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ACCELERATED VERSUS STANDARD PONSETI METHOD FOR IDIOPATHIC CONGENITAL TALIPES EQUINOVARUS: A SYSTEMATIC REVIEW AND META-ANALYSIS

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Background. The standard Ponseti method is a mainstay of treatment for children with congenital talipes equinovarus (CTEV); involving weekly manipulation and long-leg casting, this approach has proven to produce good long-term outcomes. However, it takes approximately 4–5 weeks to correct all deformity components, making compliance a challenge for patients with limited economic resources and difficulty reaching healthcare centres.
Aim. This study aims to compare treatment outcomes between standard Ponseti and an accelerated protocol — applying the same casts but changing them more frequently, every 2-5 days — for the CTEV pathology.
Methods. A systematic search was conducted based on PRISMA guidelines to identify relevant studies through PubMed, Google Scholar, and Cochrane Database. A total of seven studies (324 patients, 408 feet) were included in the meta-analysis. Five outcomes were compared between the two procedures: post-procedure Pirani score, relapse rate, tenotomy rate, number of casts, and total duration of treatment.
Results. For total duration of treatment, the accelerated Ponseti method was superior to standard Ponseti (24.25 vs. 41.54 days, $p < 0.00001$). On the other hand, it achieved comparable efficacy as measured by post-procedure Pirani score (1.01 vs. 0.87, $p = 0.19$). Furthermore, the two procedures were also comparable in terms of the total number of casts needed (4.94 vs. 5.05, $p = 0.76$), tenotomy rate (73.29% vs. 65.27%, $p = 0.07$) , and relapse rate (27.72% vs 25.23%, $p = 0.56$).
Conclusion. Accelerated Ponseti offers similar efficacy and shorter duration of treatment compared to the standard Ponseti technique.

Keywords: accelerated; clubfoot; Ponseti.

СРАВНЕНИЕ СТАНДАРТНОГО И УСКОРЕННОГО МЕТОДОВ ЛЕЧЕНИЯ ИДИОПАТИЧЕСКОЙ ВРОЖДЕННОЙ КОСОЛАПОСТИ ПО ПОНСЕТИ: СИСТЕМАТИЧЕСКИЙ ОБЗОР И МЕТААНАЛИЗ

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Обоснование. Стандартный метод Понсети составляет основу лечения детей с врожденной эквиноварусной деформацией стопы. Этот метод, включающий еженедельные манипуляции и поэтапное гипсование ноги практически по всей ее длине, показал хорошие долгосрочные результаты. Однако для исправления всех компонентов деформации необходимо примерно 4–5 нед., что затрудняет соблюдение режима лечения для

ряда родителей пациентов из-за ограниченных материальных возможностей и отдаленности медицинских центров.

Цель — сравнение результатов ускоренного и стандартного методов консервативного лечения врожденной эквиноварусной деформации стопы по Понсети.

Материалы и методы. На основе рекомендаций PRISMA для выявления соответствующих исследований был проведен систематический поиск в базах данных PubMed, Google Scholar и Cochrane Database. В метаанализ было включено семь исследований (324 пациента, 408 конечностей). Протоколы сравнивали по пяти параметрам: оценке по шкале Пирани после лечения, частоте рецидивов, количеству тенотомий, количеству гипсовых повязок и общей продолжительности лечения.

Результаты. Общая продолжительность лечения по ускоренному методу Понсети составила 24,25 дня, а по стандартному методу Понсети — 41,54 дня ($p < 0{,}00001$). При этом ускоренный метод Понсети был сравним по эффективности со стандартным методом, которую определяли по шкале Пирани после окончания лечения (1,01 против 0,87, $p = 0{,}19$). Кроме того, оба подхода были сопоставимы по общему количеству необходимых для процедуры гипсовых повязок (4,94 против 5,05, $p = 0{,}76$), количеству тенотомий (73,29 против 65,27 %, $p = 0{,}07$) и частоте рецидивов (27,72 против 25,23 %, $p = 0{,}56$).

Заключение. Ускоренный метод Понсети характеризуется сходной эффективностью и более короткой продолжительностью лечения по сравнению со стандартной методикой Понсети.

Ключевые слова: ускоренный метод; косолапость; Понсети.

