



Original Article

The Use of the Ilizarov Method in the Correction of Neglected Clubfoot

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ABSTRACT

Objectives: A clubfoot, or the Congenital Talipes Equinovarus, is one of the most common congenital orthopedic deformities, occurs in different severity. The Ilizarov method's external fixation and gradual distraction are considered the best choice of treatment for correction of severe. The aim of this study was to evaluate the effectiveness of the Ilizarov technique in the correction of neglected clubfoot deformities.

Methods: In this retrospective cross-sectional study, individuals were included in the study by census; the author treated sixteen feet in 14 children and adults with resistant club foot, the patients were treated with Ilizarov method. All patients were assessed pre operatively according to Pirani score and radiological technique and postoperatively through clinical follow up and according to the American Orthopaedic Foot and Ankle Society scores. SPSS software was used for analysis and a significance level of less than 0.05 was considered.

Results: The preoperative assessment of the patients showed that 12 (75.0%) of them were classified as having grade III Pirani scores, with a mean score of 5.063 ± 0.6551 , among them 11 (68.7%) were subjected to elongation of tendo-Achilles, plantar fasciatomy, and mid tarsal osteotomy. The radiological findings, pre- and post-operatively showed a high statistical difference in relation to Talo calcaneal angle- antero-posterior, Talo calcaneal angle- lateral, and Talo first metatarsal angle. Patients' scores showed that the outcome of 9 (56.25%) of them was satisfactory. The postoperative clinical assessment of the patients revealed that 12 (75.0%) of the patients had achieved more than 90° ankle dorsiflexion, and 13 (81.25%) had a normal foot appearance. Also, the position of the foot when standing showed that 10 (62.5%) had 5° valgus and the majority 12 (75.0%) had achieved normal gait.

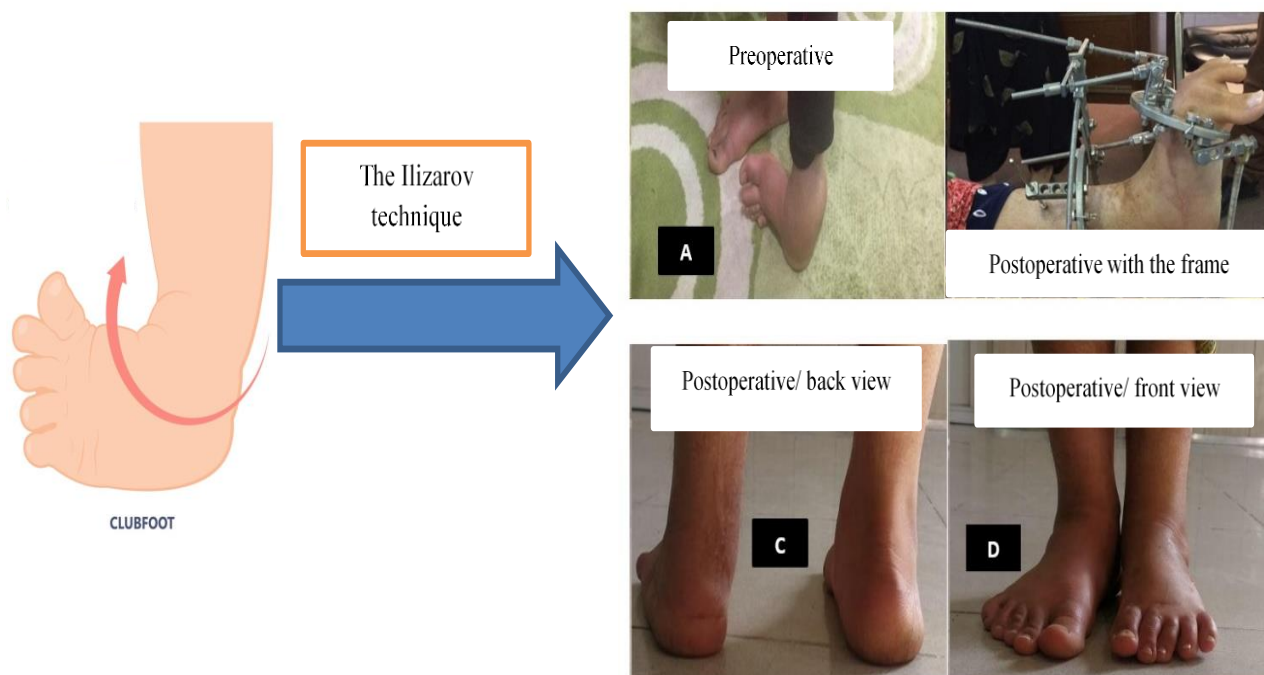
Conclusion: The application of Ilizarov technique could be considered as a convenient, efficient, and successful method for neglected clubfeet deformities.

