

Research Paper

Surgical Treatment Functional Outcome of Delayed Clubfoot in Tibebe Gihon Specialized Hospital from June 2022- June 2023: Case Series Study

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Abstract

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Idiopathic clubfoot occurs in approximately 1 in 1,000 live births, with most cases (80–91%) found in low- and middle-income countries (LMICs). Due to limited access to early treatment, many children present with delayed or neglected deformities. However, surgical outcomes for this population remain underexplored, particularly in Ethiopia. This study evaluates functional outcomes following surgical correction of delayed clubfoot at Tibebe Ghion Specialized Hospital. A case series was conducted from June 2022 to June 2023, including patients aged over 2 years who underwent soft-tissue release, tibialis anterior tendon transfer (TATT), or triple arthrodesis. Data were collected through chart review, physical examination, and a pretested questionnaire. Functional outcomes were assessed using the Laaveg-Ponseti scoring system. A total of 30 patients (36 feet) with a mean age of 10.53 years (range: 2–22) were included. Mean follow-up was 18.6 months. Postoperative Laaveg-Ponseti scores averaged 83.7%, with 40% excellent, 20% good, 33.3% fair, and 6.7% poor results. All patients achieved independent shoe wear. Younger age at surgery was significantly associated with better outcomes ($p < 0.05$). Surgical intervention for neglected clubfoot with severe deformity produced satisfactory functional and cosmetic results. Early treatment remains essential. These findings address a critical evidence gap and support the development of standardized surgical protocols in resource-limited settings.

1. Introduction

Congenital Talipes Equinovarus (CTEV) refers to a widely spread outward fold of the foot found in babies, and this is the most prevalent congenital (musculoskeletal) deformity that

orthopedic doctors deal with, with an estimated occurrence of 1 in every 1,000 live births worldwide (Chueire et al., 2016; Penny, 2005). In prior times, countries with a high per capita income had the most comprehensive treatment

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methodologies available for this condition. Still, with approximately 80-91% of cases being reported in low and middle-income countries (LMIC), the ability to receive timely treatment for the CTEV condition is severely limited (Penny, 2005; Owen et al., 2018). An example of these problems exists in Ethiopia, where it is estimated that 3,000 to 5,000 new cases are reported each year (Ayana, 2014), but there is a tremendous shortage of treatment facilities, resulting in many being treated for CTEV after the ideal treatment window has passed.

In many low-resource settings, such as Ethiopia, untreated clubfoot typically appears as untreated congenital talipes equinovarus (CTEV) beyond the (optimal/timely) treatment window of two (2) years (Owen et al., 2018). Some of the main reasons for delay in receiving proper care for children with CTEV are: 1) a lack of trained personnel to treat these patients (Aroojis et al., 2021; Pirani et al., 2009), 2) cultural considerations, 3) lack of necessary materials/equipment, and 4) geographic barriers to urban treatment centres (Owen et al., 2018; Pirani et al., 2009).

While the Ponseti method is effective even in delayed presentations of congenital talipes equinovarus (CTEV) (Eidelman et al., 2019), surgical intervention becomes necessary in cases of rigid deformity, inadequate correction, or failed conservative management. Common surgical approaches include soft tissue releases, tibialis anterior tendon transfer (TATT), and triple arthrodesis (Eidelman et al., 2019; Lindahl, 1963). Despite the established need for such procedures, there remains a notable lack of published data on the surgical outcomes of neglected CTEV, particularly in low-resource settings and sub-Saharan Africa (Penny, 2005; Sobel, 1996).

The historical dependence of Ethiopian medicine on Kite's technique and extensive posteromedial release has resulted in poor outcomes and high rates of complications (Ayana et al., 2014;

Tekaly et al., 2018). While a limited number of hospitals have reported success using the Ponseti Method for older patients (Ayana et al., 2014), most patients older than the age of two years receive either radical operations or no treatment at all (Pirani et al., 2009). This gap in the provision of therapy for patients with CTEV has serious socioeconomic implications for untreated patients, as they often experience stigma, limited educational opportunities, and limited participation in their communities (Naddumba, 2010; Pigeolet et al., 2022).

This research has addressed three main gaps in our existing knowledge, including: (1) a lack of published surgical outcome data from Ethiopia, (2) a lack of understanding as to what is the best surgical indication and technique for delayed CTEV correction, and (3) a poorly understood experience of both patients and the community regarding surgical treatment of either condition. We examined the hypothesis that surgical correction has the potential to greatly improve both foot morphology and pain, and overall functional and social outcomes within this population.

We evaluated the mid-term surgical outcomes of T4E patients receiving surgical treatment from a tertiary hospital in Ethiopia using established and validated measures of outcome, such as the Laaveg-Ponseti score (Pigeolet et al 2022), the Roye functional assessment (Baghdadi et al 2021), and the SF-36 quality of life measure (SF-36 1992). The results from this case series serve to establish basic data for Ethiopia and provide the basis for future treatment protocols and community education efforts in other limited-resource settings.

