Management of Severe Equinovalgus in Patients With Cerebral Palsy by Naviclectomy in Combination With Midfoot Arthrodesis

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Abstract

Background: Equinovalgus deformity is the second most common deformity in cerebral palsy and may be flexible or rigid. Several operative methods from joint sparing to arthrodesis have been described with varying success rates. The aim of this study was to investigate the effectiveness of naviclectomy in combination with midfoot arthrodesis (talo-cuneiform and calcaneocuboid arthrodesis) in the correction of a rigid equinovalgus foot deformity in cerebral palsy.

Methods: Forty-eight rigid equinovalgus feet were operated upon in 30 patients from 2008 to 2013. Of these, 44 feet in 26 patients with cerebral palsy (Gross Motor Function Classification System III, IV, or V) with follow-up of more than 2 years were included in the study. The mean age at surgery was 18.1 years. The outcomes were measured objectively using radiographic angles and subjectively using 5 questions to be answered by the caregiver. The feet were then graded into excellent, good, fair, and poor. The mean follow-up was 5.0 ± 1.7 years.

Results: Excellent to good results were obtained in 81% of the feet. Both objective and subjective outcomes improved significantly postoperatively ($P < .001$). Three feet in 2 patients were graded as poor and underwent a revision operation for pain and recurrence.

Conclusions: Naviclectomy in combination with midfoot arthrodesis enabled a good 3-dimensional correction of the forefoot. However, the procedure did not necessarily correct the fixed subtalar joint deformity. Several additional bony and soft-tissue procedures were necessary to achieve a complete correction in these difficult feet.

Level of Evidence: Level IV, retrospective case series.

Keywords: foot, pes equinovalgus, cerebral palsy, rigid, naviclectomy, midfoot arthrodesis

Pes valgus is the second most common foot deformity after equinus in cerebral palsy and is often combined with an equinus contracture.^{7,23,39} The incidence of pes valgus in cerebral palsy varies between 20% and 25%.^{6,7} The spectrum of presentation of this deformity is quite variable. It can present as flexible or partially flexible or rigid with or without soft-tissue contractures. The concomitant equinus contracture in a valgus foot forces a midfoot break, which in turn causes ineffective power generation by the triceps surae due to the loss of stable lever-arm function. Although disputed, the use of orthotics is thought to improve not only the static position but also gait.^{14,30,44,52}

Several kinds of bony procedures have been described for the correction of spastic equinovalgus deformity. They can be divided into joint-sparing and fusing procedures.⁵ Joint-sparing procedures such as arthroreisis^{13,34,49} or lateral column lengthening (Evans) have been found to be effective in treating mild to severe valgus feet.^{17,36,54} Severe and

rigid deformities are best managed by arthrodesis. Several types of arthrodesis such as arthrodesis of the subtalar joint (STJ), the talonavicular joint (TNJ) with or without calcaneocuboid joint (CCJ), arthrodesis of the entire medial column, and triple arthrodesis have been described.^{8,11,15,18,21,26,33} Each procedure has its advantages and disadvantages. The limitations of each procedure depend on the procedure's potential to correct the foot in all 3 planes (frontal, sagittal,

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and transverse planes) and the risk of developing a pseudarthrosis.^{5,8,11,31,40,53} Naviclectomy in combination with midfoot arthrodesis is an alternative way of treating a severe and rigid equino- and planovalgus foot in patients with cerebral palsy. To our knowledge, there is only 1 article in the French literature describing this procedure on 7 feet (nonwalkers) for severe planovalgus deformity with severe abduction of the forefoot. However the clinical outcome, advantages, and limitations of this technique were not discussed.³²

Therefore, the purpose of this article was to investigate the effectiveness of naviclectomy in combination with midfoot arthrodesis (talo-cuneiform [TC] and CCJ) in the correction of severe, rigid equino- and planovalgus feet in cerebral palsy; to present the midterm radiologic and clinical results; and to discuss its advantages and disadvantages over other conventional procedures.

