patients at the time of revision surgery was 5.1 years, the mean follow-up was 6.6 years. Surgical therapy was performed using an algorithm according to age groups. The mean Atar score at follow-up was 77 points, representing a good outcome. Out of 57 feet, 20 (35%) were rated excellent, 24 (42%) good, 5 (9%) fair, and 8 (14%) poor. The number of previous surgical interventions had no influence on the outcome. Using an age related surgical algorithm, good postoperative results could be achieved in most of our patients, thus improving their functional situation. This emphasises the usefulness of the proposed algorithm in the difficult situation of recurrent clubfoot, while thorough analysis of the underlying deformity remains essential.

Résumé Les récurrences après traitement chirurgical des pieds bots sont relativement fréquentes aux alentours de 25%. Nous avons vu 43 patients (57 pieds) traités pour récurrence de la déformation entre 1992 et 2001. L'âge moyen des patients à la révision était de 5.1 ans, le suivi moyen de 6.6 ans. Le traitement chirurgical a été réalisé selon un algorithme prenant en compte l'âge. Le score moyen d'Atar a été de 77 points, avec une bonne évolution clinique. Sur 57 pieds, 20 (35%) ont été considérés comme excellents, 24 (42%) bons, 5 (9%) comme moyens et 8 (14%) comme mauvais. Le nombre d'interventions chirurgicales utilisées n'influence pas le devenir du pied. L'algorithme selon l'âge a été utilisé pour la plupart des patients de façon à améliorer le résultat fonctionnel. Ceci nous conforte dans l'utilisation de cet algorithme dans les situations difficiles de récurrences de pieds bots. Malgré tout cela, l'analyse des déformations reste essentielle.

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Introduction

Talipes equinovarus is the most common congenital disorder of the extremities. The incidence is about 1–2 per 1,000 live births with regional and seasonal differences [19]. Conservative therapy usually starts soon after birth. Persistent and residual deformities require surgical treatment. The relapse rate of surgically treated clubfeet is about 25% (range, 13–50%) [2]. Forefoot and midfoot deformities are the most common persistent deformities [21]. According to Tarraf and Carroll, residual forefoot adduction and supination are present in 95% of residual clubfeet [24]. In their experience, these deformities result from undercorrection at the time of primary operative treatment. Viskely and Szepesi [25] concluded that relapse is most often the consequence of inadequate primary surgery, but may also

result from originally stiff and nonreducible feet predestined to need multiple reoperations.

In 1994 Lehman et al. [11, 12] published an algorithm for subsequent operative interventions in relapsing clubfeet. Raab and Krauspe [20] presented a similar surgical algorithm according to age groups with emphasis on joint-preserving procedures in children under 8–10 years of age. Unlike Lehman et al. [11, 12], fusion of the calcaneo–cuboid joint, excision of the distal calcaneus (Lichtblau), or cuboid decancellation are not used in this therapeutic regime. Soft tissue release as a peritalar or limited medial and lateral release is recommended as a secondary procedure up to the age of 8–10 years. For revision in patients between 2 and 8 years, a closing wedge osteotomy of the cuboid, a cuneiform osteotomy, and an anterior tibial tendon transfer is suggested in addition to repeated release procedures. In older patients mid-tarsal osteotomies, Ilizarov-frames, or triple arthrodeses are used to correct the deformity in a single or combined procedure (Table 1).

The aim of this study was to evaluate the outcome of revision surgery in clubfeet using this age-related therapeutic algorithm.

Materials and methods

We reviewed 43 patients (57 feet) treated for relapsed clubfoot in our institution between 1992 and 2001. All of them undergone at least one previous operation (range, 1–5 surgeries) for idiopathic clubfoot. Fifty feet (87%) had undergone one, four feet (7%) had two, two feet (4%) three, and one foot (2%) five previous surgical interventions. Fourteen patients (4 girls, 10 boys) suffered from bilateral clubfeet. Eighteen patients (26 feet, 46%) were referred to our hospital after clubfoot surgery in other institutions. Patients suffering from arthrogryposis, spina bifida, or other neuromuscular disorders were excluded from the study. Twenty-nine patients were male and 14 were female. The average age of patients at the time of revision was 5.1 years (range, 1–17 years). Follow-up averaged 6.6 years (range 1–14 years).

