

Article

A prospective study to evaluate outcomes of serial corrective cast followed by surgery in Congenital Talipes Equinovarus (CTEV)

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Abstract: Introduction: Congenital Talipes Equinovarus/Clubfoot is a common structural congenital deformity affecting approximately 1 in 1000 live births. The choice of operative procedures for clubfoot management depends on factors such as patient age, rigidity of deformity, and severity. However, there is a lack of consensus regarding the optimal surgical approach, whether comprehensive release or minimal staged surgery. This study aims to evaluate the outcomes of percutaneous tendon release and posteromedial soft tissue release for the treatment of relapsed, neglected, syndromic, and postural clubfoot. The corrective casts applied are assessed using the Pirani scoring system, podography, radiological imaging, and functional evaluation based on Laaveg Ponseti and Cummings scores.

Material and Methods: This prospective observational study was conducted in the Department of Orthopaedics at Netaji Subhash Chandra Bose Medical College, Jabalpur, over an 18-month period. A total of 27 clubfoot patients with 33 affected feet, ranging from 6 months to 7 years old, were included after meeting the inclusion and exclusion criteria. Detailed history, examination, and required investigations were performed and recorded. Patients were treated accordingly and followed up at regular intervals. Data was collected, compiled, and analyzed using SPSS 22.0.

Results: The majority of participants (37%) were in the age group of 6-11 months, with males constituting the majority (66.7%). The study included patients with relapsed clubfeet (n=18) and neglected clubfeet (n=9). Right foot involvement was more prevalent than left foot involvement. Pre- and post-operative measurements showed significant associations between Pirani scores, talocalcaneal angles, tibio-calcaneal angles, and talocalcaneal indices. The mean change in Pirani score was 4.04, and podographic measurements demonstrated increased foot bimalleolar angles. Functional assessment using Laaveg Ponseti and Cumming's Functional Score indicated good to excellent outcomes in the majority of participants.

Conclusion: Percutaneous tendon release surgery with corrective cast application is a safe, effective, and low-risk method for correcting relapsed clubfoot. Posteromedial soft tissue release, along with corrective cast application, remains the best option for neglected clubfoot, despite the potential risks of neurovascular and wound complications. These preliminary results, with an average follow-up of 1 year, suggest that soft tissue release surgery for neglected clubfoot and percutaneous tendon release for relapsed clubfoot, along with corrective casting in both methods, yield good to excellent outcomes.

Keywords: CTEV; Clubfoot; Podography; Percutaneous tendon release; Posteromedial soft tissue release.

1. Introduction

Congenital Talipes Equinovarus/Clubfoot is a common structural congenital deformity that occurs in 1 in 1000 live births. Clubfoot consists of four components: equines, hind foot varus, forefoot adductus, and cavus. Left untreated, it leads to walking on the sides and tops of the feet, causing callus formation, potential infections, difficulty wearing standard shoes, and significant mobility limitations. The Ponseti method, involving manipulation, casting, percutaneous Achilles tenotomy, and the use of a forefoot abduction brace, has shown success in initial correction. However, clubfoot has a strong tendency to relapse, often

starting with equines and progressing to heel varus. Relapse can result from incomplete initial correction or inadequate long-term splinting, especially during growth spurts [1–3].

Neglected clubfoot refers to cases without any or insufficient initial treatment. As the child begins to walk, weight bearing on the side or dorsum of the foot worsens the deformity, further contracting the soft tissues and causing abnormal bone shapes. Neglected clubfoot poses challenges for correction, and many feet require surgical intervention, especially in regions where late presentation for treatment is common, such as in India. The choice of operative procedures depends on the patient's age, deformity severity, and rigidity. There is no consensus on whether comprehensive release or minimal staged surgery is preferable. Surgical options involve soft tissue and bony procedures, including ligament, joint capsule, and tendon releases, as well as tendon transfers [4–6].

In this study, our aim is to address relapsed, neglected, syndromic, and postural clubfoot using percutaneous tendon release and posteromedial soft tissue release, based on the severity of deformity. Corrective casting will be applied, and the outcomes will be assessed using the Pirani scoring system, podography, radiological evaluation, and functional assessment with the Laaveg Ponseti and Cummings scores.

