Correction of neglected or relapsed clubfoot deformity in an older child by single-stage procedure: early results

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ABSTRACT

Background

Treatment of neglected or relapsed clubfeet in older children is a challenging task. Particularly in developing countries, limited resources and difficulties in getting frequent follow-ups make selection of appropriate surgical procedures more difficult. These difficulties led to the evolution of a new single-stage surgical-procedure consisting of percutaneous Achilles tenotomy, plantar fasciotomy, and closing wedge osteotomy. The aim of the study was to evaluate the outcome of this single-staged procedure.

Methods

Eighty-six children, with neglected or relapsed clubfeet, were operated on using the described procedure in this longitudinal follow-up study. Only children (n = 62) who had a minimum postoperative follow-up of 3 years were included. Eight children (12.9%) were lost to follow-up. Fifty-four children (77 feet) were available for preoperative, intraoperative, and postoperative follow-up evaluations. Detailed morphological, functional and radiographic scoring was done as per the International Clubfoot Study Group.

Results

The age at surgery varied from 5–13 years (mean 8.35 ± 2.64 years). Follow-up ranged from 36—62 months (mean 44.07 ± 8.22 months). Of 77 feet, results were excellent in 41 (53.25%) feet, good in 28 (36.36%), fair in six (7.8%) and poor in two (2.6%) feet. The proportion of excellent and good results was significantly higher in neglected feet as compared with relapsed feet ($P = 0.007$). However, the procedure was found to be effective and useful in relapsed feet as well as neglected feet.

Conclusions

Percutaneous Achilles tenotomy with plantar fasciotomy and dorsal closing wedge osteotomy is a good alternative to conventional procedures for management of neglected or relapsed clubfeet. It may suit the needs of developing countries, particularly in settings where patients who come from remote villages have very poor compliance.

Keywords
clubfoot, neglected, osteotomy, Ponseti, relapsed

INTRODUCTION

Neglected clubfoot deformity is the most common congenital problem leading to locomotor disability in developing countries.[1] Because these children cannot use normal foot wear, they are prone to injuries and getting repeated wounds at callosities formed over the dorsum of the foot (Figure 1). They have difficulties while playing games and walking long distances. They also have difficulty in squatting, which is a common position used for daily activities including toileting and farming. Social stigma of having reversed feet also is an important factor, and girls experience problems in getting married.

Treatment of neglected or relapsed rigid clubfeet in older children (> 5 years) is a challenging task. Particularly in developing countries, most children cannot afford surgical procedures such as the Ilizarov,[1] which require expensive implants and frequent visits to specialized centers. Quite often these children are brought in for treatment by charitable agencies or social workers, hence they demand for a onetime procedure that will give the best chance of correction.

Extensive soft-tissue releases in relapsed and late presenting cases pose problems of skin approximation, wound healing, scarring,[1,2] and persistent forefoot adduction or varus,[3,4] and they require longer hospital stays, a major concern when there are limited resources.

Conventional bony procedures alone cannot fully correct these severe deformities, and a combination of multiple procedures is required.[1,2] Triple arthrodesis is associated with stiffness and ankle arthritis as early as 3 years postoperatively.[5] Talectomy is associated with a high incidence of hindfoot recurrence, pain, and spontaneous bony ankylosis in the tibiotarsal joint.[6]

Before commencement of this study, we had tried the Ponseti technique for older children (> 5 years) with neglected clubfeet.[7,8] The biggest problem we faced was noncompliance for subsequent casting, and we had a high drop-out rate. Also, casting and tendo-Achilles tenotomy were not sufficient, and

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FIGURE 1. Thirteen-year-old girl with bilateral neglected clubfeet. These feet are prone to repeated injuries at callosities formed over the dorsum of the feet.

additional major procedures were required to get complete correction because of secondary deformation of bones.[7,9]

The dilemma in choosing the correct method of treatment for these neglected or relapsed clubfeet led to the evolution of a new single-staged, simpler, and more effective technique. The goal was to obtain a foot that was more or less plantigrade and not necessarily an anatomical correction. The aim of this study was to provide an alternative, single-staged treatment method for relapsed or neglected late presenting clubfeet and to study the outcome of this alternative method.

