PAEDIATRIC ORTHOPAEDICS

The outcomes of the single-stage, three-incision surgical approach in the treatment of neglected cases of congenital vertical talus: a single centre's experience

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Abstract

Background

Congenital vertical talus (CVT), also known as congenital convex pes valgus, is a rare orthopaedic deformity affecting approximately 1 in 10 000 live births. Neglected CVT (NCVT) cases pose a significant challenge in treatment due to the rigid and severe nature of the deformity, which often resists conservative management and requires extensive surgical intervention. Despite the importance of treating NCVT, the evaluation of their surgical outcomes in Zagazig University Hospital was limited, hence this was the aim of the current study.

Methods

This retrospective study was conducted on children with NCVT who presented to the university hospital during the period March 2019 to January 2023. The surgical technique included a single-stage correction performed through three incisions (medial, lateral and posterior) to provide comprehensive access for soft tissue release, tendon lengthening, and joint stabilisation. In two severe cases, naviculectomy was performed to achieve adequate reduction and medial–lateral arch balance. Preoperative assessment of cases included thorough clinical and radiological assessments. Data was collected, revised, coded and statistically analysed.

Results

The study included 24 feet from 16 children with NCVT, ten males and six females, with half the cases presenting as bilateral deformities. The patients' mean age was 31.6 ± 3.8 months. Postoperatively, all feet showed satisfactory improvement with successful alignment and restoration of foot mechanics as evidenced by clinical appearance and function as well as radiological parameters. Surgical complications were minimal, with only four feet (17%) experiencing wound ischaemia due to pulling on the skin. No cases of infection or avascular necrosis were noted.

Conclusion

Single-stage surgical correction can be the best option in cases of NCVT that may miss long-term follow-up treatment with more stages. The outcomes highlight the efficacy of this surgical approach in achieving functional and plantigrade feet, even in complex and neglected cases of CVT. Further studies with larger numbers of patients and long-term follow-up are recommended to confirm the current findings and investigate long-term outcomes.

Level of evidence: 2

Keywords: convex foot, convex pes valgus, vertical talus, congenital, rocker-bottom foot, talipes calcaneovalgus

Introduction

Congenital vertical talus (CVT) is also called congenital convex pes valgus, or teratologic dislocation of the talocalcaneonavicular joint.[1] It represents one of the rare congenital orthopaedic deformities. The incidence of CVT is not known with certainty, but is estimated to be about 1 in 10 000 live births. This estimate is likely to be low because these defects may not be well recognised at birth and in newborns. There are also not enough large-scale studies to determine the prevalence of these deformities on both sides and between the sexes.[2] The typical picture of such conditions is the presence of rigid and severe pes planus associated with an abnormal talar axis-first metatarsal base angle (TAMBA).[3] About half of CVT cases are idiopathic and may be referred to as isolated pathology. The exact causes of isolated lesions are unclear, although there is a familial predisposition and a genetic mutation in some cases. The other half of cases are accompanied by neuromuscular or syndromic conditions, such as myelomeningocele and arthrogryposis multiplex congenita. These cases are more severe, with greater challenges during treatment, and therefore with a higher rate of relapse.[4]

The big challenge in the CVT treatment journey is how to achieve the most desirable outcome of a pain-free, plantigrade, mobile and functional foot.[5] Treatment is always a combination of serial casting with manipulations, and then later limited or extensive surgical releases. The conservative management alone is ineffective in most cases.[4] In some cases, especially in developing countries with low socioeconomic levels, children with CVT may be detected late, after they start walking, and thus develop more severe deformities. Surgical treatment is the mandatory solution for such neglected cases.[6] In neglected cases, secondary adaptive bone changes may occur, making anatomical reconstruction unachievable. Therefore, surgical intervention may be more difficult than classic soft tissue release with limited surgical trauma; it may require bony correction including naviculectomy in addition to soft tissue release to minimise surgical trauma.[7]

The single-stage comprehensive surgical procedure represents the preferred technique for the management of NCVT.[6] Therefore, the aim of this study was to evaluate the clinical outcomes of single-stage, three-incision surgical interventions in managing NCVT in children treated at the Zagazig University Hospital. To our knowledge, this is the first study on this topic at our institution.

Methods

This was a retrospective study conducted in the Department of Orthopedics, Zagazig University Hospital, Egypt, during the period March 2019 to January 2023, of NCVT cases that received single-stage surgical treatment.

Patients

The study included 16 children with NCVT, with a total of 24 affected feet. Patients were selected based on the following inclusion criteria: severe NCVT, older than 2 years, refractory to conservative treatment, surgically fit, and managed with the indicated surgical procedure during the study period. Exclusion criteria included a history of previous surgery with relapse, infection, insufficient data, management method other than that indicated in the study, and refusal to join the study. All patients underwent surgery as well as pre- and postoperative evaluation. Approval was obtained from the Institutional Review Board (IRB) of Zagazig University, and written informed consent was obtained from the parents of the children.

