Original Article

Radiography and sonography of clubfoot: A comparative study

Satish Kumar Bhargava, Anupama Tandon, Meenakshi Prakash, Shobha S Arora[1], Shuchi Bhatt, Sumeet Bhargava

Abstract

Background: Congenital talipes equinovarus is a common foot deformity afflicting children with reported incidence varying from 0.9/1000 to 7/1000 in various populations. The success reported with Ponseti method when started at an early age requires an imaging modality to quantitate the deformity. Sonography being a radiation free, easily available non-invasive imaging has been investigated for this purpose. Various studies have described the sonographic anatomy of normal neonatal foot and clubfoot and correlated the degree of severity with trends in sonographic measurements. However, none of these studies have correlated clinical, radiographic and sonographic parameters of all the component deformities in clubfoot. The present study aims to compare the radiographic and sonographic parameters in various grades of clubfoot.

Materials and Methods: Thirty-one children with unilateral clubfoot were examined clinically and graded according to the Demeglio system of classification of clubfoot severity. Antero-posterior (AP) and lateral radiographs of both normal and affected feet were obtained in maximum correction and AP talo-calcaneal (T-C), AP talo-first metatarsal (TMT) and lateral T-C angles were measured. Sonographic examination was done in medial, lateral, dorsal and posterior projections of both feet in static neutral position and after Ponseti manouever in the position of maximum correctability in dynamic sonography. Normal foot was taken as control in all cases. The sonographic parameters measured were as follows : Medial malleolar- navicular distance (MMN) and medial soft tissue thickness (STT) on medial projection, calcaneo-cuboid (C-C) distance, calcaneo-cuboid (C-C) angle and maximum length of calcaneus on lateral projection, length of talus on dorsal projection; and tibiocalcaneal (T-C) distance, posterior soft tissue thickness and length of tendoachilles on posterior projection. Also, medial displacement of navicular relative to talus, mobility of talonavicular joint (medial view); reducibility of C-C mal alignment (lateral view); talonavicular relation with respect to dorsal/ ventral displacement of navicular (dorsal view) and reduction of talus within the ankle mortise (posterior view) were subjectively assessed while performing dynamic sonography. Various radiographic and sonographic parameters were correlated with clinical grades.

Results: MMN distance and STT measured on medial view, C-C distance and C-C angle measured on lateral view and tibiocalcaneal distance measured on posterior view showed statistically significant difference between cases and controls. A significant correlation was evident between sonographic parameters and clinical grades of relevant components of clubfoot. All radiographic angles except AP T-C angle were significantly different between cases and controls. However, they did not show correlation with clinical degree of severity.

Conclusion: All radiographic angles except AP T-C angle and sonographic parameters varied significantly between cases and controls. However, radiographic parameters did not correlate well with clubfoot severity. In contrast, sonography not only assessed all components of clubfoot comprehensively but also the sonographic parameters correlated well with the severity of these components. Thus, we conclude that sonography is a superior, radiation free imaging modality for clubfoot.

Key words: Clubfoot, congenital talipes equinovarus, pediatric, radiography, sonography

Departments of Radiology and Imaging, and [1]Orthopaedics, UCMS and GTB Hospital, Delhi, India

Address for correspondence: Dr. Satish Kumar Bhargava, Department of Radiology and Imaging, UCMS and GTB Hospital, Delhi – 110095, India.
E-mail: skbhargava9731@rediffmail.com

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Introduction

Congenital talipes equinovarus (CTEV) is a common congenital foot deformity; with an incidence varying from 0.9/1000 to 4–7/1000 live births in different population.[1,2] It is a complex deformity with four components: hindfoot equinus, hindfoot varus, forefoot adduction and talo-navicular subluxation.[2]

The treatment of clubfoot is primarily conservative by Ponseti method of serial manipulation and casting, surgical correction being reserved for resistant cases.[3] Reducibility to normal anatomy is greater when the treatment is begun early.[4]

The clinical grading of clubfoot is limited by interobserver variability and difficulties in accurate quantification of component deformities by palpation in the small feet particularly in a chubby child.[4] Hence, the need was felt for an imaging modality to detect and quantify the deformities in early neonatal period itself.

