

Resistant clubfoot deformities managed by Ilizarov distraction histogenesis

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ABSTRACT

Background: Resistant clubfoot deformities of the foot and ankle remain a difficult problem even for the most experienced surgeon. We report a series of neglected resistant clubfoot deformities treated by limited surgery and Ilizarov distraction histogenesis.

Materials and Methods: Twenty one patients with 27 feet having resistant clubfoot deformities were managed by Ilizarov distraction histogenesis from April 2005 to May 2008. The mean age was 12 years (range 8–20 years). A limited soft tissue dissection like percutaneous Achilles sheath tenotomy and plantar fasciotomy were done. Progressive correction of the deformities was achieved through the standard and simple Ilizarov frame construct setting. After removal of Ilizarov frame, a short leg walking cast was used for an additional 6 weeks, followed by an ankle foot orthosis for 3 months.

Results: The mean followup period was 18.7 months (range 20-36 months). The mean duration of fixator application was 3.6 months (range 3–5 months). At the time of removal of the fixator, a plantigrade foot was achieved in 25 feet and gait was improved in all patients. There was residual varus hind foot deformity in two patients. Out of 27 feet, 3 (11.11%) were rated as excellent, 17 (62.96%) as good, 5 (18.51%) as fair, and 2 (7.40%) as poor according to Reinkerand Carpenter scale. Excellent and good results (74.07%) were considered satisfactory, while fair and poor results (25.92%) were considered unsatisfactory.

Conclusion: The short term clinical and functional results of resistant clubfoot deformities with Ilizarov's external fixator is promising and apparently a good option.

Key words: Ilizarov frame, deformities, resistant clubfoot

INTRODUCTION

The resistant and neglected clubfoot deformity presents a significant challenge. Several corrective procedures have been described, with the goal to provide a pain free, plantigrade foot. The Ilizarov method of external fixation and gradual distraction has been reported as an alternative to conventional techniques. Encouraging results are reported with this method.¹

The Ilizarov's external fixator allows simultaneous correction

of all the severe foot deformities associated with neglected clubfoot with minimal surgery, reducing risks of cutaneous or neurovascular complications and avoiding excessive shortening of the foot.² The external fixation remains an essential tool for future orthopedic surgeons.³

The Ilizarov method is being used increasingly to correct many orthopedic deformities. The frames required for ankle and foot deformity correction are among the most difficult to construct owing to the complexity of the deformities which must be corrected.⁴ The application of Ilizarov frame is in two parts, one to the leg and one to the foot. First, a two-ring construct is applied to the leg. Each ring is fixed with two wires or one wire and one half pin. The foot construct consists of a half ring posteriorly and half ring anteriorly.⁵ A half ring is fixed to the forefoot with 2 crossed olive wires, 1 traversing the 5 metatarsals and the other fixed to the medial 3 metatarsals medially to laterally. A half ring was applied to the hind foot with 2 crossed wires through the calcaneus, with a Shanz pin fixed to the calcaneus from posterior to anterior. The forefoot half ring was fixed to the hindfoot half ring by a medial rod on a hinge and connected to the distal tibial ring by a central dorsal rod on a universal hinge. Two dorsal rods were used on each side of the central hole of the forefoot half ring in

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patients with forefoot supination.⁶ The Ilizarov technique has been suggested as an alternative to major surgery for the treatment of neglected or recurrent deformities in clubfoot.⁷ Even in those patients in whom final corrective arthrodesis is necessary, this may be carried out with minimal bone resection, since the severe deformities of the foot and ankle have been corrected.⁸ We report a series of neglected resistant clubfoot deformities treated by limited surgery and Ilizarov distraction histogenesis.

MATERIALS AND METHODS

We evaluated the results of this prospective study with Ilizarov's external fixation system in 21 patients with 27 feet without corrective osteotomies as treatment of neglected resistant clubfoot deformity, between April 2005 and May 2008. This study includes a resistant clubfeet ($n=13$) which were treated for the first time, already operated clubfeet by other methods ($n=14$), and also presented with multiple surgical scars ($n=5$).

