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Early Results of a New Method of Treatment for Idiopathic Congenital Vertical Talus

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Background: The treatment of idiopathic congenital vertical talus has traditionally consisted of manipulation and application of casts followed by extensive soft-tissue releases. However, this treatment is often followed by severe stiffness of the foot and other complications. The purpose of this study was to evaluate a new method of manipulation and cast immobilization, based on principles used by Ponseti for the treatment of clubfoot deformity, followed by pinning of the talonavicular joint and percutaneous tenotomy of the Achilles tendon in patients with idiopathic congenital vertical talus.

Methods: The cases of eleven consecutive patients who had a total of nineteen feet with an idiopathic congenital vertical talus deformity were retrospectively reviewed at a minimum of two years following treatment with serial manipulations and casts followed by limited surgery consisting of percutaneous Achilles tenotomy (all nineteen feet), fractional lengthening of the anterior tibial tendon (two) or the peroneal brevis tendon (one), and percutaneous pin fixation of the talonavicular joint (twelve). The principles of manipulation and application of the plaster casts were similar to those used by Ponseti to correct a clubfoot deformity, but the forces were applied in the opposite direction. Patients were evaluated clinically and radiographically at the time of presentation, immediately postoperatively, and at the time of the latest follow-up. Radiographic measurements obtained at these times were compared. In addition, the radiographic data at the final evaluation were compared with normal values for an individual of the same age as the patient.

Results: Initial correction was obtained both clinically and radiographically in all nineteen feet. A mean of five casts was required for correction. No patient underwent extensive surgical releases. At the final evaluation, the mean ankle dorsiflexion was 25° and the mean plantar flexion was 33°. Dorsal subluxation of the navicular recurred in three patients, none of whom had had pin fixation of the talonavicular joint. At the time of the latest follow-up, there was a significant improvement ($p < 0.0001$) in all of the measured radiographic parameters compared with the pretreatment values, and all of the measured angles were within normal values for the patient's age.

Conclusions: Serial manipulation and cast immobilization followed by talonavicular pin fixation and percutaneous tenotomy of the Achilles tendon provides excellent results, in terms of the clinical appearance of the foot, foot function, and deformity correction as measured radiographically at a minimum two years, in patients with idiopathic congenital vertical talus.

Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

Congenital vertical talus, also known as *congenital convex pes valgus*, is an uncommon foot deformity characterized by fixed dorsal dislocation of the navicular on the talar head and neck[1]. Its incidence has been estimated to be one in 10,000[2]. It occurs as an isolated (idiopathic) deformity in approximately half of all cases and is associated with neuromuscular and genetic disorders in the remaining cases[2-5]. There is evidence that some isolated deformities are transmitted as an autosomal dominant trait with incomplete penetrance[5-7].

As with clubfoot, treatment of congenital vertical talus begins with serial manipulations and casts. Cast treatment has been viewed as important for stretching the dorsal soft tissues and thereby decreasing the complexity of the operation[2,5,8,9]. However, unlike clubfoot, essentially 100% of reported vertical talus deformities have not been fully corrected with cast immobilization alone and have required major reconstructive surgery[3,9-17]. The purpose of this study was to evaluate the results of treatment of idiopathic congenital vertical talus with a

method of serial manipulations and casts, based on the principles used by Ponseti for the treatment of clubfoot deformity, followed by minimal surgical intervention.

Materials and Methods

We retrospectively reviewed the cases of eleven consecutive patients with idiopathic congenital vertical talus who had been treated by a surgeon at St. Louis Children's Hospital (M.B.D.) or a surgeon at the University of Iowa Hospitals and Clinics (J.A.M.) between 2000 and 2003. Institutional review board approval was obtained for the retrospective chart review. Criteria for inclusion in the study were the diagnosis of a congenital vertical talus confirmed by (1) a lateral radiograph, made with the foot in maximum plantar flexion, demonstrating persistent dorsal translation of the forefoot on the hindfoot (Fig. 1-A) caused by fixed dorsal dislocation of the navicular on the head of the talus and (2) a lateral radiograph, made with the foot in maximum dorsiflexion, demonstrating a persistently decreased tibiocalcaneal angle, which indicates a fixed equinus contracture of the hindfoot (Fig. 1-B). In addition, follow-up for a minimum of two years after treatment and the availability of pretreatment and post-treatment radiographs were required for inclusion in the study. Congenital vertical tali associated with neuromuscular disorders or syndromes were excluded.

