# A bloodless technique for correction of equinovarus deformities by Taylor spatial frame: a prospective case series

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## ABSTRACT

**Background:**
Rigid ankle and foot deformities as a sequela of relapsed talipes equinovarus or vascular or neurological disorders are a challenge for orthopedic surgeons. This study introduces a bloodless technique to correct the deformities of the ankle in patients with these disorders using the Taylor Spatial Frame (TSF).

**Methods:**
Eighteen feet in 18 patients with equinovarus deformities were prospectively enrolled in this study. All patients underwent preoperative clinical evaluation that included neurovascular assessment. Deformity components were measured using a goniometer. All patients had gradual correction of the rigid equinovarus ankle and foot by TSF without any soft-tissue or bony procedures. Preoperative and postoperative ankle and foot equinus and varus angles, in association with the American Orthopaedic Foot and Ankle Society (AOFAS) score, were used for assessment of the functional outcome.

**Results:**
There were 13 male patients (72.2%) and five female patients (27%). The mean age of the patients was 25.89 (range 14 to 43, SD 7.28) years. The right side was affected in 11 patients (61.1%), and left side was affected in seven patients (38.9%). At the final follow-up the average AOFAS ankle hindfoot scores improved from 25.17 (range 12 to 39, SD 9.91) preoperatively to 74.78 (range 48 to 88, SD 15.33) postoperatively, ($t = 22.13$, $P < 0.001$). Fifteen patients (83.3%) were categorized as "good", and three patients (16.7%) were categorized as "fair".

**Conclusions:**
TSF is a safe, effective, and simple method of correcting rigid equinovarus deformities of the ankle without soft-tissue releases or bone osteotomies and is a bloodless technique.

**Level of Evidence:**
Level IV.

**Key Words**
ankle deformity, equinovarus, external frame, Taylor Spatial Frame.

## INTRODUCTION

Rigid equinovarus deformity often is seen in patients who have congenital clubfoot and have been neglected or have relapsed as a sequela of ischemic contracture of the leg or peripheral nerve injuries, and it is rarely due to myelodysplasia or poliomyelitis. It represents a challenge to orthopaedic surgeons because classic open procedures, including soft-tissue releases and osteotomies usually yield bad results with high recurrence and complication rates.[1] Such risks increase with revision surgeries or in patients with soft-tissue scarring from previous surgeries, which makes correction with an external fixator the most suitable option.[2]

The Taylor Spatial Frame (TSF) (Smith and Nephew, Memphis, Tennessee, USA) is a circular external fixator consisting primarily of two rings or partial rings of variable sizes connected by six telescoping struts with universal hinges that creates a hexagonal frame and is adjusted by a software application. It is a successful alternative to the Ilizarov external fixator in acute trauma, nonunion, and deformity corrections. The TSF allows for much greater precision in deformity correction when compared to the Ilizarov.[3]

Foot and ankle deformities represent a good example of complex deformities where muliplane correction is needed. The Ilizarov fixator has been successful for management of such deformities.[1,4] However, there are very few studies presenting management of ankle and foot deformities using TSF, especially in adults. This study included patients in a variety of age groups. The purpose of this study was to review the results of managing equinovarus deformity using the bloodless technique of a TSF without performing soft-tissue releases or corrective osteotomies. The hypothesis was that TSF would be effective in treatment of equinovarus deformities of foot and ankle without need for osteotomies or soft-tissue releases.

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# MATERIALS AND METHODS

## Ethical Review and Study Design

After instutional review board approval (IRB# Ortho.Surg. 15-2013) 18 feet in 18 patients with equinovarus deformities were prospectively enrolled between May 2013 and August 2017. All patients provided written informed consent.

## Patient Selection

All patients underwent preoperative clinical evaluation that included neurovascular assessment. Deformity components were measured clinically using a goniometer and plain anteroposterior and lateral radiographs of the weight-bearing ankle and foot to measure equinus and varus angles. Ankle and foot CT with three-dimensional reconstruction to evaluate the condition of the ankle and the subtalar joints were also obtained. Inclusion criteria included stiff uncorrectable equinovarus deformity with severe contracture, bad skin condition, or multiple previous surgical procedures. There were no exclusion criteria for this study.

