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Comprehensive Analysis and Surgical Management of Neglected Congenital Talipes Equinovarus Using the Joshi's External Stabilizing System: A 3-Year Longitudinal Case Study and Biomechanical Review

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Learning Point of the Article:

The application of Joshi's External Stabilizing System (JESS) facilitates controlled, three-dimensional correction of rigid neglected clubfoot through differential distraction histogenesis, providing a superior alternative to aggressive open surgery in older children.

Abstract

Introduction: Neglected congenital talipes equinovarus (CTEV) presents a formidable challenge in pediatric orthopedics, characterized by rigid soft-tissue contractures and adaptive bony changes that occur when the deformity remains untreated past the walking age. While neonatal clubfoot is successfully managed via the Ponseti method, delayed presentations require interventions that can address fixed skeletal remodeling without the morbidity of extensive posteromedial releases. This report analyzes a single case of a child with neglected CTEV treated with the Joshi's external stabilizing system (JESS), following the patient from the pre-operative state through a 3-year follow-up period.

Case Report: A 3.5-year-old female presented with an uncorrected, unilateral, neglected idiopathic clubfoot. The clinical examination revealed a rigid, non-reducible deformity with a Pirani score of 6.0 and a Dimeglio score of 18 (Grade IV). Severe equinus, varus, cavus, and forefoot adduction were present, complicated by a large lateral-border callosity. Treatment involved the surgical application of the JESS fixator using a three-stage frame assembly. A protocol of fractional differential distraction was initiated postoperatively, distracting the medial side at twice the rate of the lateral side (1 mm/day vs. 0.5 mm/day) over 6 weeks, followed by a 6-week static stabilization phase.

Conclusion: By the 3-year follow-up, the patient achieved a painless, plantigrade, and functional foot with significantly improved radiological indices. The talocalcaneal angles in both anteroposterior and lateral views normalized, and the patient demonstrated excellent range of motion compared to historical outcomes of open soft-tissue procedures. This case underscores JESS as a versatile, minimally invasive, and effective modality for managing the complex biomechanical demands of neglected clubfoot in low-resource and delayed-presentation settings.

Keywords: Clubfoot, neglected congenital talipes equinovarus, Joshi's external stabilizing system fixator, ligamentotaxis, distraction histogenesis, pediatric orthopedic surgery.

Introduction

Congenital talipes equinovarus (CTEV) is among the most frequent congenital musculoskeletal deformities, with a global incidence of 1–2/1,000 live births [1]. In high-income countries, the diagnosis is usually prenatal or neonatal, and the Ponseti method of serial casting and percutaneous Achilles tenotomy achieves successful correction in over 90% of cases [1]. However, in many developing regions, socioeconomic factors, lack of specialized healthcare, and traditional beliefs lead to a significant number of "neglected" cases – children who present with untreated clubfoot at an age where they have already begun to walk [2].

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Author's Photo Gallery


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The pathophysiology of neglected CTEV is distinct from its neonatal counterpart. As a child begins to bear weight on a deformed foot, the initial soft-tissue contractures are exacerbated by the forces of ambulation [3]. The soft tissues on the medial and posterior aspects – including the tibialis posterior, flexor digitorum longus, and flexor hallucis longus tendons, as well as the Achilles tendon and the plantar fascia – become thickened, fibrotic, and severely retracted [4]. Simultaneously, the bones of the tarsus, which are primarily cartilaginous at birth, begin to ossify in a malaligned position. The talar head and neck are diverted medially and plantarly, the navicular is displaced medially toward the medial malleolus, and the calcaneus is held in a position of fixed varus and equinus [3]. These adaptive changes result in a rigid, "bone-on-bone" deformity that is largely unresponsive to conservative manipulation and casting [4].

Historically, surgeons addressed these rigid deformities through extensive posteromedial soft-tissue releases (PMR). While PMR can achieve initial correction, the long-term outcomes in older children are often poor, characterized by significant scarring, stiff joints, weakened intrinsic musculature, and a high rate of recurrence [2]. The "surgical" foot often becomes a "stiff" foot, leading many surgeons to seek more physiological alternatives that utilize the body's natural regenerative capacity [2].