Following the standardization of radiographic technique done by Simons *et al.* in 1977,[5] radiography has been the only imaging available for clubfoot evaluation till recently. The non-visualization of cartilaginous tarsal bones, inaccurate angular measurements on radiographs due to delayed appearance and eccentric location of ossification centers, and hazards of radiation exposure are its limitations.

Sonography has emerged as a promising imaging modality for musculoskeletal conditions due to its dynamic capability and visualization of cartilaginous structures and soft tissues. It can determine the pliability of various compartments of clubfoot and their correctability on manipulation.[4] Being radiation free, it can be repeatedly performed for monitoring response to treatment. Any spurious correction or non-responding foot can be picked up early for operative treatment.[6] Desai *et al.* sonographically picked up spurious correction in as many as 15.6% of clubfoot cases.[6]

Various authors have described the sonographic anatomy of the normal neonatal foot and clubfoot, employing different scan planes, and have devised some sonographic measurements.[1,6-10] No study so far has described the radiographic and sonographic findings in various clinical grades of clubfoot separately. Also, comparative studies of sonographic and radiographic parameters are lacking. Hence, this study was undertaken to compare the radiographic and sonographic findings in various grades of clubfoot.

Materials and Methods

A prospective case–control study was carried out in the Department of Radiology and Imaging and Department of Orthopaedics after obtaining approval from institutional ethical committee. A written and informed consent was obtained from parents/guardians of the subjects.

Thirty-one babies in the age group of 0–1 year and of either gender, having strictly unilateral idiopathic CTEV on clinical examination, were included. The unaffected foot was taken as control.

Only untreated cases of CTEV were included. All the infants whose caretakers refused consent, with prior treatment for CTEV, with associated neurological or other lower limb disorders and with isolated forefoot deformity were excluded from the study.

Data on detailed history, general physical and local examinations were recorded. Relevant clinical measurements were taken on both feet and grading of severity was done according to Diméglio system[4] in which the reducibility of four parameters with gentle manipulation is measured using a handheld goniometer: equinus in sagittal plane, varus in frontal plane, derotation of the calcaneopedal block in horizontal plane, forefoot relative to hindfoot in horizontal plane. A score was assigned to each one of the four parameters on a 4-point scale, with 4 points given for reducibility from 90° to 45°, 3 points from 45° to 20°, 2 points from 20° to 0°, 1 point from 0° to -20° and 0 point indicating reducibility of more than -20°. Four additional points were imparted, one point each for a marked posterior crease, medial crease, cavus deformity and poor muscle condition. These add up to a total of 20 points. The feet were graded according to the total score as follows: grade I: mild deformity with a score of 0–5 points; grade II: moderate deformity with a score of 5–10 points; grade III: severe deformity with score of 10–15 points; and grade IV: very severe deformity with a score of 15–20 points.[2]

Antero-posterior (AP) and lateral radiographs of both normal and affected feet were taken in position of maximum correction. AP talocalcaneal (TC), AP talo-first metatarsal (T–MT) and lateral TC angles were measured as given by Simons *et al*.[5]

A high-resolution real-time sonographic examination of both feet was done using a linear broadband 5–12 MHz transducer (Philips HDI 5000 scanner). Four standardized projections were taken: medial, lateral, dorsal and posterior. All measurements were obtained in neutral position and in maximum correction using simulated Ponseti maneuver.

Medial projection was obtained by placing the transducer at the medial border of foot in a slightly oblique position to visualize the medial malleolus and the navicular in one plane. The parameters measured in this projection were medial malleolar navicular (MMN) distance (distance between medial malleolus and navicular) and medial soft tissue thickness (STT; measured from skin surface to talus). On dynamic sonography, where the Ponseti maneuver was applied to bring the foot in position of maximum correction while performing sonography the medial displacement of the navicular in relation to the head of the talus (percentage uncovering of talar head graded as: 1=no displacement, 2=>50% coverage of talar head by navicular, 3=<50% coverage of talar head by navicular) and mobility of talonavicular joint (reducibility to normal as: 1=no mobility, 2=intermediate mobility, 3=reduction to normal position) were noted.

