American Journal of
Biomedical Science & Research

www.biomedgrid.com
ISSN: 2642-1747

Research Article

Treating Idiopathic Clubfoot in Walking-Age Children with Modified Ankle Foot Orthosis and Foot Abduction Brace for A Better Outcome

Sylvanus Nwanorue[1*], Patrick Ugochukwu Agbasi[2], Tochukwu Nze Ugorji[2], Victor Chinwendu Ezeala[3], Frank C Obiezu[4] and George Chukwuebuka Eke[5]

[1]*Prosthetic and Orthotic Unit, University of Abuja Teaching Hospital, FCT Abuja Nigeria*

[2]*Department of Prosthetics and Orthotics, Federal University of Technology Owerri, Imo State Nigeria*

[3]*Prosthetic and Orthotic Unit, Federal Teaching Hospital, Imo State Nigeria*

[4]*Prosthetic and Orthotic Unit, Federal Medical Centre keffi, Nassarawa State Nigeria*

[5]*Department of Prosthetics and Orthotics, Federal University of Allied Health Sciences Enugu, Nigeria*

***Corresponding author:** Sylvanus Nwanorue, Prosthetic and Orthotic Unit, University of Abuja Teaching Hospital, Gwagwalada, FCT Abuja Nigeria

To Cite This article: *Sylvanus Nwanorue*, Patrick Ugochukwu Agbasi, Tochukwu Nze Ugorji, Victor Chinwendu Ezeala, Frank C Obiezu and George Chukwuebuka Eke, Treating Idiopathic Clubfoot in Walking-Age Children with Modified Ankle Foot Orthosis and Foot Abduction Brace for A Better Outcome Am J Biomed Sci & Res. 2026 31(3) AJBSR.MS.ID.004043,* **DOI:** 10.34297/AJBSR.2026.31.004043

Received: May 11, 2026 **Published:** June 10, 2026

Abstract

Background: Idiopathic clubfoot remains a prevalent congenital deformity with a high risk of recurrence after initial correction, particularly among walking-age children where mobility and reduced brace tolerance complicate long-term management. This study evaluated the effectiveness of a modified Ankle–Foot Orthosis (AFO) with Tamarack joint used during the daytime in combination with a nighttime Foot Abduction Brace (FAB), compared with conventional FAB-only treatment.

Method: A mixed-method prospective cohort design was adopted, involving walking-age children previously treated using the Ponseti method across selected orthopedic centres in Abuja, Nigeria. Clinical outcomes were assessed using dorsiflexion and abduction angles, while functional indicators such as heel positioning, dynamic supination, and caregiver-reported adherence were also examined. Result: Findings revealed that the combined AFO–FAB regimen produced significantly improved maintenance of correction, with higher dorsiflexion and abduction angles, better heel seating, and reduced dynamic supination compared to FAB alone. Importantly, these improvements were achieved without increased incidence of pressure sores, indicating preserved comfort and usability.

Conclusion: The study concludes that incorporating a modified AFO into daytime bracing offers a more effective and practical strategy for relapse prevention in ambulatory children with corrected idiopathic clubfoot, with implications for improving compliance and long-term orthopedic outcomes.

Keywords: Idiopathic Clubfoot, Walking-age Children, Modified Ankle foot orthosis (AFO), Foot abduction brace (FAB)

Introduction

Idiopathic clubfoot, medically referred to as congenital talipes equinovarus, remains one of the most frequently encountered congenital musculoskeletal deformities, affecting approximately one in every 1,000 live births globally [1]. The condition is characterized by a complex combination of structural abnormalities, including forefoot adduction, midfoot cavus, hindfoot varus, and