At follow-up, all patients were evaluated by a thorough clinical examination and plain radiographs using a standard protocol. Clinical outcome was assessed using the functional rating system described by Atar et al. [2] (Table 2), which contains subjective (functional limitations, pain, satisfaction) and objective (ankle dorsiflexion, subtalar joint mobility, heel position, foot appearance, gait) clinical as well as radiological criteria. The maximum score is 100 points indicating a normal foot. An excellent result is achieved with 85–100 points, 70–84 points are considered good, 60–69 points fair, and less than 59 points represent a poor result. The radiographic evaluation involved radio-

graphs of the forefoot in antero-posterior and lateral weight bearing views preoperatively and at follow-up. Using these radiographs the talocalcaneal index (sum of the lateral and anteroposterior measurements of the talocalcaneal angle) [3] and the talus-first metatarsal angle (measured by drawing lines through the longitudinal axis of the talus and along the longitudinal axis of the first metatarsal) [23] were assessed. A talocalcaneal index $\geq 40^\circ$ shows good correction of the hindfoot [2]. The talus-first metatarsal angle indicates the degree of forefoot adduction. The normal limit was considered $\leq 10^\circ$ [2].

Surgical treatment was performed using an algorithm (Table 1) according to age groups previously published by two of the authors [20].

Statistics

The Wilcoxon signed-rank test (SPSS 11.5.1 for Windows) was used to compare pre- and postoperative variables. *P* values of 0.05 or less were considered significant.

Results

The mean age at revision surgery was 5.1 years (range, 1–17 years). The latest relapse of the deformity with the need for further surgical intervention was noted after an average of 4.2 years (range, 0.5–10) after the last operation. The most common residual deformity was residual forefoot adduction and supination in 51 feet (89%; Fig. 1). On relapse, various surgical procedures were performed using our age-related algorithm (Table 3). The mean Atar score at follow-up was 77 (range 35–100) points, representing a good overall outcome. Out of 57 feet, 20 (35%) were rated

Table 1 Surgical algorithm according to age groups [20]

Age group	Therapy
6 months–2 years	Complete peritalar release with exact subtalar reposition
2–4 years	Complete peritalar release combined with: a. Cuboid osteotomy (adductus deformity) b. Tibialis anterior tendon transfer (supination deformity)
4–8 years	Medial and lateral arthrolysis with: a. Cuboid/cuneiform osteotomy (adductus deformity) b. Tibialis anterior tendon transfer (supination deformity) c. Ilizarov frame (rigid deformity)
Over 8–10 years	Midfoot osteotomy (cavus deformity) Ilizarov frame (rigid deformity) Triple arthrodesis

Table 2 Functional rating system for clubfoot [2]

Criteria	Level	Points
1. Ankle dorsiflection (passive motion)	>90°	15
	90°	5
	<90°	0
2. Subtalar joint (passive motion)	≥15°	10
	<15°	5
	Stiff	0
3. Position of heel when standing	0–5° valgus	10
	>5° valgus	5
	Varus	0
4. Appearance of forefoot	Neutral	10
	<5° add/abd	5
	>5° add/abd	0
5. Gait	Normal	6
	Heel walk	2
	Toe walk	2
	Abnormal heel/toe sequence	0
6. Roentgenogram		
	Talocalcaneal index	
	≥40°	5
	<40°	0
Talus-first metatarsal angle	≤10°	5
	>10°	0
7. Shoe type		
	Regular	
	No pain	5
Orthopedic	With discomfort	2
		0
8. Functional limitations	None	15
	Occasional	8
	Frequent	0
9. Pain	Never	10
	Occasional	5
	Frequent	0
10. Satisfaction	High	5
	Partial	3
	Unsatisfied	0

excellent, 24 (42%) good, 5 (9%) fair, and 8 (14%) poor. Fifty feet had one, four feet two, two feet three, and one foot five previous operations. Statistically the number of previous operations had no influence on the outcome. Seventy-two percent of the feet (41 feet) were painless during daily activities, 26% (15 feet) had occasional mild pain after strenuous activity, and 2% (one foot) complained about frequent pain. Nineteen patients (28 feet, 49%) were able to wear normal footwear, 21 patients (24 feet, 42%) had to wear insoles, and three (five feet, 9%) needed orthopaedic footwear.