One of the most common congenital deformities, congenital talipes equinovarus (CTEV) — commonly known as clubfoot — affects 1–6.8 out of every 1000 live births [1]. If left untreated, this pathology can result in stiffness, weakness, and chronic pain, condemning patients to permanent disability in the absence of a series of revision surgeries [2]. Early detection and holistic care are surely important contributors to the successful management of CTEV. However, its treatment has also evolved immensely since it was first mentioned circa 400 BC in a work of Hippocrates. Later, in 1743, the condition was recognized by Nicholas Andry, the father of orthopaedics, as "*pedes equinus*", denoting the deformity's resemblance to the foot of a horse. Plaster of Paris casts were the first advance in the nonoperative treatment of clubfoot, introduced by M. Jules Guérin in 1836 [3]. Surgical intervention was preferred at the time, because it was believed to achieve best therapeutic outcomes; however, the evidence from long-term follow-up showed disappointing clinical, radiographic, and kinematic outcomes. Furthermore, when performed in infants, corrective surgery often results in adolescent pain, functional deficits, and decreased strength [4]. The next breakthrough in the field was Ponseti casting, invented by Dr. Ignacio Ponseti in the 1940s as a conservative approach to clubfoot based on the fundamental pathoanatomy and kinematics of the deformity. After refining it for over a decade, Ponseti first published his conservative method in 1963, providing evidence that it yielded satisfactory outcomes in 90% of patients. The method — which can be applied as early as 1 day old — has been proven to realign clubfoot in infants while avoiding extensive and major surgeries. Ever since, weekly corrective manipulation and long-leg casting has been chosen as the standard care of treatment in the modern era, as the best option to gradually correct all components of clubfoot deformity [1, 3].

On the other hand, even though the Ponseti casting method is considered cost- effective and safe to perform, it takes approximately 4–5 weeks to correct all deformity components [2, 5], making compliance a challenge for patients with limited economic resources and difficulty accessing care [6]. Some literature has researched the efficacy of accelerated Ponseti casting, in which the plasters are applied identically to the original protocol but changed more frequently, usually about three times a week. However, few studies have reviewed these two procedures systematically, and none at all has compared them statistically using meta-analysis. Here, we aim to objectively compare the outcomes of the accelerated and standard Ponseti method for the CTEV pathology.

Materials and methods

The study design was a systematic review and meta-analysis of relevant randomized controlled trials as well as nonrandomized comparative studies. A systematic search was conducted from December 2018 to September 2019 to identify relevant studies through PubMed, Google Scholar, and Cochrane

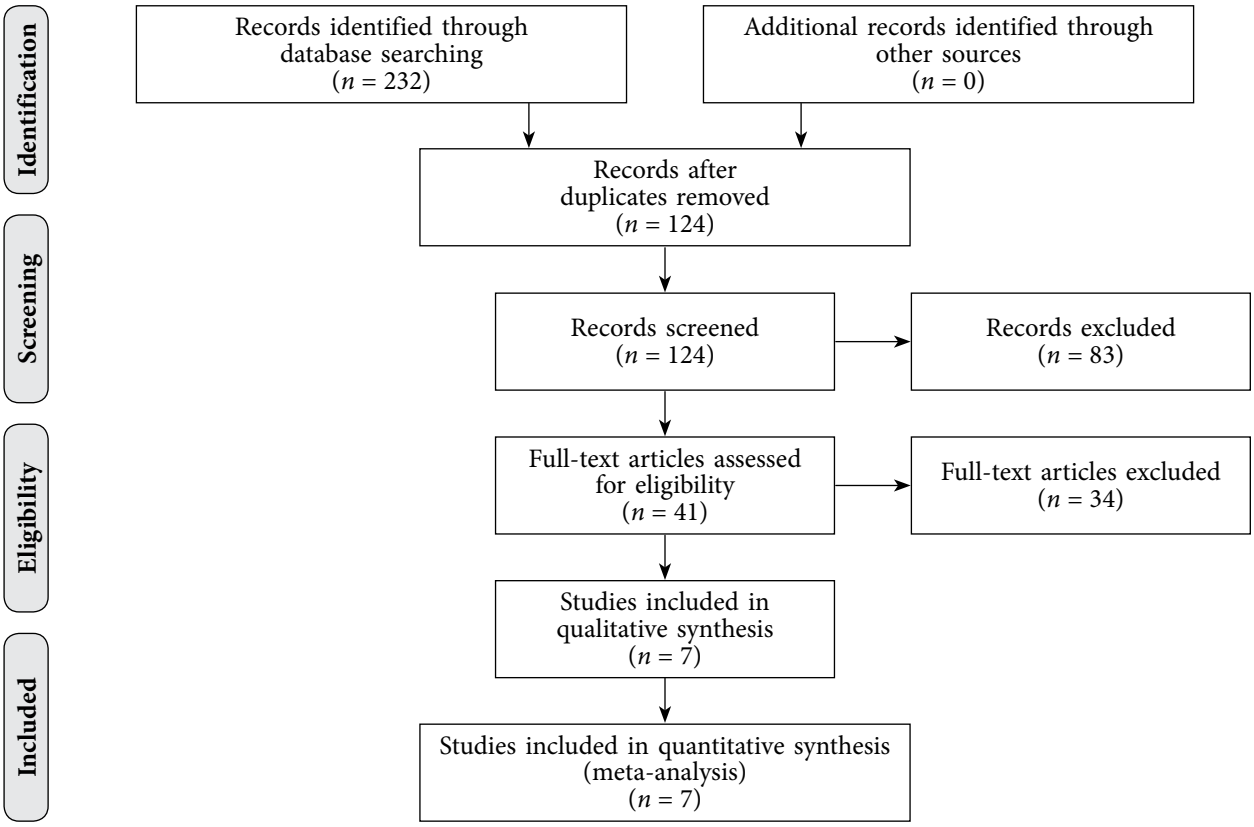

Fig. 1. Flowchart showing article selection based on PRISMA guidelines

Database based on PRISMA guidelines (Fig. 1). The keywords used were: "Accelerated" AND "Standard" AND "Ponseti" AND ("Congenital Talipes Equinovarus" OR "Clubfoot").