ankle equinus, all of which compromise normal foot alignment and gait development [2]. Although the exact cause of idiopathic clubfoot is not fully understood, evidence suggests a multifactorial origin involving genetic susceptibility and environmental influences [3]. Over the years, the introduction of the Ponseti method has significantly improved early correction outcomes; however, maintaining long-term correction, particularly beyond infancy, continues to pose a major clinical challenge [4]. Standard treatment protocols emphasize early intervention through serial manipulation, casting, Achilles tenotomy, and prolonged bracing [5]. While these approaches are highly effective in infants, children who present late or transition into the walking stage after correction often exhibit a higher risk of relapse [6]. At this stage, increased weight-bearing, muscle activity, and behavioral resistance to restrictive devices complicate adherence to traditional bracing regimens. Consequently, relapse in walking-age children remains a persistent problem, frequently linked to poor compliance with Foot Abduction Brace (FAB) protocols [7]. This underscores the need for alternative or complementary orthotic strategies that are both clinically effective and practically acceptable.

Historically, the management of clubfoot evolved from invasive surgical procedures toward conservative and orthotic-based interventions due to the long-term complications associated with surgery, including stiffness and degenerative joint changes [8]. Despite this progress, a significant treatment gap persists, particularly among walking-age children who either did not receive early care or experienced recurrence after initial correction. In such cases, reliance on FAB alone may be insufficient due to discomfort, restricted mobility, and reduced adherence [9]. The modified Ankle–Foot Orthosis (AFO), particularly when designed with dynamic components such as a Tamarack joint, offers a promising alternative by allowing controlled movement while maintaining corrective alignment [10]. From a socio-economic perspective, untreated or recurrent clubfoot carries profound consequences for affected children and their families. Functional impairment may lead to limited mobility, reduced educational participation, and long-term disability, thereby affecting overall quality of life [11]. In low- and middle-income countries, including Nigeria, these challenges are further exacerbated by delayed presentation, limited access to specialized care, and high out-of-pocket healthcare costs [12]. Families often bear significant financial and emotional burdens, particularly when recurrence necessitates repeated interventions or surgical procedures [13]. Therefore, identifying cost-effective, user-friendly, and sustainable treatment strategies is essential for improving both clinical and social outcomes. Globally, disparities in clubfoot management remain evident. While high-income countries benefit from structured screening programs and standardized treatment protocols, many resource-constrained settings struggle with inadequate healthcare infrastructure and limited professional expertise [14]. Initiatives such as the Global Clubfoot Initiative have improved awareness and access to care in regions like Sub-Saharan Africa, yet the management of walking-age children remains insufficiently addressed [1]. This highlights the importance of developing context-specific interventions that can be effectively implemented within diverse healthcare environments.

In response to these challenges, the present study investigates a modified orthotic protocol involving the combined use of a daytime ankle-foot orthosis with Tamarack joint and a nighttime foot abduction brace. The study is guided by key research questions focusing on whether the addition of AFO improves relapse prevention, enhances patient comfort, and promotes better adherence compared to FAB alone. The primary aim is to evaluate the effectiveness, comfort, and compliance associated with this combined approach among walking-age children with corrected idiopathic clubfoot. Specifically, the study seeks to determine the independent and combined effectiveness of AFO and FAB in maintaining correction and preventing recurrence. The study is grounded in biomechanical theory, neuromuscular adaptation theory, and motor learning theory, which collectively explain how sustained mechanical support, muscle reconditioning, and repetitive functional use contribute to long-term structural stability [15]. These theoretical perspectives provide a robust framework for understanding how orthotic devices can facilitate both anatomical correction and functional recovery. By integrating these concepts, the study positions the modified AFO–FAB protocol as a potentially superior strategy for managing the unique challenges associated with walking-age clubfoot patients. Ultimately, this research addresses a critical gap in pediatric orthopedic practice by evaluating a practical and patient-centered approach to relapse prevention. By focusing on effectiveness, comfort, and compliance, the study contributes to ongoing efforts to refine clubfoot management strategies and improve long-term outcomes. The findings are expected to inform clinical decision-making, enhance orthotic design and application, and support the development of age-appropriate treatment guidelines for children with idiopathic clubfoot.

