Section: Orthopedics

Original Research Article

CLINICAL AND RADIOGRAPHIC OUTCOMES OF PONSETI TREATMENT IN SYNDROMIC CLUBFOOT: A PROSPECTIVE OBSERVATIONAL STUDY

Silambarasan M[1], Cheraventhan Mani[2], PV Venkataraju[3], Lokesh Sampath[4]

[1]*Assistant Professor, Department of Orthopedics, Swamy Vivekanandha Medical College and Research Institute, Elayampalayam, Tiruchengode, Namakkal, Tamil Nadu – 637205, India.*
[2]*Assistant Professor, Department of Orthopedics, Swamy Vivekanandha Medical College and Research Institute, Elayampalayam, Tiruchengode, Namakkal, Tamil Nadu – 637205, India.*
[3]*Associate Professor, Department of Orthopaedic Surgery, Swamy Vivekanandha Medical College and Research Institute, Elayampalayam, Tiruchengode, Namakkal, Tamil Nadu – 637205, India.*
[4]*Assistant professor, Department of Orthopaedics, Saveetha Medical College, Thandalam, Chennai, Tamil Nadu – 602105, India.*

Received *: 17/09/2026*
Received in revised form *: 20/10/2026*
Accepted *: 03/11/2026*

Corresponding Author:
Dr. Silambarasan M,
Assistant Professor, Department of Orthopedics, Swamy Vivekanandha Medical College and Research Institute, Elayampalayam, Tiruchengode, Namakkal, Tamil Nadu – 637205, India.
Email: silambarasan.ortho@gmail.com

DOI: 10.70034/ijmedph.2026.4.254

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (4); 1658-1663

ABSTRACT

Background: Clubfoot associated with congenital syndromes can be difficult to correct because deformity is often rigid and accompanied by other musculoskeletal abnormalities. The amount of treatment required and the response during the initial casting period are therefore important clinical outcomes. **Objective:** To describe early changes in clinical severity and radiographic alignment after Ponseti treatment of syndromic clubfoot, together with the casting burden, tenotomy rate and need for further procedures.

Materials and Methods: From May 2018 to August 2019, 30 previously untreated children with 52 syndrome-associated clubfeet were followed at Gauhati Medical College and Hospital. Management consisted of serial Ponseti casts, Achilles tenotomy for residual equinus and subsequent foot-abduction bracing. The Pirani score and Beatson-Pearson index were used to assess clinical and radiographic correction, respectively.

Results: Arthrogryposis multiplex congenita was present in 14 children, and 22 of the 30 children had bilateral deformity. The mean number of casts was 11.23 (range, 2-24), and 50 feet (96.2%) underwent Achilles tenotomy. Mean Pirani score fell from 5.10 to 0.13 (paired $t = 35.459$; $p < 0.001$). In 30 paired radiographic observations, mean Beatson-Pearson index rose from 11.27 to 52.57 (one-tailed $p < 0.0001$). Repeat tenotomy was performed in four feet, bilateral cuboid osteotomy was required in one child, and five children experienced cast-related skin complications.

Conclusion: Serial Ponseti treatment corrected the deformity during the observed period in this cohort of children with different associated conditions. Correction frequently required prolonged casting and Achilles tenotomy; the durability of alignment beyond the available follow-up remains uncertain.

Keywords: Syndromic clubfoot; congenital talipes equinovarus; Ponseti method; Pirani score; Achilles tenotomy; arthrogryposis; foot-abduction brace.

INTRODUCTION

Congenital talipes equinovarus combines a high medial arch, inward deviation of the forefoot, inversion of the heel and plantarflexion at the ankle. These components arise from altered relationships between the tarsal bones and contracted surrounding structures. Although many children have isolated deformity, clubfoot may accompany neurological, skeletal and multisystem conditions, which can complicate correction.[1]

Ponseti treatment addresses these components in a defined sequence. Manipulation first reduces cavus; subsequent casts gradually bring the midfoot and heel into alignment while the talar head is stabilised. Achilles tenotomy is used when equinus remains after the other components have improved.[2] Once casting is complete, a foot-abduction brace is used to

preserve the position gained and limit recurrent deformity.[3]

Syndrome-associated feet cannot always be expected to respond like idiopathic clubfeet. Associated contractures, altered muscle control and skeletal abnormalities may prolong treatment or lead to recurrent deformity. A systematic review reported a mean of 7.2 casts for non-idiopathic feet compared with 5.4 for idiopathic feet and also identified more frequent recurrence in the non-idiopathic group.[4] In a separate series of 28 syndrome-associated feet, Matar and colleagues found satisfactory final outcomes in 23 feet after several years of follow-up.[5]

The Pirani score allows serial clinical assessment of the degree of deformity during casting.[6] In syndromic clubfoot, severity scores alone do not capture the extent of treatment required.