Those studies were then manually scanned and reviewed by all authors according to the following inclusion criteria: (1) the accelerated and standard Ponseti methods were interventions under comparison; (2) the population included patients aged less than 3 years old with diagnosed CTEV/clubfoot; (3) at least one of the following outcomes was reported: post-procedure Pirani score, duration of treatment, number of casts needed, relapse rate, and/or tenotomy rate, (4) the study was published

Table 1

PICO table describing inclusion and exclusion criteria

Study component	Inclusion	Exclusion
Population	• ≤3 years of age at initial treatment • Clinical diagnosis of CTEV	• >3 years of age at initial treatment • Less than 6 months of follow-up • Neglected clubfoot • Comorbid infection or malignancy • Animal studies
Intervention and comparison	• Accelerated and standard Ponseti methods (comparison)	• Surgical intervention • All other treatments
Outcome	• Pirani score, number of casts needed, duration of treatment, tenotomy rate, relapse rate	• No outcome mentioned or different outcomes
Publication	• Primary research published in English in a peer-reviewed journal	• Abstracts, editorials, letters • Duplicate publications of the same study/cohort that do not report on different outcomes • Conference presentations or proceedings
Design	• Randomized controlled trials • Prospective cohort studies	• Case reports or series • Review articles

in English, and (5) applied a randomized controlled trial (RCT) or prospective cohort study (PCS) design. The exclusion criteria were: (1) neglected clubfoot (i.e. first treated after 3 years of age), (2) less than 6 months of follow-up, and (3) comorbid infectious disease or malignancy. Surgical treatment and conservative approaches other than accelerated and standard Ponseti were excluded from the analysis. Non-comparative, non-human *in vivo* and *in vitro* studies were also excluded. Table 1 presents the inclusion and exclusion criteria according to the PICO method (Population, Intervention, Comparison, and Outcome).

From each included study, data related to patient and study characteristics (e.g. age, sex, baseline Pirani score) and outcomes were extracted and aggregated. Continuous variables — post-procedure Pirani score, number of casts needed, and duration of treatment — were compared in terms of weighted mean difference (WMD). Dichotomous variables — tenotomy rate and relapse rate — were assessed in terms of odds ratio (OR) and 95% confidence intervals (CI). Calculations were performed using Review Manager (RevMan) software (Version 5.3. Copenhagen: The Nordic Cochrane Centre, the Cochrane Collaboration, 2014). A fixed-effect model was used when heterogeneity (I2) was < 50%, whereas a random-effect model was used when it was > 50%.

Results

A total of seven studies (324 patients, 408 feet) were included in the meta-analysis. Five studies were RCTs (Level I evidence), while 2 articles were PCSs (Level II evidence) (Table 2). Critical appraisal of all studies based on the Joanna Briggs Institute Scoring System showed that none failed to meet more than two validity criteria (Table 3).

The sample size for standard Ponseti was 207 feet, while for accelerated Ponseti it was 201 feet. The age at presentation seemed similar between the two procedures, ranging from 7–161 days for standard Ponseti and 14–182 days for accelerated Ponseti. Males were more commonly affected than females; deformity was more commonly unilateral than bilateral. In all studies, casts were uniformly changed once per week in the standard interventions, while the interval adopted for accelerated Ponseti varied from every 2 days to every 5 days. Pre-procedure Pirani score seemed comparable between the two procedures; the follow-up period ranged from 6 to 71 months. Sample characteristics and outcomes of the included studies are tabulated separately in Table 4–6.

Of the five outcomes analyzed, accelerated Ponseti was statistically superior to standard Ponseti in terms of mean duration of treatment (24.25 days v. 41.54 days, $p < 0.00001$; Fig. 2). In addition,

Table 2

Studies included in the analysis

Reference	Journal	Study design	Level of evidence
Harnett et al., 2011 [7]	The Journal of Bone & Joint Surgery	Prospective randomized controlled trial	I
Elgohary et al., 2015 [5]	The European Journal of Orthopaedic Surgery & Traumatology	Prospective cohort study	II
Sahu et al., 2015 [8]	Journal of Orthopaedics, Traumatology and Rehabilitation	Prospective randomized controlled trial	I
Mageshwaran et al., 2016 [6]	International Journal of Scientific Study	Prospective randomized controlled trial	I
Barik et al., 2018 [1]	The European Journal of Orthopaedic Surgery & Traumatology	Prospective cohort study	II
Solanki et al., 2018 [3]	Journal of Orthopaedics, Traumatology and Rehabilitation	Prospective randomized controlled trial	I
Ahmed et al., 2019 [9]	Journal of Pakistan Orthopaedic Association	Randomized controlled trial	I