Preoperative assessment

Preoperatively, patients underwent thorough clinical and radiological assessments. The clinical evaluation included general and local examinations to determine the deformity, its rigidity, and any associated lesions in the body. Next, preoperative conventional X-rays were taken in multiple views, including anteroposterior (AP), lateral and medial views, as well as a lateral view in maximum plantar flexion to exclude cases of oblique talus. The following angles were measured: talocalcaneal angle (TC), talo-first metatarsal angle (TM1), tibiotalar angle (TiT), tibiocalcaneal angle (TiC), and TAMBA (*Figure 1*).

Surgical technique

All patients were given prophylactic antibiotics preoperatively. The procedure was performed under general anaesthesia with a tourniquet placed in the mid-thigh.

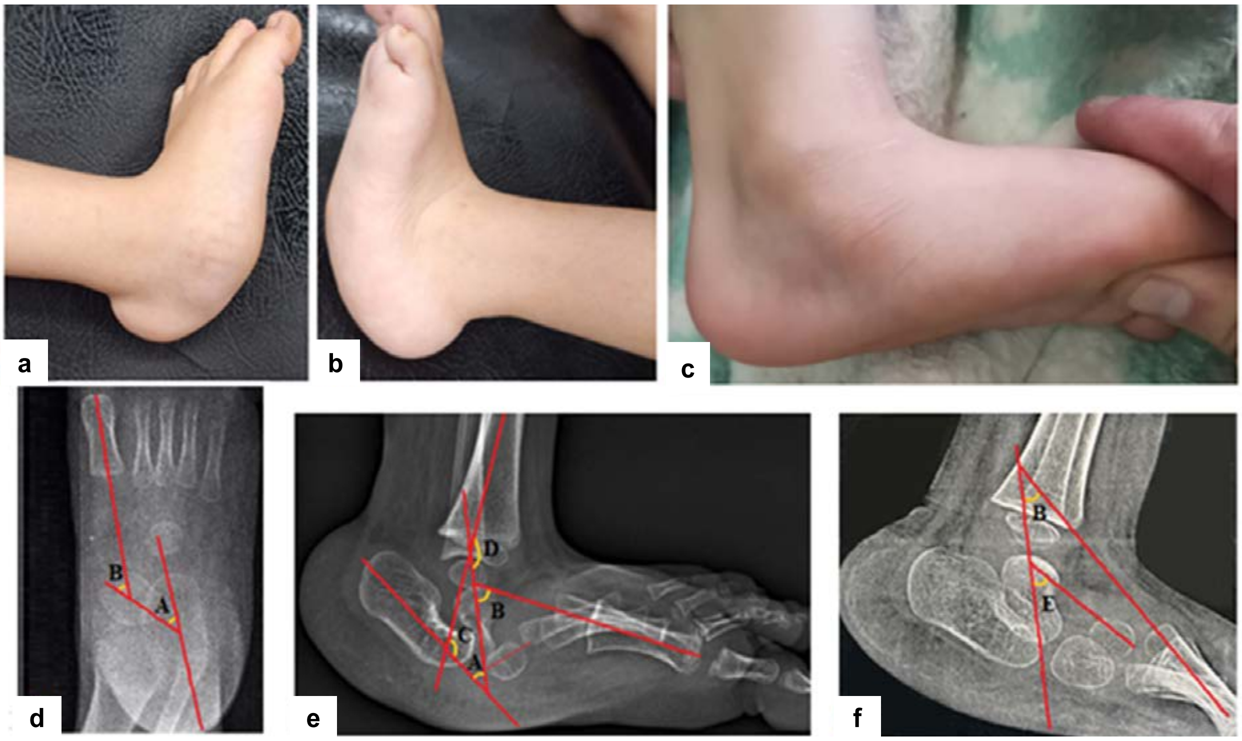

Figure 1. Clinical and radiological evaluation of CVT: a) medial view; b) lateral view; c) clinical examination of the case showing flatfoot deformity with talar head prominent at the plantar aspect; d) AP view: showing TC angle (angle at A), and TM1 angle (angle at B); e) lateral view: showing TC angle (A), TM1 angle (B), TiC angle (angle at C), and TiT (angle at D); f) lateral view: showing TM1 angle (angle at B) and TAMBA (angle at E)

Surgical incisions

- Medial incision. This incision extended from the base of the first metatarsal bone to the medial malleolus. Through this approach, the talonavicular capsule and subtalar joint capsule were released, facilitating improved mobility and alignment. Additionally, the tibialis posterior tendon plication was conducted to stabilise the medial arch, followed by a Z-lengthening of the extensor hallucis longus tendon to release tension and reduce its deforming force. The tibialis anterior tendon was released and temporarily held with Vicryl sutures. After completing the talonavicular joint reduction and achieving proper alignment, the tibialis anterior tendon was transferred to the talar neck through a drilled hole and sutured back to itself (*Figure 2a, b, c*). In cases where talonavicular joint reduction was excessively tight or difficult, and if the medial arch remains significantly longer than the lateral arch, causing severe forefoot abduction, a naviculectomy may be performed.
- Lateral incision. The second incision was made laterally, starting at the base of the fourth metatarsal and extending down the lateral malleolus. Through this approach, a Z-lengthening was performed on multiple tendons to reduce tension in the lateral column and improve flexibility, including the peroneus longus, peroneus brevis (*Figure 2d*), peroneus tertius, and extensor digitorum longus tendons. Additionally, the calcaneocuboid joint was carefully released and reduced to restore its alignment, ensuring proper balance of the lateral arch.
- Posterior incision. The third incision was placed posteriorly, directly over the Achilles tendon. This incision focused on addressing equinus deformity, which is common in CVT. Through this approach, a Z-lengthening of the Achilles tendon was performed to release tension and allow for dorsiflexion of the ankle (*Figure 2e*). Furthermore, the posterior ankle joint capsule was carefully released to enhance mobility and ensure proper hindfoot alignment.

