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ORIGINAL STUDY

Correlation between clinical outcome of surgically treated clubfeet and different radiological parameters

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The goal of this study was to determine the relationship between the clinical outcome of surgically treated clubfeet and several radiological parameters. The talocalcaneal angle, talocalcaneal index, talo-first metatarsal angle and the calcaneo-first metatarsal angle were measured on anteroposterior and lateral radiographs of 54 children with 70 idiopathic clubfeet treated surgically between 2000 and 2004. Their age at surgery ranged from 4 to 23 months. These radiological parameters were compared with the clinical results. Follow-up was conducted after 24 to 69 months following surgery. Using the functional rating system of Laaveg and Ponseti, results were graded as excellent in 28.6% (20 feet), good in 40% (28 feet), fair in 17.1% (12 feet) and poor in 14.3% (10 feet). There was a statistically significant correlation between the clinical results and two angles : the talo-first metatarsal angle on the anteroposterior radiograph and the calcaneao-first metatarsal angle on the lateral radiograph. These two angles should be considered when designing an evaluation system of clubfeet.

Keywords : clubfoot ; clinical outcome ; radiographs.

INTRODUCTION

Clubfoot is a complex deformity involving the ankle, subtalar, and midtarsal joints, in which motion or deformity at one joint can have unknown effects on the other joints (*19*). Nearly 30 years ago, Simons (*18*) established the standard radiographic measures used to assess clubfeet. However, the medical literature is controversial concerning the use of radiographic techniques in clubfoot evaluation, and several clubfoot evaluation methods include angle measurements among the grading parameters (*1,5*).

The talo-calcaneal angle has been used widely in studies as an index of correction of a clubfoot (*2, 6,18*). The talocalcaneal angle in anteroposterior projection (TCA-AP), the talocalcaneal angle in lateral projection (TCA-LAT) and the talocalcaneal index (TCI) are reflections of the anatomical talocalcaneal relationship. During eversion the calcaneus dorsiflexes, abducts, and pronates, causing the long axes of the talus and calcaneus to diverge progressively in the transverse and sagittal planes. This divergence can be demonstrated on both AP and lateral radiographs as an increase in the talocalcaneal angle. Studies have combined the information

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gathered from both the AP and lateral views of the talo-calcaneal angles to create a summated talo-calcaneal index (*6,14,15*). However, the reliability of these measures has been called into question by subsequent studies that found considerable overlap between the values of normal feet and club-feet (*12,13*).

The goal of this investigation is to determine the relationship between the clinical outcome of surgically treated clubfeet and several radiological parameters.

PATIENTS AND METHODS

A retrospective study was carried out on 54 children with 70 idiopathic clubfeet treated surgically between 2000 and 2004 at the Orthopaedic Department, Mansoura University Hospital. A complete examination was performed to exclude patients with clubfeet due to neurogenic, muscular or skeletal anomalies. Also patients with previous surgery and over 30 months of age at the time of surgery were excluded from the study. There were 42 boys (77.8%) and 12 girls (22.2%) and 16 children had bilateral clubfoot deformity. Thirty two feet (45.7%) were left and 38 (54.3%) were right. The age of the children at surgery ranged from 4 to 23 months (mean ± standard deviation, 11.65 ± 4.87 months).

Preoperatively, feet were classified according to Dimeglio *et al* (*8*). Of the 70 clubfeet included in our study, 14 (20%) were grade II, 46 (65.71%) were grade III and 10 (14.29%) were grade IV. They were treated by soft-tissue release using two skin incisions as described by Norris Carroll (*4*). Plaster fixation was applied for a total of 12 weeks followed by an ankle foot orthosis, until active dorsiflexion and eversion were established.

Assessment of the results was made according to the functional rating system described by Laaveg and Ponseti (*14*). A total score of 100 points indicates a normal foot. This includes a maximal score of 30 points for pain and a maximal score of 20 points for satisfaction and function respectively. It also includes a maximal score of 10 points each for position of the heel, passive motion and gait. Clinically, the feet were examined according to the objective criteria of passive range of motion, position of the heel and gait. Subjectively, the parameters of pain, satisfaction and function were recorded, usually as reported by the parents. Results were classified according to the number of points into : excellent (90-100 points), good (80-89 points), fair (70-79 points) and poor (less than 70 points).