Table 3

Critical appraisal of all studies included

Validity	Harnett et al., 2011	Elgohary et al., 2015	Sahu et al., 2015	Mageshwaran et al., 2016	Barik et al., 2018	Solanki et al., 2018	Ahmed et al., 2019
Same population	●	●	●	●	●	●	●
Similar exposure	●	●	●	●	●	●	●
Exposure measurement	●	●	●	●	●	●	●
Confounding factors	●	●	●	●	●	●	●
Strategies to deal with confounding factors	●	●	●	●	●	●	●
Free of the outcome at the start	●	●	●	●	●	●	●
Outcome measurement	●	●	●	●	●	●	●
Follow up time	●	●	●	●	●	●	●
Follow up completeness	●	●	●	●	●	●	●
Strategies to address incomplete follow up	●	●	●	●	●	●	●
Statistical analysis	●	●	●	●	●	●	●

it achieved comparable efficacy to the standard protocol in terms of post-procedure Pirani score (1.01 v. 0.87, $p = 0.19$; Fig. 3), total number of casts needed (4.94 v. 5.05, $p = 0.76$; Fig. 4), tenotomy rate (73.29% v. 65.27%, $p = 0.07$; Fig. 5), and relapse rate (27.72% v. 25.23%, $p = 0.56$; Fig. 6).

Discussion

Since its invention in the 1940s by Dr. Ignacio Ponseti, serial Ponseti casting has been widely adopted around the world as a non-operative approach to the treatment of clubfoot. The weekly frequency of manipulation and cast application allows the correction — as well as collagen relaxation and atraumatic remodelling of joint surfaces — to take place gradually, while reducing the risk of fibrosis associated with surgical release. Ponseti demonstrated that if this correction method is applied within the first month of life, the need for posterior medial and lateral release can be avoided in up to 95% of cases. Some reports claim its success rate is lower in older infants (7 to 10 months old) than in younger ones; however, contradictory evidence was reported by Alves, et al. (2009), who showed similar relapse rate and other outcomes regardless of the age of patients at initial treatment [10, 11].

To stretch the ligaments and gradually correct the deformity, the foot is first manipulated to correct each component in a specific sequence, following the acronym "CAVE" (*c*avus, *a*dductus, *v*arus, *e*quinus), then immobilized by a plaster cast extending from the toes to the upper third of the thigh, with the knee at 90° flexion. The cast is traditionally changed weekly; five or six cast corrections are usually sufficient to correct most clubfeet.

In a sprawling and geographically diverse country like Indonesia, travelling long distances can be bothersome for some patients for social and financial reasons, especially those living in remote areas. Distance to provider is a barrier to healthcare access and a leading cause of treatment failure. In this case, accelerated Ponseti casting should be considered as a solution. Children and their families do not need to travel long distances frequently back

Table 4

Patient characteristics

Reference	Sample size (feet)		Age		Sex		Side	
	Standard	Accelerated	Standard	Accelerated	Standard	Accelerated	Standard	Accelerated
Harnett et al., 2011	21	19	29 days (10–55 days)	21 days (7–48 days)	M: 10 (48%) F: 11 (52%)	M: 10 (53%) F: 9 (47%)	Bilateral: 10 (48%) Unilateral: 11 (52%)	Bilateral: 9 (47%) Unilateral: 10 (53%)
Elgohary et al., 2015	34 (20 children)	32 (21 children)	10.7 ± 6.28 weeks (1–23 weeks)	11.57 ± 6.9 weeks (2–26 weeks)	M: 14 (70%) F: 6 (30%)	M: 12 (57.14%) F: 9 (42.86%)	Bilateral: 14 (70%) Right: 4 (20%) Left: 2 (10%)	Bilateral: 11 (52.38%) Right: 5 (23.81%) Left: 5 (23.81%)
Sahu et al., 2015	40 (27 children)	40 (26 children)	5.6 weeks	5.25 weeks	M: 23 (85.19%) F: 4 (14.81%)	M: 15 (57.69%) F: 11 (42.31%)	Bilateral: 13 (48.14%) Right: 7 (25.93%) Left: 7 (25.93%)	Bilateral: 14 (53.85%) Right: 8 (30.77%) Left: 4 (15.38%)
Mageshwaran et al., 2016	26 (20 children)	25 (20 children)	28.4 days	28.1 days	M: 12 (60%) F: 8 (40%)	M: 11 (55%) F: 9 (45%)	Bilateral: 6 (30%) Left: 8 (40%) Right: 6 (40%)	Bilateral: 5 (25%) Left: 8 (40%) Right: 7 (35%)
Barik et al., 2018	26 (15 children)	25 (15 children)	12.35 ± 16.37 days	9.84 ± 8.97 days	M: 22 (73.3%) F: 8 (26.7%)		Bilateral: 11 (73.3%) Unilateral: 4 (26.7%)	Bilateral: 10 (66.67%) Unilateral: 5 (33.3%)
Solanki et al., 2018	20	20	4.71 months	2.70 months	M: 19 (57.69%) F: 12 (42.30%)		Bilateral: 9 (29%) Unilateral: 22 (71%)	
Ahmed et al., 2019	40 children	40 children	1.6 ± 0.79 months	1.58 ± 0.79 months	M: 24 (60%) F: 16 (40%)	M: 18 (45%) F: 22 (55%)	NA	NA