## Data Collection

All patients underwent gradual correction of the rigid equinovarus ankle and foot by TSF without any soft-tissue or bony procedures. Preoperative and postoperative equinus and varus angles of the ankle and foot in association with the AOFAS score,[5,6] were used for assessment of the functional outcome. The scores are good (complete correction and no pain), fair (partial correction with plantigrade foot and occasional pain), or poor (nonplantigrade foot and continuous pain during walking).

## Surgical Technique

Under complete antiseptic conditions, both general and spinal anesthesia were used, and both old (complete ring) and new (separate half ring) versions of the apparatus were used in this study.

The proximal ring of the old version of suitable size was inserted first around the leg without any fixation, then the distal ring was assembled in equinovarus position at the same angle of the deformed ankle. The full ring was used around the foot because the foot frame was not available. The distal ring was fixed to the calcaneus by crossing smooth wires. Another drop wire on a post was inserted in both the talus and metatarsal bones from medial to lateral, which allowed movement of the calcaneus, talus, and metatarsal bones as one unit in the beginning of correction, until the talar deformity was corrected inside the ankle mortise. The tension of the wire in the talus was released to allow free movement of the calcaneus around the corrected talus.

The position of the proximal ring was determined by attachment of medium fast-fix struts to the distal and proximal rings. The struts on the medial side were shorter than the lateral side, and the posterior was shorter than the anterior. The proximal ring was then fixed by crossing wires and 6-mm half pins on Rancho cubes in different directions.

In the new version, we followed the same sequence of application with easy insertion of the proximal ring after complete application of the distal ring because it has two halves (Figure 1).

## Postoperative Care

All patients received antibiotics, analgesics, and anti-edematous drugs for 5 days postoperatively. Weight bearing was allowed as tolerated from the first postoperative day. Plain radiographs were obtained in both anteroposterior and lateral views. The proximal ring was considered to be the reference ring in all patients in this case series, and the center of the proximal surface of the talus and the center of the tibial plafond were considered to be the corresponding points for correction until the talus was corrected. Then the point of correction was shifted to the subtalar joint to complete the correction process. The ring offset was calculated from the radiographs in both anteroposterior and lateral views. The vertical offset was obtained as the distance from the center of the proximal ring to the center of the upper surface of the talus in millimeters and then to the subtalar joint in a later stage.

The TSF website was used to follow the residual deformity program. Deformity correction began on the third postoperative day. Considering the need for education regarding the apparatus, patients were admitted to our hospital during the whole period of deformity correction. The correction was observed daily until the end of the correction sheet. Residual deformity was tabulated again, and a new prescription sheet was obtained until the foot and ankle became plantigrade (Figure 2). Removal of the fixator was performed under general anesthesia, and a short walking cast was applied for 1 month.

## Statistical Analyses

A sample size calculation was not performed in this study because all patients who had stiff equinovarus at our facility during the time of this study were included. Software (SPSS, Version 20.0 for Windows, SPSS Inc, Chicago, IL) was used for the univariate, bivariate, and stratified analyses of the data. Paired test and Wilcoxon test were applied for the comparison of quantitative variables after establishing their normal distribution by one-sample Kolmogorov-Smirnov test of normality. Differences were considered significant at $P \leq 0.05$.

# RESULTS

Patients demographic data are outlined in Table 1. There were 13 male patients (72.2%) and five female patients (27%), the mean age of the patients was 25.89 (range 14 to 43, SD 7.28) years. The right side was affected in 11 patients (61.1%), and the left side was affected in seven patients (38.9%). The etiology of the ankle and foot deformity was recurrent deformity of talipes equinovarus after multiple surgical procedures in 12 patients (66.7%) and posttraumatic Volkmann ischemic contracture in six patients (33.3%).

The mean operative time needed for apparatus application was 65.6 (range 45 to 90) minutes. The mean time needed for full correction of the deformity was 23.83 (range 16 to 36, SD 5.33) days. The mean time of fixator application was 136.44 (range 120 to 160, SD 11.72) days. The average follow-up period was 25 (range 15 to 40) months after removal of the cast.


