

## Review Article



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Dr. Shabir A Dhar



Dr. Tahir Ahmed Dar



Dr. Reyaz Ahmed Dar



Dr. Abhishek Raina



Dr. Mohd Alam



Dr. Sabqat Farooq



Dr. Abdul Maajid

#### Address of Correspondence

Dr. Shabir A Dhar,

Department of Orthopaedics, SKIMS Medical College,  
Bemina, Srinagar, Kashmir, India.

E-mail: shabirdhar@yahoo.co.in

<sup>1</sup>Department of Orthopaedics, SKIMS Medical College,  
Bemina, Srinagar, Kashmir, India.

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## Atypical Clubfoot- A Systematic Review

Shabir A Dhar<sup>MS Ortho</sup><sup>1</sup>, Tahir Ahmed Dar<sup>MS Ortho</sup><sup>1</sup>, Reyaz Ahmed Dar<sup>MS Ortho</sup><sup>1</sup>,  
Abhishek Raina<sup>MS Ortho</sup><sup>1</sup>, Mohd Alam<sup>MS Ortho</sup><sup>1</sup>, Sabqat Farooq<sup>MS Ortho</sup><sup>1</sup>,  
Abdul Maajid<sup>MS Ortho</sup><sup>1</sup>

### Abstract

**Background:** The management of congenital talipes equinovarus (clubfoot) has been transformed by the Ponseti technique. However, 5-7% of clubfeet present as atypical or complex variants that are resistant to standard treatment protocols. These challenging cases require early recognition and modified management strategies.

**Purpose:** To systematically review the literature on atypical/complex clubfoot, defining its clinical characteristics, pathogenesis, and evidence-based treatment modifications.

**Methods:** A systematic literature search was conducted across PubMed, Embase, Scopus, and Ovid databases through April 2025. Studies reporting on atypical or complex clubfoot characteristics, pathogenesis, management techniques, and outcomes were included. Quality assessment and data extraction followed PRISMA guidelines. A total of 32 studies met the inclusion criteria and were analyzed.

**Results:** Atypical clubfoot is characterized by a deep transverse plantar crease, hyperextension of the big toe, and a stubby foot appearance. Complex variants demonstrate excessive oedema and stiffness during casting. The challenges encountered during treatment are due to intrinsic anatomical factors and iatrogenic factors such as frequent cast slippage. Key management modifications include: prevention of cast slippage through metatarsophalangeal joint termination, application of the Ponseti 2 manoeuvre for forefoot equinus correction, delayed tenotomy timing, and increased vigilance for recurrence. Recurrence rates range from 15-45%, higher than idiopathic clubfoot. Long-term outcomes demonstrate satisfactory correction with modified protocols, though complex clubfoot requires more casts and closer follow-up.

**Conclusions:** Early recognition of atypical/complex clubfoot enables timely implementation of treatment modifications. Prevention of iatrogenic cast slippage, appropriate application of the Ponseti 2 manoeuvre, and extended follow-up are essential for optimal outcomes. Further research is needed to standardize terminology and establish evidence-based algorithms.

**Keywords:** Clubfoot, Atypical, Complex, Review

### Introduction

The Ponseti technique has allowed orthopedists to manage clubfoot along better defined biomechanical lines. Consequently, there has been a major improvement in functional results [1].

However, some clubfeet are not completely addressed by the classic Ponseti methodology. This type of clubfoot is variously known as Atypical or Complex clubfoot. There is evolving literature surrounding this entity, in terms of classification, etiology, pathogenesis, presentation and treatment. In addition, the terminology of complex vs atypical clubfoot is somewhat unclear and lacks complete consensus [2, 3].

In 2006, Ponseti et al reported for the first time on an entity termed the 'complex'

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clubfoot [1]. The earliest reference to this variant was made by Turco, who called it the 'Atypical Clubfoot' with a caution that operative treatment of these could result in a 'grotesquely deformed foot' [2].

There is relative agreement that atypical clubfoot is characterized by severe equinus, with a short first metatarsal, hyperextended big toe, severe plantar flexion of all metatarsals and deep folds through the sole of the foot and above the heel [4].

Literature regarding this type of clubfoot is scarce. The terminology used for this clubfoot is new, but description of this entity under various headings, perhaps, existed previously. Terms like very severe, stiff-stiff, and teratogenic might have been utilized in the past. A score of '10' on the Carroll severity scale likely addressed the same variant [5, 6, 7, 8].