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GRAPHICAL ABSTRACT



Introduction

A clubfoot, or the Congenital Talipes Equinovarus, is one of the most common congenital orthopedic deformities, occurs in different severity, around half of the feet are rigid and do not reveal full correction with conservative management [1]. In developing countries, clubfoot is a significant problem and leads to an unpredictable outcome due to late presentation and parents' ignorance. The incidence is 2-3 per 1000 live births, varying with geography and race and could be related to multi-factorial inheritance factors [1, 2].

The resistant and neglected clubfoot deformity comprises a significant challenge. Many corrective procedures have been defined to provide a plantigrade and pain-free foot. The Ilizarov method's external fixation and gradual distraction is considered the best choice of treatment for correction of severe and complex clubfoot deformity that have not responded to previous treatment measures be it conservative or surgical.

The Ilizarov method, first introduced by Gavriil

Abramovich Ilizarov in Kurgan (former USSR), was based on bone development's biological principles to achieve distraction osteogenesis [3]. The Ilizarov method uses a multi-planar circular external fixator, a multipurpose tool in the treatment of different orthopedic deformities, leading to simultaneous correction of all the severe foot deformities associated with neglected clubfoot with least surgical intervention, decreasing risks of neurovascular or cutaneous complications and avoiding excessive shortening of the foot [4-7].

Treatment of the clubfeet aims to obtain fully corrected, mobile, plantigrade feet at maturity, walking comfortably with normal shoes [8]. However, even with surgical management, individuals may present with some residual deformity and may suffer from a recurrence requiring further surgery in about 20% of cases [9, 10]. During the last two decades, the Ilizarov technique has been used commonly in the treatment of complex resistant clubfoot deformities in children [11-13]. Ilizarov's technique revealed that both soft tissue and bone are lengthened by distraction histogenesis [12].

The technique involves placing tension wires through the bony structures of the clubfoot to realign the joint surfaces and foot anatomy in all three planes [2].

Ilizarov surgical method provides the possibility of timely recovery of organ function for both children and adults and improves movement limitations in patients [14, 15].

The overall aim of this study was to evaluate the effectiveness of the Ilizarov technique in the correction of neglected clubfoot deformities.

Materials and Methods

In this retrospective cross-sectional study individuals were included in the study by census; the author treated sixteen feet in 14 children and adults with resistant club foot at the department of Orthopedic Surgery, Erbil General Teaching Hospital Erbil-Iraq, from September 2015 to February 2022. The patient's inclusion criteria were resistant clubfoot. All the patients who had severe complex clubfoot underwent correction using the Ilizarov technique. According to the faculty's permission to conduct the study, the personal consent form was completed by all the parents of sick children and adult sick people, and this form showed the informed consent of the people to participate in the study.

All patients were assessed pre-operatively using the Pirani scoring system [16].

"Pirani" score has 6 components:

A- Mid foot score, which includes the following 3 sections:

- 1) Curved Lateral Border
- 2) Medial Crease
- 3) Talar Head Coverage

B- Hind foot score which includes the following 3 parts:

- 1) Posterior Crease
- 2) Rigid Equinus
- 3) Empty Heel

In each section, normal cases are given a score of zero, average score is 0.5, and severe is a score of 1 [17].

Patients were also assessed by plain radiographic measurements which included the Talo calcaneal angle and the Talo-first metatarsal angle on weight bearing antero-posterior and lateral views

of which it ranged from 0-25 and 20-40 degrees, respectively.