**FIGURE 1.** (A and B) A patient with Volkmann's ischemic contracture after tibial fracture with compartment syndrome. Clinical photographs of the scar from fasciotomy, the equinovarus deformity at the ankle joint. (C and D) Anteroposterior and lateral radiographs of the position of the ankle and the deformities. (E and F) Clinical photographs of the ankle and foot at the early stage of deformity correction by old version of Taylor Spatial Frame (TSF). (G and H) Anteroposterior and lateral radiographs of the ankle after full correction of the deformities. (I and J) Clinical photographs of the position of the ankle and foot at the final stage of deformity correction by TSF. (K and L) Clinical photographs after removal of the TSF and the short leg cast. The ankle became plantigrade.

The mean preoperative varus ankle angle was 55.89 (range 35 to 75, SD 12.91) degrees, and the mean postoperative varus ankle angle was 1.44 (range 0 to 8, SD 2.25) degrees ($z=3.73$, $P<0.001$). The mean preoperative equinus ankle angle was 61.17 (range 30 to 81, SD 13.43) degrees, and the mean postoperative equinus ankle angle

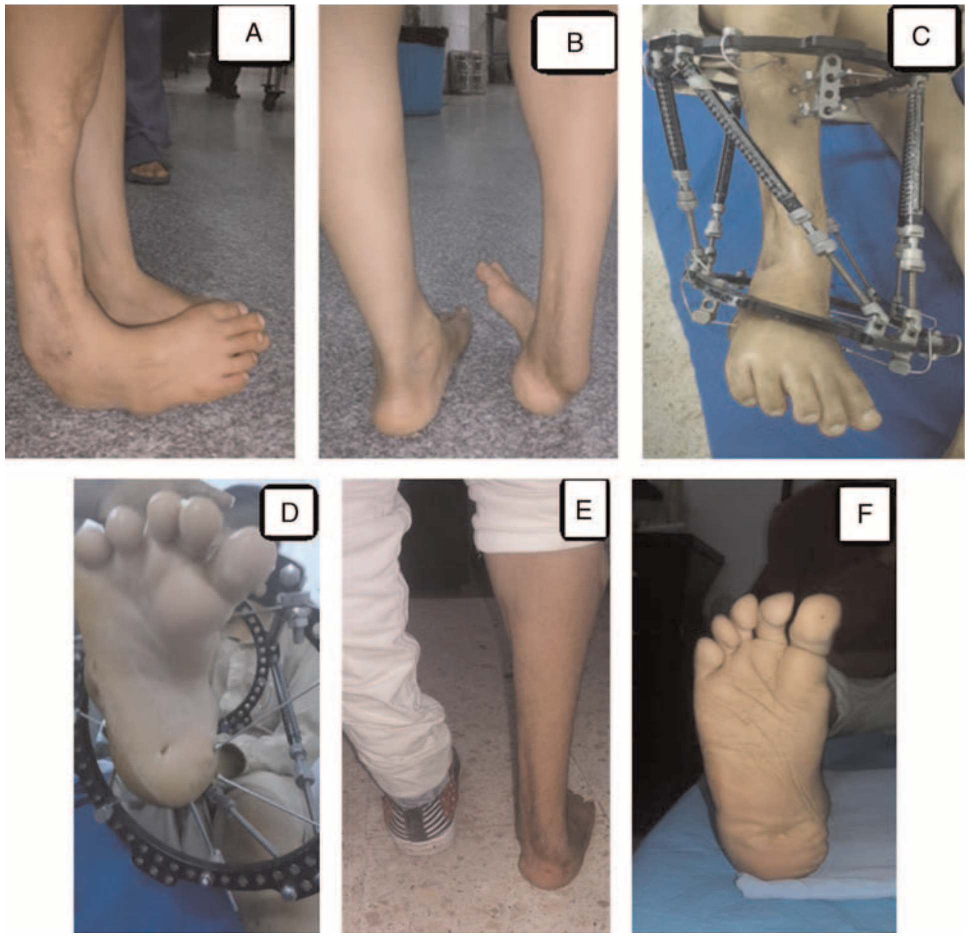


**FIGURE 2.** A patient wtih tibial hemimelia with relapsed stiff equinovarus ankle and midfoot metatarsus adductus. (A and B) Clinical photographs of equinovarus ankle, foot inversion, and metatarsus adductus. (C and D) The scars of previous operations to correct the deformities. Clinical photographs of the application of Taylor Spatial Frame (TSF) at the early stage of deformity correction. (E and F) Clinical photographs after full correction of the equinovarus deformity of the ankle and foot inversion. The metatarsus adductus was corrected by closing lateral wedge osteotomy at the midfoot.

was 0.83 (range 0 to 5, SD 1.58) degrees ($z = 3.75$, $P < 0.001$) (Table 2).

At the final follow-up the average AOFAS ankle hindfoot scores improved from 25.17 (range 12 to 39, SD 9.91) preoperatively to 74.78 (range 48 to 88, SD 15.33) postoperatively ($t$-test $= 22.13$, $P < 0.001$). Fifteen patients (83.3%) were scored as good and three patients (16.7%) as fair.

Two patients were reported to have pin track infections that were superficial and treated with dressing and antibiotics. Only one patient with Volkmann ischemic contracture developed recurrent varus deformity of 10 degrees, and the patient was satisfied and refused further intervention. No neurovascular complications were reported during or after the correction.