Clinical examination included evaluation of the skin of the foot for callus formation, breakdown, or pressure areas. Passive plantar flexion and dorsiflexion of the ankle and subtalar motion as well as varus-valgus heel alignment were measured by a single examiner with a handheld goniometer. Recurrent deformities were documented with regard to the age at the time of the recurrence and additional treatment necessary to regain correction. In addition to this objective examination, parents were questioned regarding their overall satisfaction with the appearance of the foot, the presence of any pain, and abnormal shoe wear.

Anteroposterior and lateral radiographs of the feet were made at the time of presentation, immediately postoperatively, and at the time of the latest follow-up. The talocalcaneal and the talar axis-first metatarsal base angles were measured on the anteroposterior radiograph, and the talocalcaneal, tibiocalcaneal, and talar axis-first metatarsal base angles were measured on the lateral radiographs. Radiographic measurement error is a well-recognized problem in evaluations of feet with small ossific nuclei[18]. To minimize measurement error, all angles were measured by two investigators. Foot position and radiographic landmarks were used as described by Becker-Anderson and Reimann[19]. The talar axis-first metatarsal base angle in maximum plantar flexion was used to differentiate a congenital vertical talus from an oblique talus as described by Hamanishi[4]; an angle of >35° in maximum plantar flexion was considered to be diagnostic of congenital vertical talus. Comparisons were made between the mean pretreatment and follow-up measurements and between the mean immediate post-treatment and latest follow-up measurements for all values on both the anteroposterior and the lateral radiographs. In addition, radiographic data were compared with normal values for individuals of the same age, as described by Vanderwilde et al.[20].

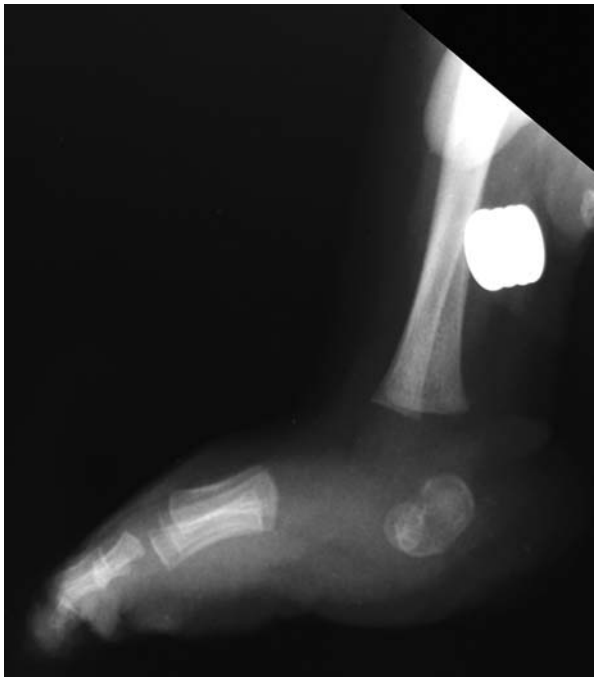

Fig. 1-A

Fig. 1-B

Fig. 1-A Lateral plantar flexion radiograph of the right foot of a six-week-old boy with idiopathic congenital vertical talus, showing persistent dorsal translation of the forefoot on the hindfoot. **Fig. 1-B** Lateral dorsiflexion radiograph of the same foot, showing persistent plantar flexion of the talus and calcaneus.

Fig. 2

Illustration of the direction of the manipulative forces applied to reduce a vertical talus deformity. The foot is stretched into plantar flexion and inversion while counterpressure is applied to the medial aspect of the head of the talus.