Reduction and stabilisation

For any residual subtalar contractures, a McDonald dissector was placed in the subtalar joint from lateral to medial to ensure complete correction of the hindfoot malalignment (*Figure 2f*).

After releasing the soft tissues and lengthening the tendons, the talonavicular, subtalar and calcaneocuboid joints were meticulously reduced to their corrected anatomical positions. In cases where naviculectomy was performed, reduction became more feasible because of the improved space and mobility in the talonavicular region. Once alignment was achieved, the corrected joints were stabilised using Kirschner wires (K-wires). Typically, two K-wires were inserted across the talonavicular and calcaneocuboid joints to maintain stability (*Figure 3*). In some cases, an additional third K-wire, ‘calcaneotalotibial’, may be placed to further reinforce the corrected hindfoot alignment.

Closure and splinting

After ensuring that all structures were properly aligned and stabilised, the surgical wounds were closed in layers, beginning with the lateral incision to minimise tension on the sutures. A well-padded above-knee splint was then applied, positioning the hindfoot in slight varus and equinus to maintain alignment during the early healing phase if the calcaneotalotibial K-wire was not inserted.

Postoperative care

Postoperatively, the patient followed a structured care protocol. At two weeks post-surgery, the initial splint was replaced with a moulded cast. By six weeks, the K-wires were removed, and a short-leg cast was applied for an additional three weeks to ensure joint stability. After cast removal, the patient transitioned to wearing an ankle–foot orthosis (AFO) with a high medial arch for six months to prevent recurrence and maintain alignment. Following the orthosis phase, the child transitioned to regular footwear to ensure functional use of the corrected foot.

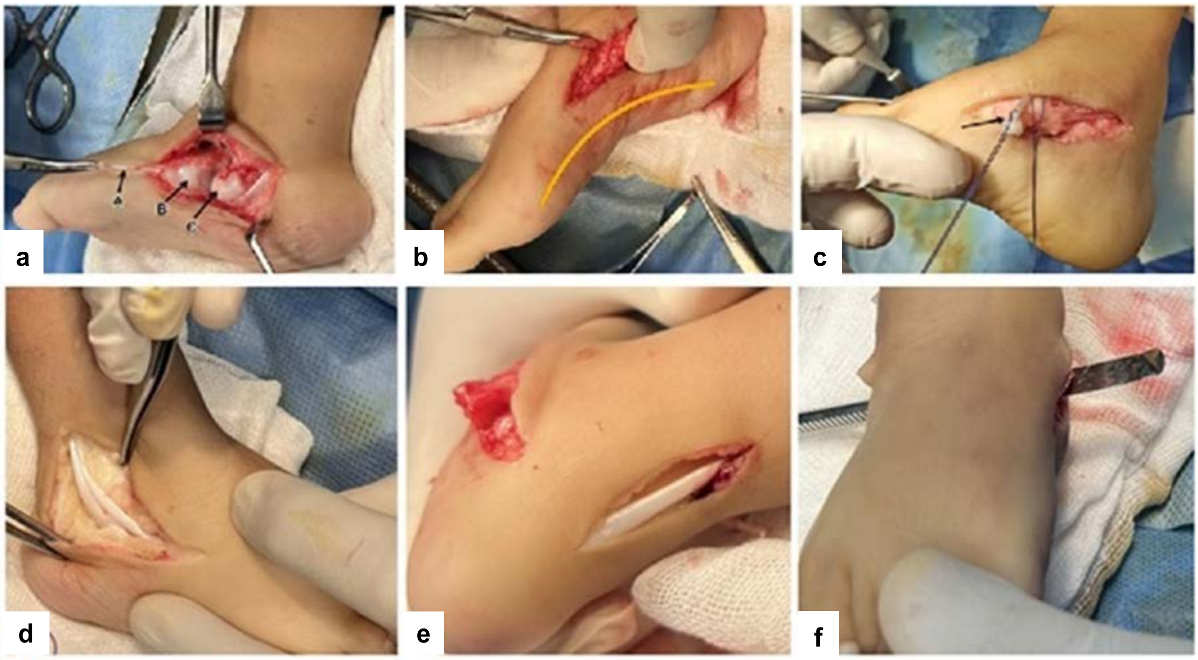

Figure 2. Surgical approach through: medial incision (a, b, c), lateral incision (d) and medial incision (e). a) Medial incision showing tibialis posterior tendon (arrow at A), navicular bone (arrow at B), and talar head (arrow at C); b) preliminary reduction of talonavicular joint (notice the restoration of the medial longitudinal arch (yellow line); c) tibialis anterior tendon (arrow) is released from its insertion as a preparation for its transfer to the talar neck to act as a sling to be a dynamic stabiliser; d) peroneal tendons exposure to do Z-lengthening; e) posterior incision with Achilles tendon exposure prior to the Z-lengthening; f) McDonald dissector placed in the subtalar joint from lateral to medial as a confirmation of complete subtalar joint release