The concept of ligamentotaxis and distraction histogenesis, pioneered by Professor Gavriil Ilizarov, provided a new paradigm for managing these cases. Ilizarov demonstrated that slow, controlled distraction of living tissue induces a state of active growth and regeneration – histogenesis – in skin, muscle, nerves, blood vessels, and bone [2]. While the Ilizarov ring fixator is a powerful tool for clubfoot correction, its complexity and the requirement for tensioned transfixing wires can be problematic in the smaller, osteopenic bones of a child's foot [5].

In response to the need for a simpler, more affordable, and patient-friendly system, Dr. B. B. Joshi developed the Joshi's external stabilizing system (JESS) in 1988 [2]. JESS is a versatile mini-external fixator that utilizes K-wires and a series of rods and distractors to apply the principles of ligamentotaxis without the weight or complexity of circular frames [6]. JESS is particularly suited for the Indian context and other similar healthcare environments due to its cost-effectiveness and the relatively short learning curve required for orthopedic surgeons [7]. The system allows for the simultaneous correction of all components of the clubfoot deformity – equinus, varus, cavus, and adduction-while preserving the joints and avoiding the extensive scarring associated with open surgery [8].

This case report details the treatment of a child with severe neglected CTEV using the JESS fixator, providing a deep dive into the surgical technique, the biomechanical rationale for differential distraction, and the long-term clinical and radiological outcomes over a 3-year period.

Case Report

Patient presentation and clinical history

The patient was a 3.5-year-old female from a rural background who presented at our orthopedic hospital with a severely deformed right foot. According to the parents, the deformity had been present since birth, but due to financial constraints and a lack of local specialized services, no medical treatment had been sought. The child had been walking on the deformed foot for over 2.5 years. Pre-operative clinical photographs are shown in Fig. 1.

On initial observation, the child demonstrated a significant gait abnormality, bearing weight on the outer, dorsal aspect of the right foot. A large, hyperkeratotic callosity was visible over the lateral border, particularly over the base of the fifth metatarsal. The right foot was

Figure 1: Pre-operative clinical photographs of the patient (age 3.5 years) showing the severely deformed right foot with fixed equinus, hindfoot varus, forefoot adduction, deep medial and posterior skin creases, and the lateral border callosity. (a) Posterior view showing heel varus and equinus. (b) Medial view showing cavus and deep medial crease. (c) Lateral view showing the lateral border callosity.

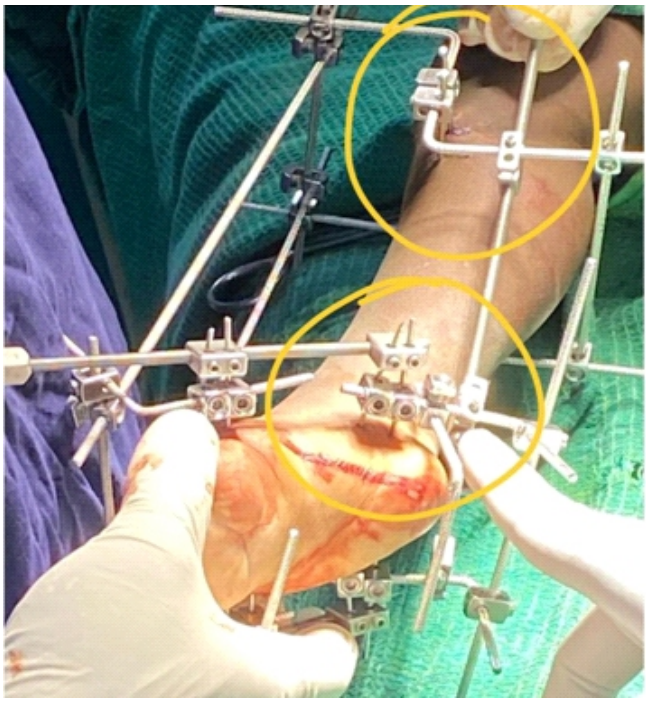

Figure 2: Intraoperative photographs demonstrating the three-stage Joshi's external stabilizing system (JESS) frame assembly showing Kirschner wire placement in the tibial, calcaneal, and metatarsal zones, and the completed JESS construct with tibio-calcaneal and calcaneo-metatarsal distractors and the static tibio-metatarsal rod in situ.

noticeably smaller than the left, and there was associated wasting of the right calf muscles.