At the time of the last follow-up, the outcome for each patient was evaluated with the 10-point scale described by Adelaar et al.[21]. The clinical appearance of the foot is assigned a maximum of 6 points, and radiographic measurements are assigned a maximum of 4 points. The maximum score is 10 points, with 1 point subtracted for each abnormality noted either clinically or radiographically. A score of 10 points is considered excellent; a score of 7, 8, or 9 points, good; a score of 4, 5, or 6 points, fair; and a score of 0, 1, 2, or 3 points, poor.

Treatment Technique

As with the Ponseti method for clubfoot correction[22], treatment begins with serial manipulations and casts, but with the forces applied in the opposite direction, and all components of the deformity are corrected simultaneously, except for the equinus, which should be corrected last. The foot is stretched into plantar flexion and inversion while counterpressure is applied to the medial aspect of the head of the talus (Fig. 2). To maintain the correction obtained by gentle manipulation, a plaster cast is applied in two sections. The first section, a short leg plaster cast extending from the toes to just distal to the knee, is applied first with the foot held in plantar flexion and inversion and with care taken to carefully mold the arch, the malleoli, the head of the talus, and above the calcaneus. Once the plaster has set, the cast is extended to a long leg cast, covering the knee and thigh, with the knee in 90° of flexion.

The casts are changed in the clinic on a weekly basis, and the manipulations are the same prior to the application of each cast. When the final cast is applied, it is important to obtain a position of maximum plantar flexion and inversion to ensure adequate stretching of the contracted dorsolateral tendons, joint capsules, and skin (Fig. 3). No attempt is made to correct the equinus deformity during this portion of the cast process. During the cast treatment, the foot simulates the position of a clubfoot. A lateral radiograph of the foot should be made while the limb is in the last cast to ensure reduction of the navicular on the head of the talus. Since the navicular is not ossified in infants, an indirect radiographic measurement (the talar axis-first metatarsal base angle on the lateral radiograph) is used.

After the talonavicular joint has been reduced (a talar axis-first metatarsal base angle in maximum plantar flexion of <30°), surgical fixation with a percutaneous Kirschner wire is used to hold the talonavicular joint in the reduced position (Fig. 4, *a*). The wire is placed retrograde from the navicular into the talus with the foot held in maximum plantar flexion. The wire is then bent and cut outside the skin to allow removal in the clinic. Accurate placement of the Kirschner wire is based on the surgeon's ability to palpate the head of the talus and the navicular, since those bones are primarily cartilaginous and difficult to visualize radiographically in infants.

If the talonavicular joint is not seen to be reduced radiographically (the talar axis-first metatarsal base angle in maximum plantar flexion is ≥30°) after six casts have been applied, then an attempt is made in the operating room to lever the talus into position percutaneously with a Kirschner wire placed into the talus in a retrograde manner. If this is successful, the talonavicular joint is then held with Kirschner wire fixation as

