

THE CLUBFOOT REVISITED

Sureshwar Pandey
Anil Kumar Pandey

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Contents

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CHAPTER

Investigations for Clubfoot

"The greatest use of life is to spend it for something that will outlast it."

—William James

INVESTIGATIONS FOR CLUBFOOT (MAINLY OF ACADEMIC VALUE)

- *X-ray*: Prognostic?
- CT scan
- 3D computer modeling
- *MRI*: Guide to treatment
- *USG*: To detect clubfoot in utero (8–32 weeks fetus)
- *EMG*: Status of calf muscles
- *Color Doppler*: Vascular status in foot and leg

Investigations for Anesthesia (General Anesthesia)

Truly speaking investigations to be done for clubfoot are limited and that too have limited utility. The main investigations are:

- Clinical photography
- X-ray
- Ultrasonography
- Arthrography
- MRI

Clinical Photography

Clinical photographs provide static picture of deformity in selected pose. Photography of any deformity, and so for the clubfoot as well, is mandatory, since it not only helps in keeping the proper records, but also proves useful in:

- Noting the progress during the course of management.
- Providing warning to the treating surgeon when the improvement plateaued, and when the mode of management has to be changed.
- Convincing the parents about the progress and result of treatment.
- Assessing even the initial relapse of any component of the deformity in clubfoot on follow-up. Comparison of the results of different modes of management of clubfoot.
- A standard protocol of taking photograph from different sides should be followed for uniformity. We follow the simple method of photographs for visualizing the main deformity components of clubfoot such as:
  - For equinus deformity snap to be taken from medial side, i.e., in sagittal plane
  - For varus/valgus deformity from the back side, i.e., in frontal plane
  - For mid foot rotation around talus/deviation from the top in frontal plane
  - For abduction and adduction from the plantar side, i.e., in horizontal plane.

After final treatment photographs should be taken in:

- Standing in walker patients (simulated standing in nonwalkers)
- Standing on the toes and on the heels
- Squatting view—from the side and behind
- Plantar view—with patient sitting on the bed or floor with both lower limbs extended in symmetrical position and the feet in maximum dorsiflexed position.

In neglected cases, besides the views noted above, photograph should be taken in standing weight-bearing position with extended knee fully included. This view demonstrates the changes in the deformity on loaded feet along with any induced rotation of legs if any.

X-rays

Barwell was the first to describe the use of radiographs to evaluate the congenital talipes equinovarus (CTEV) in 1896. Perhaps since then only the radiographic evaluation of CTEV remained in considerable controversy. X-ray of newborn's foot and ankle shows ossific nuclei of distal tibia, talus, calcaneum, and the cuboid (appearing at around 0–3 weeks). In the very young infant, the talus and the calcaneum are globular, hence they are not truly helpful, and there will be great variability in the measurements. However, if one can wait till the ossification centers acquire reasonable shape, size, site, and configuration (usually by 4–6 months of age) reasonably accurate measurements can be made. The navicular (which is most displaced in clubfoot) does not ossify until the age of 3–4 years. Thus, the ossific centers for all the foot bones can be drawn accurately only after the age of 5–6 years. Radiographic parameters for evaluation of the clubfoot are not clearly producible and have an unacceptably high rate of interobserver error. Further we agree with Rose et al. (1985) observations—**radiographs are not helpful, being flat images of three-dimensional situations**.

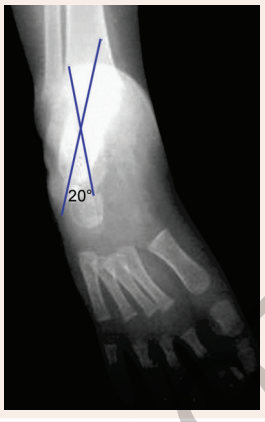
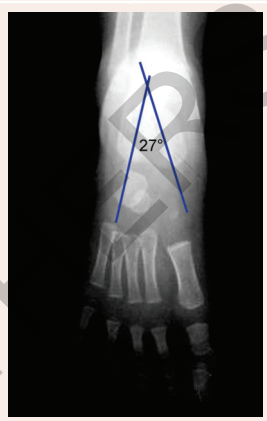
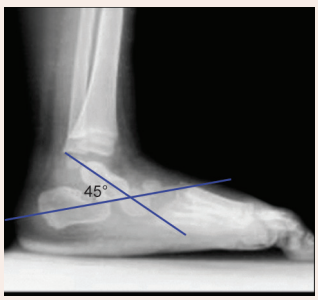
In clubfoot, X-rays are taken in several positions. However, in certain standard positions, X-rays should be taken in both pre- and post-treatment stages to compare the result of management. On the whole, the radiological assessment of clubfoot is not reliable method since it carries significant variability. It is difficult to consider the radiological angles of clubfoot in children for standard global values due to differences in positioning the infants and toddlers. Any change in position or even movement of the child will yield different measures. However, if radiological exposure and assessment is done in a particular center by same professional, the result may be accepted. Positions for taking the X-ray should be:

- Anteroposterior view X-ray of forefoot in forced abduction and adduction to assess the degree of fixation of cuboid to metatarsals and calcaneum.
- Superoinferior (dorsoplantar view) view of both feet in as far as symmetrically aligned position as possible to assess the deviation of forefeet, and to measure the Kites angle.
- Stress lateral view of whole foot and ankle, i.e., maximum dorsiflexion and plantar flexion position. The tibiocalcaneal angle should be measured on this view. Since the calcaneum assumes the adult shape early, this angle can be measured in proper way.
- Anteroposterior view of ankle joint should be taken in as far neutral position as possible, since the ankle in this view usually looks distorted due to varying degrees of fixed equinus.

Talocalcaneal angle: The talocalcaneal angle is the angle subtended between a line through long axis of talus and another line through long axis of calcaneum. Angle should be calculated in both anteroposterior and lateral view **(Table 8.1)**.

The normal range of anteroposterior talocalcaneal angle varies from 30 to 55°. In clubfoot, this angle progressively decreases

TABLE 8.1: Talocalcaneal angle in clubfoot and normal foot and radiographs (Ponseti et al. 1981).

Talocalcaneal angle	Clubfoot		Normal foot	
	Angle (degree)	Mean (degree)	Angle (degree)	Mean (degree)
Anteroposterior view	4–25	15.7	13–29	20.7
Lateral view	10–34	23.1	17–46	31.6
Talocalcaneal angle (as seen in anteroposterior roentgenogram)				
Talocalcaneal angle (as seen in lateral roentgenogram)				

in proportion to increasing heel varus. The normal range of talocalcaneal angle in lateral radiograph in dorsiflexed position of foot varies from 25 to 50°. In clubfoot, this angle progressively decreases with the severity of the deformity.

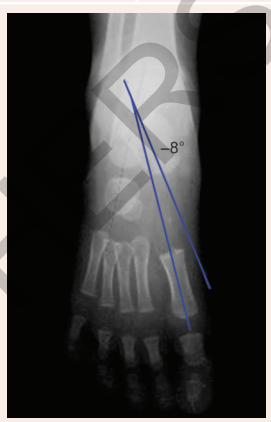
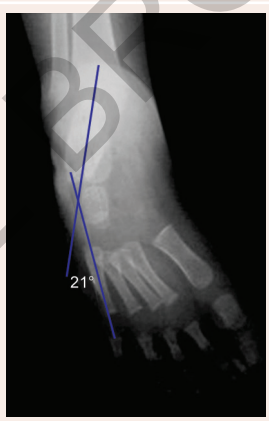
Talar first metatarsal angle: It is a radiographic measurement of forefoot adduction. A line through long axis of talus and another line through long axis of first metatarsal form the **talar first metatarsal angle**; a positive angle signifies adduction of the first metatarsal **(Table 8.2)**.

Tibiocalcaneal angle: In lateral, radiograph of ankle and foot taken in maximum dorsiflexed position. The tibiocalcaneal angle normally varies from 10 to 40°. In clubfoot, this angle usually becomes negative due to equinus position of calcaneum.

Calcaneal fifth metatarsal angle: The calcaneal fifth metatarsal angle is formed by a line through long axis of calcaneus and another line through long axis of fifth metatarsal; a positive angle signifies adduction of fifth metatarsal **(Table 8.2)**.

By and large **Kite's angles** on radiograph have been used for quantifying the deformity. This angle is measured on superoinferior (conventionally but wrongly said anteroposterior view of foot) radiograph by drawing lines along the axis of talus and calcaneum. The line of long axis of talus should coincide that of the first metatarsal and the long axial line of calcaneum should

TABLE 8.2: Talar first metatarsal and calcaneal fifth metatarsal angle in clubfoot and normal foot with radiographs (Ponseti et al. 1981).