Fig. 1. — Method of taking anteroposterior view of the foot

We used the standardized radiological method and technique of Simons (*18*) to minimize errors in measurements. Radiographs were taken during weight bearing or in a simulated weight bearing in younger infants (sitting on a stool with the knees flexed to 90°). The anteroposterior (AP) view of the foot was obtained with the foot placed as close to 30° of plantarflexion as possible and the x-ray tube directed 30° from the perpendicular (fig 1). Lines were drawn on the AP view longitudinally through the osseous nucleus of the talus parallel to its medial border and through the calcaneus parallel to its lateral border. An additional line was drawn through the longitudinal axis of the first metatarsal. In the AP view, two angles were evaluated ; the talocalcaneal angle (TCA-AP) and the talo-first metatarsal (TMT) angle (fig 2).

On the lateral view, the patient should straddle a cassette, which is preferably positioned in a slotted board on the X-ray table and the x-ray tube is directed perpendicular to the cassette (fig 3). Lines were drawn on the

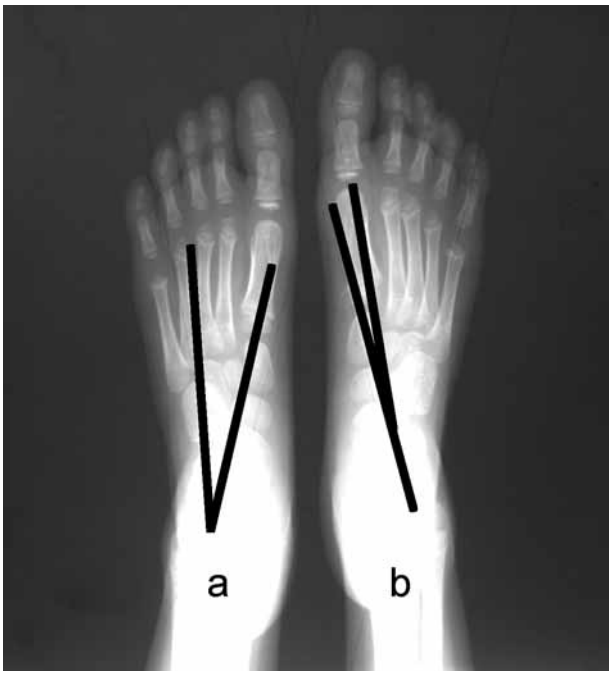

Fig. 2. — Anteroposterior view : a) talocalcaneal angle. b) talo-first metatarsal angle.

Fig. 3. — Method of taking lateral view of the foot

lateral view longitudinally through the central axis of the talus and parallel to the lower border of the calcaneus. Another line was drawn through the axis of the first metatarsal. In this projection, the talocalcaneal angle (TCA-LAT) and the calcaneal-first metatarsal (CMT) angle were evaluated (fig 4 & 5). The talocalcaneal index

Fig. 4. — Lateral talocalcaneal angle

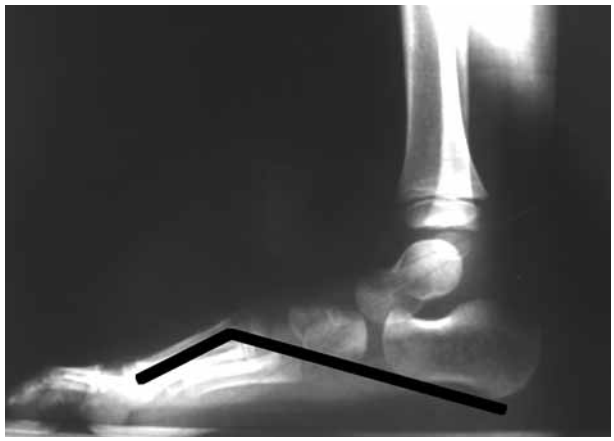

Fig. 5. — Lateral calcaneo-first metatarsal angle

(TCI), which is the sum of the talocalcaneal angles in the anteroposterior and lateral projections, was also calculated and included in the study. A control group was obtained by measuring the previous radiological parameters in the 38 normal feet of patients with unilateral clubfeet.

Statistical Analysis

Data were analyzed using SPSS (Statistical Package for Social Science) version 10 on Windows 98. Numerical data were presented as mean ± standard deviation (SD). The Kruskal-Wallis test was used to compare the results of the functional rating system of Laaveg and Ponseti *(8)* with the measurements of several radiological parameters. $P < 0.05$ was considered to be statistically significant.

