

ORIGINAL ARTICLE

Radiological study of anatomical bony arrangement of the clubfoot deformity and its correlation with the Pirani clinical scoring system: A multicenter study

Mustafa Hayder El Hadi (1), Mohamed Abdelsalam Nurein (2), Mustafa Abbas El Sheikh Bader (3), Mohamed Mahdy Ali Salih (1), Haydar Elhadi Babikir (4)

(1) Department of Anatomy Faculty of Medicine, University of Gezira, Wad Medani, Sudan

(2) Department of Anatomy Faculty of Medicine, Karary University, Omdurman, Sudan

(3) Department of Orthopedic, Omdurman Teaching Hospital, Omdurman, Sudan

(4) Department of Paediatrics and Child Health, Faculty of Medicine University of Gezira, Wad Medani, Sudan

ABSTRACT

Club foot or congenital talipes equinovarus (CTEV) is a common developmental disorder of the foot, affecting 1 per 1,000 live births. The main goal of this study is to evaluate the anatomical bony arrangement of the clubfoot deformity radiologically and to correlate this arrangement with the Pirani clinical scoring system. This descriptive, analytical study was conducted in three centres in Sudan. It recruited all the patients of both sexes with CTEV attending these centres, and excluding children on conservative cast and those who already had surgery. Data were collected using structured questionnaire. Pirani clinical scoring system, a reliable clinical assessment method, was applied. Four angles were used to measure each component of the deformity and correlate this with the Pirani score. Feet radiology was performed to assess the bone

anatomy. The index cases number was 25 with male-to-female ratio of 1.6:1. Both feet were involved simultaneously in about half of the cases. Only the dorsoplantar (DP) and lateral (L) views talo-1st metatarsal angle was used to describe the forefoot adduction and mid-foot cavus, respectively. These correlated significantly with the clinical score of Pirani, whereas the other two measures for the equinus and varus did not. The results matched with the demographic description of the deformity found in the literature. Further studies are warranted that combine both the clinical assessment and the X-ray measurements in one score to classify the severity of the deformity and guide the management options.

KEYWORDS

Clubfoot; Congenital talipes equinovarus; Pirani scoring system; Children; Sudan.

Correspondence to:

Mustafa Hayder Elhadi
Department of Anatomy, Faculty of Medicine,
University of Gezira, Sudan
Email: MHBabiker@uofg.edu.sd,
Mustafalldarsh@live.com

Received: 11 November 2019 | Accepted: 15 November 2019

How to cite this article:

El Hadi MH, Nurein MA, Bader MAE, Salih MMA, Babikir HE. Radiological Study of anatomical bony arrangement of the clubfoot deformity and its correlation with the Pirani clinical scoring system. Sudan J Paediatr. 2019;19(2):101–109. <https://doi.org/10.24911/SJP.106-1573461977>

INTRODUCTION

Children's foot disorders are frequent presentations to a range of health professionals and represent a common parental concern. Both particular paediatric conditions and foot development result in many changes and variations to foot appearance. It is important that foot problems are differentiated from growing trends, that foot pain is well diagnosed, and that any treatment is based upon best available evidence.

A considerable number of children with clubfoot have it in both feet, making it harder for the child to walk normally. The anatomical malformation of congenital talipes equinovarus (CTEV) is not well studied and the publications in this perspective are meagre if any. The prevalence of this condition in the Sudan is not well estimated, and most cases attend the clinic late.

Idiopathic congenital clubfoot is a poorly understood, but common developmental disorder of the lower limb which affects at least 1–2 per 1,000 of births worldwide [1]. It is defined as a fixation of the foot in adduction, supination and varus, with concomitant soft tissue abnormalities. Zions et al. [2] found that severity did not differ significantly by either sex or bilaterality though patients with bilateral clubfoot had a wider range of severity. Despite advances in treatment, disability often persists.

Nearly one in 1,000 babies is born with clubfoot and one-fourth of them have a family history of the birth defect, which causes the bones and joints of the foot to be aligned incorrectly. The condition occurs in boys twice as often as in girls. Standard treatment for milder forms of clubfoot involves gentle manipulation and casting of the feet over several weeks then wearing a brace for several years. Treatment for more severe forms requires surgery [2].