Methods

The study was done in patients who had a naviclectomy in combination with midfoot arthrodesis for the correction of rigid equino- or planovalgus feet between 2008 and December 2013. The inclusion criteria were the diagnosis of spastic cerebral palsy with Gross Motor Function Classification System [GMFCS] III, IV, and V; a rigid painful equino- or planovalgus foot with loss of function; and a minimum follow-up of 2 years. The exclusion criteria were rigid equinovalgus foot of other etiology, other forms of cerebral palsy, lost to follow-up, or follow-up of less than 2 years. Our database revealed 30 patients with 48 feet. Excluded were patients with an unknown syndrome (1 foot), arthrogryposis (2 patients, 1 foot each), and lost to follow-up (1 patient, 1 foot). The decision to perform the procedure was based on the presence of all the following criteria:

- severely deformed rigid foot with subluxation of TNJ and CCJ in both planes,
- inability to reduce the TNJ and STJ passively;
- severe discrepancy in the lengths of medial and lateral columns of the foot;
- painful pressure areas on the medial side of the midfoot;
- inability to wear orthotics either due to pressure sores, discomfort, or pain; and
- loss of ability to transfer or walk due to pain.

Twenty-six patients with 44 feet were included in the study. The mean age at the time of surgery was 18.1 ± 7.5 years (range, 9–42 years). The average period of follow-up was 5.0 ± 1.7 years. In 3 patients (5 feet), the preoperative subjective scores were not fully available and therefore were excluded from the statistical analysis of the subjective

outcomes but not from the analysis of the radiographs and grading of the foot.

Since all our patients were unable to stand without above-knee orthotics and 21 of the patients had both proximal joint contractures and muscle weakness, a standardized non-weight-bearing anteroposterior (AP) and lateral radiograph of the foot was performed preoperatively and at the time of last follow-up in all patients. The position of the foot and leg in both views was standardized, and the x-ray beam was centered on the TNJ. The distance of the foot from the source of the x-rays and the inclination of the x-rays to the foot were held constant in all cases. These radiographs were assessed by one of the authors for bony relationships between forefoot and hindfoot (Figure 1a-1d). Since all patients underwent naviclectomy, the relation of the forefoot to the hindfoot was measured on the AP radiographs by the talus–first metatarsal (MT) angle instead of the talonavicular coverage angle. An abduction deformity of the forefoot was represented with a negative value and an adduction deformity with a positive value. Similarly on the lateral x-ray, the supination and pronation deformity was measured by relation of the long axis of the talus to the long axis of the first MT. A supination deformity seen as elevation of the first MT was represented with a negative value and a pronation deformity seen as depression of the first MT with a positive value. The valgus deformity of the hindfoot was measured on photographs using a goniometer as the relationship of the long axis of the calcaneus (heel) to the long axis of the leg with the foot resting on the floor non-weight bearing. The resulting angle was expressed in degrees. The 4 radiologic measurements and the hindfoot valgus were used as objective parameters.

The following parameters were collected from the clinical notes: severity of the deformity, ability to wear orthotics and duration of wear, occurrence of pain or pressure sores, cosmetic appearance of the foot, and contribution of the foot to the quality of life of the patient. This information was treated as subjective parameters. The cosmetic appearance of the foot was defined as how the caregiver interpreted how closely the appearance of the medial arch, appearance of the forefoot, heel, and the alignment of foot to leg of the operated side resembled a normal foot. The information was given by the caregivers and was documented preoperatively and at the time of follow-up and was scored between 0 and 3 (Table 1).

This is a clinical study with a retrospective design. This study is in accordance with the ethical standards of the relevant local Ethics Commission, and an ethical approval was obtained.

Statistical Analysis

A post hoc analysis was done using all objective and subjective parameters of the study group using G power version

Figure 1. (a, b) Preoperative x-rays of a 13-year-old girl with Gross Motor Function Classification System IV with severe rigid equinovagis feet. (c, d) Postoperative x-rays show good correction of the feet in both planes.

Table 1. Subjective Scoring of the Foot: Parameters Assessed.

Score	Description				
	Deformity	Difficulty Wearing Orthotics	Pain or Pressure Sores	Cosmesis	Effect of Foot Deformity on the Quality of Life
0	Very severe	Unable to wear	Pain immediately on wearing orthosis	Very bad	Very bad
1	Bad	Need to remove many times a day; wear time <6 h/d	Pain and pressure sore; pressure sore persisting several minutes to an hour after removal of orthotics	Bad	Bad
2	Slight	Wear >6 h/d	Redness not persisting	Good	OK
3	Normal	No time restriction	None	Excellent	Good

3.1.9.2 to assess the power of the study. The data were subjected to statistical analysis using MatLab 7.3 (Mathworks Inc., Natick, MA). The objective (radiologic) outcome measurements (TCA, TMT 1 in frontal and sagittal planes) were analyzed using a paired t test. The subjective outcomes such as deformity, difficulty in wearing orthosis, pain and pressure sores, cosmesis, and quality of life were analyzed using the sign test. The statistical significance of the outcome was set at $P \leq .05$.