2. Material and methods

The present prospective observational study was carried out in the Department of Orthopaedics, NetajiSubhash Chandra Bose Medical College, Jabalpur, after approval by the Institutional Ethics Committee over a period of 18 months. 33 feet of 27 clubfoot patients (aged 6 months to 7 years) were screened using inclusion and exclusion criteria (all idiopathic congenital clubfoot patients below 6 months were excluded) and those willing to participate were included and followed up prospectively at the time of discharge at 1 month, 3 months, 6 months and 1 year. The patients of club feet included comprised neglected type (09), relapse type (18), syndromic (0) and postural type (0). Neglected type of clubfoot was never treated before by any type of casting and surgery. Relapse type clubfoot was treated previously by Ponseti casting method in another centre. Syndromic clubfoot was associated with other anomalies such as poliomyelitis, cerebral palsy, myelomeningocele, spina bifida, arthrogryposis.

A club foot clinic is operational in our medical college under the Orthopaedics department, where all types of clubfoot patients are registered on their first visit. The patients included in this study were first registered here, following which a detailed history was taken from their parents and both systemic and local examination was done, the details of which were recorded in a proforma. Vitals were also recorded. Basic laboratory investigations such as hemogram, blood urea and serum creatinine were done. Investigations in the form of standard radiographs of both feet i.e. dorsiflex lateral and antero-posterior view were also carried out. Thus, all club feet were assessed pre-operatively through Pirani scoring system; radiographically by foot angle measurements (Antero-posterior Talo-Calcaneal angle, Lateral Talo-Calcaneal angle, Antero-posterior Talo-First Metatarsal angle, Tibio-Calcaneal angle and Talo-Calcaneal Index); and podographically by foot bimalleolar angle. The operative procedure and its advantage was explained in detail to each patient and informed consent was obtained. Fitness was taken for surgery and patient was operated as soon as possible.

These patients were treated according to their rigidity level respectively. Patients with severe rigidity, as well as, high Pirani score (9 patients; 11 clubfeet) and not previously treated by non-operative/operative method were treated by postero-medial soft tissue release (Turco's procedure) with lateral column straightening procedure (Lichtblau and Dillwyn procedure), calcaneo-cuboid joint osteotomy followed by Kirschner wire which was used to transfix the talonavicular joint, subtalar joint and calcaneo-cuboid joint. During post-operative period, the limb was immobilized by long leg slab for 2 weeks. The sutures were then removed and long leg case was applied for 1 month. Then as per requirement, up to 3-4 casts were applied. After deformity correction, the foot was maintained in hinged ankle-foot orthosis with plantar flexion stop at neutral for upto 5 years. Patients with less rigidity, as well as, low Pirani score (18 patients; 22 feet) and previously treated by non-operative method were treated by percutaneous osteotomy, which included tenotomy of tendoachilles tendon, plantar fascia release and flexor hallucis longus. Post-operative management was done by applying corrective cast weekly up to 3-4 casts followed by maintaining in CTEV splint for 4-5 years.

3. Statistical Analysis

Data was collected, compiled and analysed using SPSS 22.0 (trial version). Results were expressed as the means and standard deviation or as numbers and percentages. Statistical analysis was done by applying paired "t" test. The level of significance was fixed at 95%. P-value < 0.05 was considered statistically significant.



Figure 1. Pre-op photo of a 7 year old patient with neglected club foot (Right side)



a: 73.2°

Figure 2. Pre-op podogram with foot bimalleolar angle of 73.2 degrees



Figure 3. Pre-op podogram with foot bimalleolar angle of 73.2 degrees



Figure 4. Pre-op lateral talo calcaneal angle



Figure 5. Pre-op AP talo calcaneal angle



a: 48.6°

Figure 6. Pre-op talar first metatarsal angle



b: 54.0°

Figure 7. Pre-op tibio-calcaneal angle



Figure 8. Post-op application of cast for 1 month



Figure 9. Post-op after 1 month



a: 86.3°

Figure 10. Post-op right foot podogram with foot bimalleolar angle of 86.3 degrees