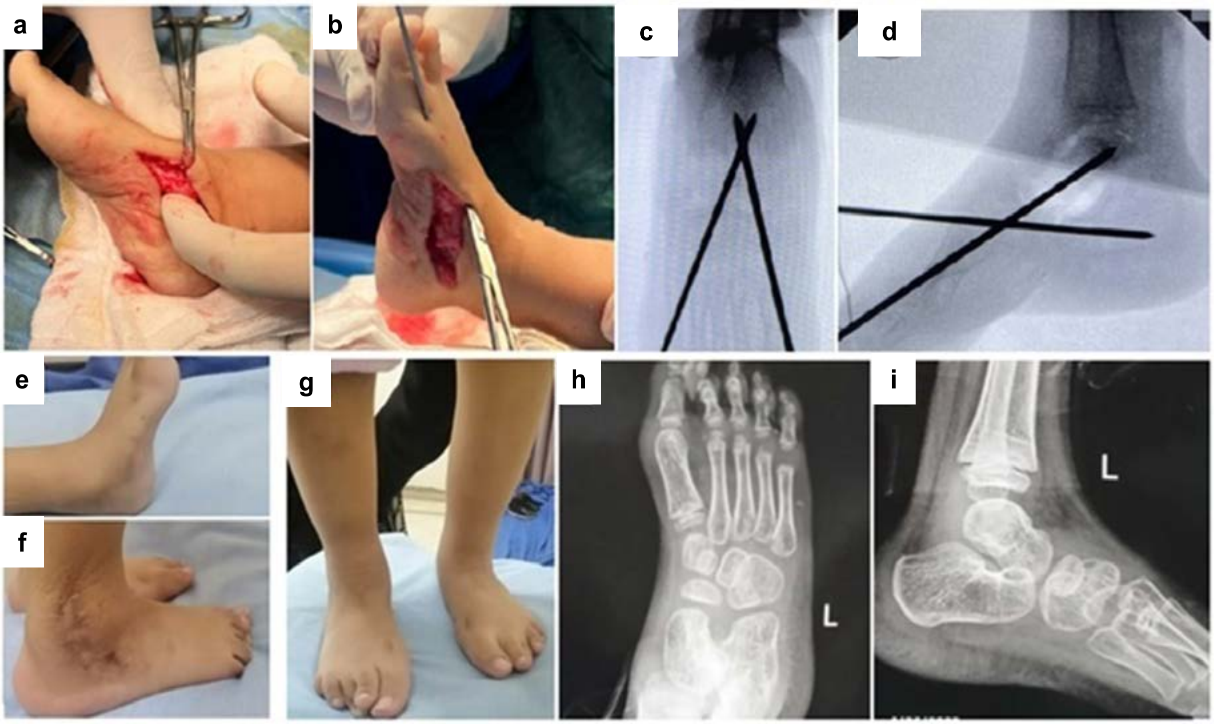

Figure 3. Intraoperative reduction and stabilisation (a–d): a) preliminary talonavicular reduction with restoration of the medial longitudinal arch; b) maintaining the reduction by K-wire fixation; c, d) C-arm images after K-wires fixation of the talonavicular and calcaneocuboid joints after reduction, with (c) the AP view and (d) the lateral view.
Postoperative 12-month follow-up clinical images with plantigrade foot (e–g): e) medial view (note the maintained medial longitudinal arch); f) standing, lateral view; g) standing, front view
Postoperative 12-month follow-up X-ray views with the corrected deformity (h, i): h) AP view; i) lateral view

Postoperative follow-up

The evaluation focused on objective measures derived from clinical and functional observation as well as established radiographic scoring systems.

Clinical and functional assessment

The clinical evaluation focused on the appearance of the foot, the presence of any residual deformity, the level of physical activity, the tolerance to walking, and the ability to wear regular footwear comfortably.[7,8] Clinical examination included observation of skin creases, the alignment of the foot, flexibility, and any signs of recurrence of deformity (*Figure 3 e–g*).[9]

Outcomes were evaluated using a modified scoring system adapted from Abdel-Razzak.[10] This scoring system incorporates both clinical parameters (32 points) and radiological parameters (8 points). The score was classified as follows: excellent outcome (35–40 points) with complete correction with no residual deformity or symptoms; good outcome (30–34 points) with minimal residual deformity, and no functional limitations; fair outcome (25–29 points) with some residual deformity and mild functional limitations; and poor outcome (< 25 points) with persistent deformity and significant functional impairment.