Lateral projection was obtained by positioning the transducer along lateral border of foot parallel to plantar aspect for assessment of calcaneo-cuboid (C–C) relationship. Parameters measured were C–C distance (as perpendicular dropped to mid-point of cuboid from tangent to calcaneus), C–C angle (angle between the tangents to calcaneus and cuboid) and maximum length of calcaneus.

Dorsal projection was achieved by positioning the transducer longitudinally and in transverse position at the dorsal aspect of foot to visualize talonavicular relation and maximum length of talus was measured.

Posterior projection was obtained by placing transducer vertically on the back of foot in midline to assess the tibiocalcaneal (tcal) relationship (tcal distance measured between the distal ossified tibial metaphysis and proximal surface of ossific nucleus of calcaneus), posterior compartment soft tissue (thickness from skin surface to tibial cortex) and tendoachilles (length of tendon measured from musculotendinous junction to distal calcaneal insertion).

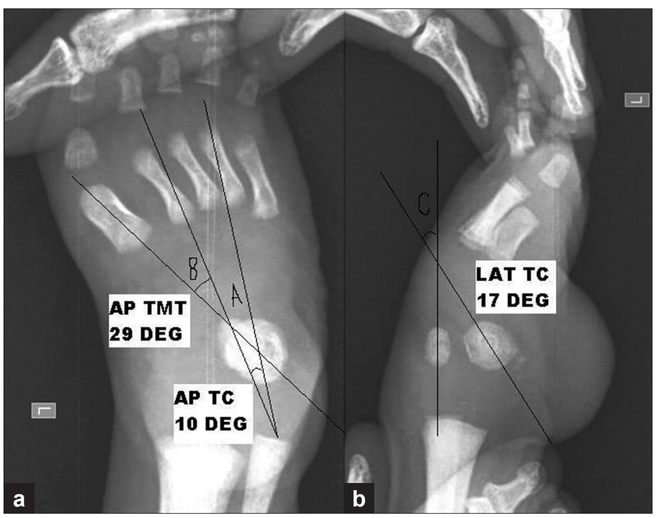

Figure 1: Anteroposterior (a) and lateral (b) radiographs of clubfoot showing AP talo-calcaneal angle-A; AP talo-first metatarsal angle-B and lateral talo-calcaneal angle –C. Normal contralateral foot (not shown) had AP TC:30º; AP TMT: (-16)º ; Lat TC: 46º

The Student's paired *t*-test was used to compare the continuous data between cases and controls. Relevant radiographic and sonographic parameters and grading of severity of clubfoot were correlated by Spearman's rank correlation. For correlation between relevant continuous parameters, Pearson correlation was used.

Results

In our study, a total of 31 babies with unilateral CTEV, comprising 11 girls and 20 boys, were included, with a mean age of 5 weeks (range 4 days to 28 weeks). The left foot was affected in 45% of cases (14 feet) and the right side was affected in 55% of cases.

According to Diméglio system of classification, 21 cases belonged to grade III (67.7%), 8 cases to grade II (25.8%), 2 cases to grade IV (6.5%) and there were no cases of grade I.

There was a statistically significant difference in the values of AP T–MT, lateral T–C angles and the T–C index between the cases and controls but not the AP T–C angle [Figure 1]. The AP T–MT angle was more on the positive side in clubfoot and the lateral T–C angle was decreased in clubfoot [Table 1].

On high-resolution sonography, optimal visualization of both bony and cartilaginous tarsal bones and the surrounding soft tissues and tendons was possible. The medial oblique coronal view showed that talar head was uncovered due to navicular subluxation in clubfoot. The MMN distance was found to be significantly reduced in cases, and medial STT and intraarticular soft tissue were found to be increased in cases as compared to controls [Table 1, Figure 2]. A thickened "gristle" was seen between MM and navicular in 42.5% (n = 14) cases with mean thickness of 2.0±1.9 mm.