2. Method and Materials

2.1. Study Design and Setting

Tibebe Ghion Specialized Hospital is a tertiary center for patients with orthopedic needs in Bahir Dar, Ethiopia, where this prospectively designed case series analysis was primarily focused.

Tibebe Ghion Specialized Hospital is considered the main endpoint for orthopedic referrals within the Northwest Region of Ethiopia and has been operating a pediatric orthopedic service level since January 2020. The orthopedic unit caters to around 150 pediatric orthopedic patients monthly and provides surgical intervention options by its staff of 9 orthopedic surgeons, including 2 orthopedic surgeons who are experts in pediatrics.

2.2. Study Population

The subjects were consecutively treated children over two years old with untreated idiopathic clubfoot as defined by either untreated, necessary to treat within six months of source/stage 0-4, failed treatment of a clubfoot, or unsuccessful treatment at conservative care after six months of follow-up. We did not include children with syndromic conditions or neuromuscular disorders, or those who either did not present to follow-up visits after surgery, or we received a refusal of consent for their treatment, or no further participation. All children obtained a minimum of six months of follow-up from the post-operative period.

2.3. Surgical Interventions

All surgery was conducted according to established protocols by fellowship-trained surgeons who specialize in children's orthopedic surgery (Ayana et al, 2014). The surgery was selected using algorithms based on the severity of the patient's condition, including age of the patient and the nature of the deformity.

For patients under 16 with residual or flexible deformities of the hind foot after initial conservative treatment, a release of the soft tissues in the posteromedial (back part of the inside of the foot) area was performed. This was done to restore normal anatomical alignment (the normal position of the bones of the foot) by releasing any soft tissue contractures on the inside or back of the foot. When a lack of balance in muscle forces crossing over the ankle and

midfoot due to a dynamic supination (the most common problem causing recurrent deformity) was found, a tibialis anterior tendon transfer (TATT) was used.

For older children and adolescents with severe, rigid, long-standing deformities for which joint preservation was no longer an option, a triple arthrodesis was indicated. This surgical procedure involved fusing the subtalar joint, talonavicular joint, and calcaneocuboid joint, stabilizing the foot in a plantigrade position, at the corrected angle. A patient-centered approach was used to determine which procedures were to be used. Thus, the decision about procedures was based on how functionally impaired a person was or what the actual examination/review of X-rays showed, rather than just based on the person's age.

2.4. Outcome Assessment

The assessment of primary outcomes was conducted employing three distinct (yet validated) assessment tools to perform a multidimensional evaluation of the efficacy. Measurement of the extent of any improvement in functional capacity was conducted using the Laaveg-Ponseti Functional Rating System, which is a 100-point scale consisting of 4 categories (poor (< 70 points), fair (70 - 79 points), good (80 - 89 points), excellent (90 - 100 points)) (Porta & Masquijo, 2016). Assessment of the three disease-specific outcomes associated with the Roye instrument (pain, functional capacity, and satisfaction) was conducted using the Roye instrument (Chu & Lehman, 2012). General health-related quality of life was assessed using the 36-Item Short Form Health Survey (SF-36), which consists of four (4) general categories of assessment (Physical Health, Mental Health, Emotional/Behavioral Health, and Family Health) (Fernandes et al., 2016).

2.5. Data Collection Procedures

The research assistants were trained in data collection utilizing structured techniques of physical examination, a complete review of patient medical records (operative notes and follow-up records), and interviews of patients and/or parents and/or guardians of patients. To guarantee that study instruments were linguistically and culturally accurate, they were translated in accordance with a standardized forward and back translation method and verified by bilingual clinicians (Eidelman et al., 2019). For patients who had surgery before the time frame for enrollment into this study, follow-up assessments occurred by telephone after getting informed consent.

2.6. Statistical Analysis

All analyses were conducted using IBM SPSS Statistics version 28.0. Descriptive statistics were calculated to summarize the data. Continuous variables are presented as the mean, standard deviation, or median with the 25th and 75th percentiles, depending on whether their distribution is normal. Categorical variables are summarized as frequencies and percentages. To compare pre- and postoperative outcome measures, paired statistical tests were selected according to data distribution. The paired t-test was used for normally distributed data, and the Wilcoxon signed-rank test was applied to non-normally distributed data.

2.7. Ethical Considerations

The study protocol received ethical approval from the Institutional Review Board of Tibebe Ghion Specialized Hospital. Written informed consent was obtained from parents/guardians of all participants, and children aged 12 years or older also provided verbal assent. All study procedures adhered to the ethical principles established by the 1964 Declaration of Helsinki and subsequent revisions.