a: 14.6°

Figure 11. Post-op talo first metatarsal angle



a: 37.2°

Figure 12. Post-op AP talo calcaneal angle



a: 24.3°

Figure 13. Post-op lateral talo calcaneal angle



b: 88.2°

Figure 14. Post-op tibio-calcaneal angle



Figure 15. Follow up after 1 year



Figure 16. Pre-op photo of a 1.5 year old female with relapsed right club foot

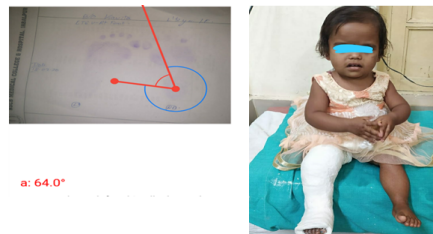


Figure 17. Pre-op relapsed right club foot with foot bimalleolar angle 64 degrees

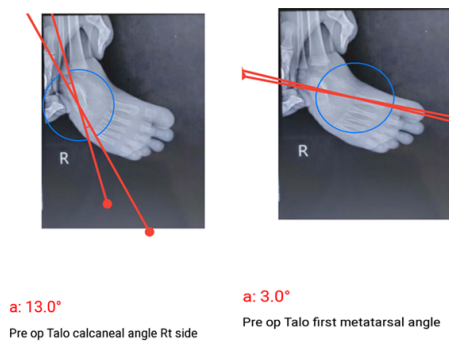


Figure 18

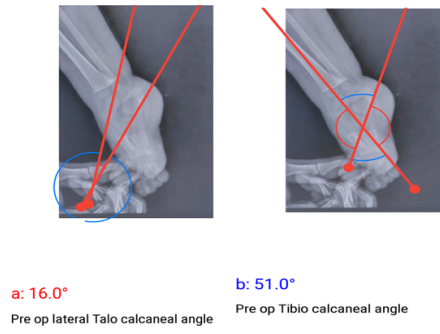


Figure 19



Figure 20. Post-op cast application for 1 month

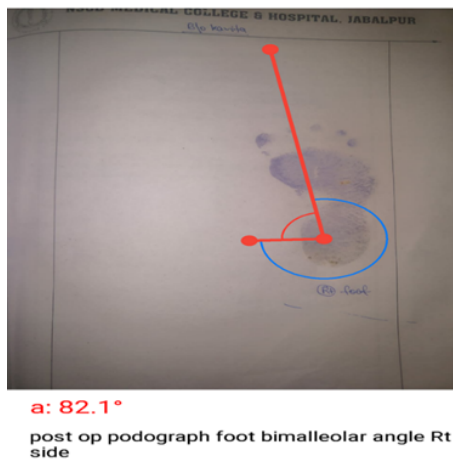
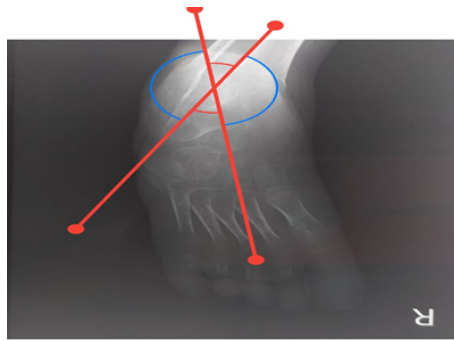
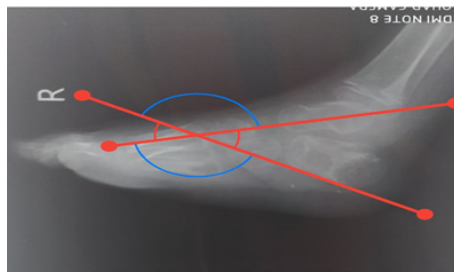