For a child with an underlying syndrome, the foot deformity may be only one part of a wider musculoskeletal disorder. Joint contractures, differences in muscle function and associated neurological findings can affect how readily the foot responds to manipulation.[7] Treatment must address the clubfoot deformity while taking account of the child's associated clinical problems. Repeated assessment during casting helps identify persistent deformity and determines whether further intervention is needed.

The aim of Ponseti casting is to obtain a corrected foot with the least possible soft-tissue disruption. In children with severe contractures, avoiding extensive soft-tissue release may help reduce postoperative stiffness. However, the number of casts required, the need for Achilles tenotomy and the possibility of recurrence remain important practical considerations. Previous series of syndrome-associated clubfeet have reported correction with the Ponseti method, although subsequent procedures were necessary in some children.[8]

Clinical assessment and radiographs provide different information during treatment. The Pirani score records visible and palpable features of deformity, allowing the change in severity to be followed from one cast to the next. Talocalcaneal angles on anteroposterior and lateral radiographs provide an additional measure of alignment.[9] Neither measure alone establishes whether a child will later walk comfortably or maintain correction as growth continues.

Because many children with syndromic clubfoot have bilateral involvement, outcomes need to be described clearly at both child and foot level. The number of casts reflects treatment burden for families, whereas tenotomy, repeat procedures and plaster-related skin problems help describe the course of treatment. This study examines these early clinical and radiographic outcomes following Ponseti management of syndrome-associated clubfoot.

MATERIALS AND METHODS

Study design and participants

Children presenting to the Orthopaedics Department of Gauhati Medical College and Hospital, Assam, were prospectively followed between May 2018 and August 2019. Eligibility was limited to children younger than five years with clubfoot associated with a congenital syndrome or neurological condition, whether the deformity affected one foot or both. Idiopathic cases and children whose parents did not consent were excluded. No child had been treated previously with corrective casts or clubfoot surgery. A parent or guardian gave written informed consent before the child entered the study.

The cohort comprised 30 children and 52 affected feet. The associated diagnoses were arthrogryposis multiplex congenita, Larsen syndrome, neural tube defects, Down syndrome, congenital annular band syndrome, Pierre Robin syndrome and pterygium syndrome. For bilateral deformity, measurements from both feet contributed to foot-level outcomes; patient characteristics were described per child.

Ethical considerations

The study received approval from the Institutional Ethics Committee, Gauhati Medical College and Hospital (EC No. MC/190/2007/Pt-I/IEC/130). Before enrolment, the treatment procedure and follow-up schedule were explained to parents or legal guardians. Written informed consent was obtained for study participation and treatment, and children whose parents declined consent were excluded.

Clinical and radiographic assessment

At presentation, the side affected, associated neurological or skeletal findings and clinical severity were recorded. Severity was graded separately for each foot with the Pirani system. Its midfoot component assesses the medial plantar crease, lateral border curvature and lateral talar-head prominence; the hindfoot component assesses the posterior crease, heel fullness and fixed equinus. Each of the six findings received a score of 0, 0.5 or 1, yielding a total between 0 and 6. Scores were recorded before casting and reassessed as correction progressed.

Anteroposterior and lateral radiographs were used to assess bony alignment before treatment and following correction. The Beatson-Pearson index was obtained by adding the talocalcaneal angles measured in the two views. Paired radiographic summaries were available for 30 observations, whereas the clinical Pirani analysis covered 52 feet. The recorded outcomes also included the number of casts, tenotomy, subsequent procedures and complications attributable to plaster immobilisation.

Treatment protocol and follow-up

Treatment began with gentle foot manipulation and an above-knee plaster cast, renewed at weekly intervals. The first correction targeted cavus by aligning the forefoot with the hindfoot. Further casts progressively abducted the foot beneath the talus to address adduction and heel varus. When the foot was

adequately abducted but ankle equinus persisted, percutaneous Achilles tenotomy was performed under local anaesthesia. A final long-leg cast was then maintained for approximately three weeks.

