Factors predicting the outcome of primary clubfoot surgery

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Background: We aimed to determine the rate of further surgery, the functional outcome and the factors associated with outcome after primary clubfoot surgery. **Method:** We conducted a retrospective study of a cohort of all children who were less than 2 years of age at the time of surgery for idiopathic clubfoot deformity at the Hospital for Sick Children, Toronto, Ont., a tertiary care pediatric hospital. Of the 91 families who could be contacted, 63 agreed to return. The children's charts were reviewed, and their feet were given a Functional Rating System (FRS) score. **Results:** Of the original operated population (n = 126), 75% were male and 41% had bilateral clubfoot. The average age at the time of surgery was 8 months, and the mean follow-up was 80.6 months. Further surgery was performed in 19% of cases. The mean FRS outcome score was 79. On average, the FRS score increased by 1.9 points as age at the time of surgery increased by 1 month. Only the presurgical talocalcaneal index was associated with the need for further surgery. **Conclusion:** The need for further surgery was 19% overall. Children who had surgery closer to 12 months of age had better functional results. Therefore, surgery should probably be performed in the second, rather than the first, 6 months of life.

Contexte : Nous voulions déterminer le taux d'interventions chirurgicales ultérieures, le résultat fonctionnel et les facteurs associés aux résultats après la chirurgie d'un pied bot primitif. **Méthode :** Nous avons réalisé une étude rétrospective d'une cohorte de tous les enfants qui avaient moins de deux ans au moment de la chirurgie d'un pied bot idiopathique à l'Hôpital pour enfants malades de Toronto (Ontario), hôpital pédiatrique de soins tertiaires. Des 91 familles avec lesquelles on a pu communiquer, 63 ont accepté de revenir. On a étudié les dossiers des enfants et attribué à leur pied un score selon le système d'évaluation fonctionnelle (SEF). **Résultats :** La population opérée à l'origine (n = 126) comptait 75 % de sujets de sexe masculin et 41 % avaient deux pieds bots. Les sujets avaient en moyenne 8 mois au moment de l'intervention chirurgicale et le suivi moyen atteignait 80,6 mois. On a procédé à une autre intervention chirurgicale dans 19 % des cas. Le score moyen des résultats selon le SEF s'est établi à 79. Le score SEF a augmenté en moyenne de 1,9 point par mois d'âge au moment de l'intervention chirurgicale. On a établi un lien seulement entre l'index sous-astragalien préchirurgical et le besoin d'une autre intervention chirurgicale. **Conclusion :** Le besoin d'une autre intervention chirurgicale s'est établi à 19 % dans l'ensemble. Plus les enfants approchaient de l'âge de 12 mois lorsqu'ils ont subi leur intervention chirurgicale, plus leurs résultats fonctionnels ont été bons. C'est pourquoi il faudrait probablement procéder à l'intervention chirurgicale au cours du deuxième semestre de vie plutôt que du premier.

Until the recent popularity of the Ponseti method,[1] the most common treatment for children with idiopathic clubfoot was extensive surgical release. Residual or recurrent deformity after surgical correction can cause pain and difficulty with shoe wear and adversely affects the appearance and function of the foot.[2,3] Repeat surgery for children after extensive surgical correction has been reported to vary between 5.3%[4]

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and 47.0% of cases.[5] Although repeat surgery may be necessary to correct deformity, repeat surgery increases stiffness that may in turn lead to loss of function.[6] Thus, children with a well-corrected foot having had the fewest procedures probably have the best function, and any factors associated with the need for further surgery would be important in the management of these children.

Clubfeet requiring repeat surgery have variable deformity, including overcorrection,[7] and the cause of deformity is controversial. Residual deformity is generally believed to be the result of incomplete correction at the time of initial surgery or other factors, such as inadequate wire fixation or inadequate postsurgical splinting.[4] Recurrence after adequate correction of deformity may occur with growth[7] or be the result of scarring[8,9] or talocalcaneal bars.[8] Overcorrection, a rare outcome, has been reported to be more common when children are less than 1 year of age at the time of initial correction.[2,4] Few studies have specifically examined patient and surgical factors that could predict the outcome of clubfoot surgery.[2,8] Although repeat surgery is the most commonly reported outcome, the widely variable rates of repeat surgery may in part be explained by different surgeons' indications for repeat surgery. Furthermore, parents and children may have different thresholds for consenting to recommended surgery. Thus, any study following clubfoot surgery needs to evaluate, in addition to repeat surgical rates, the shape, motion and function of the foot.