Surgical procedure

Under General anesthesia, the patients in supine position on radiolucent orthopedic table and under fluoroscopic control, the procedure started with soft tissue release of Achilles tendon lengthening and planter fasciotomy.

1. Distal leg support ring was applied to the lower leg 8 cm proximal to the ankle joint and stabilized by two wires and one Shanz pin.

2. The calcaneal half ring is stabilized by 2 wires and 1 Shanz pin with opposing Olive wires that were located at different levels, centered on the calcaneus. For the correction of equinus, the half ring was angled from posterior to anterior and from superior to inferior to form 28 degrees angle with the longitudinal axis of calcaneus. For the varus correction the half ring was positioned perpendicular to calcaneal axis, therefore angled from superior to inferior, from medial to lateral, and for the correction of calcaneal adduction the extreme medial portion of the half ring was positioned in a more anterior position compared with the lateral portion.

3. The metatarsal half ring was stabilized with two or three opposing olive wires to metatarsal bones, perpendicular to the forefoot to correct cavus and adduction deformities, and for the correction of supination the extreme lateral portion of half ring was positioned more planter than the medial portion (parallel to planter surface).

4. Lastly proximal leg support ring was stabilized to upper Tibia with two wires and one Shanz pin and connected to distal ring with four rods.

5. Device assembly: Calcaneal half ring was connected with distal leg support ring with 3 rods, the posterior one was connected to the center of half ring with biplanar mobile joints, while medial and lateral rods were connected to the ends of the half ring with bi-planar mobile joints. The T-shaped component was connected to the distal ring and was projected on to the base of the fifth metatarsal, and the medial and lateral rods were fixed to the T-plate and distally

connected to the metatarsal half ring by two bi-planar joints. One planter threaded rod was applied medially and was connected between the calcaneal half ring and the metatarsal half ring with a bi-planar mobile joint. The first and the second toes were caught with wires and connected to the metatarsal half rings

6. The bony procedure was performed by means of transverse osteotomy between the Chopart and Lisfranc joints.

Postoperative correction of deformity

After 7 days of surgery, we started performing distraction in a range of 1-2 mm per 24 hours.

Evaluation of the corrective program was primarily clinical, the Equinus deformity was the first to respond to treatment, followed by forefoot adduction, the correction of equinus, and adduction was slowed down or even suspended so that correction of the residual deformities could occur.

Ilizarov apparatus was removed after 4 to 6 months, then boot fiberglass cast was applied for one to three months, and then changed to Ankle-Foot brace which was applied for another 6 months, except for patients with Arthrogryposis splinting continued till skeletal maturity.

Finally, the procedure postoperatively classified into excellent, good, fair, and poor outcomes, based on the American Orthopedic Foot and Ankle Society (AOFAS) clinical rating scales.

Results and Discussion

In this study, patients' ages ranged from 3 to 32, with a mean age \pm SD of 16.4 ± 8.319 years. Around 9 (57.1%) of them were aged 10-19, and 5 (28.6%) were aged 20 and over.

Males constituted 9 (57.1%) of the study group compared to 7 (42.9%) of females with a male-to-female ratio of 1.33:1.

Regarding the clinical characteristics of the patients, 7 (42.9%) of the patients presented with right-side deformity, 5 (35.7%) had left side, and the rest 2 (21.4%) had a bilateral deformity.

The idiopathic cause was the common etiology of the club foot in 5 (35.7%) of the patients, followed by 4 (28.6%) who had Arthrogryposis. Among them, 9 (64.3%) had undergone 1- 4 operations previously, compared to 4 (28.6%) who were not exposed to any previous operation (Table 1).

The deformity was classified according to Pirani scoring into 3 groups. Group I with a score of 1.5- 2.5 points, was not seen in any foot, Group II with a score of 3 to 4.5 points was seen in 4 feet (25.0%), and group III, the most predominant category with a score of 5 points and more were seen in 12 feet (75.0%). Overall, the mean Pirani score for all feet was 5.063 ± 0.6551 , that this mean score indicates a severe deformity (Table 2).