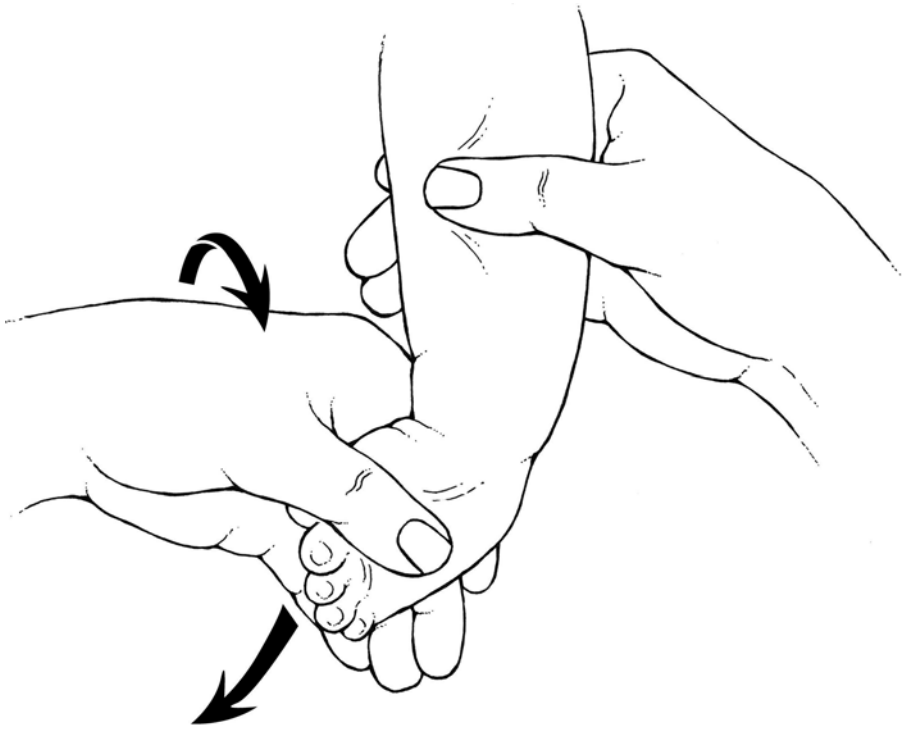

Fig. 3

Illustration demonstrating the position of the foot with maximum hindfoot varus and forefoot adduction before pinning of the talonavicular joint and lengthening of the Achilles tendon. The foot is also placed in maximum plantar flexion to ensure adequate stretching of the contracted dorsolateral tendons, joint capsules, and skin (not illustrated here).

described above. If the talonavicular joint cannot be reduced closed, then a small medial incision is made over the talonavicular joint and a dorsal capsulectomy of the talonavicular joint is performed. Traction is applied to the forefoot in the plantar flexed direction, while thumb pressure is applied simultaneously over the prominence of the head of the talus to medially push the talar head dorsally. Rarely, if the surgeon deems them to be obstacles to achieving an adequate talonavicular reduction, the peroneal brevis tendon and/or tibialis anterior tendon must be fractionally lengthened at the musculotendinous junction.

Once the talonavicular joint is reduced and stabilized with the Kirschner wire, a percutaneous tenotomy of the Achilles tendon is used to correct the equinus deformity as de-

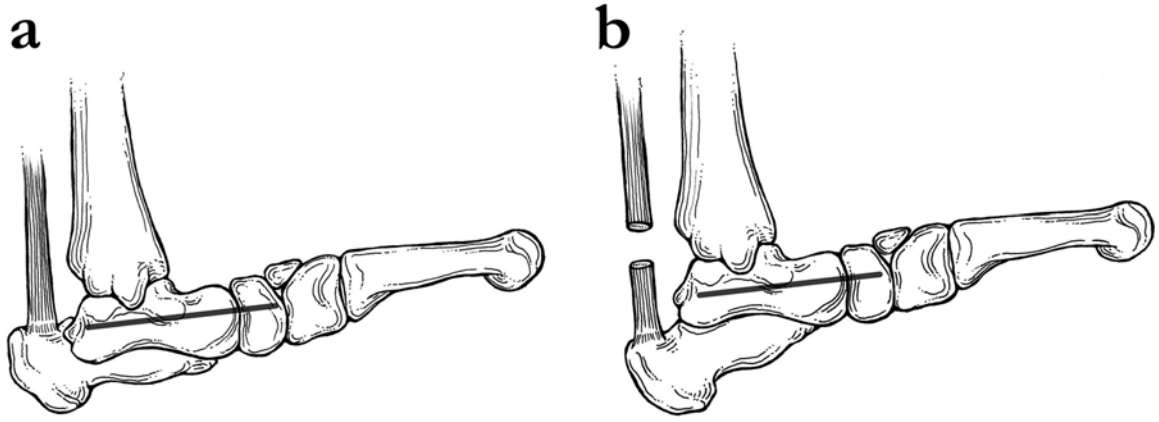

Fig. 4

Illustrations of the minor surgical procedures performed to correct the vertical talus deformity. *a:* Reduction of the talonavicular with pin fixation. Note the residual equinus of the calcaneus. *b:* After a percutaneous tenotomy of the Achilles tendon, there is correction of the equinus of the calcaneus.