Functional outcomes were assessed based on walking tolerance, foot stability, and ability to perform daily activities.[11]

Radiological assessment

Radiographic weight-bearing assessment was conducted using standardised AP and lateral radiographs of the ankle and foot during follow-up visits (*Figure 3 h, i*).[8,10]

Statistical analysis

Data was collected, revised, coded, and entered into the Statistical Package for Social Science (IBM SPSS Statistics for Windows, Version 23.0, IBM Corp., Armonk, NY, USA). The quantitative data obtained included range, mean, and standard deviation (SD). Fisher's exact test was conducted to test for relationships between qualitative variables. The t-test was used to compare two paired means and two samples when the variables were quantitative, randomly selected, and normally distributed. A parametric test was used to compare the means of two independent samples when the variables were quantitative, randomly selected, and normally distributed. Significance value (p-value) was estimated at ≤ 0.05.

Results

The study included 24 feet with NCVT in 16 children aged 28–40 months with a mean ± standard deviation of 31.6 ± 3.8. Ten (63%) were male. Eight patients (50%) had unilateral CVT, while the others had bilateral lesions. All patients had no family history of CVT. Of the feet studied, 14 feet (58%) including all unilateral cases had no other congenital anomalies; two patients with four feet (17%) had arthrogryposis; one patient with two feet (8%) had arthrogryposis with knee flexion deformity; and two patients with four feet (17%) had arthrogryposis with congenital knee dislocation. None of the feet studied had undergone any previous treatment, either surgical or non-surgical. Only two cases (8%) required intraoperative naviculectomy. Follow-up duration ranged from 10–20 months with a mean ± SD of 15.4 ± 3.1 (*Table I*). The only postoperative complication detected among the study group was wound ischaemia, which was detected in four feet (17%).

There was a postoperative improvement compared to preoperatively in measures assessed including heel position, passive foot flexion, and function. *Table II* shows the postoperative versus preoperative clinical data.

There was a statistically significant difference between the pre- and postoperative radiographic scores, with all cases showing postoperative hindfoot correction, forefoot correction and dislocation of the talonavicular joint ($p < 0.001$). Moreover, there was a statistically significant difference between the pre- and postoperative follow-up scores, with postoperative follow-up scores being higher ($p < 0.001$). All cases had a poor preoperative score, while a good postoperative score was achieved in all studied feet (*Table III*).

Discussion

The rarity of NCVT cases is particularly evident in the few studies conducted to investigate surgical treatment options for these conditions, which is mandatory to correct severe foot deformity in such cases.[6] The proper diagnosis depends mainly on radiological examination.[12] Unfortunately, the condition may not be accurately diagnosed in newborns. This may be because the ossification centres in many of the bones in the foot are not yet present at birth.[13] Delay in diagnosis can lead to delayed or neglected treatment, resulting in significant disability of the foot and ankle, including functional limitations, pain, and the formation of medial plantar callus at the prominent talar head.[2] On the other hand, surgical treatment of CVT before the age of 2 years is not difficult and shows good cosmetic results.[14]

It is important to note that CVT does not cause a delay in walking and may not be noticed by family members until the child begins to walk.[15] This may delay treatment, causing the condition to worsen and the deformities to become more rigid and stiff.[6] The age of patients, as well as the severity of deformity at the time of management, determine the line of management.[16] The best age for surgical treatment of CVT cases is under two years.[17] The mean age of our patients was 31.6 months with a range of 28–40 months. They were all at walking age, which begins at about 12 months of age.[18] Such age makes managing the CVT in reverse Ponseti method more difficult.[13] In this regard, we attempted to apply the reverse Ponseti method in two younger cases, but it was decided to perform surgery to correct the deformity.

The biggest challenge in the treatment journey of CVT is how to achieve the best desired outcome of a pain-free, mobile and functional foot. This challenge increases in NCVT after the patient begins to walk and develops a more severe deformity. Therefore, surgical treatment is recommended to correct the deformities in cases of NCVT.[6] Surgical intervention in neglected cases may be more difficult, and bony correction with naviculectomy may be necessary in addition to soft tissue release.[3,7] The authors proposed naviculectomy as a third option for salvaging CVT deformity other than serial casting with minimal surgery and extensive soft tissue release. To correct CVT in a patient over 50 years of age, Lui performed a talus head resection, which often presents with callosities in neglected cases due to weight bearing when walking.[19] The author stated that this resection could cause shortening of the medial column of the foot and thus facilitate tendon transfer to correct forefoot abduction. In this procedure, the navicular was not removed so that the tubercle of the bone and the attached tibialis posterior tendon could be used as an anchor for tendon transfers. Other authors have preferred a less invasive approach for CVT treatment, regardless of the patient's age or even associated abnormalities.[2] This approach involves serial casts followed by minimally invasive surgery that includes temporary K-wire fixation of the talonavicular joint and Achilles tenotomy. The aim of serial casting is to improve the deformity and thus reduce the steps required for the inevitable surgery.[16] The minimally invasive surgery has been reported to be better than extensive tissue release in terms of long-term pain and range of motion of the foot.[5]