Detailed clinical examination

A systematic clinical examination was performed to assess the severity and rigidity of the deformity. The foot was in a position of fixed equinus, severe varus of the hindfoot, significant cavus in the midfoot, and marked adduction of the forefoot. There were deep skin creases on the medial and posterior aspects of the foot, which were rigid and did not stretch upon manual manipulation.

To quantify the deformity, we utilized the Pirani and Dimeglio scoring systems, which are the gold standards for clubfoot assessment [9]. The combined Pirani and Dimeglio scoring is presented in Table 1. The Dimeglio score, which evaluates four parameters on a scale of 0–4 and adds points for "pejorative" factors, resulted in a score of 18 out of 20, placing the foot in Grade IV (Very Severe) [9].

Radiological evaluation

Standard weight-bearing anteroposterior (AP) and lateral radiographs were obtained. In neglected CTEV, the usual bony landmarks are often distorted, but the relationships between the talus, calcaneus, and metatarsals remain critical for assessment [10].

· AP view: The talocalcaneal (TC) angle was measured at 11° (Normal: 30°–55°). The Talo-1st Metatarsal angle was 40°, indicating severe forefoot adduction [10].

· Lateral view: The TC angle was 9° (Normal: 25°–50°), and the Tibiocalcaneal angle demonstrated fixed equinus at 60° [10].

· Foot bimalleolar axis (FBA): The FBA was measured at 62°, confirming severe internal talar spin (Normal: 82.5°) [1].

Surgical intervention: JESS fixator application

The patient was scheduled for surgical correction using JESS ligamentotaxis. The procedure was performed under general anesthesia with the patient in the supine position. While a tourniquet was placed, it was kept uninflated to allow for the assessment of digital capillary refill throughout the wire placement process [10]. Intraoperative photographs of the JESS frame assembly are shown in Fig. 2.

The surgical technique was divided into three primary phases: wire installation, hold creation, and frame connection [11].

Kirschner wire installation

The foundation of the JESS frame relies on precise K-wire placement in three key anatomical zones: the tibia, the calcaneus, and the metatarsals [11].

· Tibial zone: Two 2.0 mm transfixing K-wires were passed

Figure 3: Post-operative clinical photographs following fixator removal and cast application.

through the proximal tibial diaphysis, approximately 2 cm distal to the tibial tuberosity. The wires were passed from the lateral to the medial side, parallel to each other and to the knee joint line. In this 3.5-year-old child, a third wire was added 2 cm distal to the second wire to increase the axial stability of the tibial hold [11].

· Calcaneal zone: Two parallel 2.0 mm wires were passed through the posterior tuber of the calcaneus from the medial to the lateral side. Utmost care was taken to avoid the posterior tibial neurovascular bundle by palpating the pulse and entering the bone posterior to the vessel's course [3]. An essential "axial" half-pin K-wire was then inserted from the posterior aspect of the heel, just distal to the Achilles tendon insertion, and directed anteriorly along the longitudinal axis of the calcaneus [11].

· Metatarsal zone: A 2.0 mm transfixing wire was passed through the necks of the first and fifth metatarsals. To ensure a stable hold on the forefoot, two additional wires were passed – one through the first and second metatarsals from the medial side, and another through the fifth and fourth metatarsals from the lateral side – ensuring that all five metatarsals were integrated into the forefoot block [12].

Figure 4: Clinical photograph showing 3-year follow-up photographs demonstrating a durable, full weight-bearing on a plantigrade foot with resolved callosity and creases.