Fig. 5-A

Fig. 5-B

Figs. 5-A through 5-E Clinical photographs and a radiograph of the right foot with a vertical talus shown in Figs. 1-A and 1-B. **Figs. 5-A and 5-B** At the age of six weeks, before correction of the deformity, the lateral aspect of the foot demonstrated a rigid, convex plantar surface (Fig. 5-A) and the plantar aspect of the foot demonstrated fixed forefoot abduction (Fig. 5-B).

scribed by Dobbs et al. for the treatment of a clubfoot[23] (Fig. 4, *b*). A Beaver eye blade (Becton Dickinson, Franklin Lakes, New Jersey) is introduced through the skin onto the medial edge of the Achilles tendon about 1 cm above its calcaneal insertion with the cutting surface of the blade pointed proximally. The undersurface of the tendon is palpated with the tip of the blade, which is then rotated 45° to allow the tendon to be severed from ventral to dorsal. The Kirschner wire prevents loss of reduction of the talonavicular joint as the hindfoot is brought into dorsiflexion.

A long leg cast is then applied with the foot in a neutral position and the ankle in 5° of dorsiflexion. The cast is changed in the clinic at two weeks, at which time a mold is made for a solid ankle-foot orthosis, in 15° of plantar flexion at the midtarsal joint, to help maintain reduction of the talonavicular joint once the Kirschner wire is removed. A new long leg cast is then applied with the ankle in 10° to 15° of dorsiflexion and is worn for three weeks, after which time the cast is removed in the clinic and the Kirschner wire is pulled. The solid orthosis is applied, and the parents are instructed regarding exercises with emphasis on a range of ankle motion and foot inversion, to be performed two or three times a day at home. The orthosis is worn for twenty-three hours a day until the child reaches walking age, and then it is worn for walking (for twelve to fourteen hours in a twenty-four-hour period) until the age of two years.

Statistical Analyses

Means and standard deviations are reported. Repeated-measures analysis of variance was used to compare various radiographic measures before treatment, immediately after treatment, and at the time of the latest follow-up. An unpaired t test was used to compare radiographic values at the time of latest follow-up with published normative radiographic values for children of the same age[20]. A p value of <0.05 was selected as significant for this study before data analysis.

Results

Prior to treatment, each foot with a congenital vertical talus had a characteristic clinical appearance, with a rigid, convex plantar surface creating a rocker-bottom deformity (Fig. 5-A). The head of the talus was palpable on the medial and plantar aspects of the foot, and the hindfoot was in fixed equinovalgus. The forefoot was abducted and in dorsiflexion at the midtarsal joint (Fig. 5-B).

Eleven patients with a total of nineteen vertical tali were included in this study (see Appendix). Eight patients had vertical talus bilaterally. Two patients had a vertical talus in one foot and talipes equinovarus in the other. One patient had a vertical talus in one foot and an oblique talus in the other. There were five girls and six boys, and the mean age at the initiation of cast treatment was eight months (range, two to eighteen months). No patient had received treatment prior to referral.

Fig. 5-C

Fig. 5-D

Three years after correction of the vertical talus, a clinical photograph demonstrated a neutral appearance of the right hindfoot (Fig. 5-C) and forced dorsiflexion of the right foot demonstrated 25° of ankle dorsiflexion (Fig. 5-D).

Fig. 5-E

A lateral radiograph made at the age of five years demonstrates normal relationships between the talus and the first metatarsal, between the talus and the calcaneus, and between the tibia and the calcaneus.

A mean of five casts (four, five, or six casts) was required to achieve reduction of the navicular onto the head of the talus. All patients required percutaneous Achilles tendon lengthening for correction of the hindfoot equinus. Two patients had fractional lengthening of the tibialis anterior tendon and one had fractional lengthening of the peroneal brevis tendon as part of the initial treatment to help achieve reduction of the talonavicular joint. Seven patients (twelve feet) had percutaneous pinning of the talonavicular joint at the time of the Achilles tendon lengthening to maintain correction of the forefoot on the hindfoot. No patient underwent extensive soft-tissue releases.