Figure 21



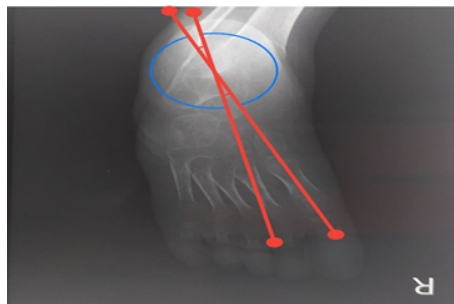
a: 38.2°
Post op AP Talo calcaneal angle. 38.2°

Figure 22



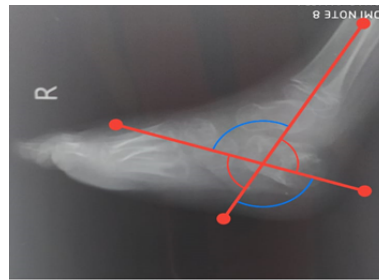
a: 38.6°
Post op Lateral Talo calcaneal angle. 38.6°

Figure 23



a: 12.0°
Post op AP Talo first metatarsal angle. 12°

Figure 24



a: 78.0°

Post op Lateral Tibiocalcaneal angle. 78°

Figure 25



Figure 26. Post-op after 1 year

4. Results

Table 1 shows that most of the participants (37%) in the present study belonged to the age group of 6-11 months followed by those (22.2%) between 2-5 years and (18.5%) <6 months of age. Males constituted the majority (66.7%) among the study participants with a male: female ratio of 2:1 (Figure 29). There were 11 club feet of females and 22 of males as depicted in Figure 29. As seen in Figure 6, there were 18 patients with relapsed club feet (number of club feet totalling to 22) and 9 with neglected club feet (number of club feet totalling to 11). It was also observed that right foot was affected more than left foot in majority cases. Regarding the type of club feet and gender distribution, it was observed as depicted in Figure 28, that 8 males and 1 female had neglected type of club feet, while 10 males and 8 females had relapsed club feet. The mean Pirani score, AP Talocalcaneal angle, Lateral Talocalcaneal angle, AP Talo-first metatarsal angle, Tibiocalcaneal angle and Talocalcaneal index were measured and recorded in all cases of relapse and neglected club feet, both pre- and post-operatively and the association was found highly significant in all cases except for the AP talo-first metatarsal angle among relapsed patients (p -value=0.144; insignificant). The same was calculated for total number of club feet as well. In the present study mean change in Pirani score was found to be 4.04. The podography by measurement of foot bimalleolar angle was also compared pre- and post-operatively, and increase in the angle was observed among most participants (Table 3). Functional assessment by LaavegPonseti and Cumming's Functional Score was done and the outcome was good in majority (61%) and excellent in 18% participants (Table 4).

Table 1. Distribution of study participants as per the socio-demographic characteristics

Socio-demographic characteristics	Frequency	Percentage	
Age Group	<6 months	5	18.5%
	6 – 11 months	10	37.0%
	1 – 2 years	3	11.1%
	2 – 5 years	6	22.2%
	>5 years	3	11.1%
	Total	27	100.0%
Gender	Female	9	33.3%
	Male	18	66.7%
	Total	27	100.0%