MATERIALS AND METHODS

This is a longitudinal follow-up study conducted at tertiary-level pediatric orthopaedic hospital. A total of 86 children (ages 5 years or older) underwent a single-stage surgical procedure consisting of percutaneous tendo-Achilles tenotomy, plantar fasciotomy, and closing wedge osteotomy in the last 5.5 years. Only children (n = 62) having a minimum postoperative follow-up of 3 years were included. Of these 62 children, eight (12.9%) were lost to follow-up. Finally, 54 children (77 neglected and relapsed types of clubfeet) were included. Inclusion criteria for the neglected type were feet that had not been treated in the past and had grade III or IV deformity (as per Dimeglio *et al.*[10]). The relapsed type included feet that had one or more surgical procedures but still had residual or recurrent grade III or IV deformity (as per Dimeglio *et al.*[10]).

The study was approved by our institutional review board. Informed consent was obtained from the parents. Data were collected in a predesigned, pretested proforma, containing information on sociodemographic characteristics of the children, preoperative evaluations by Dimeglio *et al.*'s[10] criteria, and intraoperative and postoperative evaluations. Detailed morphological, functional, and radiographic evaluations were done by the surgeon (VUS) as per the International Clubfoot Study Group (ICFSG) and Bensahel *et al.*[11] at each follow-up.

Postoperatively, the children were followed at 6 months and thereafter at yearly intervals. Help from community-based local organizations and social workers was sought to ensure that patients would return for follow-up.

All feet were scored by the Bensahel *et al.*[11] criteria by the first author. Bensahel *et al.*[11] and ICFSG described an extensive outcome evaluation scoring system[11] for treatment of clubfoot. This system is based on morphological, functional, and radiographic evaluation of treated clubfeet.[11] Each of these are further subdivided into hindfoot varus, equinus, midfoot adduction, passive motion at the ankle and subtalar joint, power in muscle groups, gait, pain, various angles on radiographs, etc. Each evaluation is scored as 0, 1, or 2. The better the evaluation, the lower the score. The parameters were totaled, and the results were graded as excellent, good, fair, or poor under this criteria (Table 1).

TABLE 1. Classification of results according to Bensahel *et al.*[11] and the International Clubfoot Study Group

Results	Score	No. Feet
Excellent	0-5	41
Good	6-15	28
Fair	16-30	6
Poor	>30	2

The children also were observed for the ability to squat preoperatively and postoperatively. Associated clinical or radiographic evidence of arthritis, if present during follow-up, was noted. In unilateral cases, foot length was noted and compared with the normal foot. The duration of pain and total recovery period to resume day-to-day activities after cast removal were recorded. Any associated findings were noted. In case of bilateral deformity (Figures 2A, B and I), both feet were operated on under the same epidural anesthesia. Surgical duration was noted for unilateral and bilateral cases.

Operative Technique

Under epidural anesthesia, the patient is placed supine; after painting and draping, the tourniquet is inflated. For correction of the cavus deformity, a percutaneous plantar fasciotomy is done from the medial aspect of the sole. (To perform it safely, the blade should be small [no. 15] and should be kept superficial just behind the fascia so as to incise the plantar fascia only and not the deeper tissues.) The foot is then stretched manually to confirm complete release of plantar fascia.

To correct the equinus, percutaneous Achilles complete transverse tenotomy is done. The Achilles tenotomy unlocks the heel, correcting equinus as well as heel varus.

Attention is then directed to the dorsal closing wedge osteotomy. An elliptical skin incision is made on the dorsal aspect at the apex of the deformed foot (Figure 2C). The incision extends from the lateral border of the foot to just short of the medial border. The elliptical skin and preformed bursa are excised. All dorsal musculature is separated and preserved with a periosteal elevator and chisel and then retracted. The dorsal neurovascular bundles are protected. The osteotomy is marked with an osteotome at the apex of the deformed foot (Figure 3). The wedge should be wider dorsally (1–2 cm) and taper towards the sole (Figure 2D). The amount of bony wedge required depends on the severity of the deformity. A rough clinical guide that can be used is that children who walk on the lateral border of the foot usually do not require more than 1–1.5 cm of wedge; those who walk on the dorsum of foot may need more than 1.5 cm of wedge. One can always remove additional bone if the correction is found to be inadequate. This also should prevent overcorrection, which did not occur in any of the feet in our study.

The cuboid and all three cuneiforms required osteotomy in all the feet in our study. Occasionally, the navicular or distal calcaneus or base of the metatarsals may require osteotomy, depending on the severity of the deformity. Occasionally impingement of the navicular against the head of the talus occurs, not allowing full correction of the deformity, even with cuboid and cuneiform osteotomy. In those patients, naviculectomy should be done, and sometimes an additional terminal portion of the talar head may need to be excised (very rare, only two feet in our study), taking care not to disturb the subtalar joint.