Materials and Methods

This study employed a mixed-method prospective cohort design to evaluate the effectiveness, comfort, and compliance associated with the use of a modified Ankle–Foot Orthosis (AFO) with Tamarack joint in combination with a Foot Abduction Brace (FAB) among walking-age children with corrected idiopathic clubfoot. The design integrated both quantitative clinical assessments and qualitative caregiver perspectives to provide a comprehensive evaluation of treatment outcomes. Participants were grouped into two cohorts based on adherence and treatment protocol: those managed with combined AFO–FAB therapy and those treated with FAB alone. This approach allowed for longitudinal observation of clinical outcomes and facilitated comparison between intervention pathways, thereby strengthening causal inference and internal validity [16]. The study was conducted across selected orthopedic and rehabilitation facilities within the Federal Capital Territory (FCT), Abuja, Nigeria, chosen for their established expertise in

pediatric musculoskeletal care. These centres provided access to trained orthopedic specialists, standardized treatment protocols, and appropriate orthotic fabrication services. The setting enabled consistent follow-up assessments and ensured that participants received uniform clinical management throughout the study period. Ethical approval was obtained from a recognized institutional review board, and written informed consent was secured from parents or legal guardians in accordance with national ethical guidelines [17]. The study population comprised children aged 1 to 5 years diagnosed with idiopathic clubfoot who had previously undergone correction, primarily through the Ponseti method, and had attained independent ambulation. This age range was selected due to the unique biomechanical and compliance challenges associated with walking-age children. A purposive sampling technique was adopted to recruit participants with relevant clinical experience of post-correction bracing. Using [18] formula and an estimated population of 250 cases within the study area, a sample size of approximately 154 participants was determined, ensuring adequate statistical power and representativeness [19,20].

Eligibility criteria were carefully defined to ensure homogeneity of the study sample. Inclusion criteria required a confirmed diagnosis of idiopathic clubfoot, prior correction using the Ponseti method, independent ambulation, and documented parental consent. Exclusion criteria included the presence of neurological or neuromuscular disorders affecting gait, dermatological conditions that could be aggravated by orthotic use, concurrent use of alternative orthotic devices, and non-idiopathic or syndromic forms of clubfoot. These criteria minimized confounding variables and enhanced the validity of treatment comparisons. A key component of the intervention was the design and application of a modified AFO with Tamarack joint, developed to address limitations associated with conventional FAB use. The orthosis incorporated a flexible Tamarack joint that allowed controlled dorsiflexion while restricting plantarflexion and inversion, thereby maintaining corrective alignment during ambulation. The device consisted of a thermoplastic foot plate, posterior calf shell, adjustable straps, and a posterior ankle wedge, all customized to each child's anatomy. The AFO was prescribed for daytime use, while the FAB was worn during nighttime rest, ensuring continuous correction throughout the daily cycle (Figure 1-5).

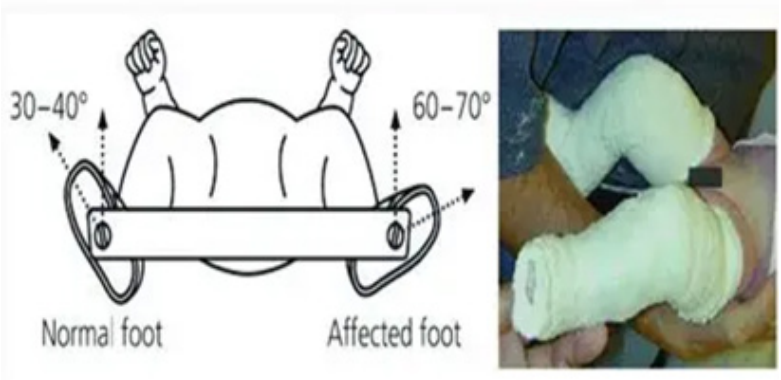

Figure 1: During impression taking, the leg is cast in 5° to 10° dorsflexion and in abduction (above 45°).