Following cast removal, children were placed in a Steenbeek foot-abduction brace. Families were instructed to maintain brace wear for about 23 hours daily during the first three months and subsequently for approximately 14 hours daily during sleep, as prescribed in the study protocol. The treatment team also discussed practical brace use and signs of recurrent deformity with parents. Review was scheduled every month for the first three months, at three-month intervals over the next year and at six-month intervals thereafter. The longest follow-up was approximately 18 months.

Statistical analysis

Patient characteristics and treatment events were summarised with counts and percentages. Continuous measures were reported as means with standard deviations or ranges, as available. The recorded before-and-after Pirani scores for 52 feet and the Beatson-Pearson indices for 30 radiographic observations were compared using paired t tests. Because some children contributed two feet, the foot-level test did not account for correlation between feet from the same child.

RESULTS

Participant characteristics

There were 19 boys (63.3%) and 11 girls (36.7%; male-to-female ratio, approximately 1.7:1) among the 30 children. Bilateral clubfoot was present in 22 children (73.3%); three had right-sided and five had left-sided unilateral deformity. At enrolment, 21 children (70.0%) were aged 0-6 months, six (20.0%) were aged 7-12 months and three (10.0%) were older than one year. Mean age at presentation was 8.8 months. Arthrogryposis multiplex congenita accounted for 14 children (46.7%), followed by Larsen syndrome in five (16.7%), neural tube defects in four (13.3%), Down syndrome in three (10.0%), annular band syndrome in two (6.7%) and Pierre Robin and pterygium syndromes in one child each (3.3%) (Table 1; Figure 1).

Correction and radiographic change

A mean of 11.23 casts was required during correction (SD, 6.10; median, 9.5; range, 2-24). Including the final post-tenotomy cast, mean time in plaster was 14.23 weeks. The average Pirani score changed from 5.10 (SD, 0.98) before treatment to 0.13 (SD, 0.26) after correction; the reported paired test gave $t = 35.459$ with 51 degrees of freedom ($p < 0.001$). The mean Beatson-Pearson index increased from 11.27 (SD, 5.39) to 52.57 (SD, 10.86) in 30 paired radiographic observations (one-tailed $p < 0.0001$) (Table 2; Figure 2). The reported paired Pirani-score difference (before minus after) was 4.96154 (95% confidence interval [CI], 4.68063 to 5.24245). The paired Beatson-Pearson difference (before minus after) was -41.300 (95% CI, -43.962 to -38.638), with a pre-post correlation of $r = 0.8213$. The clinical casting sequence and a representative pair of radiographs are shown in Figures 3 and 4.

Tenotomy, additional procedures, and complications

Percutaneous Achilles tenotomy was undertaken in 29 children (50 of 52 feet, 96.2%). A second tenotomy was performed in four feet (7.7%), affecting one child with arthrogryposis and another with Larsen syndrome. One child with arthrogryposis underwent cuboid osteotomy on both sides for recurrent deformity (two feet; 3.8%). Plaster-associated sores or other skin problems occurred in five children (16.7%); their casting schedule was interrupted for one week while the skin was treated. Initial deformity correction was documented in all 52 feet, but subsequent intervention was needed in the cases described above (Table 3). Tenotomy and post-correction bracing are illustrated in Figure 5.

Additional descriptive observations

The number of casts required varied with age at presentation. Among boys, 13 had bilateral clubfoot, two had right-sided deformity and four had left-sided deformity. Among girls, the corresponding counts were nine, one and one (Table 4).

Distribution of clinical and radiographic measures

Baseline Pirani scores were 6 in 18 feet, while scores after correction were 0 in 39 feet (Table 5). Beatson-Pearson index values before and after correction and the casts required for each child were summarised. Paired Pirani scores had a correlation of $r = 0.025$ ($p = 0.862$). The paired radiographic differences had a Kolmogorov-Smirnov distance of 0.10 ($p > 0.10$).