Table 1: Clinical characteristics of the patients

Variables	Frequency	Percentage (%)
Site of the clubfoot		
Right	7	(42.9)
Left	5	(35.7)
Both	2	(21.4)
Etiology		
Idiopathic	5	(35.7)
Arthrogryposis	4	(28.6)
Marfan syndrome	1	(7.1)
Constructed band	1	(7.1)
Poliomyelitis	1	(7.1)
Myelo meningocele	2	(14.3)
Number of previous operations		
No operation	4	(28.6)
1- 4 Operations	9	(64.3)
5 and more operations	1	(7.1)
Total	14	(100.0)

Table 2: Pre-treatment Pirani scores of the patients

Groups	Score	No. of feet	Percentage (%)
I	1.5 – 2.5	0	(0.0)
II	3- 4.5	4	(25.0)
III	5 and more	12	(75.0)
Mean± SD	5.063 ± 0.6551		
Total	16		(100.0)

The operative characteristics of the patients showed that 3 (18.8%) of them had not been subjected to any associated procedures, 11 (68.7%) had elongation of tendo Achilles (ETA), planter osteotomy, and planter fasciotomy, and 2 (12.5%) had midtarsal osteotomy. The mean duration of the Ilizarov frame application was 4.91 months, the mean casting time was 2.84 months and the mean follow-up time was 3.78 years (Table 3).

The radiological findings, pre- and post-operatively showed a high statistical difference in relation to Talo calcaneal angle- antero-posterior,

Talo calcaneal angle- lateral, and Talo first metatarsal angle ($P \leq 0.001$, 0.001 and 0.001, respectively) (Table 4).

Comparing patients scores according to the American Orthopedic Foot and ankle Society score classification showed that the outcome of 50.0% of them was good (81-90 scores), 37.5% of them were fair (71-80 scores), one case (6.25%) was classified as having a poor outcome (less than 70 scores), and only 6.25% had a got an excellent outcome (91 scores and more). Overall, the mean AOFAS score for all feet was 78.63 ± 15.5 (Figure 1).

Table 3: Operative characteristics of the patients

Variables	Frequency	Percentage (%)
Procedure of Ilizarov		
No associated procedure	3	(18.8)
Elongation of tendo Achilles, mid tarsal osteotomy and plantar fasciotomy	11	(68.7)
Mid tarsal osteotomy	2	(12.5)
Duration of Ilizarov frame application in months		
≤ 3 months	3	(18.8)
4- 6 months	11	(68.7)
≥ 7 months	2	(12.5)
Mean± SD	4.91±1.508	
Casting time in months		
≤ 2 months	5	(31.2)
1-4 months	10	(62.5)
≥ 5 months	1	(6.3)
Mean± SD	2.84± 0.85	
Follow-up time in years		
≤ 3 months	7	(43.75)
4- 6 months	7	(43.75)
≥ 6 months	2	(12.5)
Mean± SD	3.78±1.953	
Total	16	(100.0)

Table 4: Radiological findings preoperative and postoperatively

Variables	Average pre-operative Mean± SD	Average post-operative Mean± SD	Normal values	P value
Talo calcaneal angle- antero-posterior	18.071± 3.5456	36.57± 5.140	30- 35	P= 0.001
Talo calcaneal angle- lateral	1.57± 2.980	38.821± 5.4477	25- 50	P= 0.001
Talo first metatarsal angle	Negative	5.357± 2.4763	0- 10	P= 0.001