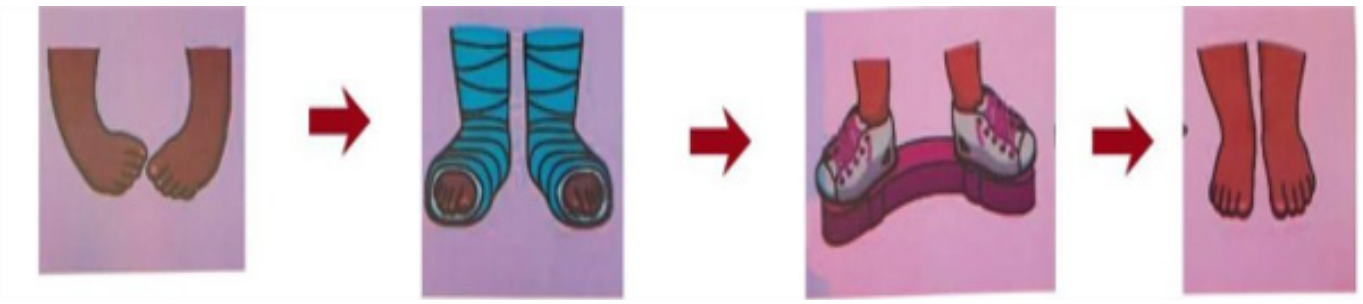

Figure 2: The reinforcement plastic (thickness =5mm, width =2cm, length 7cm) is placed at the level of achilles tendon, which serve as a platerflexion stop.

Figure 3: At the centre of the tamarack flexure joint, a horizotal line/ cut through the centre round, and at the distal tip of the proximal shell is beveled to create more ankle dorsiflexion.

Figure 4: Trime line.

A: Horizontal line 2cm below the fibular head, B: passing in front of the cuboid to enlarge the area of pressure, C: At the forefoot, the line the line is proximal to the 5th metatarsal head, D: At the medial side, Increase the coverage of the medial mid foot at the navicular / malleoli, E: The metatarsal and phalanges are covered (forefoot wedge) to prevent forefoot adduction.

Figure 5

Data collection followed a structured, multi-stage process. Baseline assessments included demographic information, medical history, and severity grading using the Pirani scoring system, a validated tool for evaluating clubfoot deformity [21]. Follow-up evaluations were conducted at regular intervals (1–2 weeks, 4 weeks, 6 weeks, 3 months, 6 months, and 12 months), during which clinical progress, gait patterns, brace fit, and signs of relapse were assessed. Compliance data were obtained through caregiver reports, structured questionnaires, and, where feasible, objective monitoring devices embedded in orthotic systems. Qualitative data on caregiver experiences were also collected to provide contextual insights into treatment adherence. Data analysis involved both descriptive and inferential statistical techniques. Descriptive statistics were used to summarize demographic and clinical characteristics, while independent sample t-tests were applied to compare continuous variables such as dorsiflexion and abduction angles between treatment groups. The chi-square test was employed to assess associations between categorical variables, including compliance and relapse indicators [22]. Qualitative data were analyzed thematically to identify recurring patterns related to caregiver perceptions and challenges. All analyses were conducted at a significance level of 0.05, ensuring rigorous evaluation of the research hypotheses.

Results

Table 1: Age group, economic class, and affected foot.

Variable	Category	Frequency	Percent
Age group at review	Under 24 months	17	16
	24–47 months	67	63.2
	48 months and above	22	20.8
Economic class of parents	Low	34	32.1
	Medium	64	60.4
	High	8	7.5
Affected foot	Left	14	13.2
	Right	32	30.2
	Both left and right	60	56.6

Note*: SOURCE: Author's computation from Survey Data. 2026

The age distribution presented in the table shows that the majority of the children included in the study were between 24 and 47 months old, accounting for 63.2% of the total sample. This clearly indicates that the dataset is largely composed of walking-age children, which is consistent with the central objective of the research that focuses on brace management after children have begun walking. A smaller proportion of the participants, 16.0%, were younger than 24 months, while children aged 48 months and above constituted 20.8% of the respondents. The pattern therefore reflects a study population concentrated around the early walking years, a period when relapse risk may increase due to weight-bearing activities.