The mean talus-first metatarsal angle was 20° preoperatively and 11° at follow-up, showing a sufficient correction of forefoot adduction (Figs. 2 and 3). The mean talocalcaneal index was 30° preoperatively and 42° at follow-up. This shows a good correction of the hindfoot. Both angles showed a statistical trend towards improvement, but failed to reach statistical significance.

Fig. 1 Recurrent clubfoot with pes equinus, adduction, and supination deformity of the foot

We saw three superficial postoperative infections (5%). All of them healed without complications after conservative treatment and oral antibiotics. There were no other postoperative complications such as damage to the neurovascular bundle, injuries to the growth plate, or iatrogenic sensory neuromas. All osteotomies healed in approximately eight weeks.

To investigate the effect of a peritalar release on the outcome of the revision surgery, we divided our patients into two groups: with peritalar release (group 1) and without peritalar release (group 2). Group 1 consisted of 26 patients with 30 feet (53%), group 2 of 17 patients with 27 feet (47%). The average age at revision surgery was 4.5 years (range, 1–8) in group 1 and 6 years (range, 3–17) in group 2. Follow-up was 5.4 years (range, 1–11) in group 1 and 7.9 years (range, 1–14) in group 2. In group 1 the average age at follow-up was 9.9 years (range, 5–17) and the mean Atar score 76.9 points (range, 35–96). In group 2 the average age at follow-up was 14.2 years (range, 4.5–23) and the mean Atar score 76.4 points (47–100). There was no significant difference between both groups indicating a better outcome in one of them. The patients in group 1 were

Table 3 Surgical procedures used for correction of residual clubfeet ($n=57$)

Surgical procedure	Number of feet
Midfoot (cuboid/cuneiform) osteotomy	43
Tibialis anterior tendon transfer	38
Peritalar release	30
Achilles tendon lengthening	22
Medial release	20
Flexor hallucis tendon lengthening	19
Tibialis posterior tendon lengthening	14
Flexor digitorum tendon lengthening	13
Lateral release	6
Plantar release	3

Fig. 2 Preoperative X-ray of a 5-year-old boy with residual clubfoot demonstrating a pathological talo-first metatarsal alignment and rotational deformity. **a** AP view. **b** Lateral view

slightly younger, because according to the algorithm the peritalar release was mostly performed in younger patients.

Discussion

Although relapse is a common problem in clubfoot surgery, there are very few reports concerning mid- and long-term results of this challenging problem. In 1992 Atar et al. [2] reviewed 24 patients with 29 feet treated for relapsed clubfoot using their age-related algorithm. After an average of 30 months they reported 8 excellent (28%), 11 (38%) good, 8 fair (28%), and 2 (6%) poor results. This is a rate of 66% combined excellent and good results and corresponds well with our study where we saw excellent and good results in 77% of our patients, while having a slightly higher rate of poor results (14%).

In a second study in 1999 [11] Lehman et al. reviewed another 20 patients (27 feet) aged 4–8 years who underwent revision surgery according to their algorithm consisting of complete soft tissue release combined with a calcaneo-cuboid fusion. They reported 8 (30%) excellent, 14 good

(48%), 4 fair (14%), and 1 (3%) poor result after a follow-up period of 5–14 years. The rate of excellent or good results was 78%, which also compares well to our results. In their series, only one patient had a rating below 59 points, indicating a poor result, who subsequently underwent a triple arthrodesis. In their hands, revision surgery in the age range of 4–8 years with a soft tissue release and an additional calcaneo-cuboid fusion produced a flexible, functional foot.