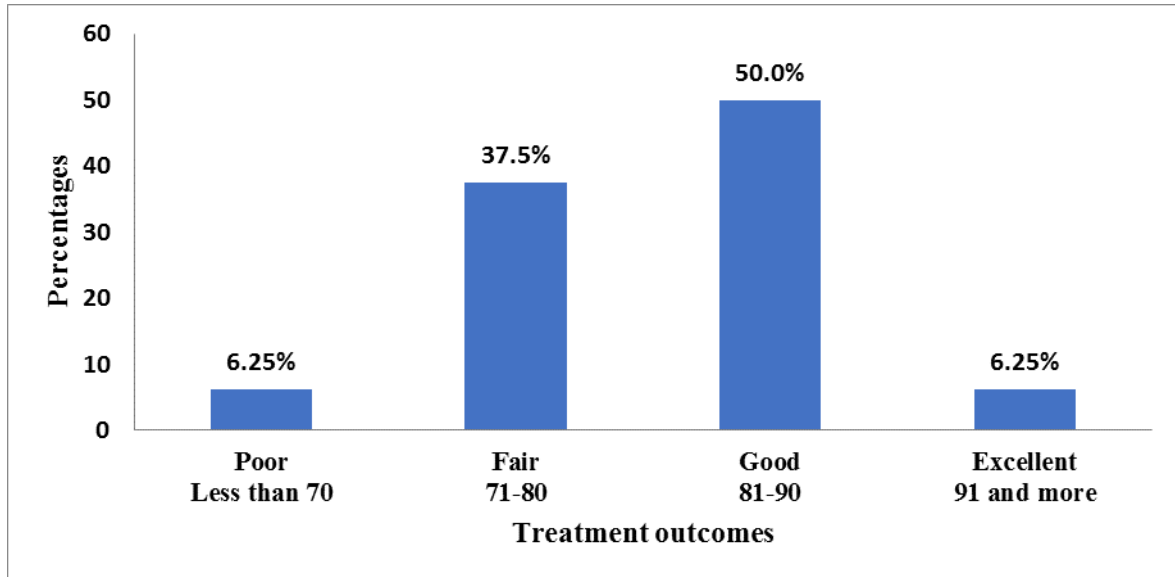
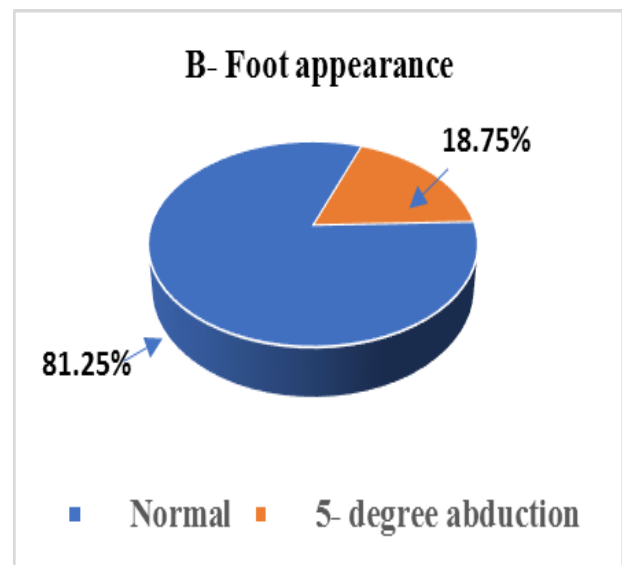
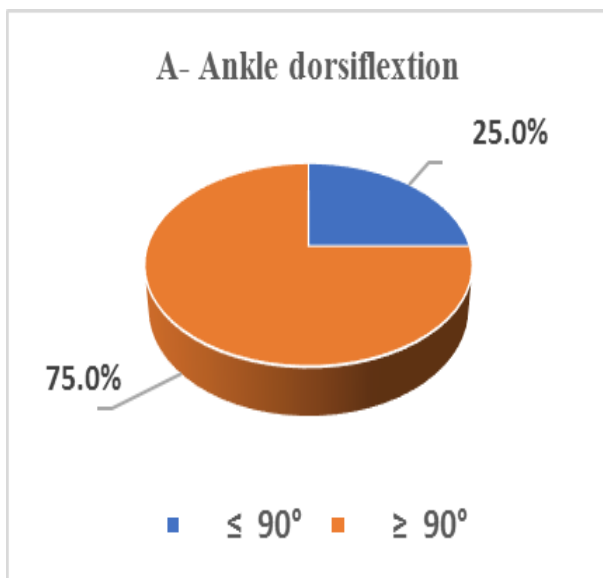


Figure 1: The postoperative American Orthopedic Foot and ankle Society scores of the patients

The postoperative clinical assessment of the patients revealed that 75.0% of the patients had achieved more than 90° ankle dorsiflexion and 81.25% had a normal foot appearance. Moreover, 43.75% of the patients had more than 15°

subtalar movement and 37.5% had less than 15° subtalar movement. Also, the position of the foot when standing showed that 62.5% had 5° degrees valgus and the majority (75.0%) had achieved normal gait (Figures 2 and 3).