The purpose of this study was to determine the functional outcome of surgically released clubfeet and to identify patient and surgical factors associated with repeat surgery and functional outcome.

Methods

We reviewed a cohort of consecutive children who were less than 2 years of age at the time of initial surgery for idiopathic clubfoot deformity between 1988 and 1990 at the Hospital for Sick Children, Toronto, Ont. Hospital charts were reviewed to obtain data about the patient and surgery. Hospital charts provided information concerning the surgeon, surgical technique and the postoperative use of casts and orthotics. Standardized presurgical radiographs including anteroposterior and lateral radiographs (in maximum dorsiflexion) of the feet were used to measure the severity of clubfoot. Radiographic assessment focused on the talocalcaneal index, tarsometatarsal angle[10,11] and the equinus angle (tibiocalcaneal angle).

The surgical technique used was uniform with some minor variations. All children were positioned prone, and a tourniquet was applied. A Cincinnati incision was used. The medial neurovascular bundle and the sural nerve were identified and protected at all times. The origin of the abductor hallucis was released from the calcaneus. The tendons of the triceps surae and tibialis posterior muscles were lengthened by a Z-plasty technique. Flexor hallucis longus and flexor digitorum longus muscles were lengthened with a conjoint Z-plasty. The ankle and subtalar joint capsules were released. The calcaneofibular ligament was released as part of a posterolateral release. The medial ankle release extended as far as the deep fibres of the deltoid ligament. The subtalar joint release also included division of the lateral part of the interosseous ligament. The proportion of the interosseous ligament released depended on the individual surgeon. The talonavicular joint capsule was divided on the medial, dorsal, plantar and, sometimes, the lateral aspects. If the forefoot adduction was resistant to manipulation, then the calcaneocuboid was released. A plantar release was performed if there was significant equinus deformity of the forefoot and a medial crease. The talonavicular and, occasionally, the calcaneocuboid joint reductions were held with single Kirschner wires across each joint. One surgeon performed release of the tibiofibular interosseous membrane distally. The tendon Z-plasty repairs were tensioned appropriately with the ankle in the plantigrade position. Wounds were closed in layers. A moulded plaster backslab was applied at the end of surgery and changed 1 week later when the foot was brought into the plantigrade position. Pins were removed after 4 weeks, and some children were fitted for orthoses postoperatively.

Patients were contacted by telephone and mail and asked to return to the orthopedic clinic for clinical and radiological assessment. Assessment of the children's feet was performed using the Functional Rating System (FRS) for clubfoot deformity.[8] The 100-point FRS scores heel position when standing, passive motion of the ankle and subtalar joints, gait, foot appearance, talocalcaneal index, talus–first metatarsal angle, type of shoe wear, patient satisfaction, function and pain. Atar and colleagues arbitrarily designated a score of 85–100 points as "excellent," 70–84 points as "good," 60–69 points as "fair" and fewer than 59 points as "poor."[8] For children with bilateral clubfoot deformity, the results for 1 foot were randomly chosen using computer-generated randomization.

We evaluated the following 10 factors that we thought may have a significant influence on the outcome of clubfoot surgery: sex of the child, preoperative talocalcaneal index, age at surgery, whether right/left/or both feet were operated upon, surgeon, calcaneocuboid release, plantar release, tibiofibular interosseous membrane release, pinning and duration of postoperative orthotics use. We chose these factors based on previous literature and those factors for which we had relatively complete information for all patients. Separate analyses were performed to determine factors associated with the FRS

score and whether further surgery was performed. Multiple linear regression analysis was used to examine the relation between the independent variables and the FRS. Both stepwise and forced regression models were used to examine the relations. A Cox proportional hazards model was used to examine these factors related to having had further surgery. Patients' data were censored, if at last clinical evaluation no further surgery had been performed.