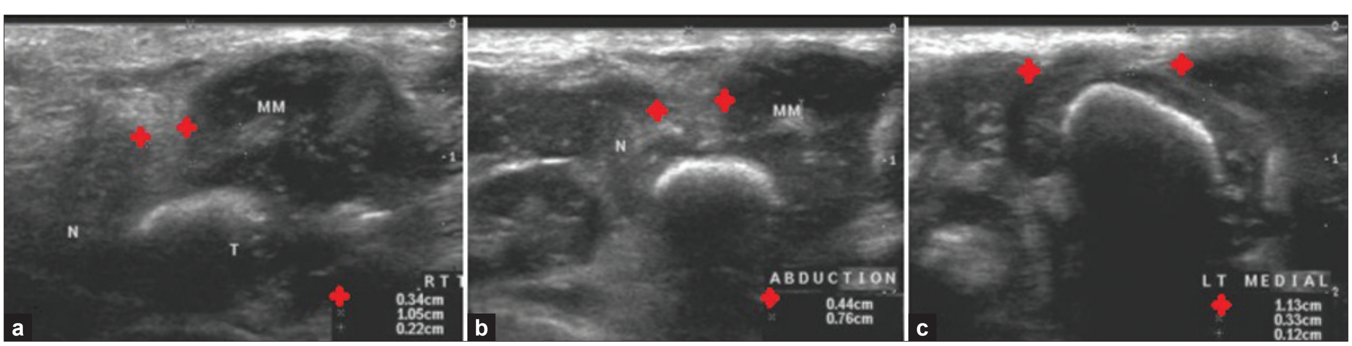

Figure 2: Medial view showing reduced MMN distance in clubfoot (a), correction on Ponseti (b) and normal foot for comparison (c)

Table 1: Comparison of the radiographic and sonographic parameters between cases and controls

Parameters	Range		Mean ± SD (in degrees)		*P* value
	Cases	Controls	Cases	Controls	
Radiographic parameters					
AP view					
a) T–C angle	7°–52°	17°–44°	25.6° ± 13.4°	29.8° ± 8.1°	0.133
b) T–M angle	(−15)°–50°	(−25)°–10°	14.9° ± 15.0°	(−12.1)° ± 7.7°	<0.05
Lateral view					
Lateral T–C angle	5°–82°	20°–90°	33.8° ± 16.1°	44° ± 14.5°	0.003
Using both views					
TC index	27°–125°	56°–130°	59.5° ± 21.2°	73.7° ± 17.3°	0.003
Sonographic parameters					
Medial view					
MMN distance (mm)					
Neutral	0.3–14.1	7.6–15.0	3.2 ± 3.3	10.1 ± 1.4	<0.001*
Abduction	0.4–17.4	8.8–15.0	5.5 ± 4.4	11.6 ± 1.2	<0.001*
Medial soft tissue thickness (mm)					
Neutral	4.6–15.8	1.9–5.9	9.7 ± 2.7	3.5 ± 1.1	<0.001*
Intraarticular soft tissue (mm)	0.1–5.3	0.1–1.8	1.9 ± 0.9	0.9 ± 0.3	<0.001*
Lateral view					
C–C distance (mm)	0.7–11	0.00–4.2	3.4 ± 1.9	0.7 ± 1.0	<0.01*
C–C angle (°)	9°–43°	0°–24°	23.7° ± 10.2°	4° ± 6.6°	0.000* (<0.01)
Posterior view					
Tcal distance (mm)					
Neutral	6.1–18.9	11.4–21.7	13.0 ± 3.2	15.7 ± 2.4	<0.01*
Dorsiflexion	6.5–24.2	12.4–22.4	14.2 ± 3.6	16.5 ± 2.4	0.001*
Plantar flexion	3.8–16.6	7.9–19.4	11.9 ± 2.6	14.1 ± 2.1	<0.01*
Dorsiflexion − plantar flexion	0.3–8.7	1.0–6.9	2.3 ± 1.8	2.4 ± 1.3	0.700
Posterior soft tissue (mm)	5.9–13.5	4.6–38.1	10.2 ± 2.1	8.9 ± 5.8	0.275
Length of tendoachilles (mm)	12.5–120.6	1.4–62.8	28.8 ± 19.3	31.4 ± 11.0	0.444