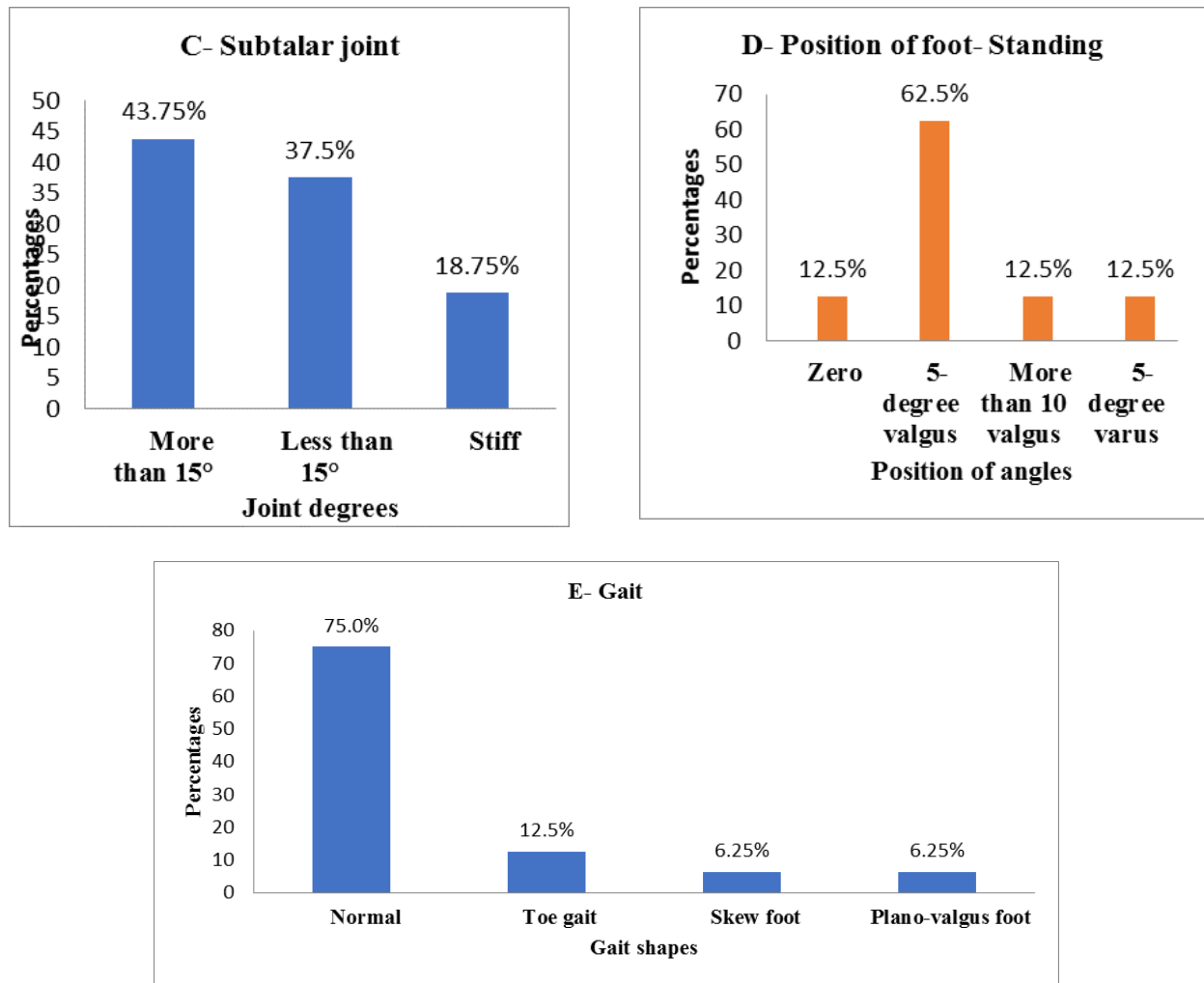


Figure 2: Postoperative clinical assessment of the patients

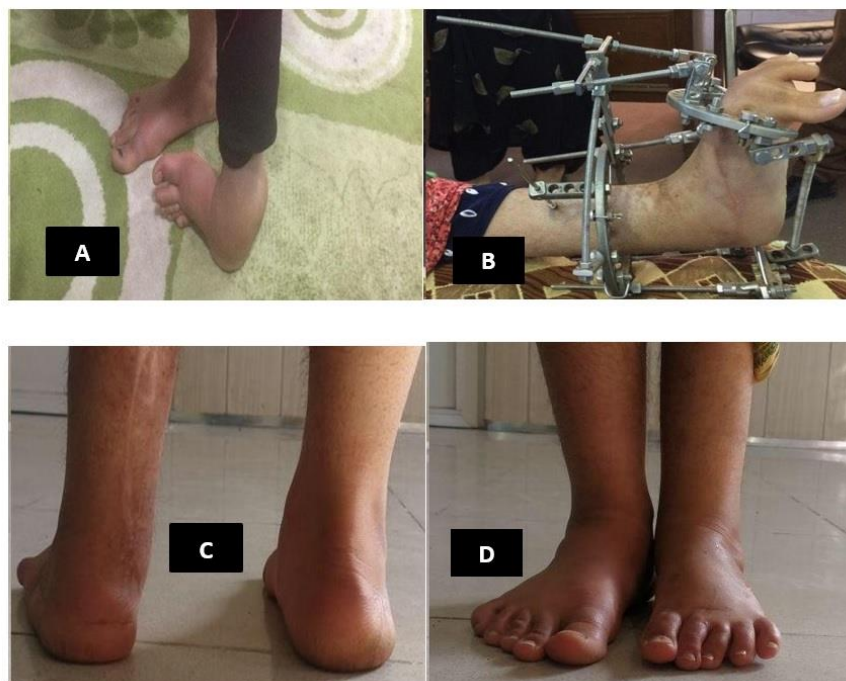


Figure 3: Photos of one of the patients: (A) Preoperative, (B) Postoperative with the frame, and (C) Postoperative/ back view and D- Postoperative/ front view

Postoperatively, few patients developed some complications, including infected wire in six patients, treated with necessary antibiotics, planovalgus deformity found in one patient, and dorsal dislocation of Navicular bone in other patients treated by surgical reduction and fusion of the Talo-navicular bone. Also, Plantar dislocation of the first metatarso-phalangeal joint happened in one patient, treated with arthrodesis of the joint. Bowing of the parallel rods attached to the T-shape plate occurred in four patients, treated by changing the parallel rods and one patient had migration of the metatarsal half ring with pressure sore on the lateral aspect of the foot, treated by re-application of metatarsal half ring fixed with two opposite olive wires and the ulcer treated with daily dressing and oral antibiotics. According to the results, the effect of the surgery was successful for all ages and there was no difference in the outcome of the surgery among the ages.