Table 1: Baseline characteristics of children with syndromic clubfoot (n = 30)

Characteristic	Children, n (%)
Sex: male	19 (63.3)
Sex: female	11 (36.7)
Age: 0–6 months	21 (70.0)
Age: 7–12 months	6 (20.0)
Age: >12 months	3 (10.0)
Laterality: bilateral	22 (73.3)
Laterality: right only	3 (10.0)
Laterality: left only	5 (16.7)
Arthrogryposis multiplex congenita	14 (46.7)
Larsen syndrome	5 (16.7)

Neural tube defects	4 (13.3)
Down syndrome	3 (10.0)
Congenital annular band syndrome	2 (6.7)
Pierre Robin syndrome	1 (3.3)
Pterygium syndrome	1 (3.3)

Table 2: Clinical and radiographic indices before and after Ponseti correction

Outcome measure	Before correction	After correction	Observations
Pirani score, mean ± SD	5.10 ± 0.98	0.13 ± 0.26	52 feet
Pirani score, median (range)	5.5 (2.5-6.0)	0 (0-1)	52 feet
Beatson-Pearson index, mean ± SD	11.27 ± 5.39	52.57 ± 10.86	30 pairs
Beatson-Pearson index, median (range)	10 (4-23)	50 (36-80)	30 pairs
Beatson-Pearson index, 95% CI for mean	9.255-13.278	48.512-56.621	30 pairs

Paired analyses: Pirani score, mean difference (before-after) 4.96154 (95% CI 4.68063-5.24245), t = 35.459, df = 51, p < 0.001. Beatson-Pearson index, mean difference (before-after) -41.300 (95% CI -43.962 to -38.638), reported one-tailed p < 0.0001; paired correlation r = 0.8213. SD, standard deviation; CI, confidence interval.

Table 3: Treatment requirements and early complications

Treatment or outcome	Value	Unit of analysis
Casts to initial correction, mean ± SD	11.23 ± 6.10	Children
Casts to initial correction, range	2–24	Children
Duration of immobilization, mean	14.23 weeks	Children
Achilles tenotomy	50 (96.2%)	52 feet
Repeat Achilles tenotomy	4 (7.7%)	52 feet
Cuboid osteotomy for recurrence	2 (3.8%)	52 feet
Cast-related skin complications	5 (16.7%)	30 children

Table 4: Laterality of syndromic clubfoot by sex (n = 30 children)

Sex	Bilateral	Right only	Left only	Total
Boys	13	2	4	19
Girls	9	1	1	11
Total	22	3	5	30

Table 5: Pirani score distributions before and after correction (52 feet)

Before: score	Feet (n)	After: score	Feet (n)
2.5	2	0	39
3.5	3	0.5	11
4	6	1	2
4.5	6	—	—
5	5	—	—
5.5	12	—	—
6	18	—	—

Pirani score distributions before and after treatment are shown for the 52 affected feet.

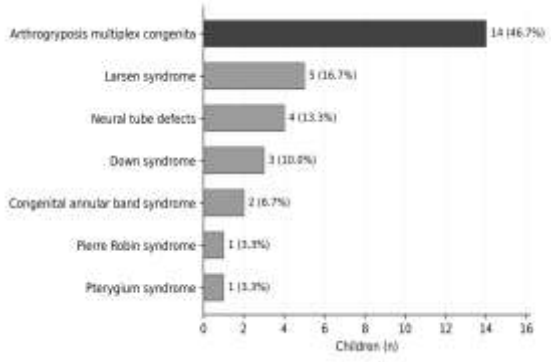


Figure 1: Associated conditions among the 30 children enrolled in the study

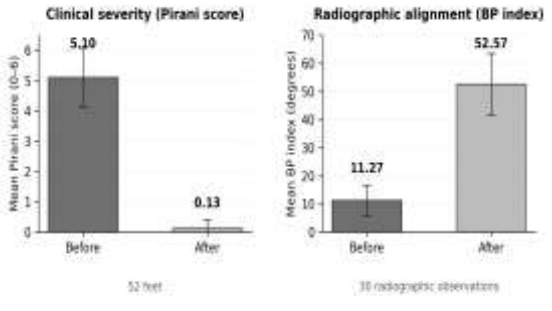


Figure 2: Mean Pirani score (52 feet) and Beatson-Pearson index (30 radiographic observations) before and after casting. Error bars indicate standard deviations.

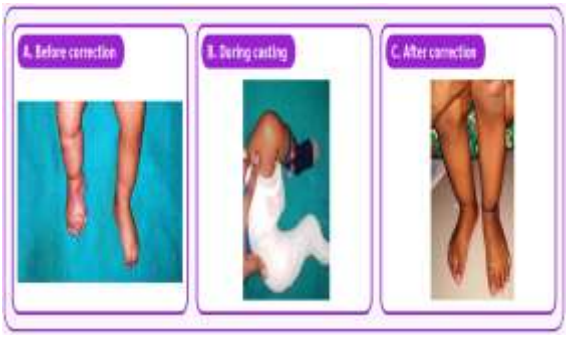


Figure 3: Unilateral clubfoot in a child with arthrogryposis multiplex congenita: (A) before treatment, (B) during casting, and (C) after correction.