Note. F, female; M, male; Right, right foot; Left, left foot; Bilateral, bilateral deformity; Unilateral, unilateral deformity; NA, not available.

Table 5

Outcomes analyzed (1)

Reference	Cast interval		Follow up period		Pre-procedure Pirani score		Post-procedure Pirani score	
	Standard	Accelerated	Standard	Accelerated	Standard	Accelerated	Standard	Accelerated
Harnett et al., 2011	Every week	Every 2 days	244 days (25–346)	258 days (70–348)	5.0	5.5	0.5 (0–0.5) at 6 months	0 (0–1.0) at 6 months
Elgohary et al., 2015	Every week	Twice a week	25.25 ± 8.67 (12–48 months)	23.38 ± 9.21 (12–44 months)	5.17 ± 0.62	5.13 ± 0.61	0.49 ± 0.42 (>12 months)	0.52 ± 0.38 (>12 months)
Sahu et al., 2015	Every week	Every 3 days	23 months		5.03 (2.5–6)	5.3 (3–6)	0.2	0.25
Mageshwaran et al., 2016	Every week	Twice a week	6 months		4.97	5.025	0.075 at 6 months	0.1 at 6 months
Barik et al., 2018	Every week	Every 3 days	71 months	68 months	5.02	5.02	1.25 ± 0.46 At 6th visit (6th week)	1.50 ± 0.00 At 6th visit (6th week)
Solanki et al., 2018	Every week	3 times a week	6.66 months	7.85 months	4.6	5.35	0.525 (3 months)	0.5 (3 months)
Ahmed et al., 2019	Every week	Every 5 days	6 months		NA	NA	NA	NA

Table 6

Outcomes analyzed (2)

Reference	Number of casts needed		Duration of treatment (days)		Tenotomy rate		Relapse rate	
	Standard	Accelerated	Standard	Accelerated	Standard	Accelerated	Standard	Accelerated
Harnett et al., 2011	NA	NA	42 (35–84)	16 (14–20)	11 (52%)	15 (79%)	7%	8%
Elgohary et al., 2015	4.88 ± 0.88	5.16 ± 0.72	33.36 ± 6.69	18.13 ± 3.02	31 (91.2%)	30 (93.8%)	5 (14.7%)	5 (15.6%)
Sahu et al., 2015	6.2 (4–10)	7.4 (5–10)	57.4	23.8	31 (77.5%)	33 (82.5%)	NA	NA
Mageshwaran et al., 2016	5.55	5.95	52.8	39.65	3 (11.5%)	6 (24%)	3 (15%)	4 (20%)
Barik et al., 2018	5.23 ± 0.59	4.72 ± 0.61	54.38 ± 8.01	33.88 ± 9.03	84%	84%	4 (26.6%)	4 (26.6%)
Solanki et al., 2018	6.35	7	47.25	18.45	11 (55%)	13 (65%)	NA	NA
Ahmed et al., 2019	NA	NA	36.88 ± 5.11	20.73 ± 3.40	NA	NA	NA	NA

Note. NA, not available.

Study or subgroup	Standard Mean	Standard SD	Standard Total	Accelerated Mean	Accelerated SD	Accelerated Total	Weight, %	Mean difference IV, Fixed, 95% CI	Year
Elgohary, 2015	33.36	6.69	34	18.13	3.02	32	33.6	15.23 [12.75; 17.71]	2015
Barik, 2018	54.38	8.01	26	33.88	9.03	25	9.4	20.50 [15.81; 25.19]	2018
Ahmed, 2019	36.88	5.11	40	20.73	3.4	40	57.1	16.15 [14.25; 18.05]	2019
Total (95% CI)			**100**			**97**	**100.0**	**16.25 [14.81; 17.69]**	

Heterogeneity: $Chi^2 = 3.81$, $df = 2$ ($p = 0.15$); $I^2 = 48\%$
Test for overall effect: $Z = 22.17$ ($p < 0.00001$)