	Clubfoot		Normal foot	
	Angle (degree)	Mean (degree)	Angle (degree)	Mean (degree)
Talar first metatarsal	–10 to +33	+3.28	–20 to +11	–3.37
Calcaneal fifth metatarsal	–20 to +20	–4	–18 to 5	–3.37
Talar first metatarsal (as seen in roentgenogram)				
Calcaneal fifth metatarsal (as seen in lateral roentgenogram)				

coincide that of the fifth metatarsal. The angle subtended between these lines if >35° indicates valgus and if <20° indicates hindfoot varus. However, it is difficult to draw these lines in the skeletally immature feet of the children with clubfoot. The talus and calcaneum in these feet appear as ossific nuclei, which tend to be round. Drawing line along the long axis of an almost round picture is inherently likely to produce errors in measurement.

The aforesaid X-ray evaluation of pre- and post-treatment of clubfoot must be done very cautiously lest a fallacious conclusion will be drawn. However, **lateral talocalcaneal angle can be more accurately and easily drawn and evaluated with comparatively more accuracy**.

McCauley (1947) stressed for the radiographic evaluation of the result of the treatment of the clubfoot. Further, he observed that except those clubfeet, which readily get corrected in early few months, others tend to recur, Yamamoto et al. (1994) and Simons (1994) observed that the **lateral tibiocalcaneal angle** is a more valid angular

measurement of equinus than the lateral talocalcaneal angle which measures only the angular relation between talus and the calcaneum, whereas the lateral tibiocalcaneal angle measures the relationship between the calcaneum and tibia. With the foot in forced dorsiflexion, the lateral talocalcaneal angle in the uncorrected clubfoot is typically <25°.

Talocalcaneal index: This index represents the sum of talocalcaneal angles measured in both anteroposterior and lateral view. In normal feet it ranges between 37 and 64° (mean 52.3°), whereas in clubfoot it ranges between 16 and 51° (mean 37.7°).

Barriolhet (1994) has described a simple angular measurement—**the first ray angle**—to evaluate the adduction and abduction of the forefoot. The "first ray angle" is the acute angle subtended between the axis of the first metatarsal and the tangential line from the base of the fifth metatarsal (the line drawn between the midpoints of base of fifth and first metatarsals on X-ray plates), the angle may be obtained without any effect of supination on the position of the hindfoot. For this measurement purpose, anteroposterior X-ray of foot is taken in which all the metatarsal heads touch the cassette and X-ray tube is placed vertically. On an average, this first ray angle should be 60° (52–70°) in a child under the age of 3 years. After the age of 4 years, this angle decreases significantly.

Kamagai et al (1977) described the **metatarsotalobimalleolar (MTB) angle** (the angle of the line from the center of the second metatarsal head to the talar head to the bimalleolar line) to measure the in-toeing deformity in congenital clubfoot.

Yamamoto and Furuya (1994) described two new angular measurements on anteroposterior view to evaluate the functional results of treated clubfoot. These measurements are:

- **Metatarsotalobimalleolar angle:** The angle of the line from the center of the second metatarsal head to the center of the talar head to the bimalleolar line—for the measurement of forefoot adduction.
- **Bimalleolocalcaneal (BMC) angle:** The angle of the longitudinal line of the calcaneum to the bimalleolar line—to measure the varus and subtalar rotation of calcaneum.

Other assessments can also be done on radiograph but they can be just the supporting findings to primary clinical evaluation.

- **Talo-first metatarsal angles:** This is measured on superoinferior (anteroposterior) projection as the angle subtended between the long axis of talus and the long axis of first metatarsal shaft. The normal angle ranges between 0 and 20°, and beyond this it denotes adduction of the forefoot in relation to the hindfoot. In the lateral projection (taken weight-bearing position in walkers and simulated weight-bearing position in nonwalker), the **talo-first metatarsal angle (Meary's angle)** helps in assessing the magnitude of cavus. Normally, Meary's angle is 0°. Anything more than 0° denotes cavus.
- **Assessment of relation between calcaneum and cuboid in clubfoot:** In anteroposterior radiograph, normally the midpoint of cuboid ossification center lies on the long axis of calcaneum. However, in calcaneocuboid subluxation, this relation changes and it can be graded into three grades:
  i. When the midpoint of ossification center lies between long axis of calcaneum and the medial tangential line (along the medial border of calcaneum) drawn parallel to the long axis of the calcaneum.
  ii. When the midpoint of cuboid ossification center lies medial to medial tangential line drawn as written above.
  iii. When the midpoint of cuboid ossification center lies proximal to the distal end of the ossification center of the calcaneum.