Management of CVT depends on many factors, including the age of the patients and the severity of the deformity. In the early stages of life, surgeons prefer to perform serial casting until the reduction of the talonavicular joint is achieved, followed by a minimally invasive surgical intervention.[20] However, NCVT cases, as well as cases associated with other neuromuscular defects, often have more rigid and severe deformities, and therefore extensive

Table I: Demographic and clinical data among the studied patients

Demographic data among the studied patients		**Patients (n = 16)**
Age (months)	Mean ± SD	31.6 ± 3.79
	Range	28–40
Sex (n, %)	Male	10 (63)
	Female	6 (38)
Laterality (n, %)	Unilateral	8 (50)
	Bilateral	8 (50)
Family history (n, %)	Negative	16 (100)
	Positive	0 (0)
Clinical data among the studied patients		**Feet (n = 24)**
Side (n, %)	Right	12 (50)
	Left	12 (50)
Other congenital anomalies (n, %)	None	14 (58)
	Arthrogryposis	4 (17)
	Arthrogryposis with flexion knee deformity	2 (8)
	Arthrogryposis with congenital knee dislocation	4 (17)
Previous management (n, %)	Non-surgical	0 (0)
	Surgical	0 (0)
Need for naviculectomy during surgery (n, %)	No	22 (92)
	Yes	2 (8)
Follow-up (months)	Mean ± SD	15.4 ± 3.11
	Range	(10–20)

Table II: Comparison between pre- and postoperative follow-up clinical appearance, mobility and function

Variables (n, %)		Preoperative (n = 24)	Postoperative follow-up (n = 24)	p-value
Heel posture	Gross valgus or varus	20 (83)	0 (0)	**< 0.001**
	Moderate valgus	4 (17)	0 (0)	
	Mild valgus	0 (0)	16 (67)	
	Neutral	0 (0)	8 (33)	
Lateral border	Gross abduction	18 (75)	0 (0)	**< 0.001**
	Slight concavity	6 (25)	2 (8)	
	Straight	0 (0)	8 (33)	
	Convex	0 (0)	14 (58)	
Talar prominence	Callus or ulceration	16 (67)	0 (0)	**< 0.001**
	Moderate	8 (33)	2 (8)	
	Minimal	0 (0)	16 (67)	
	None	0 (0)	6 (25)	
Medial longitudinal arch	Reversed	18 (75)	0 (0)	**< 0.001**
	Absent	6 (25)	0 (0)	
	Decreased	0 (0)	10 (42)	
	Normal	0 (0)	14 (58)	
Passive dorsiflexion	Gross equinus	16 (67)	0 (0)	**< 0.001**
	Slight equinus	6 (25)	0 (0)	
	Too square	2 (8)	8 (33)	
	Above square	0 (0)	16 (67)	
Passive plantar flexion	Fixed dorsiflexion	12 (50)	0 (0)	**< 0.001**
	< 10°	12 (50)	0 (0)	
	10–20°	0 (0)	12 (50)	
	> 20°	0 (0)	12 (50)	
Subtalar and midtarsal joints	Rigidity of the whole tarsus	16 (67)	0 (0)	**< 0.001**
	Stiffness of the whole tarsus	8 (33)	0 (0)	
	Subtle joint stiff	0 (0)	10 (42)	
	Useful range of tarsal joints	0 (0)	14 (58)	
Function	Difficulty walking	20 (83)	0 (0)	**< 0.001**
	Unable to do heavy work	4 (17)	0 (0)	
	Mild reduction	0 (0)	12 (50)	
	Normal	0 (0)	12 (50)	
Pain	Persistent pain	2 (8)	0 (0)	**< 0.001**
	Painful after strenuous activity	14 (58)	0 (0)	
	Occasional	8 (33)	14 (58)	
	No	0 (0)	10 (42)	

Fisher's exact test; non-significant: p > 0.05; significant: p ≤ 0.05

Table III: Comparison between pre- and postoperative follow-up radiological and total points score

Variables (n, %)		Preoperative (n = 24)	Postoperative follow-up (n = 24)	p-value
Hindfoot correction	Absent	24 (100)	0 (0)	**< 0.001**
	Present	0 (0)	24 (100)	
Talar verticality	Absent	24 (100)	0 (0)	**< 0.001**
	Present	0 (0)	24 (100)	
Forefoot correction	Absent	24 (100)	0 (0)	**< 0.001**
	Present	0 (0)	24 (100)	
Dislocation of the talonavicular joint	Absent	24 (100)	0 (0)	**< 0.001**
	Present	0 (0%)	24 (100)	
Total score	Mean ± SD	16.7 ± 1.13	39.3 ± 1.73	**< 0.001**
	Range	(15–18)	(35–42)	

Fisher's exact test; non-significant: p > 0.05; significant: p ≤ 0.05

surgical procedures may be required with an increased risk of complications.[5,12] Potential complications include inadequate repair of the deformity, wound necrosis, stiffness of the subtalar and ankle joints, bone necrosis, and possibly amputation in extreme cases.[5]