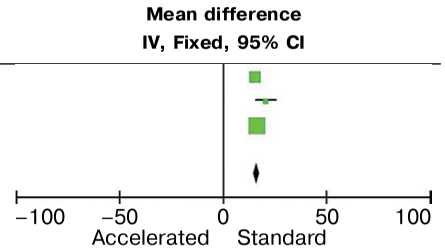

Fig. 2. Forest Plot analysis for duration of treatment

Study or subgroup	Standard Mean	Standard SD	Standard Total	Accelerated Mean	Accelerated SD	Accelerated Total	Weight, %	Mean difference IV, Random, 95% CI	Year
Elgohary, 2015	0.49	0.42	34	0.52	0.38	32	48.4	−0.03 [−0.22; 0.16]	2015
Barik, 2018	1.25	0.46	26	1.5	0.0001	25	51.6	−0.25 [−0.43; −0.07]	2018
Total (95% CI)			**60**			**57**	**100.0**	**−0.14 [−0.36; 0.07]**	

Heterogeneity: $Tau^2 = 0.02$, $Chi^2 = 2.71$, $df = 1$ ($p = 0.10$); $I^2 = 63\%$
Test for overall effect: $Z = 1.31$ ($p = 0.19$)

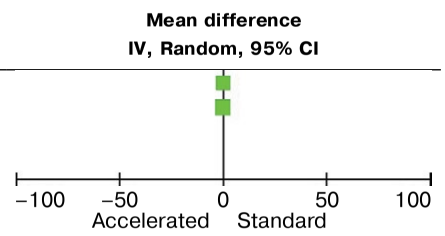

Fig. 3. Forest Plot analysis for post-procedure Pirani Score

Study or subgroup	Standard Mean	Standard SD	Standard Total	Accelerated Mean	Accelerated SD	Accelerated Total	Weight %	Mean difference IV, Random, 95% CI	Year
Elgohary, 2015	4.88	0.88	34	5.16	0.72	32	49.1	−0.28 [−0.67; 0.11]	2015
Barik, 2018	5.23	0.59	26	4.72	0.61	25	50.9	0.51 [0.18; 0.84]	2018
Total (95% CI)			**60**			**57**	**100.0**	**0.12 [−0.65; 0.90]**	

Heterogeneity: $Tau^2 = 0.28$, $Chi^2 = 9.28$, $df = 1$ ($p = 0.002$); $I^2 = 89\%$
Test for overall effect: $Z = 0.31$ ($p = 0.76$)

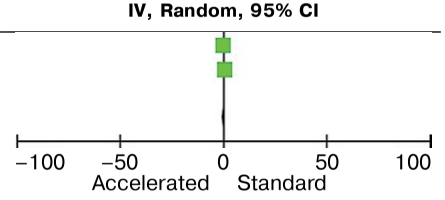

Fig. 4. Forest Plot analysis for number of casts needed

Study or subgroup	Standard Events	Standard Total	Accelerated Events	Accelerated Total	Weight, %	Odds ratio M-H, Fixed, 95% CI	Year
Harnett, 2011	11	21	15	19	23.3	0.29 [0.07; 1.19]	2011
Elgohary, 2015	31	34	30	32	8.5	0.69 [0.11; 4.42]	2015
Sahu, 2015	31	40	33	40	23.1	0.73 [0.24; 2.20]	2015
Mageshwaran, 2016	3	26	6	25	16.8	0.41 [0.09; 1.88]	2016
Barik, 2018	22	26	21	25	10.2	1.05 [0.23; 4.74]	2018
Solanki, 2018	11	20	13	20	18.2	0.66 [0.18; 2.35]	2018
Total (95% CI)		**167**		**161**	**100.0**	**0.59 [0.34; 1.03]**	
Total events	109		118				

Heterogeneity: Chi^2 = 1.93, df = 5 (p = 0.86); I^2 = 0%
Test for overall effect: Z = 1.84 (p = 0.07)

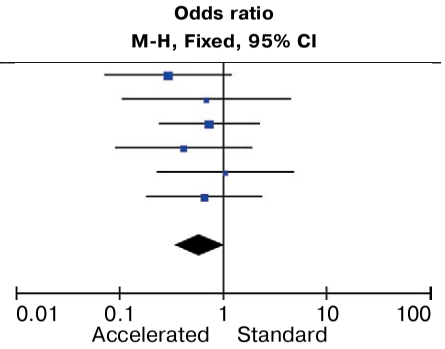

Fig. 5. Forest Plot analysis for tenotomy rate

Study or subgroup	Standard Events	Standard Total	Accelerated Events	Accelerated Total	Weight, %	Odds ratio M-H, Fixed, 95% CI	Year
Harnett, 2011	15	21	15	19	28.2	0.67 [0.16; 2.85]	2011
Elgohary, 2015	5	34	5	32	27.5	0.93 [0.24; 3.58]	2015
Mageshwaran, 2016	3	26	4	25	22.6	0.68 [0.14; 3.42]	2016
Barik, 2018	4	26	4	25	21.6	0.95 [0.21; 4.32]	2018
Total (95% CI)		**107**		**101**	**100.0**	**0.81 [0.39; 1.68]**	
Total events	27		28				

Heterogeneity: Chi^2 = 0.20, df = 3 (p = 0.98); I^2 = 0%
Test for overall effect: Z = 0.58 (p = 0.56)

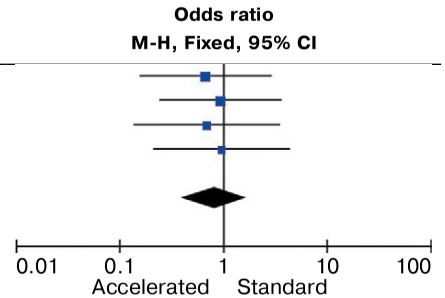

Fig. 6. Forest Plot analysis for relapse rate

and forth for each cast change; instead, they can stay in local accommodation for a shorter period, therefore reducing their overall financial burden. These benefits are hoped to improve patients' compliance and maximize functional improvement [3, 10].