- **Calcaneo-fifth metatarsal angle:** This angle is formed between the long axis of calcaneum and the long axis of fifth metatarsal. A positive angle signifies adduction of the fifth metatarsal.

ROLE OF ARTHROGRAPHY IN CLUBFOOT

Since a few tarsal bones in infants have small or absent ossific nuclei, they cannot be measured in standard radiograph. In such cases, arthrography may be a useful method to observe the relationship among the tarsal bones as well as ankle. Arthrography of ankle (using 1 mL of contrast medium injected through anterior approach) and midtarsal joints (by injecting 0.5 mL of contrast medium into the talonavicular joint through lateral approach) help in delineating the shape of talus, the growth of ossific nucleus, and the relationship between the talus and ossific nucleus of calcaneum.

ROLE OF ULTRASONOGRAPHY IN CLUBFOOT

Ultrasonography proved to be a simple cost-effective, noninvasive, useful, and promising investigation. The main role of ultrasound is to detect the clubfoot in intrauterine fetus, which it can do in about 60% of cases—earliest at 12th week and latest by 32nd week of gestation **(Figure 8.1)**. However, pursuant to a fetal ultrasonographic study, Mamm et al. (2004) have postulated that the clubfoot deformity does not develop before the 12th week of gestation. Ultrasound can be done transabdominal ultrasonography (TAS) or transvaginal (TVS). TVS provides better visualization of the fetus. Modern high resolution TVS ultrasound provides better detection of skeletal anomalies up to 4 weeks earlier than by TAS. The latest three-dimensional ultrasonographic equipment should further improve the role of detection

FIG. 8.1: Ultrasonogram showing clubfoot in a 20 weeks fetus.
Courtesy: Bhola Hospital, Kurukshetra , Haryana, India.

of clubfoot and other anomalies. The clubfoot deformity starts appearing in the first trimester of pregnancy. The deformity gradually increases and becomes variably rigid at birth.

As already written in the chapter on classification of clubfoot, the clubfeet can be grouped into three types based upon the age of prenatal ultrasonographic detection, of course there may be several fallacies, like lack of enough experience in detecting the deformity in early fetal life, false positivity, etc. The three groups are as written on pages 35 and 36 and in **Table 8.3**. For better correctional assessment, CT appears to be more useful than plain radiography, which may be even misleading.

In image assessment of clubfoot, the plain radiography provides only a single-dimension view, while MRI projects objectively in three dimensions, the volumes of cartilage and osseous structure by multiplanar reconstructions and their axes in talus and calcaneum.

Thus, a pretreatment/preoperative measurement/assessment of talus will be

TABLE 8.3: Three groups of clubfoot.

Group	When detected (by TVS)	Percentage of idopathic clubfoot at birth
Early clubfoot	12th to 17th week of gestation	45%
Late onset clubfoot	18th to 24th week of gestation	45%
Very late onset clubfoot	25th to 32nd week of gestation	10%

useful. O'connor (1998) opined that radiography has definite predictive value in talonavicular alignment in majority of cases, however, MRI predicted talonavicular relationships in all cases, hence, MRI should always be done for confirmed assessment.

INVESTIGATION FOR VASCULAR INTEGRITY

Polo and Ruiz (1968) were the first to suspect the abnormalities of anterior tibial vascular tree in clubfeet, which later on was reported by Hootnick, Packard, and Levinsohn in 1990 after anterior compartment necrosis had developed following an operation for clubfoot.

Though anatomical dissection of normal feet demonstrated absent or severely diminished anterior tibial artery/vessels in more numbers (Hollingshead 1974), the ultrasound studies of normal feet could detect deficiency of or defects in only 2.2% of persons (Chavatzas 1974).