## DISCUSSION

Since Ilizarov popularized the principle of tensile stress, many complex orthopedic deformities have been addressed. Applying gradual traction to bone and soft tissues using his circular apparatus leads to deformity correction by the stimulation of metabolic activity and regeneration power in both bone and soft tissue.[4] The Illizarov external fixator is preferred in multiplane deformities when both rotation and translation are needed. However, the need for constructing configuration adjustment, and the long learning curve for rotational corrections are the main limitations of the Ilizarov apparatus[4] that were solved by the development of TSF.

In the current study, we present the technique and results of applying the same principles as Ilizarov with the use of TSFs in gradual correction of complex equinovarus deformities without osteotomies or soft-tissue releases, which is a bloodless technique. Full correction could be achieved in an average of 23.83 (range 16 to 36) days, with only minor recurrence in one patient and without remarkable complications.

Many authors believe that osteotomies and or soft-tissue releases must be done at the time of deformity corrections with Ilizarov in patients who are older than 10 yr.[5] However, others obtained correction of the deformities without osteotomies or soft-tissue releases in pediatric and adult patients.[6,7] Soft-tissue releases are hazardous for patients who have thin skin or soft-tissue scarring, and osteotomies usually accompany removal of large bone wedges to achieve correction, which results in shortened feet.

**TABLE 1.** Patient demographic data

| | Age (yr) | Gender | Side | Pre-operative varus ankle | Post-operative varus ankle | Pre-operative equinus ankle | Post-operative equinus ankle | Time for correction (days) | Time of fixator application (days) | Preoperative AOFAS score | Postoperative AOFAS score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 14 | M | RT | 70 | 0 | 65 | 0 | 25 | 135 | 12 | 48 |
| 2 | 43 | M | LT | 40 | 0 | 60 | 0 | 23 | 146 | 12 | 48 |
| 3 | 23 | M | RT | 55 | 5 | 60 | 0 | 30 | 120 | 16 | 66 |
| 4 | 33 | M | RT | 35 | 3 | 50 | 2 | 33 | 160 | 18 | 66 |
| 5 | 26 | F | RT | 65 | 3 | 75 | 5 | 36 | 155 | 12 | 48 |
| 6 | 21 | F | LT | 70 | 8 | 75 | 4 | 25 | 125 | 25 | 66 |
| 7 | 31 | M | RT | 55 | 3 | 60 | 0 | 30 | 145 | 23 | 80 |
| 8 | 17 | M | RT | 60 | 0 | 75 | 0 | 23 | 150 | 39 | 86 |
| 9 | 19 | M | RT | 75 | 0 | 75 | 0 | 21 | 130 | 34 | 86 |
| 10 | 22 | F | LT | 45 | 0 | 60 | 0 | 18 | 120 | 23 | 86 |
| 11 | 23 | M | RT | 40 | 0 | 30 | 0 | 16 | 134 | 17 | 60 |
| 12 | 29 | M | LT | 75 | 0 | 60 | 0 | 23 | 129 | 19 | 86 |
| 13 | 34 | M | LT | 60 | 2 | 40 | 1 | 18 | 138 | 23 | 88 |
| 14 | 34 | F | RT | 55 | 0 | 45 | 0 | 21 | 126 | 36 | 84 |
| 15 | 25 | F | LT | 45 | 0 | 60 | 0 | 23 | 140 | 32 | 88 |
| 16 | 28 | M | RT | 40 | 0 | 60 | 0 | 20 | 145 | 34 | 88 |
| 17 | 26 | M | RT | 53 | 2 | 70 | 0 | 21 | 128 | 39 | 86 |
| 18 | 18 | M | LT | 68 | 0 | 81 | 3 | 23 | 130 | 39 | 86 |