With respect to socio-economic background, most of the caregivers belonged to the medium economic class, representing 60.4% of the respondents. Families in the low-income category accounted for 32.1%, while only a limited number, 7.5%, were classified as high income. This distribution is relevant because the cost of braces, clinic visits, and follow-up care can influence the ability of families to maintain recommended treatment schedules. In terms of the affected foot, bilateral involvement was most frequent, representing 56.6% of cases, while right-sided deformity occurred in 30.2% and left-sided cases accounted for 13.2%. The predominance of bilateral presentation indicates that many of the children experienced a relatively extensive form of the deformity, which may require closer clinical monitoring and sustained orthotic management (Table 2).

Table 2: Birth history, family history, walking status, and classification.

Variable	Category	Frequency	Percent
Clubfoot present at birth	Yes	99	93.4
	No	7	6.6
Family history of similar condition	Yes	21	19.8
	No	85	80.2

Child walking	Yes	99	94.3
	No	6	5.7
Classification	Untreated (under two)	87	82.1
	Neglected (over two)	14	13.2
	Recurrent	4	3.8
	Complex	1	0.9

Note*: SOURCE: Author's computation from Survey Data. 2026

The findings show that most cases (93.4%) were identified at birth, reaffirming idiopathic clubfoot as a congenital deformity arising during fetal development, while the few cases not recognized early likely reflect delayed detection. The absence of family history in 80.2% of respondents suggests predominantly sporadic occurrence, though the 19.8% with affected relatives indicates some genetic contribution. The sample was largely ambulatory (94.3%), aligning with the study's focus on walking-age children and justifying evaluation of combined AFO–FAB use. Clinically, most cases (82.1%) were early untreated presentations, with fewer neglected and recurrent cases, indicating a predominance of manageable deformities rather than severe conditions (Table 3).

Table 3: Treatment and brace profile.

Variable	Category	Frequency	Percent
Tenotomy done	Yes	49	47.1
	No	55	52.9
Brace knowledge	Poor	5	4.7
	Fair	74	69.8
	Good	27	25.5
Brace type used	Both FAB and Modified AFO	56	52.8
	FAB Only	49	46.2
	Modified AFO Only	1	0.9
Type of FAB	Miracle Brace	89	87.3
	IOWA Brace	10	9.8
	Dennis Brace	3	2.9

Note*: SOURCE: Author's computation from Survey Data. 2026

The data indicate a near-equal distribution between children who underwent tenotomy (47.1%) and those managed without it (52.9%), allowing balanced comparison of outcomes across treatment pathways. Caregiver knowledge of brace use was predominantly fair (69.8%), with fewer demonstrating good understanding, suggesting potential gaps that may affect compliance and proper brace application. In terms of orthotic management, the combined use of modified Ankle–Foot Orthosis (AFO) and Foot Abduction Brace (FAB) was slightly more prevalent than FAB alone, supporting comparative analysis of both approaches. Notably, the Miracle Brace was the most commonly used device, reducing variability linked to brace design differences (Table 4).

Table 4: Brace condition and relapse-related observations.

Variable	Category	Frequency	Percent
Brace fit	Yes	102	99
	No	1	1
Brace condition	Good	90	84.9
	Fair	9	8.5
	Overgrown	7	6.6

Heel down in boot	Yes	86	82.7
	No	18	17.3
Pressure sores	Yes	2	2.3
	No	86	97.7
Any early relapse sign	Yes	26	24.5
	No	80	75.5
Dynamic supination when walking	Yes	19	18.4
	No	84	81.6

Note*: SOURCE: Author's computation from Survey Data. 2026

The findings indicate that brace performance and condition were generally satisfactory among the children studied. Nearly all braces (99.0%) were properly fitted, suggesting effective clinical fitting procedures and adequate caregiver application, which are essential for maintaining corrective alignment. Most devices were also in good condition (84.9%), reflecting appropriate maintenance and follow-up, although a few were overgrown, indicating the need for timely replacement. Heel positioning was correct in the majority of cases, supporting effective transmission of corrective forces. Pressure sores were rare, implying good tolerance and proper use. However, early relapse signs (24.5%) and dynamic supination (18.4%) were observed in some children, highlighting the continued risk of recurrence and the importance of sustained monitoring and adherence.