Based on the Pirani score, most of the examined subjects had severe deformity. The radiological findings before and after the operation showed a high statistical difference in relation to the calcaneal-anterior-posterior angle, the calcaneal-lateral angle, and the first metatarsal ball. The scores of the patients based on the American Foot and Ankle Orthopedic Society score classification were satisfactory in most people. Clinical evaluation and foot position while standing showed that most people were satisfied with the Ilizarov technique.

Despite advances in surgical management, several children with clubfoot still have a relapse of the foot deformity or residual deformity, which limits the ability to achieve a neutral position needing more corrective treatment. Accordingly, many surgical interventions are done to have a plantigrade foot to achieve a better gait. In the past years, the Ilizarov technique has made the most outstanding contribution in correcting the most difficult and complex foot deformities in children [18, 19].

This study had shown that the idiopathic cause was the common etiology of the clubfoot in more than one-third of the patients, followed by Arthrogryposis. The true etiology of congenital clubfoot is unknown and most infants who have

clubfoot have no identifiable genetic, syndromal, or extrinsic cause [20].

This study revealed that nearly two-thirds of the patients had undergone 1-4 operations previously, compared to more than one-fourth who were not exposed to any previous operation. A study in India showed that none of the patients had any corrective surgery before the presentation [21]. This could be due to the late presentation of patients included in our study.