Table I. — Different radiological parameters in clubfeet and normal feet

Radiographic parameters	Clubfoot (n=70)		Normal (n= 38)	
	Range (degrees)	Mean ± SD (degrees)	Range (degrees)	Mean ± SD (degrees)
TCA-AP	4 to 38	16.37 ± 5.45	16 to 41	26.25 ± 6.74
TCA-LAT	0 to 36	21.43 ± 6.64	26 to 45	39.81 ± 6.71
TCI	12 to 64	42.21± 10.61	45 to 85	59.81± 11.53
TMT	-21 to 29	-5.43± 6.04	-10 to 10	-4.81 ± 4.17
CMT	115 to 167	145.48 ± 4.54	123 to 172	143.85 ± 3.71

TCA-AP, Talocalcaneal angle in anteroposterior projection ; TCA-LAT, Talocalcaneal angle in lateral projection ; TCI, Talocalcaneal index ; TMT, Talo-first metatarsal angle in anteroposterior projection ; CMT, Calcaneal-first metatarsal angle in lateral projection.

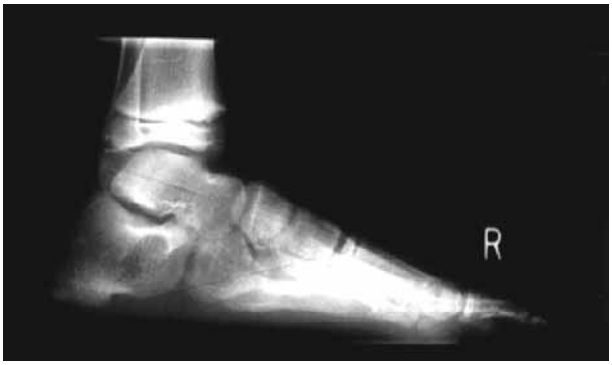

Fig. 6. — A case with flat top talus

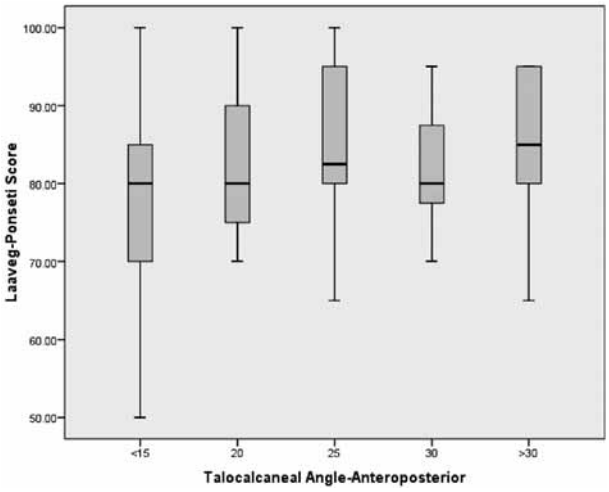

Fig. 7. — Box plots displaying the distribution of functional evaluation scores and talocalcaneal angle-anteroposterior (p = 0.147).

RESULTS

Using the functional rating system of Laaveg and Ponseti (*14*), feet were graded as excellent in 28.6% (20 feet), good in 40% (28 feet), fair in 17.1% (12 feet) and poor in 14.3% (10 feet). Follow-up was conducted after 24 to 69 months following surgery (mean ± SD, 46.34 ± 20.77 months).

Of 70 clubfeet included in the present study, 10 feet (14.29%) demonstrated a wedged navicular bone, while 14 feet (20%) showed abnormal radiographic changes like flat top talus (fig 6) and dorsal subluxation of the navicular bone.

The talocalcaneal relationship was evaluated by TCA-AP, TCA-LAT and TCI. The relationship between the hindfoot and forefoot was evaluated by the TMT angle on the AP projection and CMT angle on the lateral projection. Different radiological parameters in clubfeet and normal feet are shown in table I.

In the clubfeet group, the measurements for TCA-AP, TCA-LAT, TMT, CMT and TCI were divided into subgroups at 5° interval and compared by the Kruskal-Wallis test with the functional evaluation scores within the subgroups. The correlation between the clinical results and TCA-AP, TCA-LAT and TCI was not statistically significant (fig 7,8,9), on the other hand there was a statistically significant correlation between both the TMT and the CMT angle and the clinical results (fig 10,11).