The lower limb buds appear around the fourth embryonic week, then through the process of endochondral ossification, the skeleton of the feet starts to develop and continues to mature after birth. This starts with the calcaneus at 6th month of foetal life followed by the talus and the cuboid. The navicular is the last bone to ossify between 2 and 5 years [3].

Different criteria to assess the severity of deformity, its progression and to evaluate the results of treatment have been advocated [4]. One of these methods was the radiological assessment of the deformity [5]. However, the utility of radiographic methods and their relationship to clinical outcome is still being debated [6].

Only few radiological parameters have been considered as the most reliable indicators for assessment of clubfoot. Other studies addressed the all possible radiological parameters in relation to the various deformities [7]. The Pirani, Goldner, Di Miglio, Hospital for Joint Diseases, and Walker classifications have been published, but no classification system is universally used [8]. A reliable clinical method of assessment commonly used in Paediatric Orthopaedic Departments in Sudan is the Pirani scoring system which was used in this study.

The main goal of the present study is to evaluate the anatomical bony arrangement of the clubfoot deformity radiologically and to correlate this arrangement with the Pirani clinical scoring system.

MATERIALS AND METHODS

This a prospective hospital-based study of the gross anatomy of club foot as a common congenital malformation and its severity grading using Pirani scoring system. The study was conducted as multi-centres study. These centres were Omdurman Teaching Hospital, Omdurman; Gezira Traumatology Centre, Wad Medani; and Soba University Hospital (Paediatric Orthopaedic Centre), Khartoum Sudan. All children with congenital clubfoot (CTEV) attending the referred clinics in the study areas, during the study period were included. Exclusion criteria included children on conservative casts, those who have done surgery and children whose parents refused to contribute to the study.

A structured pre-coded questionnaire was used and all the demographic data were included. Clinical assessment of the affected limb using the Pirani clinical severity score was performed for all the subjects. The score describes six parameters and each one is graded as 0, 0.5, or 1.

The total Pirani score (TPS) was calculated with the obtained data to be grouped into two. Those who have TPS < 4.5, which was considered a low severity group, most probably respond to conservative management, and those with the score of > 4.5 who are regarded as severe, most likely to go for surgery [9].

X-ray images were taken after consenting the parents. Plane X-ray of the affected foot was taken using two views; the DP and lateral views, using a standard technique [9]. Four radiological parameters were obtained and used to describe each component of the deformity; these angles are:

The **talocalcaneal angle** on the DP view to describe the hindfoot varus with a normal value range between 25 and 40 and angle below the 25 would be regarded as hind-foot varus (Figure 1).

The **talo-1st metatarsal angle** on the DP view to describe the forefoot adduction. With the normal value between 0 and 20. Any angle more than 20 would be considered a forefoot adduction (Figure 2).

The **talo-1st metatarsal angle** on the lateral view to describe the mid-foot cavus, with normal range 0°–4° and an increase above the 4° would be considered as cavus (Figure 3).

The **tibiocalcaneal angle** on the lateral view to describe the hind-foot equinus with a normal range between 60° and 90°. Any increased angle above the 90° would be regarded as equinus (Figure 4).

Statistical analysis

The obtained data were coded and entered into a computer analysis using statistical package for social science (SPSS) for windows version 10. The data were ranked in two rows describing the Pirani clinical score above and below 4.5 as a cut-off point. The radiological parameters were categorised into four columns describing the severity as: normal, mild, moderate and severe form. Then, they were assessed and correlated with the Pirani clinical scoring system. Chi-square test was used to test the significant difference between the variables. A *p*-value of < 0.05 was considered as statistically significant.

RESULTS

Radiological angles measurement

Figures 1–4 demonstrate each angle obtained during the research, describing the view and the drawing of each angles.



Figure 1. Right foot DP view X-ray showing the talo-calcaneal angle in a patient with CTEV.