Grading of the Outcome

As the authors were not aware of any classification or criteria that could be used to grade the correction of these difficult feet in nonwalkers, many of whom who were speech and mentally challenged and lacked insight into time (GMFCS IV and V), the grading proposed by Patterson et al⁴² was modified to suit our patient group. Only 4 of the 7 criteria (pain, radiologic union, alignment of the forefoot,

Figure 2. Intraoperative picture of the foot showing the head of the talus and the articular surface of the 3 cuneiforms following naviclectomy.

and alignment of the hindfoot) described by Patterson et al⁴² were included, and the last 3 criteria describing the gait characteristics were omitted. In addition, pressure sore development was added as this was a predominant symptom and one of the essential criteria for operative correction using naviclectomy in combination with midfoot arthrodesis. Moreover, the absence of a pressure sore would reflect the comfort in using an orthotic. At the last follow-up, the feet were graded into excellent, good, fair, and poor depending on the presence of at least 1 or more of the following 4 criteria: pain and pressure sores, radiologic union, alignment of forefoot (radiologic correction of the forefoot on the AP and lateral views, abduction, and supination), and alignment of the hindfoot to the leg (hindfoot valgus). The feet were scored as excellent when all 4 criteria were negative, good when a forefoot abduction/supination deformity with or without a hindfoot valgus deformity under 10 degrees was present, and fair when the forefoot and hindfoot deformity of more than 10 degrees was present with or without pressure sores. The feet were graded as poor when a symptomatic nonunion associated with pressure sores was present in addition to severe forefoot and hindfoot deformity.

Operative Procedure

The surgery was performed under general anesthesia and with a tourniquet. The medial incision was used to expose the TNJ capsule and the NCJ capsule. The navicular bone was resected completely after detaching the tibialis posterior from its insertion (Figure 2). The head of the talus and the 3 cuneiform bones were denuded of cartilage. A standard lateral approach was then used to expose the CCJ after the tenotomy of both peroneus brevis and tertius. The articular surfaces of the CCJ were denuded as well.

The forefoot was reduced by pronation, adduction, and plantarflexion maneuver of the hindfoot. The arthrodesis was now secured using either K-wires or locking foot plates as preferred by the surgeon. The cancellous bone harvested from the navicular could be used as bone graft.

While assessing the degree of operative correction, attention was paid to the presence of the following problems.

- Structural shortening of the tibialis anterior (TA) tendon could hinder the pronation of the forefoot. This was seen in feet with severe supination deformity of the forefoot with bowstringing of the TA tendon. In such cases, a Z-lengthening of the TA was performed prior to the reduction of the foot. The lengthening was done in the distal part of the leg using a separate incision.
- Fixed and subluxated STJ could lead to undercorrection of the hindfoot valgus. The assessment of the residual hindfoot valgus was done clinically during surgery by assessing the relationship of the long axis of the heel to the long axis of the tibia and the long axis of the foot. In these cases, an osteotomy of the calcaneus was performed behind the lateral malleolus through the lateral incision. The proximal pole of the calcaneus was shifted medially as required and fixed using K-wires.
- Equinus deformity of the hindfoot. Depending on the presence of the Silverskiold Test, either an aponeurotic lengthening of the gastrocnemius in the proximal part of the leg or a lengthening of the tendon of triceps surae in the distal part of the leg through a medial incision was performed.
- Supramalleolar valgus deformity could lead to undercorrection of the hindfoot. This deformity should be recognized on the preoperative AP x-rays of the ankle joint. When necessary, a varus osteotomy of the distal tibia along with osteotomy of the fibula was performed. The osteotomy of the tibia was fixed using a distal tibia locking plate.
- Torsional deformity of the tibia. This was assessed during surgery after satisfactory correction of the foot by assessing the alignment of the second toe to the tibial tuberosity. In the presence of an internal or an external torsion of the tibia, a rotational osteotomy of the distal tibia was performed using a 6-holed dynamic compression plate (3.5-mm screws). Usually an osteotomy of the fibula was not necessary.
- Toe deformities. Hallux valgus was corrected by tenotomy of the adductor hallucis and chevron osteotomy using K-wires. Claw toes were treated by tenotomy of the flexor digitorum longus tendons using an incision on the plantar side of the corresponding toe.

Table 2. List of Additional Procedures Performed to Correct the Foot.