AOFAS, American Orthopaedic Foot and Ankle Society score; yrs, years.

**TABLE 2.** Patient outcomes

| | Median (IQR) |
|---|---|
| Age | 25.5 (20.5 to 31.5) years |
| Preoperative varus ankle angle | 55.0 (43.75 to 68.5) degrees |
| Postoperative varus ankle angle | 0.0 (0.0 to 3.0) degrees |
| Preoperative equinus ankle angle | 60.0 (57.5 to 75.0) degrees |
| Postoperative equinus ankle angle | 0.0 (0.0 to 1.25) degrees |
| Time for correction | 23.0 (20.75 to 26.25) days |
| Time for fixator application | 134.5 (127.5 to 145.25) hours |
| Preoperative AOFAS | 23.0 (16.75 to 34.5) |
| Postoperative AOFAS | 85.0 (64.5 to 86.0) |

AOFAS, American Orthopaedic Foot and Ankle Society score; IQR, interquartile range.

Cuttica *et al.*[8] used the TSF and similar multiplanar external fixation devices after extensive posteromedial soft-tissue releases for gradual correction of rigid equinovarus deformities in eight patients. They achieved correction in seven patients with an average duration of external fixation of 10.8 weeks (range 8 to 16 ± 2.8) weeks. The time needed for deformity correction in that study was 4 to 6 wk. In our study, full correction was obtained in 2 to 5 wk, and the total time of fixator application was 17 to 23 wk.

Cuttica *et al.*[8] reported high complication rates in about half of their patients, including vascular injury, infection, and recurrence of deformity. Moreover, the open technique was unsuitable for patients with contracted scarred soft-tissue from multiple previous operations. In our series using a bloodless technique, we achieved correction in all patients with no osteotomies or soft-tissue releases and avoided such complications. Table 3 compares the results of our study to other studies[9,10] that combined TSF with other procedures and resulted in higher complication rates.

The reported operative time of Ilizarov application ranges from 2.5 hr[6] to 8 hr.[11,12] Assembly of the apparatus before surgery was found to shorten operative time.[13] Our average operative time was 65.6 (range 45 to 90) minutes, reflecting the simplicity of this procedure when compared to use of the Ilizarov frame.

Wukich *et al.*[14] described several types of frame configurations for correction of foot and ankle deformities, and they concluded that TSF should be reserved for severe deformities. In this study, we present a simple frame of two rings with different levels of wire fixation. The key technique in our approach is changing the center of correction rather than usage of multiple rings.