Creation of holds

The K-wires were then organized into three rigid "holds" using JESS components:

· Tibial hold: The tibial wires were attached to two Z-rods (one medial, one lateral). Before tightening the link joints, the wires were "pre-stressed" by bowing them slightly, which increases the stiffness of the assembly and prevents wire-to-bone migration [12].

· Calcaneal and metatarsal holds: These were created using L-rods and link joints, forming rigid blocks that could be independently manipulated during the distraction phase [11].

Connection and distraction assembly

The final stage involved connecting the holds with distractors to address each component of the deformity:

· Calcaneo-metatarsal distractors: Two distractors were placed (one medial, one lateral) between the calcaneal and metatarsal holds to address midfoot cavus and forefoot adduction [13]

· Tibio-calcaneal distractors: Two distractors were placed posteriorly between the tibial Z-rods and the calcaneal L-rods to address the equinus [12]

· Static tibio-metatarsal rod: A static rod was connected between the tibial and metatarsal holds. This is a crucial biomechanical feature of JESS; it keeps the anterior portion of the ankle joint open, preventing the crushing of the talar dome and tibial plafond during the correction of equinus [11]

· Toe sling: A dynamic rubber sling was attached to the metatarsal wires to prevent flexion contractures (clawing) of the toes during distraction [12].

Post-operative protocol and distraction schedule

The patient's leg was elevated, and neurovascular checks were performed hourly for the first 24 h. Distraction was not started immediately; instead, a "latency period" of three days was observed to allow for the initial resolution of surgical edema and the stabilization of the pin-skin interface [10].

On the 3rd post-operative day, the "fractional differential distraction" protocol was initiated. The principle of differential distraction is to lengthen the medial side of the foot faster than the lateral side to correct the adduction and varus while simultaneously correcting the equinus [2]. The distraction schedule is outlined in Table 2.

The parents were trained to perform the turns using an Allen key. The distraction phase continued for 45 days. During this

Table 1: Pre-operative Pirani and Dimeglio scoring of the affected foot

Parameter	Score	Findings
Pirani scoring		
Midfoot score	3	
Curved lateral border	1	Severe curvature, no correction possible
Medial crease	1	Deep, skin-on-skin crease that does not open
Talar head palpation	1	Talar head completely uncovered laterally
Hindfoot score	3	
Posterior crease	1	Deep crease that does not stretch
Empty heel	1	Calcaneus cannot be felt in the heel pad
Rigid equinus	1	No passive dorsiflexion beyond neutral
Total Pirani score	6	Maximum severity, rigid neglected CTEV
Dimeglio scoring		
Equinus (sagittal)	4	Fixed plantarflexion >45°
Varus (frontal)	4	Fixed varus >45°
Derotation (horizontal)	4	Severe rotation of the calcaneo-pedal block
Adduction (horizontal)	4	Fixed forefoot adduction
Posterior crease	1	Present
Medial crease	1	Present
Cavus	1	Present
Muscle abnormality	1	Significant calf wasting
Total Dimeglio score	18/20	Grade IV–very severe

CTEV: Congenital talipes equinovarus

time, the foot was visually monitored for the gradual resolution of the medial crease and the improvement of the heel position. Weekly radiographs were obtained to ensure that no subluxation of the joints was occurring [13].

After full clinical correction was achieved (demonstrated by a plantigrade foot with 10° of dorsiflexion and 10° of abduction), the frame was locked in a "static phase" for an additional 6 weeks [13]. This phase is vital for the maturation of the regenerated tissues and the stabilization of the tarsal bones in their new alignment [13].

Fixator removal and post-fixator care

After 12 weeks, the JESS fixator was removed in a single stage under general anesthesia. Following removal, a below-knee walking cast was applied in the corrected position for another 6 weeks. This cast protects the bones, which are often osteopenic after a period in an external fixator, and allows the pin tracts to heal fully [13]. Post-operative photographs are shown in Fig. 3.

