Clinico-radiological assessment and their correlation in clubfeet treated with postero-medial soft-tissue release

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Abstract The controversy regarding the radiographic parameter which best represents the various deformities of clubfoot continues. The aim of our study was to clear up this controversy. Fifty surgically treated (soft-tissue release) congenital clubfeet were studied clinically using Laaveg and Ponseti score and radiologically using twelve different radiographic parameters in weight-bearing AP and lateral views. The talo-calcaneal angle (TCA) in AP and lateral view showed statistically significant correlation with the functional rating, but significant variation in the dimension of the angles among the different functional groups was found with AP angle only. The talo-first metatarsal angle in AP and lateral view averaged 10° and 19° respectively, and showed significant correlation with the functional rating. The talo-navicular subluxation in AP, the calcaneo-fifth metatarsal angle and the first-fifth metatarsal angle in lateral view did not show any significant correlation with function. Talo-calcaneal index averaged 44° in the clubfeet and showed significant correlation. The wide range of parameters representing each of the deformities gives a better radiological assessment of the clubfoot than any single parameter.

Résumé Les paramètres radiographiques des pieds bots sont toujours très discutés. Le but de cette étude est de clarifier les controverses à ce propos. Matériel et méthode : 50 pieds bots opérés (libération interne) ont été étudiés sur le plan clinique en utilisant le score de Laaveg et Ponseti et sur le plan radiographique avec douze paramètres différents, les radiographies étant effectuées en charge de face et

de profil. Résultat : l'angle Talo-calcaneen (TCA) de face et de profil est de façon significative associée aux résultats fonctionnels, l'angle talo-métatarsien (du premier métatarsien varie de 10 à 19°) et est également corrélé, de façon significative avec le score fonctionnel. La subluxation talo-naviculaire de face, l'angle calcaneo-métatarsien avec le 5^{ème} méta et le premier méta ainsi que l'angle 1^{er} et 5^{ème} méta de profil ne sont pas corrélés avec le score fonctionnel. L'index talo-calcaneen est en moyenne de 44° et a une importante signification. En conclusion : l'association de ces différents paramètres permet d'avoir une meilleure appréciation radiologique du pied bot bien plus que l'utilisation d'un paramètre isolé.

Introduction

Irrespective of the aetiology, the patho-anatomical changes associated with clubfoot are uniform for the most part [5]. A large number of parameters have been described in an effort to facilitate definition of the anatomical deviations, in AP and lateral X-Ray images. However, the utility of radiographic methods and their relationship to clinical outcome is still being debated [2, 18, 24]. Whereas some authors take the position that the feet that were pain-free and fully functional could still be considered as failures if they were anatomically imperfect [2], others noted that despite anatomical and radiological imperfections most patients demonstrate excellent levels of function [2]. Correspondingly, whereas some articles have commented on statistically significant correlations between radiographic results and function [10, 22, 25], others have found no relationship between the two [3, 8]. Some other articles commented on certain associations, but didn't address the significance or lack thereof of these various parameters [14, 19].

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Even among the studies stating significant relationships, there is little concordance of results. For example, Laaveg and Ponseti [10] and Hutchins et al. [9] found that the talo-calcaneal angle (TCA) correlated with function, but other authors [3, 8] failed to reproduce the same. Yamamoto and Furuya [25] found that AP, but not the lateral TCA, correlated with functional rating, whereas Laaveg and Ponseti [10] and Thompson et al. [22] found that the lateral TCA but not the AP-TCA correlated with their clinical measures.

Most of the reported articles [1, 3, 9, 22], which we reviewed, considered only one or few radiological parameters as the most reliable indices of assessment of clubfoot. Since neither a single nor several parameters represent all the deformities of clubfoot, we considered twelve different parameters in both AP and lateral views, representing each of the various deformities in our study.

Patients and methods

Thirty patients with a total of 50 Lehman [12] type II clubfeet (20 bilateral), treated with a standard postero-medial soft-tissue release (PMSTR) were included. There were 24 males and six females with an age range of 4 to 16 years. Of the unilateral cases, the right foot was involved in five cases and the left foot in the remaining five cases. Standardised weight-bearing plain X-rays in AP and lateral views were used for radiological assessment [20]. Radiographs of the ten normal feet in unilateral cases were used for comparison. The clinical evaluation of the foot was made using the functional rating system of Laaveg and Ponseti [10].

The twelve radiographic parameters were; in the AP view (Fig 1a), (1) talo-calcaneal angle, (2) talo-first metatarsal angle, (3) calcaneo-fifth metatarsal angle, and (4) talo-navicular subluxation; and in the lateral view (Fig 1b), (5) talo-calcaneal angle, (6) tibio-talar angle, (7) tibio-calcaneal angle, (8) talo-first metatarsal angle, (9) calcaneo-fifth metatarsal angle, (10) first-fifth metatarsal angle, (11) talar dome flattening, and (12) the talo-calcaneal index (TCI), which is a mean of the AP and Lateral TCA.