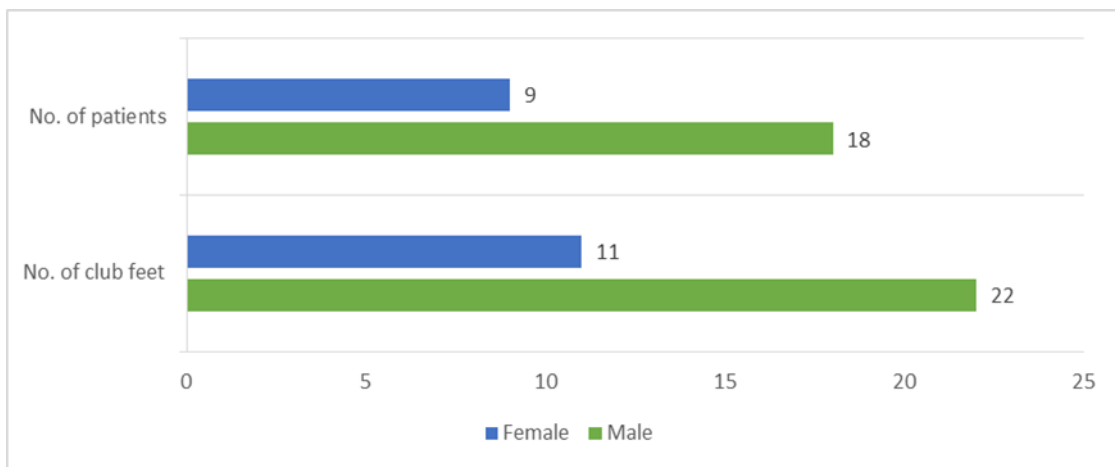


Figure 27. Distribution of patients as per gender and number of club feet

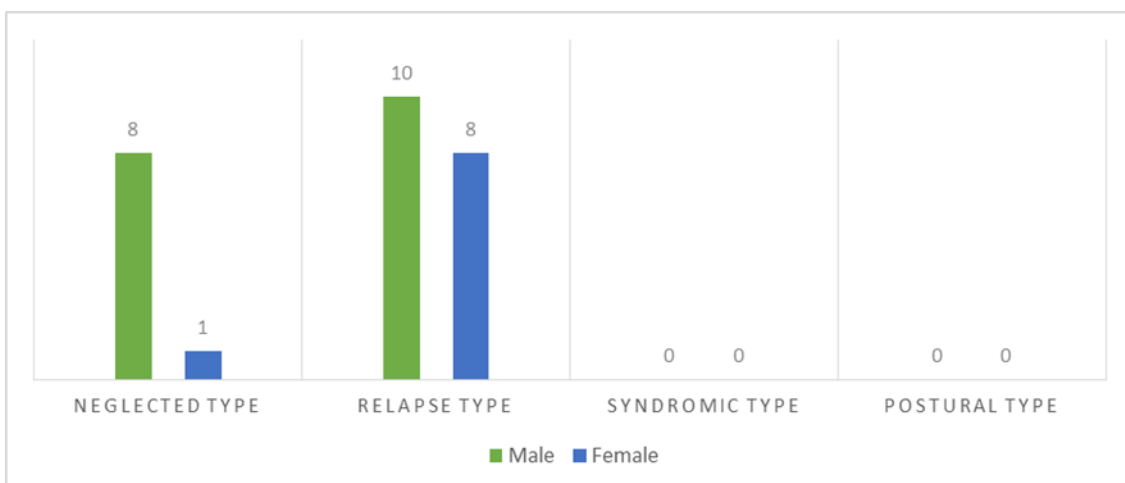


Figure 28. Distribution of patients as per gender and type of club feet

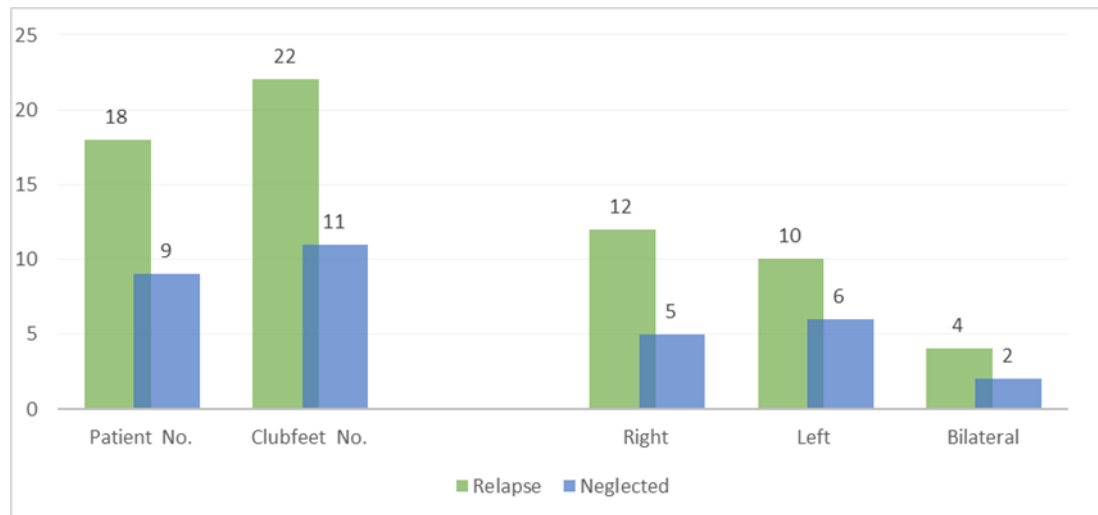


Figure 29. Distribution of patients as pertype and laterality of club feet

Table 2. Comparison of pre- and post-operative values of various parameters among the study participants

Parameters	Pre-op mean	Post-op mean	Mean change	p-value	Paired t-test value
Relapse club feet					
Pirani Score	3.68±1.02	0.40±0.47	3.27	<0.0001	16.41
AP Talo-Calcaneal Angle	15.41±3.76	22.83±3.17	7.42°	<0.0001	11.10
Lateral Talo-Calcaneal Angle	16.39±2.91	23.39±2.86	7.09°	0.0001	8.38
AP Talo-First Metatarsal Angle	13.69±23.37	6.68±4.57	7.0°	0.144	1.51
Tibio-Calcaneal Angle	57.40±6.31	76.07±6.88	18.66°	<0.0001	10.29
Talo-Calcaneal Index	31.66±6.62	46.32±5.38	14.65°	<0.0001	8.72
Neglected club feet					
Pirani Score	6.00±0.00	0.40±0.49	5.59	<0.0001	37.77
AP Talo-Calcaneal Angle	16.78±6.85	28.59±8.80	11.80°	0.001	4.508
Lateral Talo-Calcaneal Angle	13.90±8.94	24.70±8.08	10.80°	0.0001	5.31
AP Talo-First Metatarsal Angle	61.35±22.53	14.70±15.78	46.64°	0.0001	5.61
Tibio-Calcaneal Angle	48.97±16.21	80.38±8.37	31.40°	0.0001	5.31
Talo-Calcaneal Index	30.68±10.12	53.45±12.95	22.77°	0.0001	8.66