The Pirani scoring system is one of the most commonly used methods for assessing deformity severity in clubfoot. It includes six components: posterior crease, emptiness of the heel, equinus rigidity, medial crease, curvature of the lateral border of the foot, and the reducibility of the lateral talar head. Each item is given a score of 0 for no abnormality, 0.5 for moderate abnormality, or 1.0 for severe abnormality, and summed for a total score (Total Foot Score: TFS) of 0–6 points, where a higher score indicates severer deformity. Furthermore, TFS is divided into two subtotal scores (range: 0–3 pts), respectively representing contracture of the midfoot (Mid Foot Score: MFS) and hindfoot (Hind Foot Score: HFS). MFS is the sum of item scores for medial crease, lateral curvature and reducibility of talus, whereas HFS is the corresponding sum for posterior crease, empty heel and rigid equines [12, 13]. Based on this meta-analysis, we can conclude that accelerated Ponseti casting can achieve comparable Pirani scores — and therefore reductions in deformity severity — to standard Ponseti casting.

Other advantages that practitioners should note when considering the accelerated approach are its lower risk for osteopenia and pressure sores related to prolonged casting. Even though it mostly resolves naturally within a few months after plaster removal, osteopenia has been documented after immobilization in above-knee plasters in the treatment of clubfoot. Patients may benefit from the overall shorter duration of treatment of accelerated casting by avoiding or limiting harms from this condition [7, 14]. Pressure sores, skin rashes, and disuse atrophy are other commonly found complications of prolonged casting that can be minimized by the accelerated protocol [1]. The frequent changing of plasters allows practitioners to routinely monitor for these and other possible complications, while at the same time keeping the plaster dry and clean to avoid correction loss due to accumulated moisture [7].

Before the hindfoot is corrected to a neutral position, if full dorsiflexion is not possible with stretching alone (for example, in cases of atypical clubfoot), a tenotomy is sometimes required to 'unlock' the os calcis from beneath the talus. In such cases, further stretching and casting are performed afterwards to achieve complete correction [15]. In their protocol, Mageshwaran et al. (2016) performed tenotomy when cavus, adductus, and varus were fully corrected but ankle dorsiflexion remained less than 10° above neutral after serial casting; before doing so, the authors made certain that abduction was adequate [6]. Even though Achilles tenotomy can be performed surgically or percutaneously, all studies included in this meta-analysis chose the latter option, which is superior to open surgery in preventing scarring due to its simpler and sutureless technique [16]. In our study, tenotomy rate between the two procedures does not differ significantly, though it is slightly higher in accelerated Ponseti method. This might be due to slightly higher initial Pirani score in accelerated group as mentioned by Mageshwaran et al. (2016) [6], as well as the difference in the severity of deformity or technical error in casting as mentioned by Elgohary et al. (2015) [5].

We observed comparable relapse rates between the two procedures in this meta- analysis, over a wide range of follow-up periods from 6 to 71 months. However, some studies have also linked this outcome to bracing compliance and the educational level of patients' families. Relapse risk can be prevented by stressing the importance of bracing to family members during regular follow-up, while at the same time clearly teaching them how to correctly fit the orthotics and supervising as they practice their first attempts [6, 17, 18].

This study has several limitations:

(1) Some of the analyses had high study heterogeneity, especially for Pirani score and number of casts needed.
(2) Due to the limited number of available studies, it was decided to include patients who were older than 1 month of age (but not "neglected"). This may bias our results, as some literature has claimed that the age of presentation can affect outcome.
(3) Cast-changing interval was highly variable among the studies included, ranging from every 2 to 5 days, which might have increased heterogeneity in our statistical analysis.

However, this study also has several advantages:
(1) To our knowledge, it is the first meta-analysis on the relative merits of the accelerated versus standard Ponseti method.
(2) The literature included in this study consisted of higher levels of evidence (Level I or II); five of the seven were well-designed RCTs. This feature supports the accuracy and reliability of our meta-analysis.
(3) Outcomes were thoroughly assessed, in terms of several outcome measures, offering more-nuanced implications for the different dimensions of clubfoot therapy.

This study could serve as an influential bridge to future research with larger sample sizes and less heterogeneity, as well as analysis of the financial benefits afforded by the reduced treatment duration: namely, lower travel expenses due to shorter and fewer stays in accommodations near treatment centres away from patients' homes.