Once the cast was removed, the patient was transitioned into customized CTEV shoes with a lateral wedge and a night splint to maintain the correction. Physical therapy was initiated to improve the range of motion of the ankle and the strength of the calf muscles [11].

Discussion

The management of neglected CTEV remains one of the most demanding tasks in pediatric orthopedics. This case provides several insights into the advantages of JESS and the biological mechanisms of correction in older children.

Biomechanical advantages of JESS over Ilizarov

The JESS fixator occupies a unique niche between conservative casting and complex ring fixation. While the Ilizarov method is highly effective, it has several drawbacks in the pediatric population, including its significant weight and the potential for tensioned wires to cut through soft, osteopenic bone [5].

JESS addresses these issues through its low-profile, lightweight design. The use of 2.0 mm un-tensioned K-wires provides enough stability to guide the foot into correction while being less invasive than the transfixing wires of the Ilizarov system [7]. The comparison of outcomes between the two systems suggests that JESS is particularly superior in children under 10 years of age, where the foot is smaller, and the bones are less dense [7].

The "tension-stress" effect and histogenesis

The success of this case relies on the "Tension-Stress" effect described by Ilizarov, which states that living tissues, when subjected to slow, continuous tension, respond by increasing their biosynthetic activity [2]. In our patient, the rigid medial skin and fibrotic ligaments did not merely stretch; they underwent active growth. This is particularly evident in the resolution of the deep medial crease, which would have been impossible to correct with casting alone without risking skin necrosis or pressure sores [12].

Furthermore, JESS avoids the "crushing" of articular cartilage. In traditional casting or aggressive manipulation, the bones are often forced against each other, which can lead to avascular necrosis of the talus or flattening of the talar dome. The static tibio-metatarsal rod in the JESS assembly provides an "internal distractive force" that keeps the ankle joint distracted, allowing

Table 2: Post-operative fractional differential distraction protocol

Distraction type	Medial rate	Lateral rate	Schedule
Calcaneo metatarsal	1.0 mm/day	0.5 mm/day	0.25mm/turn, Medial 6 hourly, lateral 12-hourly
Tibio calcaneal	0.5 mm/day	0.5 mm/day	0.25mm/turn;12-hourly (equinus correction)

Table 3: Clinical and radiological outcome metrics at pre-operative, 12-month, and 3-year follow-up

Metric	Pre-operative	Post-operative (12 months)	3-year follow-up
Pirani score	6	0.8	0.5
Dimeglio score	18	2	1
Ankle dorsiflexion	−45°	+10°	+15°
Hindfoot varus	40°	5°	0°

the talus to glide smoothly into the mortise as the equinus is corrected [11].

Analysis of clinical outcomes and scoring

The transformation of the Pirani and Dimeglio scores in this case is a testament to the system's efficacy. The Pirani score fell from 6.0 preoperatively to 0.8 at 12 months and 0.5 at the 3-year follow-up, indicating that correction was achieved and maintained during growth[11]. The outcome data are summarized in Table 3.

The Dimeglio score's improvement from Grade IV to Grade I is equally significant. Many studies on JESS have reported similar shifts. For example, a study of 20 feet by Shaik and Kumar showed that 80% of patients achieved excellent or good outcomes following the JESS protocol, with a significant reduction in the severity of the deformity [2].

Radiological parameters and the internal talar spin

Radiological correction in neglected CTEV is often more difficult to achieve than clinical correction, as the bones have already adapted to the deformed position. However, JESS has been shown to improve the TC and Talo-1st metatarsal angles significantly [10].

In our patient, the AP TC angle improved from 11° to 32°, and the Lateral TC angle improved from 9° to 30° [14]. Perhaps more importantly, the FBA, which measures the internal talar spin, normalized from 62° to 82° [1]. Talar spin is a critical but often overlooked component of the clubfoot deformity; if the talus remains rotated within the ankle mortise, the risk of recurrence is high [1]. The differential distraction of JESS effectively derotates the calcaneo-pedal block around the talus, restoring the normal anatomical relationship between the leg and the foot [1].