3. Results

3.1. Socio-demographic Data

The study included 30 patients (36 affected feet) with delayed clubfoot, with an age range of 2 to 22 years and a mean age of 10.53 years. The cohort consisted of 16 males (53.3%) and 14 females (46.7%). The age distribution showed 12 patients (40%) were between 2-7 years, 6 patients (20%) each in the 7-12 years, 12-17 years, and 17-22 years age groups.

Socioeconomic characteristics revealed significant challenges among participants. The majority of parents/guardians (22 patients, 73.3%) were illiterate, with only 4 (13.3%) having primary education and 4 (13.3%) having secondary or higher education. Family income levels were predominantly low, with 20 families (66.7%) earning less than 1000 ETB per month, 6 families (20%) earning between 1000 and 5000 ETB, and only 4 families (13.3%) earning above 5000 ETB monthly.

Healthcare access and awareness data showed that while 20 patients (66.7%) lived within 5km of a health facility, an equal proportion (20 patients, 66.7%) were unaware that clubfoot could be treated effectively in early childhood. Only two patients (6.7%) had received any prior treatment, an incomplete course of Ponseti casting during infancy that was discontinued prematurely.

Treatment outcomes were assessed after a mean follow-up period of 18.6 months (range 7-27 months). The mean Laaveg-Ponseti functional score was 83.7, with outcomes distributed as follows: 12 patients (40%) achieved excellent results (scores 90-100), 6 patients (20%) had good outcomes (scores 80-89), 10 patients (33.3%) showed fair results (scores 70-79), and 2 patients (6.7%) had a poor outcome (score below 70). All patients achieved the ability to wear conventional footwear postoperatively.

Age significantly influences outcomes, with younger patients demonstrating superior results. Among children under 7 years (n=6), 10 (83.3%) achieved excellent or good outcomes, compared to only 6 of 18 (33.3%) older patients. The single poor outcome occurred in a 19-year-old patient with severe pretreatment deformity. Parental satisfaction scores showed a strong correlation with functional outcomes ($r=0.82$).

No major surgical complications were reported during the study period. Six patients (20%) required supplemental orthotic support for residual gait abnormalities during follow-up. The findings demonstrate that surgical intervention can achieve functional improvement even in neglected cases, while highlighting the critical impact of early treatment and socioeconomic factors on outcomes.

Table 1. Sociodemographic and Economic Characteristics of the Study Patients

Variables	Values	Frequency	Percent	Valid Percent	Cumulative Percent
Age category	2yr-7yr	12	40	40	40.0
	7yr-12yr	6	20	20	60
	12yr-17yr	6	20	20	80.0
	17-22yr	6	20	20	100.0
Gender	Male	16	53.3	53.3	53.3
	Female	14	46.7	46.7	100.0
Monthly family income (ETB)	less than 1000	20	66.7	66.7	66.7
	1-5000	6	20.0	20.0	86.7
	5000-10000	2	6.7	6.7	93.3
	Greater than 10000	2	6.7	6.7	100.0
Parents' education level	Can't read or write	22	73.3	73.3	73.3
	Can read or write/ elementary school	4	13.3	13.3	86.7
	High school	2	6.7	6.7	93.3
	Diploma/ degree	2			
Distance to the Nearest Health Facility	<1 km	4	13.3	13.3	13.3
	1 km-5 km	16	53.3	53.3	66.7
	5 km-10 km	6	20.0	20.0	86.7
	>10 km	4	13.3	13.3	100.0
Parents' Awareness of DCF	Yes	10	33.3	33.3	33.3
	No	20	66.7	66.7	100.0

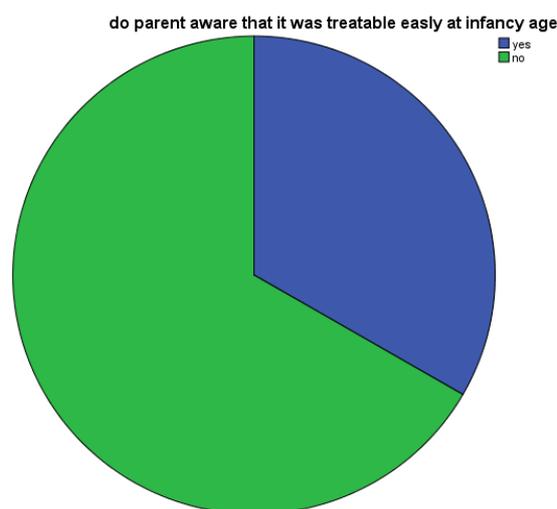


Figure 1. Pie chart representing our findings on parents' awareness of the treatability of clubfoot at infancy and their general knowledge of delayed clubfoot deformity

3.2. Burden of Disease

The study showed that there were many physical, as well as emotional and social, difficulties for individuals with delayed clubfoot deformity. Before surgery, about half of the group of individuals (14 out of 30, which included one person with bilateral clubfoot) reported that they experienced chronic pain associated with their clubfoot. Many individuals experienced a lot of difficulty with shoes. Of the 30, 18 individuals (60%, which included 6 individuals with bilateral clubfoot) could not wear regular shoes because they had big deformities.