Concomitant Additional Procedures	Number of Feet
Gastrocnemius aponeurotomy	6
Lengthening of the Achilles tendon	10
Augmentation of Achilles tendon	31
Lengthening of the long extensor tendons (tibialis anterior, extensor digitorum longus, and peroneus tertius)	6
Transfer of tibialis anterior tendon to second cuneiform	21
Medial sliding calcaneal osteotomy (Gleich)	16
Supramalleolar varus torsional osteotomy	5
Supramalleolar torsional osteotomy	3
Great toe metatarsophalangeal joint arthrodesis	16
Secondary wound closure	3

These additional problems were corrected in the same sitting. The skin was closed in a single layer over silicon drains, avoiding tension especially on the lateral border of the foot. If necessary, an Epigrad (a synthetic skin replacement material) was used to close the wound temporarily. The foot was immobilized postoperatively in a below-knee cast for 6 weeks. Following removal of hardware (K-wire), the foot was further protected for 3 months using a custom-made ankle-foot orthosis, and weight bearing was permitted in the ankle-foot orthosis.

Results

A number of additional surgeries were performed and are listed in Table 2. Primary wound closure was achieved in all except 4 feet, which were closed secondarily at an average of 5 days following surgery. No plastic procedures were necessary. The arthrodesis healed in all cases, except in 1 foot, which was revised for symptomatic TC pseudarthrosis (Figure 3a, b). One patient had a revision surgery on both feet 4 years after the primary operation for recurrent pain on the medial side of the midfoot and pressure sores in an orthosis. This was due to severe undercorrection of the hindfoot on both sides and an overlooked valgus deformity of the distal tibia on one side. Recurrent valgus deformity of the distal tibia was seen in 1 patient (2 feet) 18 months following acute varus correction of the ankle at the time of foot surgery. This was treated with an epiphysiodesis of the distal medial tibia.

Post hoc analysis indicated a power greater than 0.8, and an effect size greater than 1.4 for parameters FTMT1, STCA, and STMT1. For the parameter FTCA, only a small effect (0.07) was observed, so that for this parameter, the study was underpowered with 0.11.

Radiologic Outcomes

Significant postoperative improvements ($P < .001$) were seen in the AP talus–first MT angle, lateral talocalcaneal angle, and lateral talus–first MT angle. The preoperative and postoperative angles, difference, and significance values are depicted in Table 3.

Clinical Outcomes

The average preoperative subjective score in the 5 measured areas was 0.37, with significant improvements ($P < .001$) following surgery. The low preoperative scores were given for cosmesis (0.15) and effect of the foot deformity on the quality of life (0.15). The mean preoperative and postoperative scores are presented in Table 4. Irrespective of the ambulatory status of the patients, all caregivers perceived that the deformity of the foot played an important role in the patient's quality of life. The 44 feet were graded postoperatively as follows: excellent = 20, good = 16, fair = 5, and poor = 3.

Discussion

The aim of treating the rigid equinovalgus feet in cerebral palsy patients with GMFCS IV and V is to facilitate shoe and orthotic wear and to provide cosmetically acceptable feet. This enables them to assist in transfers and participate in therapy. In our experience, naviclectomy in combination with midfoot arthrodesis (TC and calcaneocuboid) allowed for good correction of the forefoot in all 3 planes (Figure 4a, b). The improvement in the foot shape was reflected in the postoperative subjective scores given by the caregivers. In the feet that were graded as excellent or good, there was absence of pain, pressure scores, increased duration of orthotic wear, standing, and improved cosmesis (appearance of forefoot with restoration of the medial arch of the foot, alignment of the hindfoot, and alignment of foot to the leg). On the other hand, in the feet that were graded as fair or poor, only modest to no improvements in the above areas were seen.

Although triple arthrodesis is advocated by many authors^{1,3,28,29} to treat such difficult feet, some have cited the limitations of the procedure.^{47,48,50} The advantage of such a procedure is the repositioning and fusion of all 3 subluxated joints (TNJ, CCJ, and STJ), and it may be combined with the lengthening of the lateral column.²⁸ This would necessitate a source of bone graft from a distant harvest site. Moreover, lengthening the lateral column would increase skin tension and the risk of wound breakdown. Complications such as wound dehiscence are not unknown following foot surgery.²⁴

Naviclectomy in combination with midfoot arthrodesis has 4 distinct advantages in these feet:

Figure 3. (a) Lateral view of the foot showing nonunion (patient had pain) and loss of correction at the site of arthrodesis between head of talus and the cuneiforms. (b) Lateral view following reoperation and bone grafting and supramalleolar torsional correction showing bony consolidation at the site of nonunion.