All resistant clubfeet with common deformities like adduction or supination, or both, of the forefoot, short medial column and long lateral column, varus of the hind foot, and equinus of the ankle were included to decide the same surgical planning with Ilizarov in all patients because it permits simultaneous correction of these multiplanar deformities. Resistant clubfeet with non healing ulcers over the callosities on the dorsum of lateral column due to weight bearing were excluded from the study. Minimal soft tissue procedures for those were done below the age of 12 years depending upon their flexibility to correct the deformities without stress over the soft tissues with Ilizarov method during distraction and compression.

Gait of all patients like their walking pattern were assessed clinically through functional mobility scale⁹ at the time of admission and every step was planned like physical assistance, bracing, and assistive devices to improve the speed, distance and efficiency while walking. They were also assessed for skin and soft tissue conditions, range of ankle and subtalar joint movement, levels of the particular deformity, limb shortening. The radiographs were obtained for standard anteroposterior and lateral views with and without weight bearing. The condition of ankle and other joints of foot, angles of individual deformities were assessed.

Operative procedure

The limb was painted and draped from foot to hip. Ilizarov frame was preassembled according to the deformity of foot as well as radiographs to correct without any stress over the related soft tissues.

Two full rings, mostly of 16 and 18 hole sizes, were assembled and connected with two rods and mounted over the tibia with one transverse wire and two 5 mm half pins with rancho cube system in each ring. One half ring was mounted to the calcaneus, using one plain wire and two shanz screws with rancho system. Another half ring with two plain crossed wires was applied through 1st to 3rd metatarsal and from 5th to 2nd or 3rd metatarsal and connected with the rings applied over the tibia through the hinges, plates, and conical washers were also used wherever required. The calcaneal half ring had three connections to the lower ring of the tibia frame (posteriorly, medially, and laterally), while the forefoot half ring had two connections situated medially and laterally and sometimes only one connection situated centrally to the long axis of the foot. The hinges allow the rods to move without bending and also prevent the subluxation of joints during distraction.

Half ring over the calcaneus was used as a distractor or pusher and compression or pulling was achieved through the half ring over dorsum of the fore foot. Varus deformities of the heel were corrected through medial and lateral rods by compression and distraction method. These rods with hinges were applied in the rings fastened over the calcaneus and forefoot to increase or decrease the medial or lateral column according to the need of deformity correction. For correction of rotational like supination and pronation deformities, two frontal rods with hinges were applied in oblique directions connected with the ring in the forefoot and assembly over the leg and corrected accordingly. The sequence of deformities' correction was gradual distraction of medial column and compression of lateral column to correct the forefoot adduction, 1–2 mm/day, which was started on the 2nd postoperative day. After correction of forefoot adduction supination, hind foot varus and finally equinus were corrected through the setting of the Ilizarov's external fixator. During distraction, tension over the soft tissues, neurovascular status, and improvement in the correction of the deformities were observed clinically, and radiologically dislocation or subluxation of tarsal and ankle joints was observed [Figure 1].

After application of Ilizarov, a limited soft tissue dissection, percutaneous Achilles sheath tenotomy, and plantar fasciotomy were done for patients under 12 years and Achilles tendon lengthening was done for those above 12 years of age. Achilles tendon lengthening was performed in 9 (59.93%) feet, Achilles tendon sheath tenotomy in 8 (29.62%) feet, and planter fasciotomy in 6 (22.22%) feet.

Approximately 8°–10° deformity was over corrected and this over lengthening of soft tissues avoided the recoil that could occur in the soft tissue after frame removal. All feet

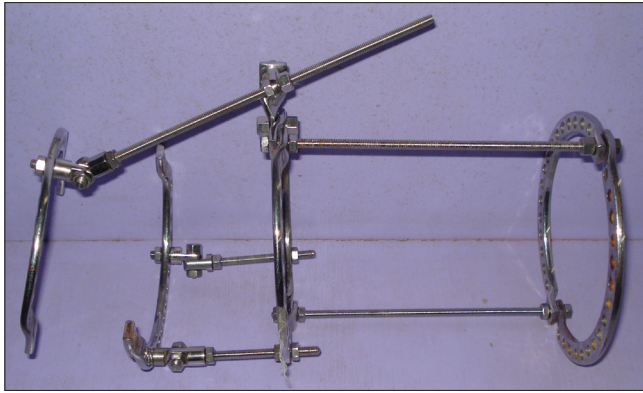


Figure 1: Ilizarov frame for ankle and foot with two full rings for leg, one half for calcaneum and one half for forefoot over the metatarsals

were also assessed radiologically as well as clinically every week during the followup period.