In line with the results of this study, studies conducted by ZA Mohammed (2019) and OM Jawad (2022) also showed that the use of Ilizarov technique can be considered as a suitable and efficient method for the neglected anomalies of the bracket leg [22, 23].

This study has shown that the most predominant category of patients was classified into the third group Pirani scores who scored 5 points and more preoperatively, followed by one-fourth of the patients who were classified as group 11 with a score of 3 to 4.5 points and overall, the mean Pirani Score for all feet was 5.063 ± 0.6551 . Studies in India showed almost similar results with a mean Pirani score of 5.01 and 4.8 [24]. This could be due to the parents ignorance and late presentation of the patients with more severe deformities or complications of previous operations.

The operative characteristics of the patients showed that less than one-fifth of them had not been subjected to any associated procedures, the majority had an elongation of tendo Achilles (ETA), planter fasciotomy, and only a few cases were subjected to midtarsal osteotomy. A study in Yemen showed that Achilles tendon elongation was done in eight feet (72.7%) [25]. Another study in Egypt showed that 3 (16.7%) had midtarsal osteotomy and soft tissue distraction in 15 (83.3%) feet with no soft tissue release and only 16.7% of the patients needed tendo Achilles lengthening [26]. Also, in another study in Pakistan Achilles tendon sheath tenotomy was performed in 29.62%, planter fasciotomy in 22.22%, and Achilles tendon lengthening in 59.93% of feet [27].

In our study, the mean duration of the Ilizarov frame application was 4.91 months, the mean casting time was 2.84 months, and the mean

follow-up time was 3.78 years. A study in Egypt showed that the mean period of frame application was 3.64 months; the mean follow-up period after the removal of the apparatus was 14.28 months [8]. This could be due to the severity of the cases, and different surgical procedures, accordingly needing more time to fix the needed changes to achieve better results.

In this study, the radiological findings, pre-and post-operatively showed a high statistical difference in relation to Talo calcaneal angle- antero posterior, Talo calcaneal angle- Lateral, and Talo first metatarsal angle ($P= 0.001, 0.001$, and 0.001 , respectively). Similar significant results were reported in studies in India, China, and Iran [28, 29].

Comparing patients' scores, according to the American Orthopedic Foot and ankle Society score classification showed that the outcome of 56.3% of them was satisfactory (excellent and good) and the other 43.7% of were unsatisfactory (fair and poor). Overall, the mean AOFAS score for all feet was 78.63 ± 15.5 . Studies in China and Italy showed significant improvement in AOFAS scores [30], while that of the United Kingdom showed that an excellent/ good rate was achieved in only 37.5% of the patients [31]. Another study in Egypt showed that the post-operative AOFAS scores were improved from a mean of 43.48 ± 14.1 to 82.32 ± 11.86 [8]. The Satisfactory postoperative outcome in our study could be due to the proper operative procedure, early mobilization of the patients and good follow up plan.

The postoperative clinical assessment of the patients revealed that the majority of the patients had achieved more than 90° ankle dorsiflexion, and had a normal foot appearance. Likewise, the position of the foot when standing showed that 62.5% had 5° valgus, and the majority had achieved normal gait. Studies in China and Korea showed almost similar results where the differences in the angle of plantar flexion, dorsiflexion, range of motion of the ankle joint, and talo calcaneal angles pre- and postoperatively were significant [32].

Postoperatively, few patients developed some complications including wound infections, planovalgus deformity, dorsal dislocation of

navicular bone, plantar dislocation of the first metatarso-phalangeal joint, bowing of the parallel rods, and migration of the metatarsal half ring with pressure sore. Studies in China showed almost similar results from slight pin track infections to late bone and joint complications that required additional surgery or interventions.

Conclusion

We concluded that the good clinical and functional results of managing resistant clubfoot deformities with Ilizarov external fixation and additional procedures are hopeful and relatively, it is a good option, which could be considered as a convenient, suitable, efficient, and successful rescue procedure for neglected clubfoot deformities.

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No potential conflict of interest was declared by the authors.

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Authors' Contributions

All authors contributed to data analysis, drafting, and revising of the manuscript and agreed to be responsible for all the aspects of this work.

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