A review article on complex or atypical clubfoot is required to summarize the available data and will hopefully lead to an improved understanding of this difficult clinical problem.

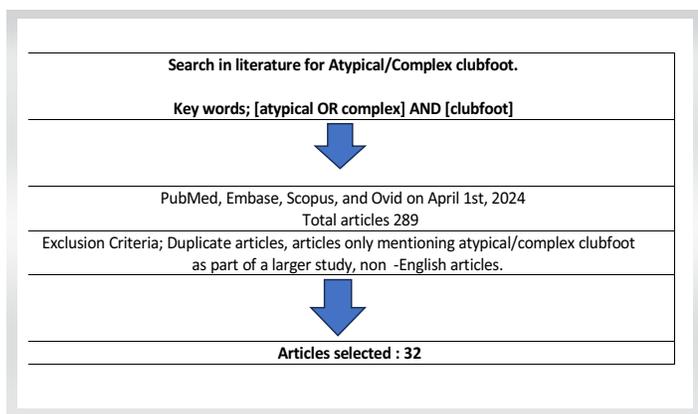
### Methodology

A literature search was carried out in the databases of PubMed, Embase, Scopus, and Ovid on April 1st, 2024 using the keywords [atypical OR complex] AND [clubfoot]. We included articles that were published from the inception of each database until the date of search.

289 articles were found. We excluded duplicate articles.

The articles obtained from the literature search were screened based on title and abstract by three groups of authors independently. Any conflict regarding the inclusion or exclusion of studies among the two authors was resolved by discussion with all the authors.

36 articles were selected for the review.



### Discussion

Clubfoot is the most frequent congenital deformity of foot, with an incidence of 0.51 to 2.03 per 1,000 live births. Complex clubfoot is a term used to describe a subset of patients that have received previous treatment, have typical anatomic characteristics, are severe and resistant to manipulation. Regarding occurrence, different series have reported incidence

rates ranging from 7 to 17%. [1,2,9]. Boys are affected more commonly than girls. [10]

Mandlecha et al reported a male to female ratio of 3.3:1 in their series of 27 feet. The Right foot was more commonly affected in a ratio of 3:2. [12]

Mosca considered clubfoot to be a complex, multi-segmental, 3-dimensional, congenital foot deformity. The segmental deformities have been recognized for centuries. They are cavus of the forefoot/midfoot, adductus of the midfoot, varus of the hindfoot, and equinus of the ankle, often referred to by the acronym CAVE. [13] The atypical clubfoot has additional metatarsal equinus and a cocked-up big toe, adding to the complexity.[1]

Some clubfeet which do not respond to the standard serial casting protocol have been termed as complex or atypical. [1]

Even though the term 'atypical clubfoot' is used interchangeably with 'complex clubfoot', the two terms are ideally used for different entities. The controversy surrounding these terms was addressed by the Ponseti International foundation with the help of Iowa guidelines which described two different entities:

1. The atypical clubfoot: not treated previously and having a deep plantar crease, short hyperextended great toe and flexed metatarsals causing cavus.
2. Complex clubfoot: a treated clubfoot with the above features, accompanied by edema, redness, irritation, and a history of slipped casts. [3]

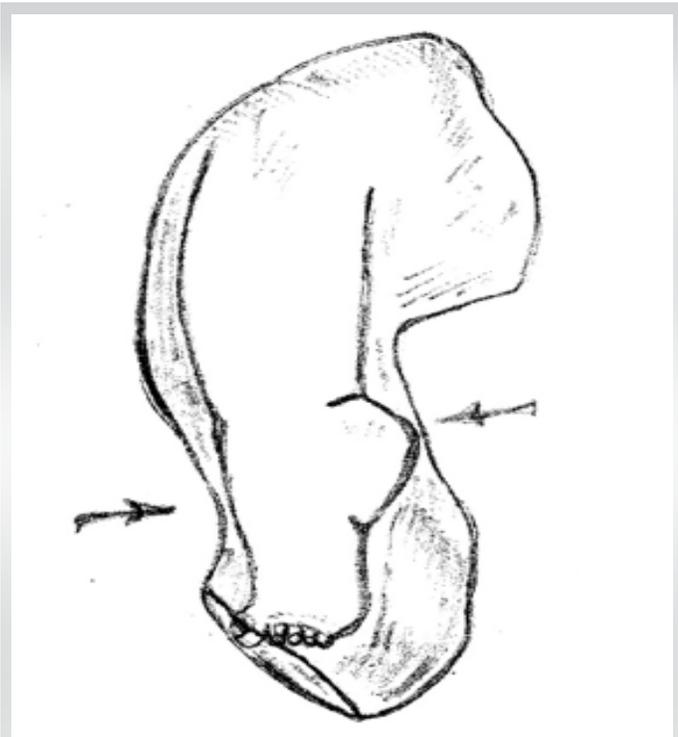
The confusion could be avoided by naming the primary untreated deformity as 'atypical clubfoot' and if previous cast intervention has worsened the condition, the term 'complicated atypical clubfoot' could be used.