Total club feet					
Pirani Score	4.45±1.38	0.40±0.47	4.04	<0.0001	16.94
AP Talo-Calcaneal Angle	15.86±4.94	24.75±6.19	8.88°	<0.0001	8.69
Lateral Talo-Calcaneal Angle	15.50±5.64	23.83±5.11	22.910	0.0001	6.46
AP Talo-First Metatarsal Angle	29.57±32.21	9.35±10.31	20.220	0.001	3.86
Tibio-Calcaneal Angle	54.59±11.16	77.50±7.75	22.91°	<0.0001	17.84
Talo-Calcaneal Index	31.34±7.81	48.70±9.12	17.36°	<0.0001	11.17

Table 3. Comparison of pre- and post-operative foot bimalleolar angle (podography) among the study participants

Parameters	Foot bimalleolar angle				Total
	<65°	65-69°	70-74°	>75°	
Relapse club feet					
Pre-treatment	11 (50%)	7 (32%)	3 (14%)	1 (4%)	22 (100%)
Post-treatment	0 (0%)	1 (4%)	2 (9%)	19 (87%)	
Neglected club feet					
Pre-treatment	5 (46%)	1 (9%)	2 (18%)	3 (27%)	11 (100%)
Post-treatment	2 (18%)	1 (9%)	0 (0%)	8 (73%)	
Total club feet					
Pre-treatment	16 (49%)	8 (24%)	5 (15%)	4 (12%)	33 (100%)
Post-treatment	2 (6%)	2 (6%)	2 (6%)	27 (82%)	

Table 4. Distribution of study participants as per the LaavegPonseti and Cumming's Functional Score

Score		Relapse club foot N (%)	Neglected club foot N (%)	Total club feet N (%)
Excellent	85-100	4 (18%)	2 (18%)	6 (18%)
Good	70-84	12 (54%)	8 (73%)	20 (61%)
Fair	60-69	3 (14%)	0 (0%)	3 (9%)
Poor	Below 59	3 (14%)	1 (9%)	4 (12%)