*Significant at *P* value <0.05; highly significant at *P* value <0.01; T–C: Talo-calcaneal; T-M: Talo-first metatarsal; TC index: Sum of AP and lateral TC angles; MMN: medial malleolus navicular; CC: calcaneo cuboid ; tcal: tibiocalceneal

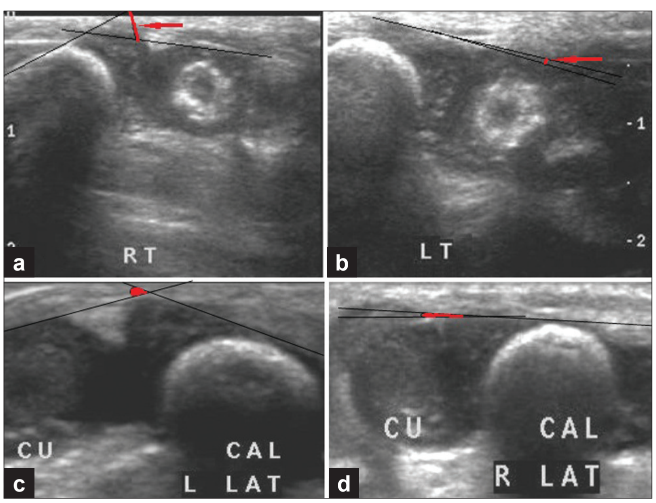

Figure 3: Lateral view showing increased C-C distance (a), increased C-C angle (c), in clubfoot. Normal C-C distance (b) and angle (d) for comparison

The lateral view demonstrated the medial deviation of cuboid in clubfoot as evident by the significantly increased C–C distance and angle in clubfeet [Table 1, Figure 3].

The dorsal longitudinal and transverse views demonstrated the alignment of talus and navicular. The visualization of partly ossified talus and cartilaginous navicular in the same plane signified altered relationship in clubfeet (n = 30; 96.8%).

The posterior view revealed the talus to be within ankle mortise in all normal feet on posterior views, but not so in clubfeet (completely outside mortise in 22 cases and partly outside in 9 cases) [Figure 4].

The tcal distance measured was found to be significantly shorter in clubfeet as compared to normal feet [Table 1, Figure 4]. The mean posterior STT was more on the affected side; however, this difference was not statistically significant. The length of Achilles tendon, seen posteriorly as hyperechoic fibrillar structure, was reduced in CTEV cases vis-à-vis controls, but again, the difference was not significant statistically.

On dynamic sonography, mobility of talonavicular and C–C joint and reducibility of talus within ankle mortise was assessed. In 7 (22.58%) cases, talonavicular joint was completely reducible to normal, 22 (70.97%) cases were partly reducible and 2 (6.45%) cases showed no mobility. In 13 (41.9%) cases, C–C joints were reducible to normal and the rest were partly reducible. In 12 (38.7%) clubfeet, talus was completely reducible within ankle mortise and in remaining cases it was partly reducible.

Table 2a: Correlation of grading of clubfoot severity with radiographic and sonographic parameters