After wedge removal, care is taken to remove cartilage from the osteotomy bed and approximating edges to prevent nonunion and pseudarthrosis. No attempt is made to touch the subtalar joint. The deformity is then corrected by closing the space manually by everting and dorsiflexing the foot and by approximating the bony surfaces, as if closing an open book (Figures 2E and F). The forefoot is stabilized to the hindfoot with three Kirschner-wires passed from the metatarsals to the calcaneus. Cancellous bone from the resected wedge is grafted at the osteotomy site.

No attempt is made to look for radiographic correction because judgement is clinical. The wound is closed after placing a drain (Figure 2G) and the tourniquet is deflated.

An above-knee cast was applied. A window was made in the cast (Figure 2J), and the limb was kept elevated on pillows.

Postoperative Management

Three days of intravenous antibiotics are given along with an epidural for pain relief. On the third postoperative day, the wound is inspected through the window in the cast (Figure 2J). Hematoma, if present, should be removed along with the drain. Patients are discharged on the fourth postoperative day and nonweight bearing is advised for 6 weeks. After 6 weeks, the Kirschner-wires and cast are removed, and a plastic molded ankle-foot orthosis is applied to be worn for 6 months. Squatting is encouraged at home.

Statistical Methods

Data were entered in MS excel and analyzed with STATA software (Version 9.0, StataCorp LP, College Station, TX). Descriptive measures such as mean, standard deviation, and range were used to summarize data on continuous variables. Data on categorical variables were summarized by frequencies and percentages. Differences between means were analyzed with a Student's *t*-test and differences between proportions by the Pearson chi-square test. For small frequencies in categorical data, the Fisher exact test was applied. A *P*-value of < 0.05 was considered statistically significant.

RESULTS

A total of 54 children (77 feet) were available for final evaluation. Twenty-three children had bilateral deformity and 31 had unilateral deformity. Among 54 children, 36 (52 feet) were of the neglected type and 18 (25 feet) were of the relapsed type.

The age at surgery varied from 5-13 years (mean 8.35 ± 2.64). The follow-up period ranged from 36–62 months (mean 44.07 ± 8.22). There were 37 boys and 17 girls.

Preoperative Evaluations

Of the 77 feet, 62 feet were classified as grade IV and 15 were grade III (Dimeglio *et al.*[10]) deformity. All patients had difficulty in squatting and using normal foot wear before surgery.

FIGURE 2. (A and B) Preoperative photograph of a 9-year-old child with bilateral neglected grade IV clubfoot deformity. The deformity is rigid and bones are severely deformed. (C) After percutaneous plantar fasciotomy and Achilles tenotomy, an elliptical skin incision is taken over dorsum of foot at apex of the deformity. (D) After preserving dorsal structures, the osteotomy is marked with osteotome at the apex of the deformed foot. The wedge is wider dorsally (1–2 cm) and tapers towards the sole. (E) Once the wedge is removed, the deformity is corrected by closing the space manually by everting and dorsiflexing the foot. (F) Bony surfaces are approximated, and the deformity is completely corrected. (G) The forefoot is stabilized to the hindfoot with three Kirschner-wires. The drain is in place. (H) Posterior view shows complete correction of equinus and heel varus. (I) Good correction of all components is achieved in both feet. (J) A window was made in the cast for inspection of the wound.

Intraoperative Evaluations

Average intraoperative time was 80 ± 12 minutes (range 60–110 minutes) for unilateral and 180 ± 25 minutes (range 120–240 minutes) for bilateral cases. No intraoperative or immediate postoperative complications occurred.

Postoperative Evaluations

No child had any neurovascular compromise or infection at the osteotomy site. One foot had a pin track infection at the Kirschner-wire site and was treated with intravenous antibiotics. One child had bilateral skin necrosis at the osteotomy site, which healed within 10 days.