5. Discussion

On the basis of clinical examination and Pirani scoring, the severity of club foot and deformity level was decided and surgery was performed accordingly. All relapse clubfoot patients were partially corrected by ponseti method, hence there was no need to apply any extensive soft tissue release procedure. Only percutaneous tendon release was preferred. Since neglected clubfoot was never corrected before by any kind of cast or surgical method, they become rigid and hence, posteromedial soft tissue release was done along with lateral column straightening in some cases. In the present study, 37% of the participants belonged to the age group of 6-11 months followed by 22.2% between 2-5 years and 18.5% <6 months of age. The mean age was 21.48 months. Males constituted the majority (66.7%) with a male: female ratio of 2:1. The optimal age for surgical intervention has always been controversial. Turco recommended that surgery should be done after one year of age when foot size allows for easier identification of the structure. (Carroll et al., 1978)[2] recommended that surgery be done at around 2 months because at this time foot is sufficient size to identify pertinent anatomy at time of operation. As per (DePuy and Drennan, 1989)[4] surgery should be done by the age of 3-6 months as it would be easier to achieve the correction. (Franke & Hein, 1988)[6] and (Main, 1977)[14] demonstrated that better results are obtained when posterior or posteromedial release are performed in patient younger than six months (Cummings & Lovell, 1988)[3], (HerringJA, 2002)[7], (Magone et al., 1989)[12] reported early surgical treatment led to severe fibrosis and development of rigid foot, thus surgeries should be delayed between 12 to 24 month after the infant has begun walking so recurrence also prevented.(Osterman & Merikanto, 1996)[17] and (Osterman & Merikanto, 1996)[17] recommended surgery at earlier age of three to six months to utilize the remodeling potential of the foot. (Yamamoto et al., 1994)[25] found the male: female ratio to be 3:1. In the present study, there was improvement in the pre-op mean values of all parameters after the procedures i.e. post-operatively which included the Pirani score, AP Talocalcaneal angle, Lateral Talocalcaneal angle, AP Talo-first metatarsal angle, Tibiocalcaneal angle and Talocalcaneal index. Similar findings were observed in a study by (Park et al., 2009)[18], (Park et al., 2009)[18]. In the present study, the association between the pre- and post-op values was found highly significant in all cases except for the AP talo-first metatarsal angle among relapsed patients (p-value=0.144; insignificant). However, (Yamamoto et al., 1994)[25] found a statistically significant correlation of clinical scoring with AP Talo calcaneal angle. (Laaveg & Ponseti, 1980)[10] found positive correlation between lateral Talo calcaneal angle and functional score. (Turco, 1971)[24] found that lateral Talo calcaneal angle correlated well with the functional rating and is a good indicator of the hind foot deformity. However, (Yamamoto et al., 1994)[25] did not find any correlation with lateral Talo calcaneal angle. (Beatson & Pearson, 1966)[1] TR reported that Talocalcaneal index was one of the very good indicators of hind foot varus deformity. (DeRosa & Stepro, 1986)[5] showed Talocalcaneal index had a strong correlation with functional rating.(DeRosa & Stepro, 1986)[5]

In the present study, the podography by measurement of foot bimalleolar angle was also compared pre- and post-operatively, and increase in the angle was observed among most participants. It was also observed that foot bimalleolar angle (FBA) was significantly related to functional score. Of the 22 relapse clubfeet, 21 (96%) had FBA (>70°) and of these 16 (72%) had good to excellent score (>70). Of the 11 neglected cases, 8 (73%) had FBA (>70°) and of these 10 (91%) clubfeet had good to excellent functional score (>70). When considering overall 33 clubfeet, 29 (88%) had FBA (>70°) and of these 26 (79%) had good to excellent (Laaveg & Ponseti, 1980)[10] and (Cummings & Lovell, 1988) [3]functional score (>70).(Jain et al., 2001) [4] concluded that foot bimalleolar angle was a good representative of the severity of deformity and was used to classify clubfoot pretreatment and post treatment with good correlation towards successful outcome. (Trivedi et al., 2017) [23]observed that management of idiopathic clubfeet by ponseti technique showed 92% patients with

good correction (Foot bimalleolar angle greater than 70°). They also reported that foot bimalleolar angle was significantly related to functional score. They proposed that 85% cases had Magone's score greater than 80 (good to excellent). (14)