The impact of their clubfoot condition on their education was very significant. Fourteen out of the thirty individuals (46.7%) who participated in the study dropped out of school completely. An additional four individuals (13.3%) were still in school, but they were in school at a level that was below what would have been expected for an individual their age. Only six of the individuals (20%) continued with their education at the same level as other individuals their age.

The emotional and social impacts of delayed clubfoot deformity were also evident in employment settings. Eight individuals out of the thirty (26.7%) reported experiencing discrimination or social exclusion in their employment due to their clubfoot deformity.

This study provides strong evidence that delayed clubfoot deformity imposes an enormous amount of physical (46.7% with chronic pain), functional (60% are unable to wear shoes), educational (66.7% with educational interruptions), and social (26.7% experienced discrimination) burden on individuals with clubfoot deformity. The data presented in this study are most likely only a small fraction of the total burden of delayed clubfoot deformity. Many psychosocial issues may not be able to be captured through clinical assessments, and, therefore, further studies need to be done to assess the total psychosocial burden.

The high rates of educational disruption and social exclusion highlight the condition's far-reaching consequences beyond physical disability. The inability to wear standard footwear - affecting most patients represents both a functional limitation and a visible marker of difference that may contribute to social stigma. These findings underscore the importance of early intervention to prevent both physical deformity and its associated socioeconomic consequences. Table 2 presents the multifaceted burden of delayed clubfoot on pediatric patients. Although these parameters cannot comprehensively represent the full spectrum of the deformity's consequences, they offer critical insight into its profound impact. The table

outlines functional limitations (inability to wear preferred shoes), physical symptoms (pain under different conditions), educational consequences (school non-attendance or dropout), and psychosocial challenges (experiences of discrimination and isolation in the workplace).

Table 2: *Functional, Educational, and Psychosocial Burden of Delayed Clubfoot Deformity*

Variables	Values	Frequency	Percent	Valid Percent	Cumulative Percent
Ability to wear shoes (Preoperative)	Yes	12	40.0	40.0	40.0
	No	18	60.0	60.0	100.0
Pain (Preoperative)	Yes	14	46.7	46.7	46.7
	No	16	53.3	53.3	100.0
Educational Impact	Not joined at all	6	20.0	20.0	20.0
	Started but discontinued due their foot condition	14	46.7	46.7	66.7
	Less than his/her peers	4	13.3	13.3	80.0
	Equal with his/her peers	6	20.0	20.0	100.0
Experience of Discrimination	Never	22	73.3	73.3	73.3
	Sometimes	8	26.7	26.7	100.0



Figure 2. *Preoperative image of a female patient. She is 18 years old and has had left foot deformity since birth. She has a rigid, severe deformity and bears weight on the dorsum of the foot, as shown in the picture*

3.3. Surgical Intervention Details

All patients underwent initial treatment with the Ponseti splinting technique before surgical consideration. The splinting protocol was implemented in collaboration with hospital physiotherapists, with an average of 5 casting sessions performed on a weekly basis. Surgical intervention was ultimately recommended when deformities proved unresponsive to conservative management, as determined by senior pediatric

orthopedic specialists at the Pediatric Orthopedics Referral Clinic (PORC).

There were three different surgical techniques used, which all depended on both patient age and the severity of their deformity. Soft tissue procedures were performed as the primary surgical approach for younger patients (younger than 11 years of age) and included percutaneous Achilles tendon lengthening, plantar fascial

release, and abductor hallucis tenotomy. Eight of these ten patients (in total 11 feet) required tibialis anterior tendon transfer (TATT) for total correction. Older patients (typically over 15 years old) underwent the combination of triple arthrodesis (i.e., fusion of the three bones) with wedge resection of the subtalar and midtarsal joint. A unique case was the 9-year-old patient, whose deformity was extreme and very stiff, who had to have the same procedure. Of the surgical cohort, 14 patients (in total 16 feet) had triple arthrodesis; 10 patients had soft tissue releases and TATT; and 6 patients had only soft tissue releases. All surgical procedures were combined in one stage with no need for internal fixation. Post-operative management included intravenous antibiotics for 24-48 hours and oral pain medications, and daily monitoring of swelling of the toes as well as the blood supply to the toes and the status of the incisions.