Results

Of the 126 children who had surgery for idiopathic clubfoot deformity during the study period (Table 1, Table 2), 94 (75%) were male and 51 (41%) had bilateral clubfoot. Although 9 surgeons performed clubfoot surgery at the Sick Children's Hospital, 1 surgeon had performed 79 (63%) surgeries. Mean age at the time of surgery was 7.6 (range 2.7–12.0) months. The calcaneocuboid joint was released in 25 (20%) cases, and the joint was pinned in 29 (23%) cases. The talonavicular joint was pinned in 117 (93%) cases. Plantar release was performed in 45 (36%) cases. Only 15 (12%) had a release of the tibiofibular interosseous membrane. After surgery, children wore an ankle–foot orthosis for a mean period of 9.0 months.

Of the 126 children, 91 could be contacted, and 63 of their families agreed to attend the clinic for clinical and radiological assessment. The mean follow-up, defined as the date of further surgery or the last review, was 80.6 months. Of the 63 children reviewed, their mean talocalcaneal index was 29.6, and repeat surgery was performed in 19% of cases. The mean FRS outcome score for the group of 63 children was 79. The FRS rating was "poor" for 3, "fair" for 16, "good" for 23 and "excellent" for 21.

As shown in Table 3, of the 10 variables examined, 5 had a significant effect on the FRS score at final evaluation. Children who were older at the time of surgery had better FRS scores. The regression coefficient can be interpreted as follows: for every month older the child was at the time of surgery, the FRS score increased by 1.9 points. Children with higher talocalcaneal indices (i.e., less severe radiographic deformity) also had better FRS scores. Children with right-sided clubfoot only, compared with children with bilateral or left-sided clubfoot deformity, had worse FRS scores. Patients who had release of the tibiofibular interosseous membrane and pinning of the calcaneocuboid joint had lower FRS scores. The R^2 of the models ranged from 0.35 to 0.44.

The Kaplan–Meier curve for repeat surgery is shown in Figure 1. Second surgery was performed between 20 and 90 months after initial surgery. Of all the variables tested in the Cox regression analysis, only lower presurgical talocalcaneal index was associated with the need for further surgery.

Discussion

The treatment of idiopathic clubfoot is controversial. The Ponseti technique, which uses minimal surgical

Table 1

Patients' characteristics and details of surgical and postsurgical care

Characteristic	Mean	SD	Range
Age at surgery, mo (*n* = 126)	7.6	6.3	2.7–12.0
Preoperative TC index (*n* = 63)	29.6	16.3	1.0–76.0
Duration of postoperative orthotics use, mo (*n* = 116)	9.0	6.2	0–33.4
Follow-up duration, mo (*n* = 63)	80.6	15.6	33.5–119.2

SD = standard deviation; TC = talocalcaneal.

Table 2

Patients' characteristics and details of surgical care

Characteristic	No. (and %) of patients
Female	32 (25.4)
Right foot affected only	31 (24.6)
Left foot affected only	44 (34.9)
Both feet affected	51 (40.5)
Calcaneocuboid joint release	25 (19.8)
Plantar release	45 (35.7)
Tibiofibular membrane release	15 (11.9)
Calcaneocuboid joint pinning	29 (23.0)

Table 3

Factors related to the Functional Rating System score at final evaluation

Factor	Regression coefficient (β)	Standard error of coefficient	*p* value
Age at surgery, mo	1.9	0.7	< 0.001
Preoperative talocalcaneal index	0.2	0.1	0.06
Right-sided clubfoot only	–4.7	2.3	0.05
Tibiofibular membrane release	–10.2	5.1	0.05
Calcaneocuboid joint pinning	–8.1	4.1	0.05
Further surgery	–5.9	4.6	0.20