Many surgical techniques have been proposed to treat such conditions but there is no consensus and they raise many concerns.[6,14,21] In the current study, we described and evaluated our surgical technique used to treat NCVT cases. Our technique consisted of three carefully planned incisions, ensuring optimal access to comprehensively address deformities and facilitate precise repair and fixation. The first incision was made medially, starting at the base of the first metatarsal and extending to the medial malleolus. This approach provides access to critical structures for effective correction including reduction of the talonavicular joint to its correct anatomical position, tightening of the tibialis posterior tendon, lengthening of the extensor hallucis longus tendon, and release and transfer of the tibialis anterior tendon. The second incision was made laterally, starting at the base of the fourth metatarsal and extending down the lateral malleolus. Through this incision, reduction of the lateral foot column tension was achieved through lengthening the peroneal and extensor digitorum muscles. Furthermore, calcaneocuboid joint release and reduction and subtalar joint release were performed. The third incision was made posteriorly over the Achilles tendon to lengthen it. In this regard, we agree with Sanzarello et al., that Achilles tendon lengthening and release of the ankle and subtalar joints are necessary for all cases.[6] Contracture of these structures is the main cause of the hindfoot equinovalgus.[2]

In the current surgical approach, we exposed the surgical field through three incisions instead of two incisions, namely the posteromedial and lateral incisions, as proposed in the Sanzarello et al. study.[6] Instead of making a single posteromedial incision, we made two small incisions, posterior and medial. The single Cincinnati incision has been used successfully in previous studies for surgical exposure in cases of CVT deformity repair and also for insertional Achilles tendinopathy.[15,22] It is a single circumferential incision to expose the three sides of the ankle and foot, the anterolateral, posterior and posteromedial.[23] In the current approach, by making three small incisions instead of one large incision, we have tried to avoid extending the incision around the ankle and foot and make it easier to detect and correct deformities without excessive dissection of the subcutaneous tissue. This may reduce the possibility of infection and enable good healing.

Traditional surgical treatment of CVT is intensive and long term and can be associated with short- and long-term complications. Complications of surgery in such cases include under- or over-correction, requiring additional surgical intervention with increased risk of morbidity.[2] Complications also include talar necrosis, wound necrosis, pseudarthrosis, and joint stiffness.[24] No major postoperative complications, including infection and avascular necrosis, occurred in the current study. This result is generally consistent with another similar study.[6] Surgical complications were few and mainly involved wound ischaemia in about 17% of cases, which was treated by suture release in addition to administering abundant fluids along with anti-oedema medications. Other authors have suggested that open reduction with midtarsal release gives satisfactory results in CVT management.[25] However, they noted persistent secondary dislocation of the talonavicular joint in approximately 20% of the cases investigated during follow-up.

The rarity of CVT cases, as well as the increasing incidence of NCVT cases worldwide, is reflected in the scarcity of literature on reports of management of such a deformity.[6] Some authors have reported extensive surgical release for CVT repair. The surgical approach has been performed through combined medial, posterior and lateral incisions, multiple incisions, or through a single circumferential or dorsal incision.[15,25,26] In the current study, we evaluated cases of children who were already walking, which are considered stubborn cases to treat as they are more rigid and often do not respond to treatment easily. Our surgical approach was to make three incisions in one stage. The triple incision allowed us to obtain good exposure of the surgical field and correct the CVT complex deformity. Other authors proposed serial casting with minimally invasive surgery.[23,27] However, correction of CVT by sequential fixation and surgery may require a long time with frequent follow-up treatments.[6] This may be difficult to achieve, especially in cases where timely treatment has been neglected. Therefore, single-stage treatment may be the preferred approach for NCVT cases.

Some authors have re-evaluated the old surgical procedure involving naviculectomy as a salvage technique for the management of severe and intractable CVT in two cases, and concluded that it is a promising technique in the short term.[7] Navicular excision may be necessary in some children after the age of 3 years when open surgery is performed.[18] We have performed naviculectomy as part of surgery in only two cases where the talonavicular reduction proved too tight or difficult, and the medial arch remained significantly longer than the lateral arch, resulting in severe forefoot abduction. Navicular excision in some cases of our series can allow for improved reduction, alignment, and balance of the medial and lateral arches, ultimately restoring a more anatomically congruent foot structure. It has been suggested that a common reason for failure of surgical repair in such cases may be due to inadequate reduction of the navicular dislocation.[9]

The key to the surgical approach to correcting CVT is understanding the pathoanatomy of the existing deformities. We performed surgery to release the contracted joint capsules and then lengthened the contracted tendons that cause such deformities. These include the peroneal and tibialis anterior tendons, whose contraction is responsible for the lateral everted position of the foot with the foot valgus. Furthermore, Achilles tendon contracture is the cause of the hindfoot equinus.[19] Regarding tibialis anterior tendon, we transferred it to the talar neck creating a dynamic stabiliser to prevent abnormal plantar flexion of the talus. Likewise, lengthening of Achilles tendon has been performed to overcome its contracture. Ramanoudjame et al., performed similar procedures in children during the first two years including Achilles tendon lengthening and tibialis anterior tendon transfer to the talus neck.[25] However, the authors noted that tibialis anterior tendon transfer may result in some subsequent forefoot pronation and pes planovalgus. The development of these signs after surgery, which may be due to muscle imbalance, was not observed in our group of patients.