Clinical grading of equinus		
Sonographic parameter	**r**	***P* value**
Tcal distance		
Neutral	−0.490*	0.005
Dorsiflexion	−0.453**	0.010
Posterior soft tissue	−0.018	0.922
Length of tendoachilles	−0.289	0.115
Radiographic parameter		
Lateral T–C angle	−0.015	0.938
Clinical grading of hindfoot varus		
Sonographic parameter	**r**	***P* value**
C–C distance	0.260	0.157
C–C angle	−0.412**	0.021
Radiographic parameter		
AP T–C angle	−0.220	0.235
AP talo-first metatarsal angle	0.271	0.140
Clinical grading of derotation of calcaneopedal block		
Sonographic parameter	**r**	***P* value**
MMN distance		
Neutral	−0.380*	0.035
Abduction	−0.488**	0.005
Medial soft tissue thickness	0.283	0.123
C–C distance	0.145	0.436
C–C angle	0.368*	0.042
Radiographic parameters		
AP T–C angle	−0.229	0.215
AP talo-first metatarsal angle	0.190	0.306
Clinical grading of forefoot adduction relative to hindfoot		
Sonographic parameter	**r**	***P* value**
MMN distance		
Neutral	−0.610*	<0.001
Abduction	−0.601*	<0.001
Medial soft tissue thickness	0.269	0.143
C–C distance	0.194	0.295
C–C angle	0.372**	0.039
Radiographic parameters		
AP T–C angle	−0.151	0.418
AP talo-first metatarsal angle	0.144	0.440

*Correlation is significant at the 0.01 level (two-tailed); **Correlation is significant at the 0.05 level (two-tailed)

The mobility of talonavicular joint was found to reduce significantly with reduction in MMN distance and with increase in medial STT, C–C distance and angle. A significant decrease in total and ossified parts of talus and calcaneum was evident in clubfeet with reduced foot lengths.

On correlating sonographic and radiographic parameters with clinical grading [Tables 2a and 2b], the *grading of equinus* was found to be significantly correlated with tcal distance; the tcal distance decreased as the severity of equinus increased. The posterior STT and length of tendoachilles did not show any significant correlation among various grades. The severity of hindfoot varus was found to be significantly correlated with C–C angle but not C–C distance; the C–C angle increased as the grading of hindfoot varus increased. The MMN distance significantly decreased with increasing *derotation of calcaneopedal block*. Also, C–C angle was significantly correlated with grading of derotation of calcaneopedal block showing an increasing pattern with increasing grading. No such correlation was noted with medial STT and C–C distance. *Grading of forefoot adduction relative to hindfoot* showed a significant correlation with MMN distance and C–C angle but not with medial STT. The MMN distance reduced and C–C angle increased with increasing grade. None of the radiographic angles showed any significant correlation with grading of severity.

Discussion

In spite of being one of the commonest skeletal malformations, there is still no universally accepted method for assessing clubfoot. Wainwright *et al.* studied the reliability of four most commonly used clinical classification systems – those described by Catterall, Diméglio *et al.*, Harrold and Walker, and Ponseti and Smoley, but found none of them to be entirely satisfactory.[4] Hence, the need was felt for an imaging method as a guide while treating foot deformities in children. For this study, the system of Diméglio *et al.*, the most reliable of the above four, was adopted as it graded the severity of individual components of clubfoot deformity allowing a correlation with relevant sonographic and radiographic parameters.

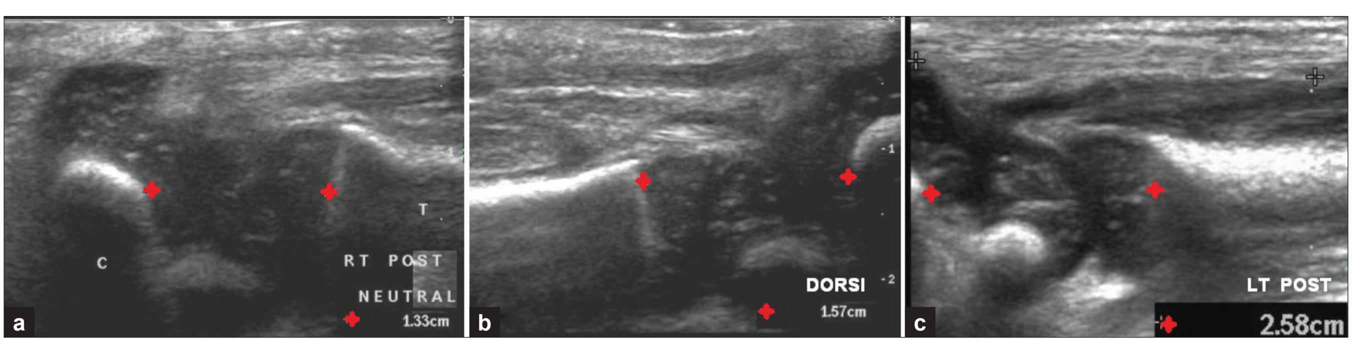

Figure 4: Posterior projection showing reduced tcal distance in clubfoot (a), correction on Ponseti (b) and normal foot for comparison (c)