In the age group of 2–8 years, we emphasise on joint preserving bony procedures in our algorithm. We recommend the use of a closing wedge osteotomy of the cuboid bone alone up to the age of 4 years eventually combined with an opening wedge osteotomy of the medial cuneiform in older children 8–10 years of age. According to Tarraf and Carroll [24] the most common persistent deformities in the residual clubfoot are forefoot adduction and supination. One key principle in understanding the physiopathology of

Fig. 3 Radiological outcome of the same patient 9 years after surgical correction by medial release, Achilles tendon lengthening, and cuboid-osteotomy demonstrating physiological radiological angles. **a** AP view. **b** Lateral view

the forefoot adductus is the imbalance between an elongated lateral column and a shortened medial column [14]. This “bean-shaped foot” is the result of a combination of forefoot adductus, midfoot supination, and hindfoot varus that produces an elongated lateral column of the foot and thereby an internally rotated gait [10, 15]. The patients usually present progressive deformities affecting their gait, shoe fitting, and sporting endeavours [16]. The opening wedge medial cuneiform osteotomy was originally proposed by Fowler et al. [4] for correction of the cavovarus foot. Later the technique was redefined by other authors [8, 13] for correction of residual forefoot adduction after congenital clubfoot and metatarsus varus. The combination of two commonly used procedures, opening wedge medial cuneiform osteotomy and closing wedge cuboid osteotomy, addresses the pathology in two planes and thereby effects the desired functional clinical improvement [15]. According to Gordon et al. [5], this procedure should be reserved for patients aged 5 years or older because the medial osteotomy is technically difficult in a small, partially ossified cuneiform and there is a high rate of medial graft dislocation with loss of correction. Lourenco et al. [14] treated 39 feet with a closing wedge osteotomy of the cuboid and opening wedge osteotomy of the medial cuneiform with an average follow-up of 4.8 years and saw clinical and radiographic improvement in all patients. They also stressed the importance of a well-formed ossification centre in the medial cuneiform before osteotomy, which is usually present in children older than 4 years. In 1993, McHale and Lenhart [15] reported six patients aged 4–10 years using an opening wedge medial cuneiform and closing wedge cuboid osteotomy and found good resolution of the prominent midfoot supination and forefoot adductus without the need for significant soft tissue dissection and invasion of growing areas in the foot. As part of their study cadaver reproductions showed that the cuboid closing wedge osteotomy is responsible for the change in the midfoot, whereas the cuboid and cuneiform osteotomies both contribute to the change in the forefoot. Schaefer et al. [22] used this combined cuboid/cuneiform osteotomy to treat 27 feet with residual adductus deformity in idiopathic and secondary clubfeet with a mean follow-up of 5.0 years (range, 2.0–9.8 years). At follow-up, all patients with idiopathic (22) and two with secondary clubfeet were free of pain and satisfied with the result. Therefore they concluded that in most idiopathic clubfeet a cuboid/cuneiform osteotomy can provide satisfactory correction of adductus deformity, but those with secondary deformity require other procedures. In our study group, 43 joint preserving midfoot osteotomies were performed and showed the same favourable results with good correction of the adductus deformity.

To investigate the effect of peritalar release on the outcome of the revision surgery, we divided our patients

into two groups: one with and one without peritalar release. There was no significant difference between the two groups. With good clinical results in both groups, there is no statistical evidence against the proposed algorithm.

Following the correction of severe deformities, problems with skin closure can occur. To resolve this problem it is possible to close the skin in undercorrection of the foot, followed by serial casting to correct the residual deformity [2, 7]. It is also possible to use local [9], myocutaneous, or fasciocutaneous flaps [6, 18] or tissue expanders preoperatively [1]. In our series, serial casting was used to avoid these skin problems.

The primary treatment of clubfoot today is still controversial. There is a current trend towards nonoperative treatment of this deformity with favourable long-term results using the Ponseti method with limited surgical intervention (tenotomy of the Achilles tendon) [17]. However, relapses are seen in severe clubfeet whether treated surgically or nonsurgically. Thus, it appears that a strict therapeutic regime is necessary to treat these debilitating deformities.

Conclusion

Relapse rates of surgically treated clubfeet requiring reoperation are about 25%. Using an age-related surgical algorithm excellent and good postoperative results could be achieved in 77% of our patients. We observed a statistical trend towards improvement in radiological forefoot and hindfoot correction, and 91% of our patients were able to wear normal footwear with or without insoles. This shows the usefulness of the proposed algorithm in the difficult situation of recurrent clubfoot, although thorough analysis of the underlying deformity remains essential.

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