All patients were encouraged and weight bearing was allowed according to tolerance of the patients and their degree of correction. Adjustments were done by the surgeon and postgraduate students during stay in the hospital, and after discharge by either the patient himself/herself, and if the patient was a child, the family members were trained to move the nuts for compression, distraction, and lengthening through the markings. Care of pins was taken during their stay in the hospital, and patients and their attendants were trained to take care of pins by themselves after discharge. All the pins were cleaned with normal saline and dressed with sterilized dry gauzes initially after 24 hours than after 72 hours. Loose clamps, nuts, and bolts were tightened regularly in outpatient clinic initially weekly up to deformity correction, then fortnightly up to removal of the fixator. The fixator removal was decided after correction of all required deformities and the time needed for correction of the deformities was variable depending on the resistance and rigidity of the deformities. After complete correction, the distraction stopped and the Ilizarov was retained in a fixed position for a further period of 4–6 weeks. During this period, up to the removal, the patients were encouraged and allowed to bear full weight and improve the gait. Fixator was removed, all the pin wounds were washed, and aseptic dressings were done; a short leg walking plaster of paris (POP) cast was applied for 2 weeks, the patients were reviewed at the outpatient clinic after 2 weeks, and the POP cast was removed. The status of wounds was checked and again short leg walking cast was applied for 4 more weeks. The total time of the POP cast was 6 weeks after removal of the fixator, followed by an ankle foot orthosis (AFO) for 3 months.

RESULTS

The mean age was 12 years (range 8-20 years). Eight feet

were above the age of 15 years. There were 8 females and 13 males. The mean distraction time for deformity correction was 7.2 weeks (range 4-12 weeks). The mean duration of fixator application was 4.5 months (range 3–06 months). The mean followup period was 18.7 months (range 20-36 months). Ilizarov was removed after an average of 2.5 weeks (range 4-6 weeks) after correction of deformities. At the time of removal of fixator, a plantigrade foot was achieved in 25 feet and gait was improved in all patients. There was residual varus hind foot deformity in two patients

The correction of the deformity and function were assessed and the results were graded based on the Reinker and Carpenter scale as follows: Excellent: Painless, plantigrade foot with no functional limitations; good: Plantigrade foot in a patient able to ambulate long distances with mild pain; fair: Mild residual deformity, required bracing, and/or some functional limitations, but the patient leading an active life; and poor: Significant residual deformity, pain, and activity limitations.

Out of 27 feet, 3 (11.11%) were rated as excellent, 17 (62.96%) as good, 5 (18.51%) as fair, and 2 (7.40%) as poor. Excellent and good results (74.07%) were considered satisfactory, while fair and poor results (25.92%) were considered unsatisfactory. Thus, the Ilizarov technique gave satisfactory results in resistant club foot deformities that were difficult to treat by other conventional methods.

Superficial pin tract infection with hypergranulation over the Schanz screws were in 4 feet, and only superficial pin tract infection with watery discharge from the wires noted in 2 feet and were managed with regular dressings and short term 4th generation oral cephalosporin. Loose wires were re-tensioned and infection settled after these reasonable measures.

Kinking of the skin with temporary edema over the callosities was noticed in 6 feet above the age of 15 years due to shortening of lateral column and resolved after 4–6 weeks after the deformity correction. Flexion deformities of toes developed due to increasing tension on the long flexor tendons during deformity correction and was controlled by toe slings, supports over forefoot, and insertion of K-wires. There were 8 feet above the age of 15 years, and the overall outcome was good in 5, fair in 2, and poor in 1 foot [Figures 2 and 3].