Hospitalization duration averaged 14 days, ranging from 5 days for most unilateral cases to 38 days for a bilateral case requiring staged admissions. Following discharge, patients were placed in long leg casts with scheduled follow-up at 6 weeks. The PORC follow-up protocol involved comprehensive evaluations by orthopedic residents and specialists, with

transition to ankle-foot orthoses (AFO) at the first postoperative visit. Subsequent evaluations occurred at 3-6 months and 1 year postoperatively.

The study documented an average postoperative follow-up duration of 18.6 months (range: 7-27 months), with patients typically completing 4 clinic visits (range: 2-8). Surgical burden averaged 2 procedures per patient (range: 1-4), with secondary operations often involving cast wedging and repositioning during the initial admission period.

Functional outcomes, as measured by the Laaveg-Ponseti scale (mean: 83.47/100) and Roye score (mean: 89.5/100), demonstrated satisfactory results across the cohort. The standardized treatment protocol and consistent follow-up regimen contributed to reliable outcome assessment and postoperative management. Table 3 summarizes the overall treatment course and duration. It details the number of pre-operative splinting sessions, surgical procedures, total hospital days, postoperative follow-up period (up to June 30th), and outpatient clinic visits. The table also presents the functional outcomes, as measured by the Laaveg-Ponseti and Roye scores.

Table 3. Summary of Treatment Course, Follow-up Duration, and Functional Outcome Scores

Descriptive Statistics					
Variable	N	Minimum	Maximum	Mean	Std. Deviation
Number of splints applied before surgery	30	6	14	4.67	1.175
Number of operative theatre (OR) visits	30	2	8	2.00	1.000
Total duration of hospital stay (days)	30	5	38	13.80	10.936
Postoperative follow-up duration (months)	30	7	27	18.60	7.462
Number of postoperative outpatient (OPD) follow-up visits	30	2	8	3.80	2.077
Laaveg-Ponseti Foot Functional Score (0-100)	30	63	94	83.47	9.913
Roye Functional Score (0-100)	30	67.5	100.0	89.500	11.1082
Valid N (listwise)	30				

Figure 3 illustrates the distribution of surgical procedures performed. Triple arthrodesis was the most common procedure, followed by tibialis

anterior tendon transfer (TATT) and soft tissue release.

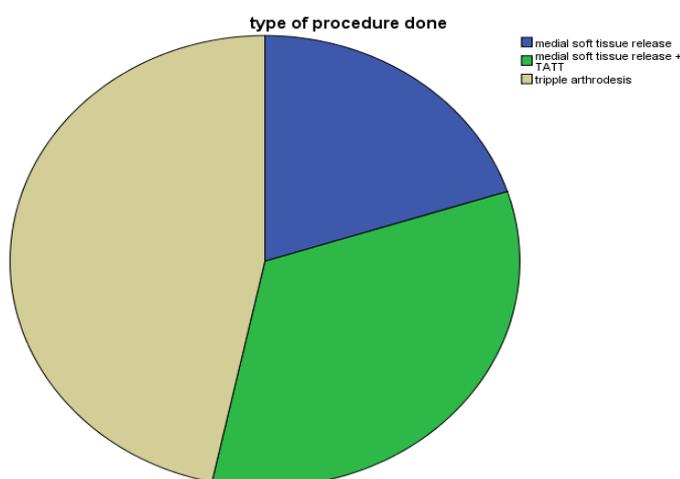


Figure 3. *Distribution of Surgical Procedures Performed*

3.4. Postoperative Outcomes

Participants in this study experienced very good functional recovery after undergoing surgical treatment. As well, almost all patients ambulated independently and unaided after surgery; the exception to this was one patient who was still not yet fully recovered 7 months after surgery. Many participants had limited pain during high-impact activities such as running and prolonged walking; only 4 patients (13.3%) reported having pain during these types of activities. The remaining patients reported no pain at any time while performing the majority of their daily routines.

With regard to assessing mobility, all patients demonstrated the ability to walk up at least 1 block of stairs, 60% (18 of 30) of patients had no limitations in their stair-climbing ability and were able to perform this activity unrestricted. In addition, 66.7% (20 of 30 patients) had fully returned to their age-appropriate daily activities. The remaining 10 patients only had enough capacity to complete light daily activities. Fewer than half of the patients in the study reported having fully returned to competitive sports 46.7%, or 14 patients) when compared to their

peers who were not affected, while 26.7% (or 8 patients) had not returned to competitive sports because of limitations associated with their severe deformity.

Patient satisfaction and satisfaction of their parent/guardian was universal and at a high level; 80% or 24 out of 30, stated they were “very satisfied” with their surgical outcomes. Of the remaining patients, 20% (6 out of 30 patients) stated they were “satisfied.” all families reported they were satisfied with the appearance of their child's foot after surgery and 46.7% (14) of the total patients were very pleased with the cosmetic outcome.