Table 3. Radiologic Measurement of Feet in Load-Bearing AP (Frontal) and Lateral Views.

Radiologic Parameter	Preoperative Angle, degrees	Postoperative Angle, degrees	Difference (Mean)	P Value
FTCA	19.4 ± 19.4	19 ± 7.99	+0.4	.85
FTMTI	-29.4 ± 21.6	-0.7 ± 6.15	-8.7	<.001
STCA	59.4 ± 16	41.3 ± 8.42	+18.1	<.001
STMTI	-41.1 ± 9.09	-3.2 ± 8.56	-37.9	<.001

Abbreviations: AP, anteroposterior; FTCA, frontal talocalcaneal angle; FTMTI, frontal talus–first metatarsal angle; STCA, sagittal talocalcaneal angle; STMTI, sagittal talus–first metatarsal angle.

Table 4. Pre- and Postoperative Scores of the Specifically Tailored Questionnaire and the Statistical Significance of the Measured Areas.^a

Parameter	Preoperative Score	Postoperative Score	Difference (Mean)	P Value
Deformity	0.24 (± 0.435)	2.64 (± 0.489)	2.4	<.001
Difficulty in wearing orthosis	0.66 (± 1.11)	2.55 (± 0.833)	1.89	<.001
Pain and pressure sores	0.66 (± 0.99)	2.73 (± 0.452)	2.07	<.001
Cosmesis	0.15 (± 0.364)	2.59 (± 0.522)	2.44	<.001
Quality of life	0.15 (± 0.364)	2.55 (± 0.564)	2.40	<.001

^aStandard deviations are given in parentheses.

Figure 4. (a) Preoperative photographs of the 13-year old girl with Gross Motor Function Classification System IV with severe rigid equinovagis feet. (b) The postoperative photographs with assisted standing show an excellent correction on the right side and a good correction on the left.

- equalization of the lateral and medial column lengths without the need for bone grafting,
- reduction of skin tension on the lateral side of the foot,
- resected navicular bone serving as a source of cancellous bone graft to fill the defect and increase the contact area between the talus and the cuneiform bones, and
- dorsoplantar instability both in TNJ and NCJ simultaneously addressed.

Although naviclectomy is a versatile procedure to correct both equino-valgus and cavo-varus feet, the available literature on this subject is very sparse and the number of corrected feet is small. Naviclectomy as an isolated procedure to correct congenital vertical talus was first described in 1888 by Golding-Bird.²⁵ The effectiveness of this procedure for the correction of deformed feet due to different etiologies has been reported by other authors.^{12,22,27,51} Clark et al¹² reported this technique to correct congenital vertical talus without a fusion between talus and cuneiform bones. Their results showed a hindfoot valgus deformity in 40% and a marked forefoot abduction deformity in 60% of the cases. This underlines the need to stabilize the foot with a fusion between the talus and cuneiform to prevent recurrence.^{32,37,41}

Undercorrection of the foot can be in the forefoot, hindfoot, or both. In 8 feet, an undercorrection (abduction and supination more than 10 degrees) was observed in the forefoot. An undercorrected forefoot would affect the position of the hindfoot and vice versa even following arthrodesis due to loss of the tripod effect.³⁶ The progression of the hindfoot valgus is even more likely in the presence of ankle valgus. Therefore, an AP radiograph of the ankle joint is mandatory in long-standing pes valgus.⁵ The valgus deformity of the distal tibia was not appreciated since AP radiographs of the ankle joint were not done preoperatively in 2 feet. In both of these patients, the hindfoot remained undercorrected. In the opinion of the authors, an acute varus osteotomy is indicated even in a growing skeleton to prevent undercorrection of the hindfoot as well as loss of correction of the foot due to abnormal loading. An epiphysiodesis of the distal medial tibia is recommended only in the case of recurrence of valgus deformity of the distal tibia. The 17% incidence of hindfoot valgus in our series was due to insufficient intraoperative correction of the hindfoot. Such hindfoot valgus deformity up to 33% has been also described following triple arthrodesis.²¹ Therefore, a calcaneus medial sliding osteotomy was performed where necessary through an additional incision on the lateral aspect of the heel. This is an important step in the correction of these difficult feet.