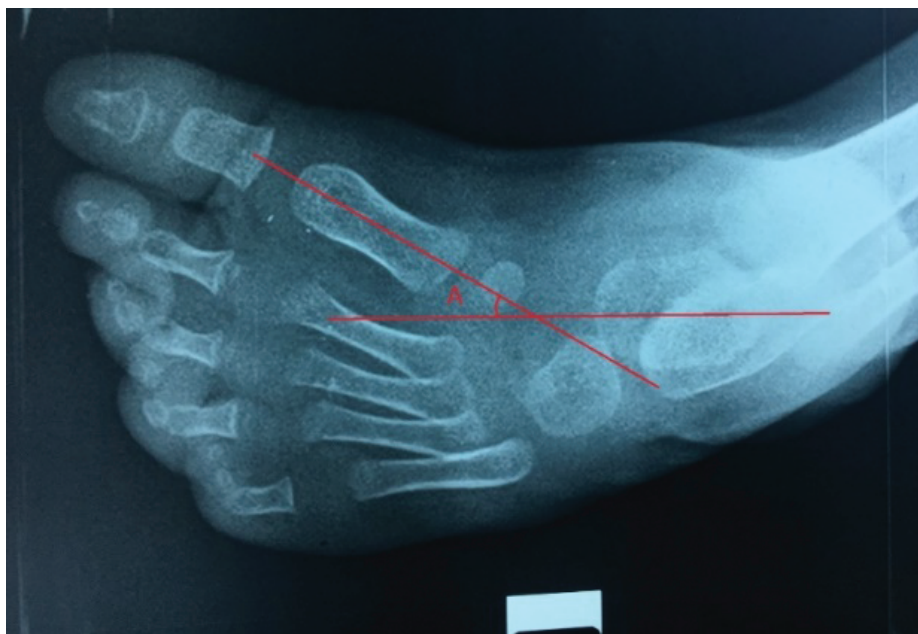


Figure 2. Left foot DP X-ray shows A; talo-first metatarsal angle in a patient with CTEV.



Figure 3. Left foot lateral view X-ray showing A; the talo-first metatarsal (Meary's) angle.

The majority of patients (70.6%) were below the age of 6 months, and only 17.7% presented later than 1 year. The male to female ratio was 1.6:1, and 56.3% of patients were bilaterally affected.

The correlation between the clinical Pirani score and the radiological measures

The following tables describe the correlation between the clinical Pirani score categorising

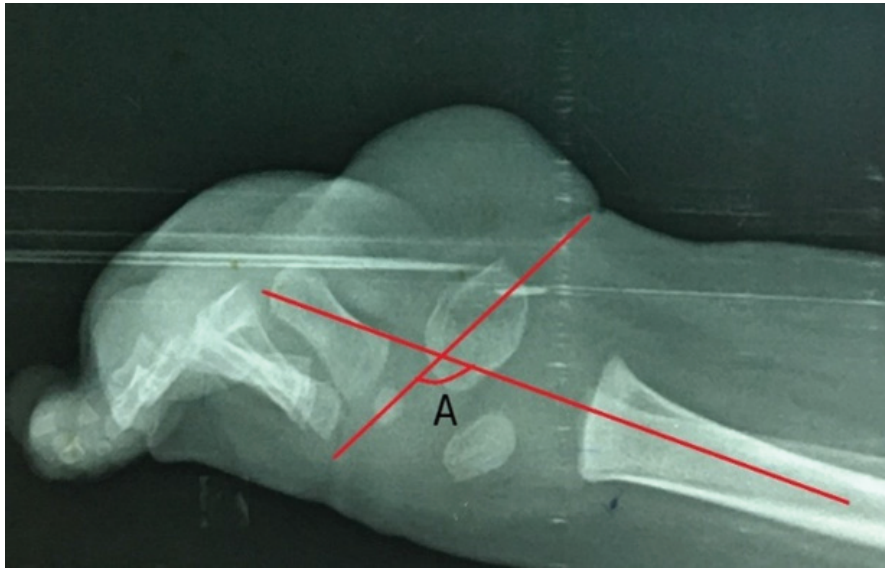


Figure 4. Right foot lateral view X-ray depicting the tibio-calcaneal angle in a patient with CTEV.

the data into two rows. The first one is 0–4.5, describing the patients who obtained TPS of less than 4.5 and the second groups who obtained TPS of more than 4.5.

These data compared with angles used to describe each one of the four deformities, which are:

- Talo-1st metatarsal DP view for the fore-foot adduction.
- Talo-1st metatarsal L view for the mid-foot cavus.
- Tal-calcaneal angle DP view for the hind-foot varus.
- Tibio-calcaneal angle L view for the hind-foot equinus.