Conclusion

The present meta-analysis supports the conclusions that the accelerated Ponseti method can achieve comparable efficacy to the standard technique in terms of post-procedure Pirani score, number of casts needed, tenotomy rate, and relapse rate. Furthermore, accelerated Ponseti seems to offer shorter duration of treatment, increasing the likelihood of patient compliance.

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Author contributions. Both authors performed literature selection to be involved in the study, performed systematic and meta-analysis, and discussed with each other to sort out differences, formulate discussion and conclusion.

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References

1. Barik S, Nazeer M, Mani BT. Accelerated Ponseti technique: Efficacy in the management of CTEV. *Eur J Orthop Surg Traumatol*. 2019;29(4):919-924. https://doi.org/10.1007/s00590-018-2353-1.
2. Fletcher C. The neglected clubfoot. *Glob J Med Res*. 2017;17(1).
3. Ajmera A, Solanki M, Rawat S. Comparative study of accelerated Ponseti method versus standard Ponseti method for the treatment of idiopathic clubfoot. *Journal of Orthopedics, Traumatology and Rehabilitation*. 2018;10(2):116. https://doi.org/10.4103/jotr.jotr_11_18.
4. Svehlik M, Floh U, Steinwender G, et al. Ponseti method is superior to surgical treatment in clubfoot — long-term, randomized, prospective trial. *Gait Posture*. 2017;58:346-351. https://doi.org/10.1016/j.gaitpost.2017.08.010.
5. Elgohary HS, Abulsaad M. Traditional and accelerated Ponseti technique: A comparative study. *Eur J Orthop Surg Traumatol*. 2015;25(5):949-953. https://doi.org/10.1007/s00590-015-1594-5.
6. Mageshwaran S, Murali VKB, Devendran R, et al. Evaluation of outcome of correction of clubfoot by conventional Ponseti and accelerated Ponseti. *Int J Sci Study*. 2016;4(10):199-202.
7. Harnett P, Freeman R, Harrison WJ, et al. An accelerated Ponseti versus the standard Ponseti method: A prospective randomised controlled trial. *J Bone Joint Surg Br*. 2011;93(3):404-408. https://doi.org/10.1302/0301-620X.93B3.24450.
8. Sahu B, Rajavelu R, Tudu B. Management of idiopathic congenital talipes equinovarus by standard versus accelerated Ponseti plaster technique: A prospective study. *Journal of Orthopedics, Traumatology and Rehabilitation*. 2015;8(1):30. https://doi.org/10.4103/0975-7341.183960.
9. Ahmed J, Shahid S, Alam W, et al. Outcome of patients suffering from congenital idiopathic club foot: A comparative analysis of using classical versus accelerated Ponseti techniques. *J Pak Orthop Assoc*. 2019;31(2):44-47.
10. Herring JA. Tachdjian's pediatric orthopaedics: From the Texas Scottish Rite Hospital for Children. Saunders; 2013. 1696 p.
11. Alves C, Escalda C, Fernandes P, et al. Ponseti method: Does age at the beginning of treatment make a difference? *Clin Orthop Relat Res*. 2009;467(5):1271-1277. https://doi.org/10.1007/s11999-008-0698-1.
12. Lampasi M, Abati CN, Bettuzzi C, et al. Comparison of Dimeglio and Pirani score in predicting number of casts and need for tenotomy in clubfoot correction using the Ponseti method. *Int Orthop*. 2018;42(10):2429-2436. https://doi.org/10.1007/s00264-018-3873-3.
13. 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. https://doi.org/10.1302/0301-620X.88B8.17482.

14. Lourenco AF, Morcuende JA. Correction of neglected idiopathic club foot by the Ponseti method. *J Bone Joint Surg Br*. 2007;89(3):378-381. https://doi.org/10.1302/0301-620X.89B3.18313.

15. Goriainov V, Judd J, Uglow M. Does the Pirani score predict relapse in clubfoot? *J Child Orthop*. 2010;4(5):439-444. https://doi.org/10.1007/s11832-010-0287-1.

16. Rahman A, Shahiduzzaman M, Alam MK, Rahman MS. Percutaneous needle tenotomy for Ponseti technique in the management of Congenital Talipes Equinovarus (CTEV). *Journal of Dhaka Medical College*. 2015;23(1):55-59. https://doi.org/10.3329/jdmc.v23i1.22695.

17. Cosma DI, Vasilescu DE. Ponseti treatment for clubfoot in Romania: A 9-year single-centre experience. *J Pediatr Orthop B*. 2014;23(6):512-516. https://doi.org/10.1097/BPB.0000000000000081.

18. Dobbs MB, Rudzki JR, Purcell DB, et al. Factors predictive of outcome after use of the Ponseti method for the treatment of idiopathic clubfeet. *J Bone Joint Surg Am*. 2004;86(1):22-27. https://doi.org/10.2106/00004623-200401000-00005.

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