Analysis of t-test and Chi-square (Table 5)

Table 5: Independent t-test comparing combined regimen and FAB only.

Outcome	Combined regimen (Both FAB + Modified AFO) Mean ± SD	FAB Only Mean ± SD	t-value	p-value
Final dorsiflexion angle with brace	13.31 ± 3.66	10.42 ± 5.62	3.079	0.003
Final abduction angle with brace	57.57 ± 13.00	49.74 ± 17.77	2.545	0.013
Baseline abduction before brace fitting	36.94 ± 6.03	40.46 ± 5.94	-2.991	0.004
Baseline dorsiflexion before brace fitting	9.15 ± 3.96	9.85 ± 3.00	-1.027	0.307

Note*: SOURCE: Author's computation from Survey Data. 2026

The independent t-test results demonstrate significant differences between the combined AFO–FAB regimen and FAB-only approach in maintaining correction. Children managed with the combined protocol achieved higher final dorsiflexion (p=0.003) and abduction angles (p=0.013), indicating better preservation of ankle mobility and foot alignment. Although the FAB-only group had slightly higher baseline abduction, this advantage was not sustained, suggesting treatment effect rather than initial disparity. Baseline dorsiflexion showed no significant difference (p=0.307), confirming group comparability at the outset. Overall, the findings indicate that incorporating a daytime modified AFO enhances stability and reduces the risk of relapse in walking-age children (Table 6).

Table 6: Change in angles from pre-brace to final review.

Outcome	Combined regimen Mean change	FAB Only Mean change
Abduction change (final minus baseline)	+20.63°	+9.70°
Dorsiflexion change (final minus baseline)	+4.16°	+0.57°

Note*: SOURCE: Author's computation from Survey Data. 2026

The comparison of pre-brace and follow-up measurements further highlights the superiority of the combined orthotic regimen. Children managed with daytime modified ankle-foot orthosis and nighttime foot abduction brace recorded a substantial mean improvement in abduction (+20.63°), compared with a more modest gain (+9.70°) among those using FAB alone, indicating stronger maintenance of forefoot alignment. A similar trend was observed for dorsiflexion, where the combined group achieved a notable increase (+4.16°), while the FAB-only group showed minimal improvement (+0.57°). These findings suggest that the combined approach provides enhanced mechanical support during both activity and rest, thereby improving overall correction stability.

Discussion of Results

The study revealed that the combined use of a modified ankle–foot orthosis (AFO) with Tamarack joint during the day and Foot Abduction Brace (FAB) at night achieved superior maintenance of correction compared with FAB alone. This was clearly reflected in significantly improved final dorsiflexion and abduction angles, key indicators of sustained alignment after initial treatment. Consequently, the null hypothesis on the ineffectiveness of the modified AFO is rejected. The finding aligns with evidence that relapse is often linked to inadequate maintenance rather than poor initial correction [14]. Given the mechanical demands of ambulation in walking-age children, daytime orthotic support provides continuous stabilization, enhancing long-term outcomes and reducing recurrence risk [7,8]. The study further demonstrated that the combined daytime AFO and nighttime FAB regimen was associated with improved functional outcomes and better indicators of practical brace use. Children managed with this approach showed more consistent heel seating and reduced dynamic supination, both of which reflect proper brace application and enhanced stability during movement. Importantly, these benefits were achieved without an increase in pressure sores or fitting problems, suggesting that comfort was not compromised. Although a direct compliance scale was not employed, these clinical indicators strongly imply better adherence among caregivers. This supports existing evidence that effective clubfoot management depends not only on correction but also on tolerability and usability of orthotic devices [9,1].