None of the patients had nonunion or pseudarthrosis at the osteotomy site. All children had some degree of pain and plantar discomfort on weight bearing after cast removal. The duration of this discomfort ranged from 10–90 days (mean 30.72 ± 15.09 days). Average recovery period, after removal

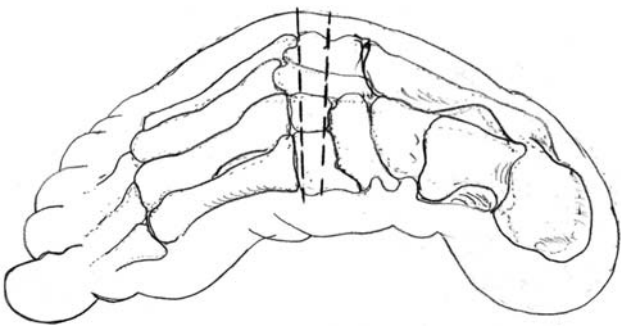

FIGURE 3. The osteotomy location at the apex of the deformed foot. Broken lines represent the planes of the osteotomy. They are wider dorsally and taper towards the sole. The wedge usually includes the cuboid and all three cuneiforms. If the deformity is severe, then the wedge may include part of the calcaneus, bases of metatarsals, navicular, and rarely the terminal portion of the talar head.

TABLE 2. Comparison of results in relapsed and neglected feet

	Type of feet					
	Relapsed		Neglected		Total	
Results	No. feet	Percentage	No. feet	Percentage	No. feet	Percentage
Excellent and good	19	76.0	50	96.1	69	89.6
Fair and poor	6	24.0	2	3.9	8	10.4
Total	25	100.0	52	100.0	77	100.0

of the cast, for resuming day-to-day activities was 56.89 ± 22.30 days (range 21–120 days).

Follow-up Evaluations

At final follow-up, of 77 feet, 41 (53.25%) had excellent results, 28 (36.36%) had good results, six (7.8%) had fair results and two (2.6%; one patient with bilateral deformity) had poor results (Table 1).

Comparative results of relapsed and neglected feet are presented in Table 2. Among 25 relapsed feet, 19 (76.0%) had excellent and good results. Similarly, among 52 neglected feet, 50 (96.1%) had excellent and good results. These observations suggest that the described technique is effective and useful in both relapsed and neglected feet. However, the proportion of excellent and good results was significantly higher in neglected as compared with relapsed feet ($P = 0.007$).

The relationship between the age at which surgery was performed and results is shown in Table 3. Of 69 feet with excellent or good results, most (42 feet, 60.9%) were in children younger than 10 years. However, in eight feet with fair or poor results, most (six feet) were in children older than 10 years. This observation indicates that the relative frequency of good results was significantly ($P = 0.052$) higher in younger (< 10 years) children than older (10 + years) children.

While evaluating the movements at the ankle joint, it was found that the more dorsiflexion was restricted the poorer the results were (Table 4), and these finding were statistically significant ($P = 0.001$). Likewise, the greater the stiffness at the subtalar or midtarsal joints the poorer the results, and these findings also were statistically significant ($P = 0.001$).

Seventy-four (96.1%) feet had grade 5 power in triceps-surae, suggesting that percutaneous complete transverse tenotomy does not affect the power of this muscle. None of the patients had pain in the foot or the operative area in any activities at final follow-up. The results of our procedure were independent of radiographic findings (Figure 4). Squatting (Figure 5B) was possible in all patients; however, difficulty in the terminal act of squatting was noted in 18 feet because of restricted dorsiflexion. None of the patients had clinical or radiographic evidence of arthritis at the ankle or any other joint. The average foot length was 1.18 cm shorter than the normal foot in unilateral cases (range 0.5–2 cm).

DISCUSSION

Reluctance to perform bony procedures for neglected clubfoot was found in the older literature.[12] In one article, Professor Lorenz stated that every bone operation in clubfoot is a ''crime.'' This statement was based on excision of the talus in a single patient without much scientific evidence.[12] Subsequent literature did not focus much on neglected cases, because patients come for treatment early in the Western world. Also, the literature that mentions relapsed deformities is based on the cases that had minimal residual components, because experts operated on most of them early.[2,13–16]

Patients with relapsed clubfeet in developing countries usually present late to the hospital and may have been operated on at hospitals where no experts are available. Hence, at the time of presentation, they usually have severe (grade III/IV) deformities that cannot be corrected with conventional procedures such as those described by Dwyer or Dillwyn Evans alone, and a combination of procedures is required.[14–16]

With the described technique, excellent and good results were achieved in 69 (89.6%) feet. As evident from Table 2, the technique is effective and extremely useful in both relapsed as well as neglected clubfeet (Figure 5). The lower proportion of excellent and good results in relapsed feet compared with neglected feet could be from scarring of previous surgeries with resultant stiffness at the ankle, subtalar, or mid tarsal joints. This is consistent with other studies.[14–16]