Figure 4: Radiographs before and after correction in a child with bilateral clubfoot (talocalcaneal angles 8° before and 35° after correction).



Figure 5: Treatment photographs showing (A) percutaneous Achilles tenotomy and (B) use of the foot-abduction brace after correction.

DISCUSSION

Clinical and radiographic measurements changed considerably over the casting period. The reduction in Pirani scores was accompanied by a rise in the Beatson-Pearson index, indicating improved alignment at the end of initial treatment. This finding should not be confused with a measured improvement in walking ability or pain, neither of which was assessed with a standardised outcome scale. Treatment was also intensive: the mean of 11.23 casts in this cohort contrasts with 6.4 casts reported by Janicki and colleagues among 40 non-idiopathic feet.[10] Boehm and colleagues likewise observed that children with distal arthrogryposis needed more casts than children with idiopathic clubfoot.[11] The mean presenting age in our series was 8.8 months, which may have contributed to treatment duration, although the effect of age was not analysed separately.

Residual equinus commonly required additional treatment. Achilles tenotomy was performed in 96.2% of affected feet despite repeated manipulation and casting. Moroney and colleagues described a lower tenotomy proportion in their non-idiopathic cohort.[12] The difference cannot be attributed to a single factor because our participants had several different underlying diagnoses and generally severe initial deformity. In this setting, the tenotomy rate is best interpreted as part of the treatment burden rather than as an independent indicator of success.

All affected feet were initially corrected, but some required further treatment. Four feet underwent repeat tenotomy and one child eventually required bilateral cuboid osteotomy. In children with arthrogryposis, Kowalczyk and Felus also described further procedures after initial Ponseti-based correction.[13] Gerlach and colleagues found that recurrence was more frequent in clubfeet associated with myelomeningocele than in idiopathic cases.[14] Repeat casting and another Achilles procedure were also necessary in some myelomeningocele-associated feet followed by Matar and colleagues.[15] Arkin and colleagues reported substantial relapse during longer observation of children with spina bifida.[16] These reports support continued follow-up after initial correction to identify recurrence during growth.

The cohort included children with several distinct underlying diagnoses. Fourteen of the 30 children had arthrogryposis, but the remaining cases included Larsen syndrome, neural tube defects, Down syndrome and less common conditions. Published experience with congenital annular band syndrome describes satisfactory correction after Ponseti casting in some affected feet.[17] Carpiaux and colleagues similarly reported its use in amniotic band-associated clubfoot, including children with neurological findings.[18] The response may differ between underlying conditions, but the small numbers in each diagnostic group prevented meaningful comparisons.

Plaster-related skin problems occurred in five children, requiring a one-week interruption of casting. Families should know at the outset that treatment may continue for several months, often includes Achilles tenotomy and depends on consistent bracing after correction. Follow-up needs to address pressure injuries as well as any return of equinus, adduction or heel varus.

CONCLUSION

In 30 children with 52 syndrome-associated clubfeet, Ponseti casting was followed by marked improvement in clinical deformity scores and radiographic alignment. The average treatment course involved 11.23 casts, and almost every affected foot underwent Achilles tenotomy. Repeat tenotomy and, in one child, bilateral cuboid

osteotomy were required after initial correction. Ponseti treatment appears to be a reasonable initial option in this setting, provided that prolonged bracing and continued surveillance for recurrence are maintained.

Declarations

Ethics and consent to participate

The study received approval from the Institutional Ethics Committee, Gauhati Medical College and Hospital (EC No. MC/190/2007/Pt-I/IEC/130). Written informed consent for study participation and treatment was obtained from a parent or legal guardian of each child.

Consent for publication

The clinical images included in this report are cropped to exclude patient names and identifiable facial features.

Data availability

The numerical summaries underlying the reported results are presented in the manuscript tables and figures.

Author contributions

The authors participated in study planning, patient assessment, clinical data collection, interpretation of findings.