There are, however, some disadvantages of resecting the navicular apart from a shorter foot length. Although the foot length was not measured, we assume the shortening to be

less than 2 cm. Clark et al¹² reported shortening between 0.5 cm and 1 cm following naviclectomy. Another limitation of naviclectomy is its inability to correct the rigid and subluxated STJ. The importance of a medial sliding osteotomy of the calcaneus has been already mentioned above. Loss of inversion and eversion movements in the STJ must be expected following arthrodesis between the talus and cuneiforms just as in feet with TN arthrodesis with or without CC arthrodesis.⁴ This will have to be compensated for by the ankle joint.⁴³ The long-term consequence of such compensation is the likely development of osteoarthritis of the ankle, which is debated.^{3,11,16,20,21,43,46} Our patients were nonwalkers or therapy walkers needing only bracing with diminished demands on their foot function. This reduces abnormal movements in the ankle joint and presumably the long-term adverse effects on the ankle joint.

We could not find any grading system in the literature that could be used in our patient group. Our patients had difficulties in expressing, understanding, and communicating. Therefore, we had to depend on the caregivers who knew our patients best. Using the Oxford foot score or American Orthopaedic Foot & Ankle Society Score would not have been appropriate as our patients were also nonwalkers.³⁵ For the same reason, we could not use all the criteria of Patterson et al⁴² to grade the feet, as our patients were nonwalkers. Alternatively, using Caregiver Priorities and Child Health Index of Life with Disabilities (CP Child) would not reflect the local impact following an intervention. CP Child would measure only the overall change in the quality of life following the intervention, and the change in the quality of life would be affected by other issues that may be present in such severely affected tetraplegic patients.³⁸ In line with the current trends in the management of cerebral palsy patients, our patients were treated with single-event multilevel surgery where necessary. Therefore, only 7 of our 26 patients received isolated foot surgery. The rest received single-event multilevel surgery. In these patients, simultaneous multiple surgeries such as supracondylar osteotomies, patella surgery, or hip release were performed. In others who developed painful hips following foot surgery, a resection of the femoral head or valgus osteotomies of the proximal femur were performed. All of these surgeries would act as confounding factors affecting the CP Child scores positively or negatively at last follow-up and would not reflect the true improvement in the quality of life after foot surgery. On the other hand, 2 of our patients developed painful scoliosis during the period of follow-up, which affected their sitting time without deterioration of the foot. This would negatively influence the CP Child scores. Therefore, 5 common questions were used to assess the subjective foot form and function of our patients, and the criteria to grade the feet were adapted from the grading system proposed by Patterson et al⁴² after modification to suit our patient group.

The importance of soft-tissue balancing in foot surgery should not be underestimated. Since equinus contracture occurs in 70% of the foot deformities,^{23,39} this has to be corrected irrespective of the type of foot surgery to achieve lasting correction.^{2,9,10,19,45} We performed lengthening of the gastrosoleus complex only in 18 feet. The others had either a primary insufficiency of the triceps surae or insufficiency following previous lengthening of the Achilles tendon, which needed to be addressed by augmenting the Achilles tendon with the tibialis posterior. The difficulty in realigning the forefoot due to shortening of the TA or long extensor muscles was seen in 7 feet. In these cases, the TA tendon was lengthened prior to the reposition of the forefoot as mentioned above. Failing to recognize this shortening may lead to undercorrection of the forefoot in supination and dorsiflexion in relation to the hindfoot.

The study has some limitations. It is a retrospective study. Despite the group being homogeneous with regard to the disease (cerebral palsy), there was a wide distribution of patient age groups. The study reflects only the intermediate results. No weight-bearing radiographs of the foot could be taken. Therefore, x-rays may not have reflected the absolute amount of initial deformity. However, following arthrodesis, we do not expect any deformation with weight bearing. The scoring reflected the caregivers' perception of the feet and not the patient's. As our patients were nonambulatory, the existing grading criteria had to be modified to suit our patient group.

In conclusion, naviclectomy in combination with midfoot arthrodesis (TC and calcaneocuboid) offered a good operative option to correct the midfoot deformity in severe rigid deformed pes equinovagis deformities in cerebral palsy. This method achieved equalizing the medial and lateral column lengths and addressed the instability in the NCJ with a single procedure. The complication rate was low. However, it was unable to correct the valgus deformity of the hindfoot, which often needed an additional procedure. It is important to understand the complex pathological mechanisms behind these deformities in order to achieve good results. Failure to do so can result in insufficient correction, even with naviclectomy in combination with midfoot arthrodesis.

Declaration of Conflicting Interests

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