TABLE 3. Relationship between age at surgery and results

	Age at surgery					
	Less than 10 years		10 years and above		Total	
Results	No. feet	Percentage	No. feet	Percentage	No. feet	Percentage
Excellent and good	42	60.9	27	39.1	69	100
Fair and poor	2	25.0	6	75.0	8	100
Total	44	57.1	33	42.9	77	100

TABLE 4. Relationship between dorsiflexion score at final follow-up and results

	Dorsiflexion score							
	0		1		2		Total	
Results	No. feet	Percentage	No. feet	Percentage	No. feet	Percentage	No. feet	Percentage
Excellent and good	59	100.0	10	66.7	0	0.0	69	89.6
Fair and poor	0	0.0	5	33.3	3	100.0	8	10.4
Total	59	100.0	15	100.0	3	100.0	77	100.0

The higher frequency of good results in younger (<10 years) children could be explained on the basis that older children have greater bony incongruency and less ability to remodel.[1] Bones in these feet are so deformed that they cannot achieve normal radiographic relationships. Our results were independent of radiographic findings and were consistent with other studies.[16,17]

Only one child with poor results (bilateral relapsed feet) had complete correction of the deformity intraoperatively but was lost to follow-up for 59 months. The patient neither

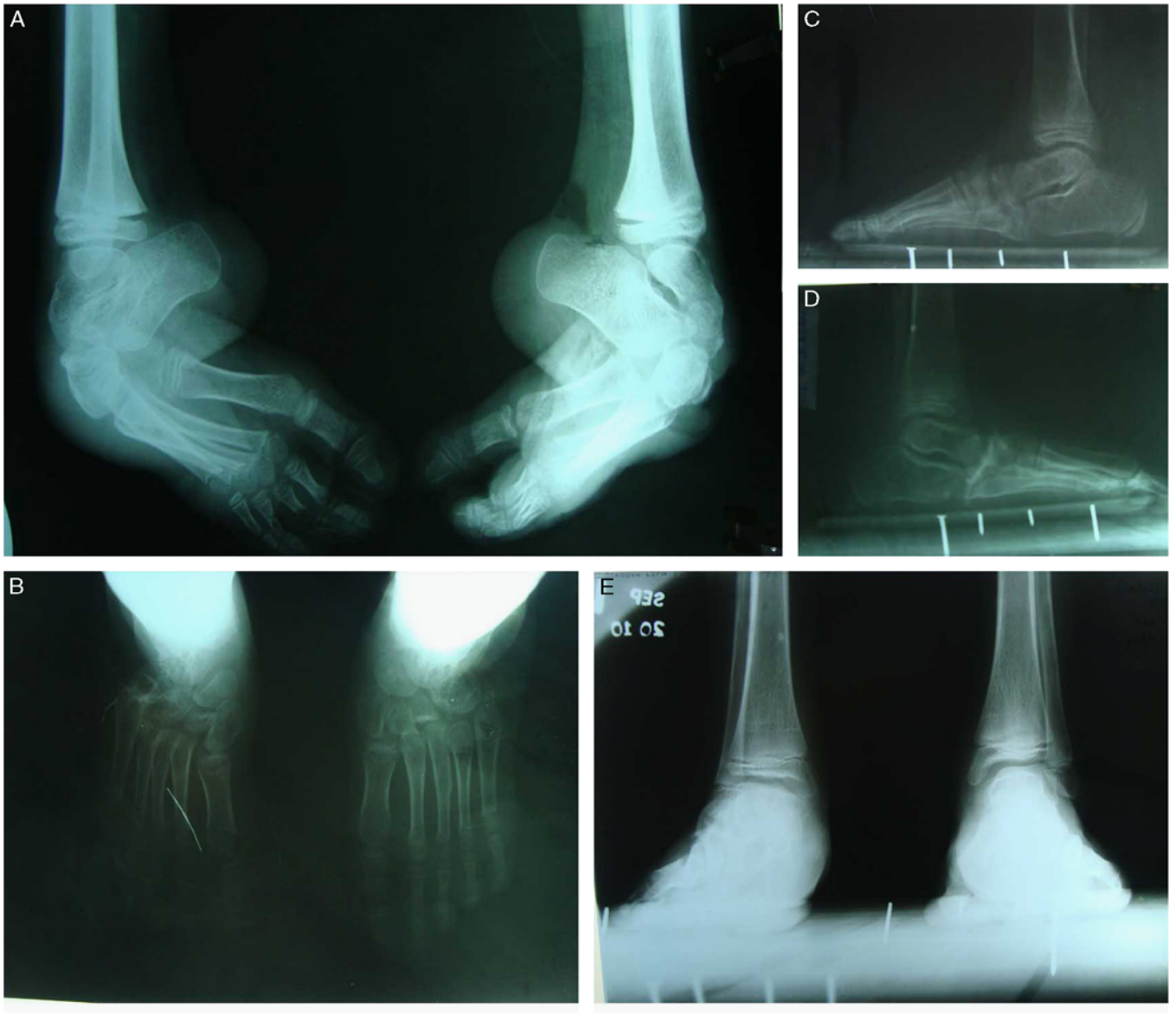

FIGURE 4. (A) Preoperative radiograph suggesting severe bony deformation. (B) Postoperative, standing anteroposterior radiograph suggesting good union at the osteotomy site and restoration of the bony relationship to a great extent, but it is not anatomical. (C) Postoperative standing lateral radiograph left-side. (D) Postoperative standing lateral radiograph right-side. (E) Postoperative ankle, standing anteroposterior view suggesting near normal ankle joints for both feet.

FIGURE 5. (A) Six-year-old girl with bilateral grade IV neglected clubfeet. (B) Five years after surgery with good maintenance of the hindfoot, forefoot, and midfoot correction, bilaterally. Squatting was possible. The child was able to perform all day-to-day activities without any pain.

performed squatting exercises nor used splints, leading to recurrence. This suggests that squatting has an important role to play. In spite of poor results, he maintained good function.

No feet (including those with poor results) had clinical or radiographic evidence of arthritis at the ankle or any other joint at 3–5 years of follow-up. A possible reason could be that our procedure preserves the subtalar joint. This is an advantage over triple arthrodesis[5]; however, longer follow-up will be required to look for development of stiffness, arthritis, and recurrences in the future.

All patients had foot discomfort and plantar pain during the initial few months after cast removal. This could be attributed to sensitivity of the sole and disuse osteoporosis of the calcaneus and metatarsals. None of the patients had pain subsequently, which might be attributed to good fusion at the osteotomy site with the use of cancellous grafting.