Functional assessment by LaavegPonseti and Cumming's Functional Score was done in the present study and the outcome was good in majority (61%) and excellent in 18% participants overall. Among 11 neglected cases, functional score was excellent in 2 feet (18%), good in 8 (73%) and poor in 1 (9%). Among relapsed feet, functional score was excellent in 4 feet (18%), good in 12 (54%), fair in 3 (14%) and poor in 3 (14%). (Turco, 1971)[24], (McKay, 1983)[16], (Simons, 1985)[21], (Rumyantsev & Ezrohi, 1997)[20], (Magone et al., 1989)[12], (Jalil et al., 2011)[12], (Lehman et al., 1999)[11] and (Lehman et al., 1999)[11] reported 84%, 71%, 72%, 69%, 63%, 54.45%, 78% and 78% excellent and good results in their study respectively. (2, 15, 16, 17, 18, 19, 20, 21) As per the results of (Singh & Vaishnavi, 2005)[21], 82% had good to excellent score while recurrence was observed in 6% with forefoot adduction, 3% with equinus and heel varus and 3% with cavus. (22)

(Mahapatra & Abraham, 2016)[13] did a comparative analysis of two most common surgical exposures for clubfoot. They performed PMSTR procedure by 2 methods: Hemi Cincinnati in 18 patients (30 clubfeet) and Turco method in 17 patients (30 clubfeet). On comparison with our study, it was observed that our results were better with the PMSTR procedure. Dr. (Patel & Rathod, 2020)[19] studied the result of posteromedial soft tissue release (PMSTR) in congenital talipes equinovarus (CTEV) children with Pirani score. Results were excellent in 12 (60%) with final Pirani scoring <1, Good in 4 (20%) with Pirani score <2, Fair in 4 (20%) with final Pirani score >2. In the present study, we had done PMSTR procedure over neglected clubfoot which were never corrected before. Comparing our result to this study on the basis of Pirani scoring our result was excellent in 5 feet (45%) (<0.5 post-op Pirani score), good result in 5 feet (45%) (Post-op Pirani score <1.5), fair in 1 foot (9%). But the major difference in both study is age group. (lakhansinghmaravi) used triple percutaneous needle release technique for relapse clubfoot. Their results on Pirani score system basis, modified by Flynn on 20 clubfeet of 15 patient. Result was excellent in 5 feet (25%), good in 12 feet (60%), fair in 3 feet (15%). In the present study we operated 22 clubfeet of 18 relapse patient by percutaneous triple tendon release by needle and 11 no. surgical blade. We released tendon according to deformity in this study. Our result as per Pirani score was excellent in 10 feet (45%), good in 10 feet (45%) and fair 2 feet (9%).

6. Conclusion

Congenital Talipes EquinoVarus deformity is a common birth defect. Relapse and neglected clubfoot both are moderate to severe rigid clubfoot condition, and without surgery and application of corrective cast, their correction is very difficult. In our study we demonstrated that relapse clubfoot is partially corrected by previous cast method so correction of relapse clubfoot by percutaneous tendon release surgery with application of corrective cast is an easy, safe and effective method with low risk of neurovascular injury and wound complication. Correction of neglected clubfoot by posteromedial soft tissue release procedure with application of corrective cast is still the best option but risk of neurovascular and wound complications may arise. The early result in this series with average follow up of 1 year suggested that soft tissue release surgery for neglected clubfoot and percutaneous tendons release for relapse clubfoot along with the application of serial corrective cast in both methods provided good to excellent results.

Author Contributions: All authors contributed equally to the writing of this paper. All authors read and approved the final manuscript.

Conflicts of Interest: The authors declare that they do not have any conflict of interests.

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