There were no major complications observed, and all surgeries had a low complication rate. There were no instances of recurrence of a deformity within the follow-up period (range 6-27 months). No differences in patient outcomes based on sex; consistency was maintained across genders. On the basis of functional evaluation using validated measurement tools, the mean scores were: 83.47 (Laaveg-Ponseti) with a range of 63 to 94, and 89.5 (Roye), indicating that outcomes were generally good. The results classified by Laaveg-Ponseti criteria were

excellent (40% (12), good (20%) (6), fair (33.3%) (10), poor (6.7%) (2)).

A particularly striking finding was that, without exception, patients wanted the treatment to continue. All 30 participants said that they would tell someone else who had similar issues to seek

out this procedure. Of the 30 patients who participated in the study, 14 (46.7%) had their procedure covered by their health insurer, and 12 patients (40%) believed the treatment was expensive, even though they received a benefit of improved function from the surgery.

Table 4. Postoperative Functional Outcomes, Patient Satisfaction, and Treatment Perceptions

Variables	Values	Frequency	Percent	Valid Percent	Cumulative Percent
Parent/Patient satisfaction with treatment outcome	Very satisfied	24	80.0	80.0	80.0
	Satisfied	6	20.0	20.0	100.0
Postoperative pain	Yes	4	13.3	13.3	13.3
	No	26	86.7	86.7	100.0
Postoperative foot shape	Very satisfied	14	46.7	46.7	46.7
	Satisfied	16	53.3	53.3	100.0
Ability to walk without assistive devices	No restriction	26	86.7	86.7	86.7
	Some restriction	4	13.3	13.3	100.0
Postoperative activity level of the foot	No restriction	20	66.7	66.7	66.7
	Some restrictions during strenuous activities	10	33.3	33.3	100.0
Ability to ascend and descend stairs postoperatively	No restriction	18	60.0	60.0	60.0
	Restricted to one flight of stairs	12	40.0	40.0	100.0
Participation in sports activities after surgery	Equal to age-matched peers	14	46.7	46.7	46.7
	Limited participation in strenuous sports	4	13.3	13.3	60.0
	Limited participation in all sports	8	26.7	26.7	86.7
	Never attempted sports activities	4	13.3	13.3	100.0
Laaveg–Ponseti Functional Rating Score (FRS)	Excellent (90-100)	12	40.0	40.0	40.0
	Good (80-89)	6	20.0	20.0	60.0
	Fair (70-79)	10	33.3	33.3	93.3
	Poor (<70)	2	6.7	6.7	100.0
Perceived cost of treatment (including OPD visits)	Costly	12	40.0	40.0	40.0
	Fair	4	13.3	13.3	53.3
	Covered by health insurance	14	46.7	46.7	100.0
Willingness to recommend the treatment to others	Yes	30	100.0	100.0	100.0
	No	0	0	0	100.0

Table 4, presented above, summarizes postoperative functional outcomes by measuring key performance indicators, such as satisfaction with treatment, pain relief, function (appearance), use of ambulatory aids, level of activity, ability to climb stairs, and ability to play sports. Besides, included in Table 4 above are functional assessment scores (Laaveg-Ponseti). Data related to patient attitudes on advocating for the treatment, and willingness to recommend the procedure to others, as well as the cost of the treatment, have also been included in Table 4.

The following figure shows the postoperative image of a 10-year-old child 12 months following a TATT procedure. Preoperatively, the patient experienced activity-related pain, was unable to wear his choice of footwear, and could not participate in sports with his peers. At one-year follow-up, he is pain-free, wears desired shoes without issue, and demonstrates full ankle range of motion with neutral heel alignment. He now participates equally in sporting activities with his peers.



Figure 4. Postoperative outcome 12 months after TATT procedure in a 10-year-old male

The figure below shows a 17-year-old male, two years following a triple arthrodesis. Preoperatively, the patient experienced pain with activity and at rest. He was unable to wear a shoe on the affected left foot and bore weight on the dorsum of the inverted foot, which resulted in a

large callosity. Currently, he is pain-free, can wear any shoe, and demonstrates a reasonably good range of motion with a neutrally aligned heel. Both the patient and his parents report a high level of satisfaction.



Figure 5. Two-year postoperative result following triple arthrodesis in a 17-year-old male

According to the FRS Laaveg-Ponseti scoring system, 28 of the 30 patients (93.3%) achieved excellent, good, or fair results, while only two patients (6.7%) had a poor outcome. The mean postoperative score was 83.7%, which falls within the 'good' range (80–90%).

Younger children (aged <12 years) had excellent to good outcomes, as measured by the Laaveg-Ponseti score, and better outcomes than older children did. All children aged less than 7 years had excellent (90-100) scores.