Table 2b: Various sonographic parameters in different grades of clubfoot severity

Grades of equinus	No. of cases (%)	Tcal distance (mm) Dorsiflexion	
		Range	Mean ± SD
1	0		
2	18 (58.07)	1.11–2.42	1.57 ± 0.33
3	13 (41.93)	0.65–1.68	1.23 ± 0.30
4	0	-	-

Grades of hindfoot varus	No. of cases (%)	C–C angle (°)	
		Range	Mean ± SD
1	7 (22.58)	9–29	17.28 ± 6.96
2	12 (38.71)	10–36	22.75 ± 7.71
3	12 (38.71)	10–43	28.41 ± 12.20
4	0	-	-

Grades of derotation of calcaneopedal block	No. of cases (%)	C–C angle (°)		MMN distance (mm) Abduction	
		Range	Mean ± SD	Range	Mean ± SD
1	6 (19.35)	9–29	16. ± 7.2	2.5–17.4	10.7 ± 5.0
2	15 (48.39)	10–40	24.1 ± 9.1	1.1–16.1	5.0 ± 3.9
3	10 (32.26)	10–43	27.6 ± 11.6	0.4–4.9	3.1 ± 1.4
4	0	-	-	-	-

Grades of forefoot adduction relative to hindfoot	No. of cases (%)	C–C angle (°)		MMN distance (mm) Abduction	
		Range	Mean ± SD	Range	Mean ± SD
1	4 (12.90)	0–4	2 ± 1.8	11.6–17.4	13.5 ± 2.6
2	22 (70.97)	0–24	3.9 ± 6.7	1.1–16.1	4.8 ± 3.3
3	5 (16.13)	0–17	6 ± 8.3	0.4–4.6	2.4 ± 1.5
4	0	-	-	-	-

Although the radiographic views were easy to obtain and reproducible, there was difficulty (35% cases) while drawing the long axis of talus and calcaneus due to small and round ossific nuclei. Such difficulty was not encountered by Simons *et al.*[5] in their study, possibly because their study group had older children (3 months to 2 years) as compared to our study (<8 weeks in age). In our study, the cut-off values concurred with those described by Simons *et al.*[5]: ≤17° (Simons *et al.*: < 20°) for AP T–C angle, >0° for T–MT angle (Simons *et al.*: toward positive side) and <39° for lateral T–C angle (Simons *et al.*: <35°). However, in contradiction to Simons *et al.*,[5] the AP T–C angle did not vary significantly between cases and controls (*P* value: 0.133). Ippolito *et al.*[11] had also found AP T–C angle to be a poor predictor of hindfoot correction in 75% of cases. The possible explanation given by Howard and Benson[12] was that AP T–C angle did not correspond to real anatomic relationships owing to eccentric position of ossific nucleus in the markedly medially angulated neck of talus.

Simons *et al.*[5] had proposed AP T–C angle as an indicator of varus, AP T–MT angle as indicator of talonavicular subluxation and lateral T–C angle for equinus. Taking these associations into account; in the present study, the various angles were compared with clinical grades, but these correlations were not found to be statistically significant. Our findings are in concurrence with those of Herbsthofer *et al.*[13] who reported that definitive assignment of angle measurements to healthy feet or clubfeet was not possible due to overlap in the values and categorization of clubfeet severity on the basis of radiographs makes little sense due to high standard deviation within the individual groups.

In this study, a combination of sonographic views from those previously described by various authors[6-10] were adopted. Thus, all the components of clubfoot, i.e. medial, lateral, dorsal and posterior, were comprehensively evaluated in the same sitting. Besides static views, a dynamic assessment of talo-navicular mobility and calcaneo-cuboid relationship was done on simulated Ponseti maneuver.