Six feet in three patients had recurrent deformity, noted radiographically as dorsal subluxation of the navicular on the head of the talus at a mean of five months (range, three to six months) after the initial correction. None of the six feet had had Kirschner wire fixation of the talonavicular joint at the time of the Achilles tenotomy. All required repeat cast treatment, and four also required Kirschner wire fixation of the talonavicular joint to maintain reduction. Open surgery was not required in these three patients. Only one patient (one foot) who was not treated initially with talonavicular pinning did not have a recurrence. In contrast, no patient who had initial talonavicular pinning had a recurrence by the time of writing.

The mean age at the time of latest follow-up was three years (range, two and one-half years to six years). All parents were satisfied with the appearance of the foot. No patient required custom shoes or complained of abnormal shoe wear, and none had pain. There were no operative complications. According to the Adelaar scoring system, five patients had an excellent result, six had a good result, and none had a fair or poor result. There was no significant difference in the Adelaar score at the time of final follow-up between the patients who had had a recurrence and needed further treatment and those who had not had a recurrence.

TABLE I Comparison of Latest Follow-up Radiographic Values with Age-Matched Normative Data

Variable	Study Cohort at Final Follow-up* (N = 19)	Age-Matched Norms*[20]	P Value†
Anteroposterior talocalcaneal angle	32 ± 3.0	35 ± 4	0.17
Anteroposterior talar axis-first metatarsal base angle	8 ± 4.3	10 ± 8	0.36
Lateral talocalcaneal angle	40 ± 2.3	44 ± 7.5	0.18
Lateral talar axis-first metatarsal base angle	8 ± 1.8	10 ± 3.5	0.12
Lateral tibiocalcaneal angle	65 ± 3.8	66 ± 5.5	0.57

*The values are given, in degrees, as the mean and standard deviation. †P values were derived with an unpaired t test comparing the final follow-up data in the present study with the values in a sample of four-year-olds in the study by Vanderwilde et al.[20].

At the time of the latest follow-up, the hindfoot was seen clinically to be in neutral in fifteen feet (Fig. 5-C) and in 5° to 8° of valgus in four feet. Ankle dorsiflexion averaged 25° (range, 18° to 35°) (Fig. 5-D), and plantar flexion averaged 33° (range, 15° to 35°). Subtalar motion was normal in all nineteen feet.

The mean radiographic measurements made at the time of diagnosis were compared with the same measurements made immediately postoperatively and at the time of final follow-up (see Appendix). There was a significant decrease in the lateral talocalcaneal and lateral tibiocalcaneal angles on the immediate postoperative radiographs compared with pretreatment values ($p < 0.0001$), indicating correction of the hindfoot equinus. The lateral talar axis-first metatarsal base angle was also significantly improved immediately postoperatively compared with the pretreatment angle ($p < 0.0001$), indicating reduction of the talonavicular joint (Fig. 5-E). The anteroposterior talar axis-first metatarsal base angle reflects the amount of forefoot abduction, with greater angles representing more forefoot abduction. There was a significant ($p < 0.0001$) decrease (improvement) in this angle immediately after treatment. The anteroposterior talocalcaneal angle reflects the alignment of the hindfoot, with the angle increasing with greater valgus deformity. There was a significant decrease ($p < 0.0001$) in this angle after treatment. There were no significant changes in any measured angle on the anteroposterior or lateral radiographs between the immediate post-treatment period and the time of the latest follow-up ($p \geq 0.14$), indicating maintenance of correction. In addition, at the time of final evaluation, all radiographic angles were within normal values for the patient's age, as determined by Vanderwilde et al.[20] (Table I). At the time of the latest follow-up, the size and shape of the navicular and the talar head did not differ radiographically from those of a normal foot of a child of the same age.