According to Al-Mohrej, the incidence of cast slippage is underreported. [14]

The importance of cast slippage is reflected in the paper by Sinha et al who mentioned that cast slippage can be avoided by using the tug test. They mentioned that the conical shape of the thigh along with the straight equinus are static factors and flexion of the toes by the baby is the dynamic force promoting cast slippage. According to the authors, applying the cast to the metatarsal heads prevents repeated application of downward pressure by the toes onto the cast. [15]

Sinha et al also advocated moulding of the cast around the heel along with a knee flexion of 110 degrees to prevent cast slippage. Conventional cotton has also been recommended to prevent slippage. Other methods to prevent cast slippage are placing the tibia with a post drawer force in flexion and flattening the cast over the thigh. Ibrahim et al used tincture benzoin to improve cast retention. [16]

Rangaswamy et al considered both the conditions to be the same for the sake of evaluation. [17] Dragoni et al questioned the ability to recognize this entity at birth and considered all



**Figure 1:** The cast slippage causes compression at the dorsum of the foot and the heel, resulting in the stubby edematous foot.



**Figure 2:** The toes tend to push the cast down dynamically. A cast that ends at the metatarsophalangeal joints is less likely to slip.



**Figure 3:** The Ponseti 2 manoeuvre is central to the management of the complex clubfoot. This addresses the forefoot equinus.

cases to be iatrogenic. [18]

Williams and Dobbs wrote that both the atypical and complex type clubfoot have the same features. However, atypical type foot is characterized by the absence or weakness of active dorsiflexion of the foot or toes. They also have weak eversion of the foot. [19]

The current literature suggests that improper treatment might be responsible for converting an atypical clubfoot into a complex clubfoot. [14,15,16] There is sparse literature on complex clubfoot, whether idiopathic or iatrogenic. [12]

Ponseti also described severe fibrosis in the quadratus plantae, gastrocsoleus, and ligaments.[1] This is a little confusing as cast slippage is not considered to be severe enough to cause fibrosis of the muscle and changes in ligaments. The complex clubfoot has also been equated with complex regional pain syndrome. [17,18]

There is a relative consensus about the deformities present in atypical clubfoot. Clinically, complex clubfoot is defined as having rigid equinus, forefoot adduction and supination, severe plantar flexion of all metatarsals, a deep transverse crease in the sole of the foot, a deep crease above the heel, and a short and hyperextended first toe. The achilles tendon is exceptionally taut and fibrotic extending to the middle of the calf. [1,12,14,15,20]

In the complex clubfoot, it is the gastrocsoleus and the plantar intrinsic muscles and ligaments that are more severely involved. The medial ligaments and tendons of the foot can be stretched easily, but the cavus and the equinus strongly resist correction. [1,15,20]

In their series, Yoshioka et al. noticed that 8 out of 111 complex clubfoot patients had peroneal nerve dysfunction. The severity of dysfunction varies from weakness of active dorsiflexion of toes and ankle to no active dorsiflexion.[20] Edmonds et al. mentioned the lack of active dorsiflexion of toes as a “drop toe” sign, and it should be clinically evaluated before commencing casting and during the treatment course. The complex clubfeet associated with peroneal nerve dysfunction are difficult to treat, and relapses/recurrences are expected. [21]

The Ponseti method is modified for the management of this type of clubfoot. [1] The index finger of one hand is placed over the posterior aspect of the lateral malleolus while the thumb of the same hand applies counter pressure over the lateral aspect of the head of talus while the forefoot, grasped by the opposite hand, is slowly abducted. This maneuver is done while stretching and during application of a below-knee plaster cast. The below-knee cast is then converted to an above-knee cast, maintaining the knee in 100 – 110 degrees flexion to avoid cast slippage. The subsequent casts are applied every week using same maneuver till the forefoot is abducted to 40 degrees and hindfoot varus is corrected.[14]

The foot should not be abducted beyond 40 degrees, and one



**Figure 4:** The appearance of an atypical clubfoot. The cocked-up toe, transverse plantar crease and a deep crease above the heel.