REFERENCES

1. Dobbs MB, Gurnett CA. Update on clubfoot: etiology and treatment. Clin Orthop Relat Res. 2009;467(5):1146–1153. doi:10.1007/s11999-009-0734-9.
2. Ponseti IV. Treatment of congenital club foot. J Bone Joint Surg Am. 1992;74(3):448–454.
3. Radler C. The Ponseti method for the treatment of congenital club foot: review of the current literature and treatment recommendations. Int Orthop. 2013;37(9):1747–1753. doi:10.1007/s00264-013-2031-1.
4. De Mulder T, Prinsen S, Van Campenhout A. Treatment of non-idiopathic clubfeet with the Ponseti method: a systematic review. J Child Orthop. 2018;12(6):575–581. doi:10.1302/1863-2548.12.180066.
5. Matar HE, Makki D, Garg NK. Treatment of syndrome-associated congenital talipes equinovarus using the Ponseti method: 4–12 years of follow-up. J Pediatr Orthop B. 2018;27(1):56–60. doi:10.1097/BPB.0000000000000434.
6. Dyer PJ, Davis N. The role of the Pirani scoring system in the management of club foot by the Ponseti method. J Bone Joint Surg Br. 2006;88(8):1082–1084. doi:10.1302/0301-620X.88B8.17482.
7. van Bosse HJP, Zlotolow DA. The orthopaedic management of arthrogryposis multiplex congenita: current concept review. J Pediatr Orthop Soc N Am. 2021. doi:10.55275/JPOSNA-2021-277.
8. van Bosse HJP. Challenging clubfeet: the arthrogrypotic clubfoot and the complex clubfoot. J Child Orthop. 2019;13(3):271–281. doi:10.1302/1863-2548.13.190072.
9. Jain AK, Kohli N, Bansal N, Sahni G, Aggarwal HO, Mathur M. Evaluation of results of Ponseti technique in idiopathic clubfoot using clinical evaluation and radiological assessment. Int J Appl Basic Med Res. 2022;12(1):43–46. doi:10.4103/ijabmr.ijabmr_281_21.
10. Janicki JA, Narayanan UG, Harvey B, Roy A, Ramseier LE, Wright JG. Treatment of neuromuscular and syndrome-associated (nonidiopathic) clubfeet using the Ponseti method. J Pediatr Orthop. 2009;29(4):393–397. doi:10.1097/BPO.0b013e3181a6bf77.
11. Boehm S, Limpaphayom N, Alaee F, Sinclair MF, Dobbs MB. Early results of the Ponseti method for the treatment of clubfoot in distal arthrogryposis. J Bone Joint Surg Am. 2008;90(7):1501–1507. doi:10.2106/JBJS.G.00563.
12. Moroney PJ, Noël J, Fogarty EE, Kelly PM. A single-center prospective evaluation of the Ponseti method in nonidiopathic congenital talipes equinovarus. J Pediatr Orthop. 2012;32(6):636–640. doi:10.1097/BPO.0b013e31825fa7df.
13. Kowalczyk B, Felus J. Ponseti casting and Achilles release versus classic casting and soft tissue releases for the initial treatment of arthrogrypotic clubfeet. Foot Ankle Int. 2015;36(9):1072–1077. doi:10.1177/1071100715581656.
14. Gerlach DJ, Gurnett CA, Limpaphayom N, et al. Early results of the Ponseti method for the treatment of clubfoot associated with myelomeningocele. J Bone Joint Surg Am. 2009;91(6):1350–1359. doi:10.2106/JBJS.H.00837.
15. Matar HE, Beirne P, Garg NK. Effectiveness of the Ponseti method for treating clubfoot associated with myelomeningocele: 3–9 years follow-up. J Pediatr Orthop B. 2017;26(2):133–136. doi:10.1097/BPB.0000000000000352.
16. Arkin C, Ihnow S, Dias L, Swaroop VT. Midterm results of the Ponseti method for treatment of clubfoot in patients with spina bifida. J Pediatr Orthop. 2018;38(10):e588–e592. doi:10.1097/BPO.0000000000001248.
17. Zionts LE, Habell B. The use of the Ponseti method to treat clubfeet associated with congenital annular band syndrome. J Pediatr Orthop. 2013;33(5):563–568. doi:10.1097/BPO.0b013e31829178fd.
18. Carpiaux AM, Hosseinzadeh P, Muchow RD, et al. The effectiveness of the Ponseti method for treating clubfoot associated with amniotic band syndrome. J Pediatr Orthop. 2016;36(3):284–288. doi:10.1097/BPO.0000000000000444