4. Discussion

This study evaluated the functional outcomes of surgical management for delayed idiopathic

congenital talipes equinovarus (ICTEV) in a tertiary Ethiopian hospital, providing important evidence on mid-term outcomes in a low-resource setting. Our findings indicate that appropriately planned surgical interventions, whether soft tissue procedures or bony reconstructions, can achieve substantial improvements in function, pain relief, and psychosocial well-being among patients with neglected clubfoot.

This cohort's age-stratified surgical treatment plan divides patients into 2 age groups (those aged < 11 years old, for whom soft tissue releases were performed and those aged \geq 11 years, for whom bony procedures (mainly triple

arthrodesis) were performed), and follows the standard practices set forth by Ponseti and corroborated by multiple international studies (Eidelman et al., 2019; Yadav 1981; Pigeolet et al., 2022; Brodsky, 2010; Aggarwal, 2017; Julieta and Javier, 2016). One exception to this surgical classification system occurred when a 9-year-old girl with significant, stiff deformity required a triple arthrodesis. This case demonstrates the necessity of individualized surgical plans based on the severity of deformity, rather than rigid age cutoffs, to ensure that patients with neglected clubfoot are managed optimally through a patient-centered approach that considers flexibility, severity, and functional impairment.

The socioeconomic status of our cohort exposes systemic barriers that lead to delayed care. The pattern of households with low incomes and low levels of educational attainment, combined with limited awareness of clubfoot management, is similar to findings from other low-resourced areas of sub-Saharan Africa and South Asia (Aggarwal, 2017; Willis et al., 2009; Park et al., 2009; Faldini et al., 2013; Akini & Aklani, 2015). Low levels of health literacy in parents and their limited educational experience, economic circumstances of the family, and structural barriers likely contribute to the average age of 10.53 years that we found when children presented for surgery. The cumulative impact of delayed presentation on function and psychosocial wellbeing is substantial; children who presented late experience discomfort (46.7%), have difficulty with customary shoes (60%), and experience interruption in their education (46.7% school dropout rate). The fact that nearly all the patients who underwent surgery showed improvement in terms of mobility, pain, and participation in society reflects how transformative surgery can be, despite the patients' delayed access to surgical care.

The Roye score (mean: 89.5) and Laaveg-Ponseti scale (mean: 83.47) both showed functional outcomes that were on par with or marginally better than those observed in other low- and middle-income countries (LMIC) contexts. While research from India and Africa has shown inconsistent results ranging from fair to good functional outcomes (Aggarwal, 2017; Faldini et al., 2013), a Pakistani cohort with neglected clubfoot, for instance, attained mean functional scores of 77% (Yadav, 1981). The rigorous postoperative rehabilitation regimen and meticulous, customized surgical planning may have contributed to our study's marginally better outcomes, underscoring the significance of organized follow-up even in settings with limited resources.

The outcomes of surgery were consistent with previous studies that have found that soft tissue operations are generally performed on younger patients and have better functional results, less pain, and greater levels of activity when compared to older patients who had undergone a bony fusion (i.e., triple arthrodesis). Older patients reported limitations in doing strenuous activities (71.4%) and had pain that persisted (28.6%). Therefore, the limitations that older adults experience with difficult tasks represent the ability to achieve corrected joints, while also maintaining mobility of those joints. This finding supports the inverse relationship between age at the time of intervention and functional outcome, emphasizing the importance of early detection/referral programs (Julieta & Javier, 2016) for optimal functional outcome.

Another highlight is the zero major surgical complications in our study group compared to previous studies, where complications included wound infection, skin necrosis, and neurovascular compromise (Yadav, 1981; Faldini et al., 2013). This is probably due to careful surgical technique, consistent perioperative protocols, and close monitoring while in the hospital. The low incidence of

complications shows that with the appropriate level of surgical expertise, complex procedures such as triple arthrodesis can be performed safely in areas where there are limited resources.

In addition to functional gains, this study illustrates the psychosocial and educational opportunities afforded by surgical correction. Patients being able to wear regular shoes at the same time that they have had significant pain relief and improved mobility provides a pathway for reintegrating socially, participating in educational pursuits, and developing higher self-esteem. In addition, the fact that all patients and their families reported they would recommend this treatment to others indicates a high level of satisfaction with the process and a belief in the value of these interventions in the community. This has potential implications for the development of public health and community-based programs that focus on early identification and referral of clubfoot cases.

The study has several limitations. The small sample size of 30 patients and an average of 18.6 months of follow-up limit the ability to generalize the results or to effectively evaluate long-term outcomes (i.e., the risk of post-arthrodesis degenerative changes). In addition, there was no control group, which prevented the ability to compare conservative management with surgical management, and the design of the study as a single center limits its external validity. Regardless of these limitations, the study offers valuable evidence in a setting where there is little published literature on the consequences of delayed surgery for clubfoot.