Conclusion

The findings indicate that combining a daytime modified Ankle–Foot Orthosis (AFO) with Tamarack joint and nighttime Foot Abduction Brace (FAB) provides superior maintenance of correction compared with FAB alone, as evidenced by improved dorsiflexion and abduction angles. This supports the rejection of the null hypothesis and aligns with evidence that relapse is primarily linked to inadequate maintenance rather than initial correction failure [2]. Improved heel positioning and reduced dynamic supination further suggest enhanced functional stability and better adherence, without increased discomfort. These outcomes reinforce the importance of combining effectiveness with usability in long-term clubfoot management [1,9].

Acknowledgements

None.

Conflict of Interest

There is no conflict of interest.

References

1. Pavone V, et al. (2018) Epidemiology of idiopathic clubfoot. Journal of Orthopaedics 15(2): 1-5.
2. Dobbs MB, Gurnett CA (2009) Update on clubfoot: Etiology and treatment. Clin Orthop Relat Res 467(5): 1146-1153.
3. Basit S, Khoshhal K I and Ali Z (2020) Genetic insights into congenital clubfoot. Journal of Pediatric Genetics 9(1): 25-34.
4. Herzenberg J E, Radler C and Bor N (2002) Ponseti versus traditional methods of casting for idiopathic clubfoot. Journal of Pediatric Orthopaedics 22(4): 517-521.
5. Ponseti I V (2005) Treatment of congenital club foot. The Journal of Bone and Joint Surgery. American Volume 87(2): 448-454.
6. Segev E, et al. (2019) Treatment challenges in walking-age clubfoot. Journal of Children's Orthopaedics 13(2): 123-130.
7. Dobbs M B, Nunley R and Schoenecker P L (2004) Long-term follow-up of patients with clubfeet treated with extensive soft-tissue release. The Journal of Bone and Joint Surgery 86(1): 22-27.
8. Dyer P J and Davis N (2006) The role of the Ponseti method in the management of clubfoot. Current Orthopaedics 20(2): 94-102.
9. Thompson G H, et al. (2014) Relapse in clubfoot treatment. Clinical Orthopaedics and Related Research 472(4): 120-128.
10. Richards B S, et al. (2007) AFO use in pediatric orthopedics. Journal of Pediatric Orthopaedics 27(2): 1-6.
11. Mabrouk A, et al. (2021) Social implications of untreated clubfoot. International Orthopaedics 45(3): 765-772.
12. Adegbehingbe O O, Oginni L M and Ogundele O J (2001) Ponseti clubfoot management: The Nigerian perspective. Journal of Orthopaedic Surgery and Research 16(1): 43-48.
13. Tindall, A. J., et al. (2005). The burden of clubfoot in developing countries. Journal of Bone and Joint Surgery 87(10): 1-6.
14. Dobbs M B, Rudzki J R, Purcell D B, Walton T, Porter K R, et al. (2006) Factors predictive of outcome after use of the Ponseti method for the treatment of idiopathic clubfeet. The Journal of Bone and Joint Surgery 86(1): 22-27.
15. Graham H K, Rosenbaum P, Paneth N, Dan B, Lin JP, et al. (2019) Cerebral palsy. Nature Reviews Disease Primers 2 Article 15082.
16. Creswell J W and Plano Clark V L (2011) Designing and conducting mixed methods research (2nd edn) Sage.
17. National Health Research Ethics Committee of Nigeria. (2017) National code of health research ethics NHREC.
18. Yamane T. (1967) Statistics: An introductory analysis (2nd edn) Harper & Row.
19. Nwankwo O C (2016) A practical guide to research writing University Press.
20. Manisha R, Priyanka K (2017) Congenital Clubfoot: A Comprehensive Review. Ortho & Rheum Open Access 8(1): 555728.

21. Pirani, S, Outerbridge H, Moran M, and Sawatzky B (1999) A method of evaluating the virgin clubfoot with substantial interobserver reliability. Iowa Orthopaedic Journal 19: 67-71.

22. Field A (2013) Discovering statistics using IBM SPSS statistics (4th edn) Sage.