MMN distance was significantly shorter in clubfoot compared to controls (*P* value: <0.01) in all positions, i.e. neutral and abduction. The mean value for MMN in abduction was 5.5±4.4 mm in cases and 11.6±1.2 mm in controls in the present study, while Shiels *et al.* reported the same to be 5.3±2.8 mm in cases and 11.9±2.6 mm in controls.[1] Medial STT was also significantly greater (nearly three times) in club foot than in controls (mean value of 9.7±2.7 mm in club foot and 3.5±1.1 mm in controls). In comparison, Aurell *et al.*[8] reported the same to be twice in cases as compared to controls (mean value of 11.6±2 mm in cases and 4.8±1.2 mm in controls). When these parameters (MMN and STT) were compared with the clinical grading of forefoot adduction and derotation of calcaneopedal block, MMN distance decreased and STT increased with increase in the grading of deformity. These correlations were highly significant (*P* value: <0.01), suggesting that these parameters can be used not only for defining but also for grading of severity of clubfoot.

The calcaneo-cuboid relationship was assessed with C–C distance and C–C angle; both were significantly increased in clubfoot. In the present study, mean C–C distance was found to be 3.4±2.0 mm in cases and 0.8±1 mm in controls as against a mean of 2.5±1.3 mm in cases and 1.0±1.1 mm in controls reported by Aurell *et al.*,[8] the only author group to measure this. The C–C angle in the present study was 23.7°±10.24° in cases and 4°±6.6° in controls; Gigante *et al*.[9] reported a mean of 20° in clubfoot and 10° in normal foot. They observed that the C–C angle was always less than 12° in normal feet, while in the present study, a C–C angle of >7° was found to have a sensitivity of 83.9% and specificity of 100% for the presence of CTEV. The C–C angle correlated significantly with forefoot adduction (*P* value: <0.05) and hindfoot varus (*P* value: <0.05) and increased with increase in forefoot adduction (r = 0.37) and hindfoot varus (r = 0.41). Also, the degree of reducibility of the C–C angle on everted position between various grades correlated significantly with the degree of hindfoot varus. This angle is an indicator of medial deviation of cuboid, which, if left untreated, results in residual deformity (locked cuboid) and is not easily detected by external inspection and radiographs as it ossifies late. Sonographic assessment can help pick up this deformity early.

Posterior view was useful to evaluate the tcal relationship and the ankle mortise. The tcal distance was a direct indicator of equinus; the mean tcal distances in neutral and maximum dorsiflexion were 13.0±3.2 mm and 14.2±3.6 mm in cases and 15.7±2.4 mm and 16.5±2.4 mm in controls, respectively. Gigante *et al.*[9] reported a mean tcal distance of 9 mm in neutral and 10.5 mm in maximum dorsiflexion among cases and 10 mm and 20 mm, respectively, in controls. The tcal distance decreased significantly with increase in the severity of equinus (*P* value: <0.05). Length of tendoachilles was reduced in CTEV, though the difference was not statistically significant, possibly due to technical errors as there was difficulty in defining the upper limit of musculotendinous insertion. Although Bialik *et al.*[14] measured the length of tendoachilles; no clear end points have been defined. This is possibly the reason why no statistically significant difference between the tendon lengths was found between cases and controls in the present study.

Summarily, sonographic parameters correlating with clinical components of CTEV are: forefoot adduction with MMN distance, medial STT and C–C angle, derotation of calcaneopedal block with MMN distance, medial STT and C–C angle, equinus with tcal distance and hindfoot varus with lateral C–C angle.

The corelation of the observation with severity of CTEV was not possible in view of small number of feet in each grade. However, the results obtained from the present study point toward the potential of sonography as an imaging-based classification tool.

Conclusion

Both radiographic (except AP T–C angle) and sonographic parameters were significantly different between cases and controls. However, on comparing various grades of severity, only sonographic parameters showed significant correlation. Hence, we believe that sonography is a superior alternative to radiography for clubfoot imaging and should be increasingly used.

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