In conclusion, this research indicates that surgical treatment for delayed ICTEV can lead to both functional and psychosocial improvements, even when the patient presents late or in a resource-constrained setting. Our data support the combination of appropriate-age surgical techniques and structured care after surgery as yielding high levels of satisfaction from patients, significant pain relief, and enhanced mobility,

which supports judicious surgical intervention for neglected deformities. Our study also draws attention to the critical need for early detection, parental education, and community outreach in order to maximize functional restoration to the patient and minimize the long-term consequences for untreated patients with clubfoot. Future studies should include larger multi-center cohorts, longer follow-up periods, and cost-effectiveness evaluations to guide the development of policy and effective allocation of resources for clubs for disabled children in low- and middle-income countries (LMICs).

5. Conclusion

While surgery can be an option for clubfoot treatment, it does not provide complete restoration of the normal anatomy after a delay. The results of this study indicate that using appropriate surgical techniques (such as soft tissue release and tibialis anterior tendon transfer, along with triple arthrodesis) does provide meaningful functional improvements. Approximately 60% of patients in this study experienced good or excellent outcomes without complications from surgery and were able to achieve adequate pain control and regain function. As such, the findings from this study support the continued careful use of surgical treatment to correct severely neglected clubfoot deformities within low-resource settings. The findings from this study also indicate that early evaluation and referral will yield optimal outcomes, leading to an urgent need for improved evaluation and referral systems. Future research should examine multicenter studies involving larger populations over extended periods of time to identify the variables that predict long-term outcomes.

6. Recommendations

According to the findings of this research, strategies for enhancing the identification, management, and follow-up of children's clubfoot with delay include the following recommendations. Health policy-makers at all

levels (including Ministry of Health (MoH) and Regional Health Bureaus (RHBs), should create awareness of clubfoot and assist in its early identification by conducting national public relation campaigns via mass media, community outreach initiatives, and electronically producing information on how to identify clubfoot and beginning treatment for that child as early as possible will provide an opportunity for his/her foot/feet to function normally. To improve their ability to recognize musculoskeletal abnormalities in newborns and infants, educational programs should be developed and implemented for community health workers and primary care physicians, enabling them to refer patients to specialists for timely diagnosis and treatment. The health system must also be supported; there should be developed standard referral pathways to ensure that suspected cases of clubfoot are referred to the appropriate provider promptly and that Ponseti implementation capacity is increased at both primary and secondary healthcare levels, to decrease time to treatment and prevent the development of severe neglected deformity. Additionally, funding should be provided to specialized centres that can provide care for children with complex deformity, and ongoing professional development should occur for orthopedic surgeons to ensure delivery of high-quality surgical care.

Continued early intervention should be supported by systematic screening for referral at an early stage, with the age and severity of each child's deformity determining which surgical options will be considered. The clinician will take into account the potential for function to improve against the degree of mobility that can be maintained when developing a treatment plan for each child.

The importance of providing families of children with additional information on realistic postoperative expectations, including limitations and the possibility of needing rehabilitation, as

well as anticipated functional outcomes following surgery, cannot be overstated. The psychosocial and educational burdens associated with these patients before surgery have been shown to be substantial.

The results of this study highlight the urgent need for further research on the management of delayed clubfoot in low-resource countries. Multicenter studies with long-term follow-up should be performed to assess how long the surgical outcomes from different methods of treatment are maintained; how quality-of life measures differ in children after surgery; and how cost-effective different surgical procedures are for resource allocation decisions. Barriers preventing families from seeking early treatment for their children should be identified in order to design targeted intervention strategies and developing appropriate and meaningful assessments for resource-limited settings is crucial for patient benefit. This study's findings will directly inform the development of future patient assessments using measures that aim to improve patient functional outcomes, decrease the psychosocial burden, and improve overall quality-of-care for children with delayed clubfoot.

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Ethical Approval and Consent

The Institutional Review Board of the Bahir Dar University College of Medicine and Health Sciences approved the study ethically. Informed verbal consent from human subjects, or their legal representatives, was given after all subjects

were fully informed on the study's purpose and their rights as subjects. All subjects voluntarily participated in the study, and their identity is kept confidential during and after the collection and analysis of data. Personal identifiers of the subjects were eliminated from the records.

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Data Availability

The anonymized dataset supporting this study's findings is available from the corresponding author upon reasonable request, in compliance

with Ethiopian research regulations and participant confidentiality agreements.

Authors' Contributions

AG, YA, AC, and BW contributed to study conception, protocol development, methodology design, data analysis, and interpretation. W provided critical manuscript revision, editorial oversight, and substantive intellectual contributions to enhance the manuscript's scientific quality. All authors reviewed and approved the final manuscript.

Competing Interests

The authors declare no competing interests, financial or otherwise, related to this work. No external funding sources or commercial relationships influenced the study design, execution, or reporting.

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