Discussion

The overall goal of treatment of a congenital vertical talus is the restoration of a normal anatomic relationship among the talus, navicular, and calcaneus. Pain and disability are thought to be inevitable if this condition is not treated[10,12]. Most physicians who treat this disorder believe that major reconstructive surgery is necessary to correct the deformities in the majority of patients[3,9-17]. Serial cast treatment of the foot is viewed as beneficial for stretching the soft tissues and neurovascular structures on the dorsum of the foot and ankle, but it is not seen as a way to achieve definitive correction of the deformity[2,5,8,9]. Of the different types of major reconstructive surgery, single-stage releases, two-stage releases, soft-tissue releases with navicular excision, and Grice-Green subtalar fusion after release have all been reported to be effective[1,8,10,14,24-27]. However, all of these techniques have been associated with substantial complications, including wound necrosis[2], talar necrosis[5,26], undercorrection of the deformity[10], stiffness of the ankle and subtalar joint[25], pseudarthrosis[3], and the eventual need for multiple operative procedures such as subtalar and triple arthrodeses[28,29]. Seimon[8] reported success with a more limited surgical approach that involves release of the dorsal talonavicular joint capsule and lengthening of the peroneus tertius, extensor hallucis longus, and tibialis anterior tendons followed by Kirschner wire fixation of the talonavicular joint. His report included seven patients with a total of ten vertical tali followed for an average of five years after treatment. However, all patients in his study had some restriction of inversion-eversion, which ranged between 25% and 75% of normal. In addition, one patient had a fixed equinus contracture. We used a similar approach in one patient in whom the talonavicular joint had failed to reduce after application of six casts. This patient was not included in the study because of the lack of a two-year follow-up.

Serial cast treatment has been tried by several authors but has been deemed ineffective for attaining adequate correction in the vast majority of patients. Eraltug[17] reported seven cases of congenital vertical talus that were not corrected by serial cast treatment. Four of the seven patients had associated neuromuscular disorders. Storen[30] reported that cast correction started a few weeks after birth was initially successful for five feet with congenital vertical talus. Two of the five feet had recurrences before the patient was one year of age, and major surgical reconstruction was required. Storen did not provide details about the procedure used to apply the casts or the treatment after the cast immobilization was discontinued.

In contrast with previously reported experience, we

observed initial success with serial manipulation and cast treatment followed by minor surgical intervention for the definitive treatment of idiopathic congenital vertical talus. In our experience, patients with neuromuscular and genetic disorders have tended to have more rigid deformities that are less amenable to cast correction.

The principles of manipulation and treatment with plaster casts are similar to those used in the Ponseti method of clubfoot correction[31], but the forces are applied in an opposite direction. A thorough understanding of the anatomy and the deformities present is necessary to achieve correction. An average of five casts were required to reduce the forefoot onto the head of the talus in our study. By the time that the last cast is applied, the hindfoot should be in marked varus; thus, at this stage, the cast is applied so that the foot mimics the appearance of an untreated clubfoot, achieving maximum stretch of the soft tissues that are hindering correction.

Once the forefoot is seen radiographically to be reduced on the head of the talus, the reduction is best held with a Kirschner wire placed percutaneously across the talonavicular joint with the foot in maximum plantar flexion. Once the forefoot is held in the reduced position, the hindfoot equinus can be corrected with a percutaneous Achilles tendon lengthening without risking loss of forefoot reduction. No deformities recurred in any of the feet that we initially treated with Kirschner wire fixation of the talonavicular joint, but there was a recurrence in six of seven feet in which the talonavicular joint had not been pinned. We also recommend that a solid ankle-foot orthosis built in 15° of plantar flexion at the midtarsal joint be worn full time until the child reaches walking age and then for walking until the age of two years to keep the forefoot plantar flexed and to prevent recurrence of the deformity.

The described technique of serial manipulation and cast treatment, pin fixation of the talonavicular joint, and a percutaneous Achilles tenotomy provided good early results (at a minimum of two years after correction) in terms of the clinical appearance of the foot, foot function, and radiographic evidence of correction. It is recommended that, as with clubfoot[32], treatment with manipulations and casts be initiated for idiopathic congenital vertical talus as soon as the diagnosis is made. Longer follow-up is necessary to determine if correction has been maintained. Since 50% of the cases of congenital vertical talus are idiopathic, this technique may allow many children to avoid traditional surgical treatment while maintaining increased flexibility of the foot.

Appendix

eA Tables showing the clinical details for all patients and the radiographic measurements obtained at different time-points are available with the electronic versions of this article, on our web site at jbjs.org (go to the article citation and click on "Supplementary Material") and on our quarterly CD-ROM (call our subscription department, at 781-449-9780, to order the CD-ROM). ■

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