DISCUSSION

Resistant clubfoot deformity is a multiplanar deformity. It also includes deformed feet with poor soft tissue coverage, relapsed or neglected cases.¹⁰ The introduction of the

Ilizarov technique to Italy in 1981 changed the concepts of the management of congenital and posttraumatic foot deformities. The technique allowed for a three dimensional approach to the foot without the need for additional wide surgical exposure¹¹ [Table 1]. Professor Ilizarov recognized that his technique could be used to treat foot pathologies such as clubfoot; physicians continue to expand the applications of the Ilizarov procedure in treating complex foot pathologies.¹² Complications were numerous but manageable, and for the most part, did not compromise overall patient satisfaction in this very difficult to treat clinical condition.⁶ The technique, however, is difficult and should be performed by surgeons who are familiar with correction

of pediatric foot and ankle deformities and are versed fully in Ilizarov fixation techniques.¹³

Our study included 27 resistant clubfeet in patients with ages ranging from 8 to 20 years (mean 12 years) who underwent limited soft tissue dissection with Ilizarov distraction. Achilles tendon sheath tenotomy was performed in 8 (29.62%), plantar fasciotomy in 6 (22.22%), and Achilles tendon lengthening in 9 (59.93%) feet. Of the patients, 74.07% considered it as satisfactory, 3 (11.11%) as excellent, and 17 (62.96%) as good, while 25.92% considered it as unsatisfactory, 5 (18.51%) as fair, and 2 (7.40%) as poor. Gradual soft tissue compression and distraction with the setting of Ilizarov frame was used for correction of the deformities in all patients. The same evaluation criteria were used in all patients as the same principle was used in them.

Our results were compared with those of Ferreira *et al.*, who reviewed 30 patients (38 feet) with a mean age of 19 years (range 5–39 years) with severe deformities and studied stiff feet associated with neglected clubfoot. A limited soft tissue dissection, Achilles tenotomy, and



Figure 2A: (a) Preoperative clinical photograph of the feet, from the front of neglected congenital telepesequinovarus; (b) Preoperative clinical photograph of the same feet, from behind; (c) Preoperative lateral radiographs of both feet showing the deformity (d) Preoperative anteroposterior radiographs of both feet showing the deformity

Table 1: Types of foot deformities (Catagni *et al.*)⁵

Deformity	Description
Type 1	There is an alteration of the relationship of the foot to the tibia (e.g. equines deformity)
Type 2	There is a deformity within the foot without alteration of the relationship of the foot to the tibia (e.g. cavus foot)
Type 3	There is both deformity within the foot and an alteration of the relationship of the foot to the tibia (e.g. fibular hemimelia)
Type 4	There is a foot deformity secondary to supramalleolar deformity and a supramalleolar osteotomy is required (e.g. posttibial pylon fracture deformity)
Type 5	There is bone loss or absence within the foot and a reconstructive procedure is required (e.g. postlandmine blast injuries, calcaneal destruction, or congenital agenesis of the forefoot)



Figure 2B: (a, b) Clinical photograph of the same patient showing application of Ilizarov and deformity correction; (c) Postoperative anteroposterior radiographs of the same patient showing fixator *in situ*



Figure 2C: (a, b) Clinical photograph of the same patient after removal of Ilizarov showing deformity correction (c, d) Followup photographs showing maintenance of correction

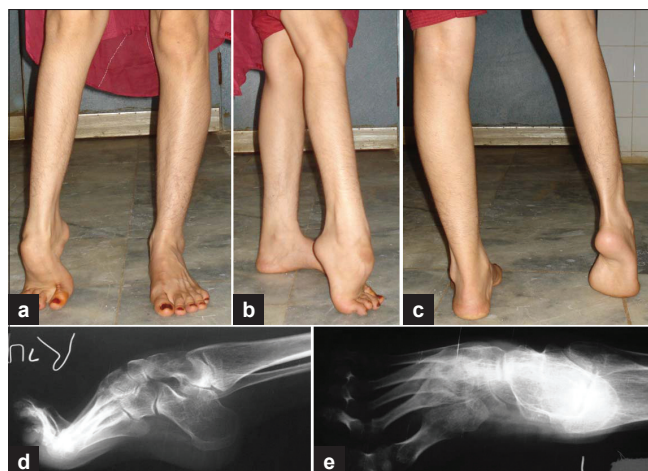


Figure 3A: A 20-year old girl with right sided clubfoot (a) Preoperative clinical photograph of the feet from the front; (b) preoperative clinical photograph of the feet from the side; (c) preoperative clinical photograph from back; (d, e) preoperative lateral and anteroposterior radiograph of the right foot showing deformity

plantar fasciotomy were done. The device was used for 16 weeks on average, and after removal, a shortleg walking cast was used for an additional 6 weeks, followed by an AFO for 6 months.