Anterior tibial arterial hypoplasia has been arteriographically observed in >85–90% of clubfeet (Ben–Menachem and Butler 1974, Greider et al 1982, and Hootnic et al. 1982). Further, the cutaneous vascular perfusion is variably deficient in the medial and lateral malleolar region. Hence, any incision which surrounds the malleoli may interrupt cutaneous arterial branches threatening for the wound margin necrosis and subsequent cicatrization. To avoid the vascular complications especially in surgical treatment, the clubfeet should be tested for vascular integrity, mainly by the **Doppler technique**. One should remain apprehensive about the possibilities of vascular compromise and as a precautionary measure; the foot and leg should be only partially exsanguinated. However, one should not be too much concerned about the blood flow to the foot. Even though various vascular studies have warned against the vast and variable limitation of blood flow to the foot, there is hardly any serious vascular complication after cautiously performed clubfoot surgery and proper postoperative care. It appears as unexplained contradiction.

One should be more cautious in operating upon the older children with severe clubfeet, since larger number of such feet lack dorsalis pedis vessels.

Sometimes unexplained vascular complications develop—one example is (as noted below patient with vascular complication): Operation was double incisional soft-tissue release in a neglected clubfoot, of a boy aged 22 months. Operating time was 38 minutes under tourniquet.

Vascularity returned little delayed after releasing the tourniquet; but fully. Routine bivalving of plaster cast was done immediate postoperatively.

Vascularity remained fine postoperatively.

Some swelling of toes with blebs in operated zone developed by third postoperative day. Plaster cast was further loosened.

Daily dressing, oral corticosteroid, and vasodilator were started on third postoperative day and continued for 25 days, by which time the wound healed, of course in deformed position of foot, with varying recurrence of clubfoot deformity.

THE CLUBFOOT REVISITED

With the developments in the thoughts and practices of preventing congenital deformities, but if they happen—managing them at the earliest possible—the thinking in practices for preventing and managing the clubfoot has also improved, as a result incidence in clubfoot is also decreasing?—No dependable publications have come recent years to my best of the knowledge. On the other hand, though incidence of clubfoot is also dressing. However, in rural population of India and developing countries, still demand over attention for detection, management, and their proper follow-ups—is definitely a remaining pressing challenge. This book is a result of our continuous attention toward the above problems.

Sureshwar Pandey MBBS(Hons) MS(Gen) FICS FIAMS MS(Ortho) FACFAS FACS FNAMS, is a Professor Emeritus, Ranchi University, Ranchi, Jharkhand, India; Founder and Director, Charitable GNH Handicapped Children Hospital and Ram Janam Sulakshana (RJS) Artificial Limb Centre, Ranchi; Founder and Consultant, RJS Institute of Orthopaedics and Research, Ranchi; Founder and Chairman, RJS Pandey Charitable Cancer Hospital & Research and Rehabilitation Centre, Ranchi; and Hon President, Asia-Pacific Society of Foot and Ankle Surgery. He has a brilliant academic career with more than 45 years of teaching experience. He has been selected as the International Teacher to conduct courses in various countries. He authored six books, two of which have bagged the Best Book Award. One book has the Japanese and American editions; another book "Clinical Orthopaedic Diagnosis (3rd edition)" has the Spanish edition. He has contributed extraordinary chapters in encyclopaedia published by Churchill Livingstone, UK; Martin Dunitz Limited, UK; Springer Verlag, USA; and M/s Jaypee Brothers Medical Publishers (P) Ltd, New Delhi, India. Out of his 137 articles published in various International and National Journals, several of them have been quoted in the textbooks of various countries.

Anil Kumar Pandey MBBS CORM PhD(Ortho) MAMS, is the Director and Consultant, Ram Janam Sulakshana Institute of Orthopaedics and Research (RJSIOR), Ranchi, Jharkhand, India; Associate Director and Consultant, Charitable GNH Handicapped Children Hospital and RJS Artificial Limb Centre, Ranchi; Executive Director and Consultant, RJS Pandey Charitable Cancer Hospital & Research and Rehabilitation Centre, Ranchi; and Consultant, Kiran Centre for Education and Rehabilitation, Varanasi, Uttar Pradesh and Raigarh Ambikapur Health Association (RAHA), Chhattisgarh, India. He is a Reconstructive Surgeon, Rotary International Project, Government of Nigeria. He received the Yamamuro and Ogiwara International Traveling Fellowship by Japanese Pediatric Orthopedic Association (JPOA), Japan. He has done enormous work in the field of pediatric orthopedics, deformity correction, and rehabilitation across the world. He is the co-author of five published textbooks, two of which are having international editions. He has published many articles in the National and International Journals.

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