Comparison with published literature of JESS outcomes

Our results are consistent with a broad body of evidence supporting JESS for neglected CTEV. Several series have evaluated the long-term efficacy of this method, as summarized in Table 4.

Suresh and Ahmed's study highlighted that while the results are overwhelmingly good, the complication rate of 27% is a factor that surgeons must manage [15]. The most common complications are superficial pin tract infections, which occurred in our case as well. These are generally managed with local care and oral antibiotics and rarely lead to the failure of the procedure [15]. More serious complications like skin necrosis or epiphyseal separation are extremely rare with JESS compared to the Ilizarov system [15].

Management of complications and technical pearls

The success of JESS in this case can be attributed to several technical "pearls" identified during the 12-week treatment period:

· Avoid over-distraction: If the digital capillary refill time exceeds 3 s, distraction must be paused for 24 h. In our case, a brief period of edema in the 2nd week was managed by pausing the distraction for 48 h [15]

· Pin tract care: Daily cleaning of the pin sites with saline and the application of a dry dressing are mandatory to prevent infection. Keeping the skin around the pins "tension-free" by making small skin incisions at the entry points significantly reduced the rate of infection [12]

· The toe sling: Flexion contractures of the toes are a common complication of distraction as the long flexors are stretched. The consistent use of the toe sling in this patient prevented "clawing," which is often difficult to correct once established [15]

· The static Phase: Many early failures of JESS were due to premature frame removal. Maintaining the frame for a minimum of 6 weeks after correction is achieved is essential for collagen stabilization [13].

Long-term implications and growth

At the 3-year follow-up, our patient showed no signs of recurrence. This is a crucial finding, as the high growth velocity during pre-adolescence can often trigger a relapse if the initial

Table 4: Summary of published literature on JESS outcomes for neglected/resistant CTEV

Author (Reference)	Cases (Feet)	Excellent/good results (%)	Complication rate (%)
Ajmera et al. [8]	30	85	13%
Suresh *et al*. [15]	44	90	27 (mainly pin infection)
Shaik and Kumar (2024) [2]	20	80	15 (loosening/infection)

JESS: Joshi's External Stabilizing System, CTEV: Congenital talipes equinovarus

correction was incomplete or if muscle balance was not restored. The fact that the patient has a functional, plantigrade foot and can participate in normal childhood activities demonstrates that JESS-mediated correction is durable [1]. Three-year follow-up photographs are shown in Fig. 4.

Conclusion

The management of neglected CTEV with the JESS represents a significant advancement over traditional, more aggressive surgical techniques. This case demonstrates that the rigid, unyielding deformities of a 3.5-year-old child can be corrected physiologically through the principle of distraction histogenesis.

The JESS fixator provides several key advantages:

· Minimally invasive: It avoids the extensive scarring and joint stiffness associated with open posteromedial releases

· Controlled correction: The fractional differential distraction protocol allows the surgeon to tailor the correction to the specific biomechanical needs of the foot, addressing cavus, adduction, varus, and equinus simultaneously

· Joint preservation: By distracting the ankle and midtarsal joints during correction, the system protects the articular cartilage and promotes normal ossification of the tarsal bones

· Cost-effective and practical: Its simplicity and affordability make it an ideal choice for orthopedic departments in developing countries

· At the 3-year mark, our patient maintains a supple, plantigrade foot with normalized radiological indices and high functional scores. For the orthopedic community, JESS remains a vital tool in the armamentarium against the disability caused by neglected clubfoot, offering a biological solution to a complex mechanical problem.

Clinical Message

In children with rigid neglected CTEV, the JESS fixator facilitates a "biological" correction through differential distraction histogenesis. This modality effectively bypasses the limitations of casting and the morbidity of extensive open surgery, resulting in a durable, functional, and plantigrade foot. Success is contingent upon a rigid frame assembly, a disciplined distraction schedule, and a prolonged static stabilization phase.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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