Freedman in 2006¹ conducted a review of 21 resistant clubfeet in 17 patients, who had undergone previous

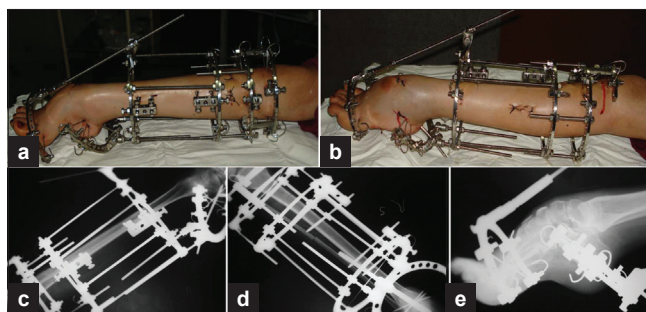


Figure 3B: (a, b) Clinical photograph of right foot from medial and lateral side showing ilizarov fixator in situ (c, d) Lateral and antero posterior view of right leg and (e) Antero posterior view of right foot showing ilizarov fixator *in situ*

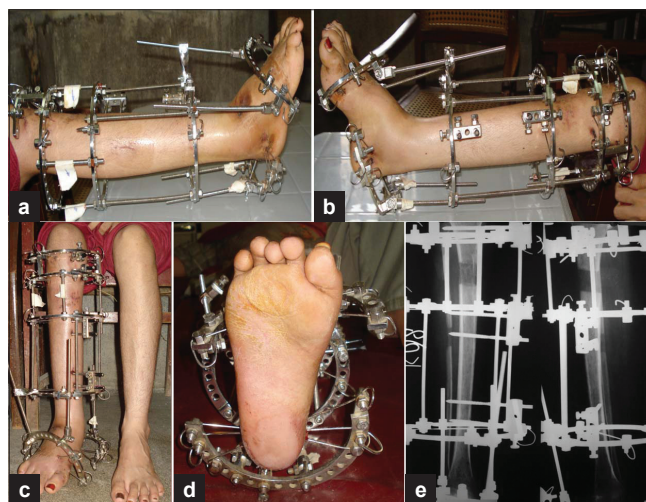


Figure 3C: (a,b,c,d) Clinical photographs showing ilizarov *in situ* (e) Anteroposterior and lateral radiograph showing limb lengthening

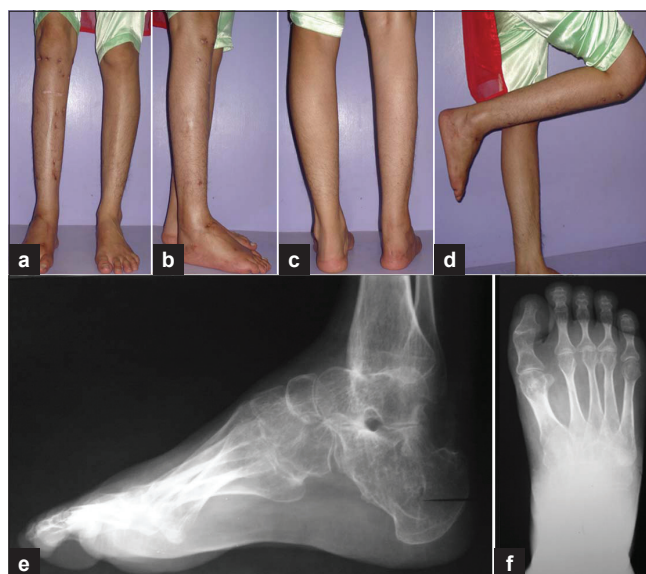


Figure 3D: (a,b,c,d) Clinical photographs showing good correction (e, f) Lateral and antero posterior radiograph of foot at final followup showing correction

surgery, and were treated with Ilizarov's external fixation and gradual distraction by one of the two surgeons.