Mid-foot Cavus

Correlating the angles on X-ray images with Pirani classification using the talo-1st metatarsal angle on the Lt view (Table 1) with the normal value of 0°–4°, and as described in the literature any degree above 4° would be considered as mid-foot cavus. These data were further classified as mild, moderate and severe. This angle showed a statistical significant correlation (p -value < 0.05) which means any increase in the Pirani score above the 4.5 this angle will increase accordingly.

The Fore-foot Adduction

Measuring the talo-1st metatarsal angle on the DP view with a normal value ranged between the 0° and 20° and any increase above the 20° will be described as fore-foot adduction, and further classification to mild, moderate and severe accordingly. The data showed a statistical significance correlation (p -value < 0.05) which can be described as the increase in TPS above the 4.5. The patient is probably having a higher degree of the talo-1st metatarsal angle (Table 2).

The hindfoot varus

The talocalcaneal angle on the DP view was measured, with the normal value between 25° and 40° and any degree less than 25° would be considered as hindfoot varus, with further classification to mild moderate and severe accordingly. The data obtained showed no statistical significance (p -value > 0.05) which is explained by the random distribution of the angle with 61.5% of patients with TPS above the 4.5 having a normal talocalcaneal angle (Table 3).

The hindfoot equinus

Measuring the tibio-calcaneal angle on the DP view, with the normal value between 60° and

Table 1. The correlation between the Pirani clinical score value and the degree of the lateral talo-1st metatarsal angle.

Pirani score	The lateral talo-1 st metatarsal angle								Total	
	Normal 60–90	Mild 90–110	Moderate 110–130	Severe >160	No.	%				
0–0.4	03	25.0%	03	25.0%	01	08%	05	41.7%	12	48%
4.5–6	00	00	03	23.1%	04	30.8%	06	64.2%	13	52%
Total	03	12.0%	06	24%	05	20.0%	11	44.0%	25	100%

Chi-square tests = 0.004; *p*-value = 0.005.

Table 2. The correlation between the Pirani clinical score value and the degree of the dorsoplantar talo-1st metatarsal angle.

Pirani score	Talo-1st metatarsal angle DP								Total	
	Normal 0–20	Mild 20–40	Moderate 40–60	Severe >60	No.	%				
00–4.5	03	25.05%	04	33.3%	02	16.7%	03	25.0%	12	48%
05–06	00	00.0%	01	07.7%	00	00.0%	12	92.3 %	13	52%
Total	03	12.1%	05	20.0%	02	08.0%	15	60.0%	25	100%

Chi-square tests = 0.002; *p*-value = 0.001.

Table 3. The correlation between the Pirani clinical score value and the degree of the dorsoplantar talocalcaneal angle on the DP view (hindfoot varus).

Pirani score	Dorsoplantar Talocalcaneal Angle on the DP view								Total	
	Normal 25–40	Mild 20–25	Moderate 15–20	Severe >15	No.	%				
00–4.5	03	25.0%	05	41.7%	03	25.0%	01	8.3%	12	100.0%
05–06	08	61.5%	03	23.1%	01	07.7%	01	07.7%	13	100.0%
Total	11	44.0%	08	32.0%	04	16.0%	02	08.0%	25	100.0%

Chi-square tests = 0.156; *p*-value = 0.161.

Table 4. The correlation between the Pirani clinical score value and the degree of the lateral tibio-calcaneal angle on the DP view (hindfoot equinus).

Pirani severity score	Tibio-calcaneal angle L							Total		
	Count	% within Pirani score	Normal 60–90	Mild 90–110	Moderate 110–130	Severe >130				
0–4.5	03	25.0%	03	25.0%	01	08.3%	05	41.7%	12	100.0%
4.5–6	00	00.0%	03	23.1%	04	30.8%	06	46.2%	13	100.0%
Total		% within Pirani score	03	06	05	11	25			
			12.0%	24.0%	20.0%	20.0%	100.0%			

Chi-square tests = 0.105; *p*-value = 0.206.

90°, any increase in the angle more than 90° would be considered hindfoot equinus, with further classification to mild moderate and severe, accordingly. The data obtained showed no statistical significance (p -value > 0.05) which can be explained by the random distribution of the angle with 41.7% of patient with TPS below the 4.5 having a severe talocalcaneal angle measures (Table 4). No patient of those having TPS above the 4.5 had a normal tibio-calcaneal angle.