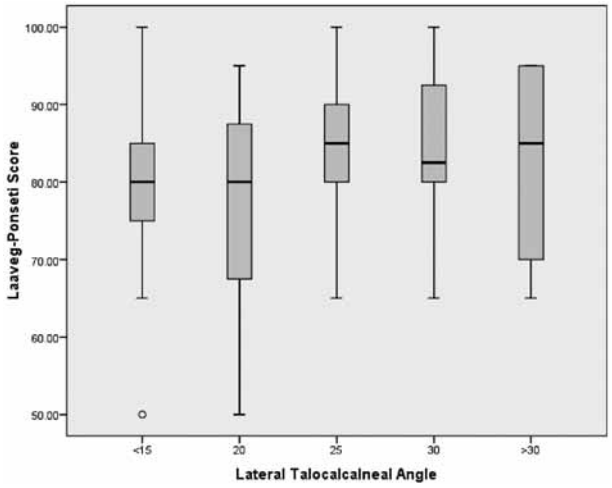

Fig. 8. — Box plots displaying the distribution of functional evaluation scores and lateral talocalcaneal angle (p = 0.217).

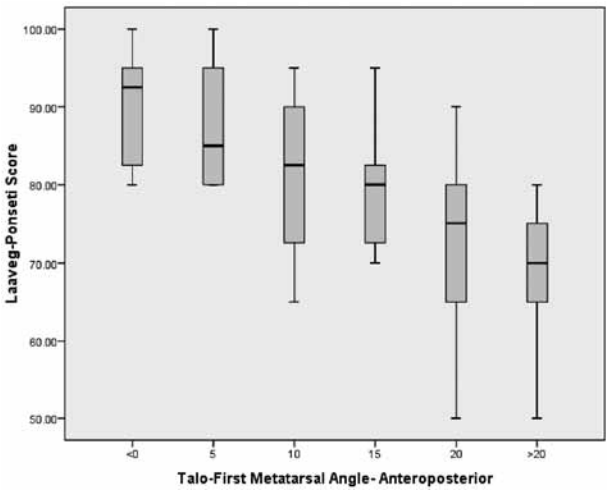

Fig. 10. — Box plots displaying the distribution of functional evaluation scores and talo-first metatarsal angle-anteroposterior ($p < 0.0001$*).

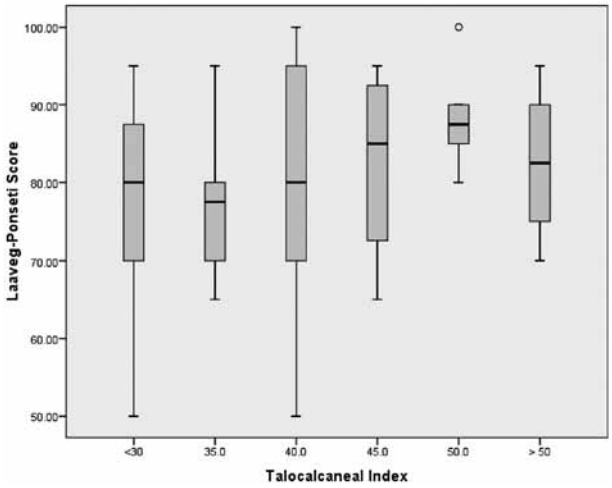

Fig. 9. — Box plots displaying the distribution of functional evaluation scores and talocalcaneal index (p = 0.473).

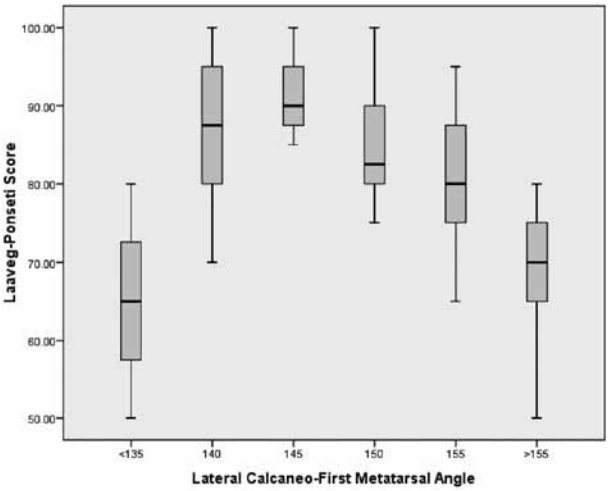

Fig. 11. — Box plots displaying the distribution of functional evaluation scores and lateral calcaneo-first metatarsal angle (p < 0.042*).