Mangagla *et al.*[15] compared the outcome of deformity correction of the foot and ankle using TSF versus Ilizarov. They concluded that TSF has a better outcome than the Ilizarov. Several authors described foot and ankle osteotomies in association with TSF application,[8,10,14,15] and others described soft-tissue release and tendon lengthening.[16]

Regarding the other types of computer-assisted deformity correction devices, Takata *et al.*[17] described several constructs for correction of foot and ankle deformities using the Ortho-SUV frame (OSF; Ortho-SUV Ltd, St. Petersburg, Russia). Riganti *et al.*[18] reviewed 10 patients with foot and ankle deformities who were treated with the Ortho-SUV frame and supramalleolar and V-shape foot osteotomy. They reported

**TABLE 3.** Comparison of current study to different studies using Taylor Spatial Frame (TSF) in complex foot deformities

| | Sample size | Etiology | Surgical technique | Results |
|---|---|---|---|---|
| Eidelman *et al.*[9] | • Fifteen patients.<br>• Mean age was 6.5 yr.<br>• Mean time of frame was 3.6 mo. | • Idiopathic talipes equinovarus.<br>• Developmental club foot.<br>• Fibular hemimelia club foot. | Two types of frames were described:<br>• Ponsetti-Taylor type 1<br>Stage A:<br>• Two rings, proximal in tibia, distal at the ankle and foot.<br>• Wire was inserted in the distal tibial physeal plate connected to the proximal ring.<br>• Olive wire inserted into the talus attached to the proximal ring to prevent talar rotation during varus correction.<br>Stage B:<br>• Remove the talar wire from the proximal ring and reattach to the distal ring.<br>• Tibiotalar distraction, over correction of equinus by 20 degrees.<br>• Ponsetti-Taylor type 2<br>• Same as type 1 but with correction of foot cavus and adductus. | • One patient had talar subluxation.<br>• One patient had metatarsophalangeal joint subluxation.<br>• One had residual equinus and forefoot adductus.<br>• Two patients undercorrected.<br>• Nine patients had superficial pin track infection.<br>• One patient had revision. |
| Waizy *et al.*[10] | • Seven patients, Eight severe foot and ankle deformity.<br>• Mean age of the patients was 15.1 yr. | • Residual deformity talipes equinovarus with multiple surgical procedures. | • Double Taylor Spatial Frame construct was mounted on the limb.<br>• Two osteotomies were performed on all patients, midtarsal osteotomy, and calcaneal osteotomy. | • According to Fierreira criteria, seven patients were good, fair in one patient, poor in none.<br>• No foot was corrected to full physiological position.<br>• Five feet had pathological supination in the forefoot. |
| Current study | • Eighteen patients, 13 males and 5 female.<br>• Mean age was 25.89 yr. | • Six patients had post traumatic Volkman ischemic contracture.<br>• Twelve patients had sequela of residual club foot deformity, one patient had fibular hemimelia with talipes equinovarus. | • One frame technique:<br>• First stage:<br>• Complete ring on the ankle and foot take the shape of the deformity in the foot and ankle.<br>• Complete ring on the tibia.<br>• Olive wire inserted in the talus attached to the distal ring until the position of the talus is corrected inside the ankle mortis.<br>• Wire in the metatarsal bone attached to the distal ring.<br>• Second stage:<br>• Release the tension in the talar wire but still attached to the distal ring to keep the position of the talus. | • Correction was achieved in all patients without over correction in any deformity plane.<br>• One patient had recurrence of mild varus ankle deformity. |

eight feet plantigrade and relapses in two patients. The results had AOFOS scores that were classified as good in six, fair in two, and poor in two, which improved from 33.9 preoperatively to 67.25 postoperatively. In our study, the average AOFAS improved from 25.17 (range 12 to 39) preoperatively to 74.78 (range 48 to 88) postoperatively. Fifteen patients (83.3%) were scored as good, and three patients (16.7%) were fair.

Several observations were noted in this study. The correction steps were easier in young patients than adults, and pain tolerance was good in all age groups. Great care was taken in correction steps in skeletally immature patients to avoid physeal injury. Pin-track infections and soft-tissue complications were not affected by the etiology of the deformity or the age of the patients because the correction was done gradually. During the follow-up period, younger patients reported greater satisfaction than adults.

## Limitations and Future Perspectives

The main limitation of this study is the lack of direct comparison to the other modalities of treatment of equinovarus foot and ankle deformity. However, published studies about the use of TSF in the management of foot and ankle deformities, especially in adults, are limited and have small sample sizes with little description of surgical techniques. Future comparative study is planned to compare TSF and Ilizarov fixators in the management of rigid equinovarus feet.