DISCUSSION

This is a prospective hospital-based study, conducted to describe the anatomical bony arrangement of the CTEV deformity by measuring four angles, each one referring to a component in the deformity, and to correlate these findings with the clinical scoring system subjectively used to describe the severity of this deformity.

The study was conducted over a period of nine months. The sample was selected as an overall coverage of children affected with the clubfoot encountered during the research period. Although it had been reported in the literature that clubfoot is a common congenital malformation, the small sample size in this study (25 children) can be explained by the fact that, in average, only few cases present as new case every month and most of the cases attending the clinic were excluded according to the exclusion criteria. A prospective study of all congenital anomalies presenting at the neonatal unit of Queen Elizabeth Central Hospital, Banter, Malawi, conducted in 2 year period, reported that the recorded number of children with clubfoot deformity was 64 or 1 in 496 births, translating to 2 per 1,000 births [10].

In the present study, the majority of cases were males (62.5%). The male-to-female ratio obtained was 1.6:1. This is similar to that found in the literature [10]. The age distribution was categorized into three groups: a) before age 6 months which comprised the majority (70.6%). This majority can be explained by the fact that such congenital deformity presents earlier. This determines the management options [11]. b) Between 6 month to 1 year constituted 11.8% of cases and c) more than one year was 17.65%.

This is a normal walking age for the child and those were considered neglected cases as they asked for medical opinion late, making the surgery the likely method of treatment [12]. Fifty per cent of cases presented with bilateral deformity [2,10]. The relation between the underlying bony anatomy and the Pirani scoring system was obtained by categorising the TPS into two groups using the 4.5 as cut-off point, above and below, for which the severity and management option differ [9]. Four bony measurements were used to describe each component of the deformity, categorising the four angles measurement into normal, mild, moderate and severe.

The first measure was the Talo-1st metatarsal angle on the DP view to describe the fore-foot adduction, with 0°–20° as a normal value and any increase above the 20° would be considered as a forefoot adduction. Twelve patients had a low severity score (TPS < 4.5) and 13 cases were having a high severity score (TPS > 4.5), and 92.3% (12 feet) of those having the high clinical score were having a severe angle measure of more than 60 degrees. Those with the low TPS of less than 4.5 had a random distribution to the angle ranging from 25% having a normal angle, 33.3% with mild (20–40 degree), 16.7% having a moderate (40°–60°). Severe forms were encountered in 25% of cases. This is statistically significant with a p -value of 0.001 conforming to similar previous studies [7,13].

The Talo-1st metatarsal angle on the lateral view was used to measure the mid-foot cavus with a normal value of 0°–4°, and any increase above 4° was considered a pes cavus. Similar distribution of the data to the above was obtained, with 92.3% of those with a high TPS having a severe form of >30° for this angle. The rest were distributed randomly within a low TPS with 16.7% having a normal angle, 50% having a moderate angle of 15°–30°, and 33.3% having a severe angle. This was found statistically significant with a p -value of 0.005, which is similar to the data by Younger et al. [14].

Conversely, measuring the talocalcaneal angle on the DP view to obtain the hind-foot varus, with 20°–40° as a reference, was found to be

statistically insignificant with a *p*-value of 0.161. About 61.5% of patients with a high TPS had a normal angle and random distribution among those having a low TPS. This is in agreement with Thompson et al. [15] who found no correlation between AP-TCA and functional rating. In contrast to this opinion, Yamamoto and Furuya [16] found a statistically significant correlation of clinical scoring with AP-TCA.

The tibio-calceal angle on the lateral view for the hind-foot equinus was measured, with a normal range between 60° and 90°, and any increase above the 90 degree was considered equinus. This angle was found statistically insignificant with a *p*-value of 0.206. It showed a random distribution among those having a higher TPS, with 46.2% having a severe angle of more than 130°, 30.8% having a moderate angle and 27.3 having a mild form; but no patient was having a normal angle. In contrast, in those having low TPS only 23.1% of those with low TPS had a normal angle and 41.7% had a severe angle. This contradicts with what has been reported in the literature [17,18]. In fact, this angle provided the most reliable angle index of correction. According to some authors, in those with low TPS having a higher angle, the equinus is the last one to be corrected in the deformity by serial casting.