Clubfoot is a three-dimensional deformity, with a contracted tendo-Achilles being the main deforming force. Achilles tenotomy unlocks the heel and corrects equinus and heel varus. No separate procedure or calcaneal osteotomy is necessary for varus correction (Figures 2F and H). All feet had good correction of all components intra-operatively (Figures 2F, H and I) and allowed varus-valgus movements on the table. Meticulous preservation of dorsal structures preserves function and prevents wound complications.

In bilateral cases, operating on both feet under a single anesthesia reduces the rehabilitation time, saves resources, and provides a unique opportunity for correction.

This single-stage technique is easy, safe, and reproducible, and it can be performed with basic orthopaedic instruments. There are no rigid criteria about specific bones to be osteotomized. If the surgeon performs an osteotomy at the apex of a deformed foot and takes out a wedge dorsally, tapering towards the sole, no error can occur. There is no risk of neurovascular damage. By removing a dorsal wedge, tension in the system is released. Problems of medial scarring and wound breakdown are avoided because the technique is percutaneous medially. No iliac crest graft or major implants are required. Fewer follow-ups are required than with other techniques. We believe that the technique is cost effective, requiring only 10% of the cost involved in the Ilizarov or other techniques.

The only disadvantage is possible shortening of foot length in unilateral cases. We observed an average shortening of 1.18 cm which is comparable to other series of bony procedures and even those feet treated conservatively.[14,17,18] Although long-term follow-up until maturity will be required to determine the final shortening of foot, early results are encouraging.

We agree that the best approach in developing countries to reduce the load of neglected cases and to avoid long-term problems associated with extensive soft-tissue releases is early intervention during infancy.[19] This can be achieved by seeking help from paramedical persons like nurses or physiotherapists to use the Ponseti technique at outlying hospitals,[20] but until that time this load of neglected cases persists. The described technique provides a good alternative procedure to surgeons of the developing world.

On the basis of our study, we conclude that a procedure including percutaneous Achilles tenotomy with plantar fasciotomy and dorsal closing wedge osteotomy is a good alternative to conventional procedures for management of neglected or relapsed, late presenting clubfoot deformities. We do not claim that this is the only best alternative, but it may suit the needs of developing countries, particularly in

settings like ours, where patients mostly of low socio-economic means come from remote villages and are unable to comply in terms of follow-up.

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