Amin Abdel-Razek Youssef Ahmed (2010)¹² included 18 feet in 13 children with ages ranging from 3 to 12 years (mean 5.5 years). Soft tissue distraction by Ilizarov was done in 12 feet, with elongation of the tendo achilles in 3 patients and midtarsal osteotomy in 3 patients, and the average followup period was 15.8 months. Of the patients, 72.2% considered it as satisfactory (2 excellent and 11 good) while 27.8% considered it to be unsatisfactory (4 fair and 1 poor). Franke *et al.*¹³ succeeded to achieve plantigrade feet in all the feet with relapses in 3 feet in 8–15 years age group. They reported on 13 feet in 12 patients. Paley¹⁴ treated 25 feet with complex foot deformities. Twenty two feet were plantigrade and three feet showed recurrence after 18 months of followup. El Barbary *et al.*¹⁵ achieved satisfactory correction using an Ilizarov fixator for treatment of 66 relapsed or neglected club feet (40 months followup). Prem *et al.*¹⁶ followed 19 feet managed by Ilizarov soft tissue distraction for 5–10 years postoperatively. They reported on 14 of 19 feet graded good or excellent and 13 of 14 children satisfied with the results of the treatment. Utukuri *et al.*¹⁷ treated 26 resistant clubfeet in 23 children using Ilizarov technique. They reported unsatisfactory results of soft tissue and bony distraction with a recurrence rate of 70% for soft tissue distraction and 55% for bony distraction after a longer period of followup (47 months), but found that functional results (patient based outcomes) were better despite a poor surgical outcome.

Reinker and Carpenter¹⁸ achieved excellent and good results in 21 of 23 feet treated by Ilizarov's external fixation. Nineteen feet had received one or more osteotomies at the time of Ilizarov's external fixation application; additional procedures were required during the course of treatment, including four percutaneous tendo Achilles lengthening, two first metatarsal phalangeal joint fusions, and talectomy, ankle arthrodesis, Achilles tenodesis, and plantar arthrodesis in one case.

Hosny¹⁹ used the bloodless technique in treating 23 foot deformities in 22 patients without any real surgical incision; there was no need for soft tissue release or osteotomy, all patients had a plantigrade foot, and the results were rated as good in 20 and fair in 3 cases.

De La Huerta²⁰ reported on 12 feet in seven adults with the achievement of complete correction in all patients except three in whom mild adduction of the forefoot reoccurred¹⁷ [Table 2].

The average followup in our study was 18.7 months, and in situations like these, where the original foot and ankle deformities are so severe that the treatment option involves the use of an external fixator, minor or major recurrence of the deformities can be expected over time. As the followup time increases, further re-evaluation can

Table 2: Comparison of surgical outcome in different studies surgeries with present study

Author	Mean age in years	Number of previous surgeries	Surgical outcome
Ferreira <i>et al.</i> , 2006 ⁸	19	Not mentioned	Good in 30 feet (78.9%), fair in 3 feet (7.9%), and poor in 5 feet (13.2%)
Amin Abdel-Razek Youssef Ahmed, 2010 ¹²	5.5	All patients underwent previous surgery (1–3 operations)	72.2% were satisfactory (2 excellent and 11 good) while 27.8% were unsatisfactory (4 fair and 1 poor)
Franke, 1990 ¹³	8–15	Not mentioned	A plantigrade foot was achieved in all cases
El-Barbary <i>et al.</i> , 2004 ¹⁵	8.5	Not mentioned	Satisfactory correction comparable to the literature
Prem <i>et al.</i> , 2007 ¹⁶	5–10	Not mentioned	Only one patient experienced recurrence of the deformity. Subjectively, 13 of the 14 children in the study were satisfied with the result of the treatment
Utukuri, 2006 ¹⁷	9	Not mentioned	Good to excellent in 52% for satisfaction, 57% for cosmesis, 48% for walking, and 73% for teasing. Patient based outcomes were better despite a poor surgical outcome
De la Huerta, 1994 ²⁰	27	Not mentioned	Correction in all patients except three in whom mild adduction of the forefoot reoccurred
Present study	12	First time 13 feet, 14 feet had been already operated by other methods, and 5 presented with multiple surgical scars	74.07% considered satisfactory (excellent 3, good 17) while 25.92% were not satisfied (fair 5 and poor 02)

reveal higher incidence of complications, some minor (stiff toes, callus, mild deformity recurrence) and others major (severe recurrence of the deformities, painful arthritis). It is easier to deal with the late complications than it was before the correction. Conventional surgical procedures, like osteotomies, limited arthrodesis, or soft tissue procedures, can be useful in order to correct residual mild deformities under safer conditions.

We conclude that the short term clinical and functional results of treating resistant clubfoot deformities with Ilizarov's external fixator are promising and apparently it is a good option.

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