## CONCLUSIONS

In the current study, we presented a bloodless technique with the use of a simple construct of TSF with changeable reference centers in the management of severe equinovarus deformities associated with a soft-tissue compromise. We concluded that TSF is a safe and simple bloodless technique for correcting rigid equinovarus deformities without soft-tissue releases or bone osteotomies and has a satisfactory clinical outcome.

## REFERENCES

1. Paley D. The correction of complex foot deformities using Ilizarov's distraction osteotomies. *Clin Orthop Relat Res*. 1993; 239:97–111.
2. Steinwender G, Saraph V, Zwick EB, *et al*. Complex foot deformities associated with soft-tissue scarring in children. *J Foot Ankle Surg*. 2001; 40:42–49.
3. Manner HM, Huebl M, Radler C, *et al*. Accuracy of complex lower-limb deformity correction with external fixation: a comparison of the Taylor Spatial Frame with the Ilizarov ring fixator. *J Child Orthop*. 2007; 1:55–61.
4. Burns JK, Sullivan R. Correction of severe residual clubfoot deformity in adolescents with the Ilizarov technique. *Foot Ankle Clin*. 2004; 9:571–582.
5. Galante V, Molfetta L, Simone C. The treatment of club foot with external fixation - a review of results. *Curr Orthop*. 1995; 9: 185–188.
6. Hosny GA. Correction of foot deformities by the Ilizarov method without corrective osteotomies or soft tissue release. *J Pediatr Orthop B*. 2002; 11:121–128.
7. Jeong BO, Kim TY, Song WJ. Use of Ilizarov external fixation without soft tissue release to correct severe, rigid equinus deformity. *J Foot Ankle Surg*. 2015; 54:821–825.
8. Cuttica DJ, Decarbo WT, Philbin TM. Correction of rigid equinovarus deformity using a multiplanar external fixator. *Foot Ankle Int*. 2011; 32:5533–5539.
9. Eidelman M, Katzman A. Treatment of complex foot deformities in children with the Taylor spatial frame. *Orthopedics*. 2008; 31:993.
10. Waizy H, Windhagen H, Stukenborg-Colsman C, *et al*. Taylor spatial frame in severe foot deformities using double osteotomy: technical approach and primary results. *Int Orthop*. 2011; 35: 1489–1495.
11. PF PA, Paley D, Bell D. Use of Ilizarov apparatus in the management of recurrent club foot deformities. *Orthopaedic Transactions*. 1988; 12:567.
12. Ferreira RC, Costa MT, Frizzo GG, *et al*. Correction of severe recurrent clubfoot using a simplified setting of the Ilizarov device. *Foot Ankle Int*. 2007; 28:557–568.
13. Rosman M, Brown K. Preoperative Ilizarov frame construction for correction of ankle and foot deformities. *J Pediatr Orthop*. 1991; 11:238–240.
14. Wukich D, Belczyk RJ. An inroduction to the Taylor spatial frame for foot and ankle applications. *Oper Tech Orthop*. 2006; 16:2–9.
15. Manggala Y, Angthong C, Primadhi A, *et al*. The deformity correction and fixator assisted treatment using Ilizarov versus Taylor spatial frame in foot and ankle. *Ortho Rev (Pavia)*. 2017; 9:7337.
16. Dabash S, Potter E, McGarvey W. Using TSF multi-planar external fixation for overcorrection of severe equinus contractures of the ankle joint.foot and ankle ortho. AOFAS Annual Meeting October 2019. *Foot Ankle Orthop*. 2019; 4:4.
17. Takata M, Vilenisky VA, Tsuchiya H, *et al*. Foot deformity with hexapod external fixator, the Ortho-SUV frame. *J Foot Ankle Surg*. 2013; 52:324–330.
18. Riganti S, Cappa V, Nasto LA, *et al*. Treatment of complex foot deformities with hexapod external fixator in growing children and young adults patients. *Foot Ankle Surg*. 2018; 25:623–629.