DISCUSSION

To determine the efficacy of treatment and to compare different treatment methods of any condition, it is essential that outcomes of therapeutic interventions are critically evaluated (*14*). Over the years, various authors have proposed systems for evaluating treatment outcomes in clubfoot (*1,14,15, 16,20*). Some of these systems involve computing a numerical score, whereas others do not. The variables assessed in these evaluation systems differ, and the scores allocated to each of the assessment variables also differ a great deal. We believe that there is an urgent need for "a common language for evaluating clubfoot" as Bensahel *et al* (*1*) also argued.

We used the functional rating system of Laaveg and Ponseti (*14*) in the present study mostly because

it relies only on clinical aspects, without any kind of radiographic measurements, which are commonly used in other systems (*1,2,5*) and it also simplifies the understanding and the statistical analysis of the results. We also closely supervised all the radiological examinations to ensure the correct positioning of the foot and the X-ray tube. A standard method of drawing and measuring the angles was also followed.

The talo-calcaneal angles in anteroposterior and lateral projections and the talo-calcaneal index have been used widely in studies as indices of correction of clubfoot (*2,6,18*). In our study, there was no statistically significant correlation between the clinical results and these radiological parameters. This finding supports the idea that an adequate correction of the deformity cannot be assumed by an isolated study of the hindfoot radiological relations. In view of the fact that a proportion of untreated clubfeet has talo-calcaneal angles within the normal range, it is unwise to suggest that a talo-calcaneal angle of 30° indicates a satisfactory correction (*12*). Similarly, the suggestion that a talo-calcaneal index of more than 40° implies an adequate correction is unacceptable, as untreated clubfeet may have a talo-calcaneal index of more than 40° to begin with. Hence it is not surprising that the talo-calcaneal index also did not correlate with the clinical results in some other studies (*7,14*).

Moreover, previous studies, based on cadaveric dissections and magnetic resonance imaging of feet of infants, have also shown that the long axes of the ossific nuclei and the cartilage anlage of the talus do not coincide (*3,9,10,11*). This explains why the "ossific" talo-calcaneal angle differs from the "cartilage" talo-calcaneal angle. With time, the first will increase in size and progressively assume the shape of the second, leading to a decrease in the talocalcaneal angle, which must not be seen as evidence of recurrence of hindfoot varus.

The study of Joseph *et al* (*12*) showed that the talo-calcaneal angles assess the subtalar relationship and give some indication of the deformity at the ankle. However, they did not give any insight into the extent of forefoot adduction and forefoot equinus (cavus), all of which have a bearing on the final correction of a clubfoot. It is, therefore, inappropriate to rely on the talo-calcaneal angles alone to assess the overall correction of a clubfoot.

The talo-first metatarsal angle in anteroposterior projection reflects the relative position between the hindfoot and the forefoot while the calcaneal-first metatarsal angle in lateral projection may show the presence of a cavus deformity. In the present study, there was a statistically significant correlation between the previously mentioned two angles and the clinical results. The hindfoot equinus and varus is not the only deformity in clubfoot , there is also a variable degree of forefoot adduction, inversion and cavus deformity. This could explain why the group of angles that reflect the foot alignment are more indicative for a residual deformity after surgical correction.

Radiographic analysis of the feet, in our study, showed that, although those with satisfactory final results had a relatively normal appearance and normal function, there were often persistent abnormal radiographic changes such as a flat top talus and a wedged or slightly dorsally displaced navicular bone. Follow-up to skeletal maturity and beyond is needed as premature osteoarthritis of the ankle and foot and consequently development of pain can be expected to occur in such patients.

CONCLUSIONS

Talocalcaneal angles and the talocalcaneal index are not good indices of overall clubfoot correction. When assessing the status of the postsurgical clubfoot, the talo-first metatarsal angle on an anteroposterior radiograph and the calcaneo-first metatarsal angle on a lateral radiograph show a significant correlation with the clinical results. These two angles should be considered when designing an evaluation system of clubfeet.

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