ACKNOWLEDGEMENTS

The authors would like to thank the families and patients who have been enrolled in the study.

CONFLICT OF INTERESTS

None.

FUNDING

The study was funded by MHE (1st author) and University of Gezira Deanship of Graduate Study.

ETHICAL APPROVAL

Ethical clearance was obtained from the Ethics Committees of the University of Gezira and State Ministry of Health. Written consents were

obtained from the parents of eligible infants for study enrolment and publication of medical details. Confidentiality was ensured at all the stages.

REFERENCES

- Gibbons, PJ, Gray, K. Update on clubfoot. *J Paediatr Child Health*. 2013;49(9):E434–7. PMID: 23586398. <https://doi.org/10.1111/jpc.12167>.
- Zionts LE, Jew MH, Ebramzadeh E, Sangiorgio SN. The influence of sex and laterality on clubfoot severity. *J Pediatr Orthop*. 2017;37(2):e129–33.
- Evans A. *Paediatrics. The pocket podiatry guide*. London, UK: Churchill Livingstone, Elsevier, Chapter 2; 2010. p 18.
- Lehman WB, Mohaideen A, Madan S, Scher DM, Van Bosse HJ, Iannacone M, et al. A method for the early evaluation of the Ponseti (Iowa) technique for the treatment of idiopathic clubfoot. *J Pediatr Orthop*. 2003;12(2):133–40.
- Bansal VP, Daniel J, Rai J. Radiological score in the assessment of clubfoot. *Int Orthop*. 1988;12(3):181–5. PubMed PMID: 3182121.
- Joseph B, Bhatia M, Nair N. Talocalcaneal relationship in clubfoot. *J Pediatr Orthop*. 2001;21:60–4.
- Prasad P, Sen RK, Gill SS, Wardak E, Saini R. Clinico-radiological assessment and their correlation in clubfeet treated with postero-medial soft-tissue release. *Int Orthop*. 2009;33(1):225–9.
- Hussain FN. The role of the Pirani scoring system in the management of club foot by the Ponseti method. *J Bone Joint Surg Br*. 2007;89(4):561; author reply 561-2.
- David BH, Olayinka OA, Oluwadare E, Ayodele OE, Joseph OM, Olujide A. Predictive value of Pirani scoring system for tenotomy in the management of idiopathic clubfoot. *J Orthop Surg (Hong Kong)*. 2017;25(2):2309499017713896. <https://doi.org/10.1177/2309499017713896>. PubMed PMID: 28617179.
- Mkandawire NC, Kaunda, E. Incidence and patterns of congenital talipes equinovarus (clubfoot) deformity at Queen Elizabeth Central Hospital, Banter, Malawi. *East Central Afr J Surg*. 2004;9(2):28–31.
- Göksan SB, Bursali A, Bilgili F, Sivacioğlu S, Ayanoğlu S. Ponseti technique for the correction of idiopathic clubfeet presenting up to 1 year of age. A preliminary study in children with untreated or complex deformities. *Archives of orthopaedic and trauma surgery*. 2006 Jan;126(1):15–21.

12. Lourenço AF, Morcuende JA. Correction of neglected idiopathic club foot by the Ponseti method. *Bone Joint J.* 2007;89-B(3):378–81. Accessed October 04, 2017.
13. Laaveg SJ, Ponseti IV. Longterm results of treatment of congenital clubfoot. *J Bone Joint Surg (Am).* 1980;62:23–31.
14. Younger AS, Sawatzky B, Dryden P. Radiographic assessment of adult flatfoot. *Foot Ankle Int.* 2005;26(10):820–5. PubMed PMID: 16221454.
15. Thompson GH, Richardson AB, Westin GW. Surgical Management of resistant congenital talipes equinovarus. *J Bone Joint Surg (Am).* 1982;64:652–65.
16. Yamamoto H, Furuya K. One stage postero medial release of congenital clubfoot. *J Paediatr Orthop.* 1988;8:590–5.
17. Reimann I, Anderson HB. Early surgical treatment of congenital clubfoot. *Clin Orthop* 1974; 102:200–6.
18. Handelsman JE, Soloman L. The assessment of correction in clubfeet. *SA Med J.* 1973;13:1909–11.