**Figure 5:** The repeat tenotomy is best done under vision as the vital structures are in close apposition.

should be cognizant of the formation of a lateral skin crease indicating possible midfoot break. [23]

In the modified technique, the plantarflexed metatarsals are corrected by holding the ankle with both hands, placing the thumbs under the metatarsals, and applying a dorsiflexion force. The foot should not be abducted beyond 40 degrees, as continued attempts at abduction push the metatarsals into

flexion and abduction but does not correct the hindfoot varus. [1]

Braces are worn 23 hours per day for 3 months following treatment and then 12 to 14 hours a day (while the child is sleeping) until the child is 4 years old. The brace abduction angle could be changed and set to the regular 60 to 70 degrees as soon as the feet gain flexibility, usually at the end of the 23-hour period. [15]

The tenotomy rates in atypical clubfoot range from 95 – 100%. [10,11,12,17] However, Mandlecha et al mentioned that percutaneous tenotomy should be attempted in cases where the tendon was thin and easily felt. They recommended that thick and broad tendons should be managed by mini-open tenotomy. [12]

**Results**

Loose in a longer-term study of 16 years showed good correction with modified Ponseti, but the relapse rate was up to 66 percent. Cast slippage was reported in 22 out of 27 feet. [25]

**Table 1. The comparison of clinical features in Idiopathic and Atypical/Complex clubfoot.**

IDIOPATHIC CTEV	ATYPICAL/COMPLEX CTEV
Hindfoot equinus	Severe equinus
Hindfoot varus	Short first metatarsal
Midfoot cavus	Hyperextended big toe
Forefoot adduction	Severe plantar flexion of all metatarsals
	Deep folds through the sole of the foot and above the heel

**Table 2. Table comparing studies on complex/atypical clubfoot.**

Study	Previous casts	Casts applied during study	Tenotomy [percent]	Pre treatment Pirani	Post treatment Pirani	Relapse [Percent]	TAT [%]	Additional tenotomies [percent]
Allende et al [24] [2020]	25-May	5[3-13]	96	4.5-6	0-2.5	29.8	18	3
Ponseti [1] [2006]	9 [3-20]					14		
Gupta et al [27] [2015]	18-Apr	7 [4-9]	95	3.5-6		5		
Goksan et al [10] [2006]	11					38		
Matar et al [11] [2017]	17	7 [5-10]	100	5.5 [4.5-6.0]		53	18	
Mandlecha et al [12] [2018]	0	7.44 [6-10]	100	5.6	0.2	11		11
Rangaswamy et al [17] [2022]								
Bozkurt et al [28] [2021]		7	100	5.2	0.4	30		
Duman et al [29] [2020]		5	93.8	5.1		17		
Elseddik et al [30] [2018]		5.6	100	6	0	0		
Yoshioka et al [20] 2010		5				40	16	
Patel A et al. [32] 2022		8.3	50	5.69	0.45	20		

**TAT. Tibialis anterior transfer.**

Agarwal et al described a clinical method of hallux length quantification in complex clubfeet. The deep medial crease recovered in all feet. The recovery of hallux length was delayed in some patients and might indicate persistent posteromedial soft tissue contracture/fibrosis in these feet. The shortening of hallux in clubfeet is probably because of contracted soft tissues resulting in a retracted hallux. Further, the interphalangeal joint may flex and metatarsophalangeal joint may extend adding to the shortened appearance of hallux. [26]

The recurrence rate in complex clubfoot has been reported to be between 0 and 53 percent. [24,28,30]

The management of recurrences is quite variable, from repeat casting [25] to extensive release [11]. However, no clear conclusions can be drawn as the series are small and opinions varied. [26,27,28,29,30]

According to Loose et al, there is poor correlation between radiology and functional outcomes [25]. However, Addosooki reported a positive correlation in idiopathic CTEV. [31]

Allende et al proposed interference with venous return as a contributing factor to the complex clubfoot. [15] [Figure 1]. They also mentioned that the picture resembled that of Complex regional pain syndrome [CRPS].

### Clinical Pearls

Look for the triad: Deep creases, cocked-up toe, stubby appearance

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**Declaration of patient consent :** The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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