In our series, we inserted two or three K-wires to stabilise the bone position after reduction and removed them after six weeks, with the addition of a short leg splint for an additional three weeks to ensure joint stability. In very young children, only one wire may be needed for stabilisation.[14]

There are several ways to score and evaluate the outcome after surgery including clinical, functional and radiological criteria.[8] All of these criteria showed improved outcomes after surgery. No major complications occurred and no relapses were observed during the follow-up period. Clinically, all parameters were improved. Gross hind valgus was not observed, only mild deformity was noticed in 16 (67%) cases. The talar head protrusion has largely disappeared except for a slight prominence. No callosities or ulcerations were noted. The medial longitudinal arch of the foot improved; it was corrected in 58% of cases while it was reduced in about 42%. Passive dorsiflexion and plantar flexion movements as well as stiffness and rigidity of subtalar and midtarsal joints were greatly improved. The pain and difficulty in walking have almost disappeared, except for some episodic pain in some cases. The radiographic evaluation indicated improvement, with decrease in all radiological angles postoperatively ($p < 0.001$), except for lateral TM1 which increased postoperatively ($p < 0.001$). Although the values obtained in the present work indicate general improvement, they may be lower than those obtained in the correction obtained in young patients in other studies.[14,25] However, the range of preoperative deformity angles in the current series of patients was mostly higher than in these previous studies. After follow-up after the surgery for at least one year, the results showed satisfactory results for the patients and their families, with good walking in 50% of cases, and others showing fair improvement with a slight decrease in radiological angles. No patient in our series required reoperation.

The relatively good results of the surgical procedure observed in this study may support it being an option in managing such cases. Good postoperative scores were achieved in all feet studied compared to preoperative scores ($p < 0.001$). We therefore agree with other authors that a single-stage comprehensive surgical procedure represents the preferred technique for the management of NCVT.[6]

Although this study describes a suitable surgical approach to correct one of the most challenging orthopaedic conditions to treat with a low rate of surgical and postoperative complications, it has some limitations. These limitations include the relatively small number of patients, which may be due to the rarity of the cases. A comparison between surgical methods has also not been made because previous studies are limited by the rarity of cases. Furthermore, the relatively short follow-up time of the cases in the current study constitutes another limitation. The short follow-up period may be attributed to the fact that patients in rural and remote areas often return for follow-up only when they have a health problem and need medical assistance. Losing them to follow-up may not necessarily indicate poor outcomes.

Conclusions

CVT is a rare, complex deformity. Severe cases present with greater stiffness and disability, and treatment is surgical. Single-stage surgical correction can be the best option in cases of NCVT that may miss long-term follow-up treatment with more stages. The surgical approach is performed through three incisions: anterolateral, posterior and posteromedial. The treatment includes subtalar release and lengthening of the peroneal and extensor digitorum muscles and Achilles tendon, as well as transfer of tibialis anterior tendon to neck of talus. Furthermore, naviculectomy may be added in cases with severe forefoot abduction to achieve adequate reduction and medial–lateral arch balance. The satisfactory results of this surgical procedure observed in this study may add to its potential as an option in the management of such cases. This is particularly important for patients in rural and remote areas where access to healthcare facilities may be difficult, travel costs are high, and there is a lack of awareness of the importance of staged surgeries. Additionally, single-stage surgery remains most appropriate in cases that have already been neglected in terms of treatment. In this regard, we recommend conducting further studies with a larger number of patients and long-term follow-up in order to confirm the current results and investigate the long-term outcomes. This can be done in parallel with future efforts that should focus on enhancing early detection and treatment of CVT to reduce the prevalence of neglected cases.

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Ethics statement

The authors declare that this submission is in accordance with the principles laid down by the Responsible Research Publication Position Statements as developed at the 2nd World Conference on Research Integrity in Singapore, 2010.

All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Approval was obtained from the Zagazig University Institutional Review Board (IRB) of number (IRB#: 10043/30-10-2022), and written informed consent was obtained from the parents of the children participating in the study, without revealing their identity. All patients underwent surgery as well as pre- and postoperative evaluation.

Consent was obtained for the case to be described in this report and anonymised photographs to be used.

Declaration

The authors declare authorship of this article and that they have followed sound scientific research practice. This research is original and does not transgress plagiarism policies.

Author contributions

MAH: shared in all steps of the research, reviewed and edited the manuscript and approved the final version of the manuscript

HMK: shared in all steps of the research, reviewed and edited the manuscript and approved the final version of the manuscript

AAH: shared in all steps of the research, reviewed and edited the manuscript and approved the final version of the manuscript

MAEFS: shared in all steps of the research, reviewed and edited the manuscript and approved the final version of the manuscript

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