intervention, generally results in flexible feet.[1] Extensive release may result in a more complete correction, but with increased risks including overcorrection and possibly less motion. The wide range of reported recurrence rates after extensive release can be attributed to many factors including, but not limited to, severity of the initial deformity, surgical expertise or postoperative care. We used 2 outcome measures in this study. The first outcome was repeat surgery. The repeat surgery rate of 19% reflected the experience of 9 surgeons and, therefore, is probably a reasonable estimate of need for repeat surgery performed in a tertiary care centre. The second outcome measure, the FRS score, averaged 79. Although the functional outcome of this group of patients overall was categorized as "good," scores ranged from "poor" to "excellent," and only 33% of patients' feet were rated as "excellent." Whether the results for these children would be better if the Ponseti technique had been used is uncertain. Although the Ponseti technique uses minimal surgical intervention, even with this technique, up to 40% of these children will receive further surgery.

Although multivariate analyses showed several factors were related to clubfoot prognosis, only one, patient age, is amenable to modification. Our study showed that older children at time of initial surgery had better outcomes. The FRS score increased by almost 2 points for every month older the child was at the time of initial surgery. Thus, it appears to be advantageous to operate on children who are closer to 12 months rather than 3 months of age. Children are beginning to stand or walk at the end of their plaster immobilization, and this may improve surgical results. Tibiofibular interosseous membrane release and pinning of the calcaneocuboid joint were also related to the outcome of surgery. However, it is probable that children requiring such procedures had more severe deformity in the first place. No factor other than severity of clubfoot as measured by the talocalcaneal index was related to repeat surgery.

This study has 2 potential limitations. First, the classification established by Atar and colleagues[8] has not been evaluated for reliability and validity. However, at the time this study was performed no validated outcome scale had been developed for pediatric foot disorders. Furthermore, the scale contains most of the important elements such as appearance, pain, functional limitations and satisfaction. Second, the reliability of measurements from radiographs of children with clubfeet is uncertain. However, the radiographs were all performed in a standardized fashion and blind to the first outcome. Thus, even with some variability in measurement, radiographs were related to outcome.

In conclusion, the incidence of further surgery for clubfoot deformity in children under 2 years of age was 19%. The functional outcome of these children was generally good, with a mean FRS outcome score of 79. If extensive release is chosen, it should probably be performed in the second, rather than the first, 6 months of life.

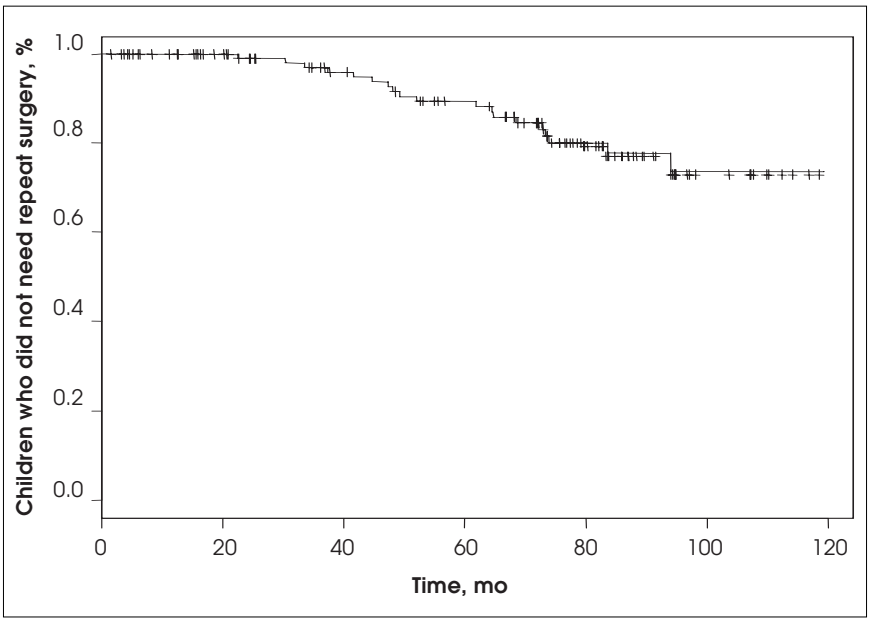

FIG. 1. Kaplan–Meier curve for repeat surgery for clubfoot.

Competing interests: None declared.

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