Results

Clinical parameters

Based on the Laaveg and Ponseti [10] score, 58% of the patients were grouped under very good and good results, while the remaining 42% had satisfactory to poor results (Table 1). There was no limitation of activities whatsoever in 70% of the children, and none had limitations during

Fig. 1 **a** Antero-posterior view of the foot showing the following angles: *A* talo-calcaneal angle, *B* talo-first metatarsal angle, *C* calcaneo-fifth metatarsal angle. **b** Lateral view of the foot showing the following angles: *D* tibio-talar angle, *E* tibio-calcaneal angle, *F* talo-calcaneal angle, *G* first-fifth metatarsal angle, *H* calcaneo-fifth metatarsal angle

routine activities (Table 2). The foot was never painful in 66%, 26% had mild pain during strenuous activities, and in 8% pain was usually present during strenuous activities. None had pain during routine activities. There was some degree of heel varus in 46% of the feet (Table 3). All except seven patients were able to walk on heels. Limping was present in two patients due to residual deformity. Five were

Table 1 Results using Laaveg and Ponseti [10] score

Results	Number of feet	Percentage	Mean Laaveg and Ponseti score
Very good	17	34%	91.7%
Good	12	24%	83.6%
Satisfactory	12	24%	75.9%
Poor	9	18%	61.1%

Table 2 Functional limitations of the child

Limitations	Percent
No limitation of activities	70%
Occasional limitation of strenuous activities	22%
Usually limited during the the strenuous activities	8%
Limitation of routine activities	0
Limitation of walking	0

not able to heel-strike properly at the beginning of stance phase.

Radiological parameters

AP-TCA In healthy feet of unilateral clubfoot cases, 31.6° (range 38°–26°, standard deviation (SD) 4.6°). Clubfeet in very good group measured 24.8° (range 39°–16°, SD 6°), good 18.6° (range 48°–6°, SD 10.8°), satisfactory 15.8° (range 40°–5°, SD 9°) and poor 10° (range 24°–0°, SD 9°).

Talo-first metatarsal angle: AP view In normal feet –8.3° (range –23° to 5°, SD 7°), in very good feet –12.8° (range –22° to 8°, SD 7.5°), in good 0° (range 47° to –32°, SD 28), in satisfactory 18° (range 43° to –7°, SD 13°) and in poor 38.6° (range 71° to 8°, SD 20.5°).

Calcaneo-fifth metatarsal angle: AP

Healthy feet –8° (range 2° to –18°, SD 5.8°). The variance range increased as the clinical clubfoot results worsened. Very good –3.5° (range 35° to –25°, SD 13.8°), good 9°

(range 20° to –9°, SD 9.8°), satisfactory 8.8° (range 18° to –10°, SD 8.3°) and poor 15.1° (range 39° to –30°, SD 21.7°).

Talo-navicular subluxation: AP view When the navicula was not yet ossified it was measured indirectly as described by Simon [21]. AP-TCA of <15° and talo-first metatarsal angle of >15°, suggestive of talo-navicular subluxation. According to this method, six had subluxation and 13 did not show any subluxation. When the navicula was ossified, subluxation was graded into four grades according to Hutchins [9] et al. Of the 19 feet who had subluxation, eight were grade I and 11 grade II. None had grade III subluxation. Thirteen did not have any subluxation.

TCA-lateral view Normal feet averaged 33.7° (range 46°–20°, SD 9.8°). Very good group 31.4° (range 53°–14°, SD 9.8°), good 27.3° (range 45°–16°, SD 10.8°), satisfactory 23° (range 40°–14°, SD 7°) and those rated as poor, 25.6° (range 50°–12°, SD 12.9°).

Tibio-calcaneal angle-lateral Represents the equinus deformity, averaged 55.8° (range 68°–42°, SD 8.7°) in healthy feet. The average increased as the clinical results worsened, very good 58.7° (range 75°–42°, SD 9.5°), good 76.5° (range 113°–56°, SD 16°), satisfactory 81° (range 100°–62°, SD 12°) and in poor 91.3° (range 107°–68°, SD 10.7°).

Tibio-talar angle-lateral Averaged 99.7° in the normal feet (range 109°–89°, SD 9°). Very good group 95.9° (range 138°–58°, SD 16°), good 109° (range 140°–86°, SD 16.5°), satisfactory group 108.6° (range 130°–89°, SD 10°) and poor group 128.4° (range 171°–108°, SD 23°).

Lateral calcaneo-fifth metatarsal angle Healthy feet averaged 157.8° (range 175°–147°, SD 9°). Variance among different clinical grades was not significant. Very good group 157° (range 178°–127°, SD 13°), good 156° (range 175°–132° SD 14°), satisfactory 162.9° (range 178°–137°, SD 13°) and poor group 152.6° (range 174°–122° SD 19°).

First-fifth metatarsal angle-lateral view Represents fore-foot supination, in healthy feet 39° (range 92°–0° SD 29°). very good 49.4° (range 83°–2°, SD 28°), good 46.3° (range 94°–1°, SD 29.6°), satisfactory group 55.7° (range 92°–11°, SD 27.5°) and poor group 27.6° (range 54°–2°, SD 21.2°). Variance among the different groups was not significant.

Talo-first metatarsal angle-lateral view Measures midfoot cavus 33° (range 81°–0°, SD 30.5°), Very good 34.2° (range 91°–0°, SD 33.7°), good 26.4° (range 80°–1°, SD 30.6°), satisfactory group (range 60°–0°, SD 18.5°), poor 3.2° (range 8°–0°, SD 2.8°).

Table 3 Movements of the foot and ankle clinically

Position of the heel while standing	Number of feet	Percentage
0° or some valgus	27	54%
1–5° varus	20	40%
6–10° varus	3	6%
Movements;		
Dorsiflexion		
<5°	17	34%
5–10°	16	32%
10–15°	7	14%
15–20°	6	12%
>20	4	8%
Total varus-valgus movement of the heel		
<10	22	44%
10–20	21	42%
>20	7	14%
Fore-foot inversion–eversion		
<25	19	38%
25–50	31	62%

TCI Measures hind-foot varus, averaged 65.3° (range 83° – 50° , SD 12°) in healthy feet. Very good 56.1° (range 92° – 36° , SD 13°), good 46° (range 83° – 29° SD 16°), satisfactory 38.8° (range 66° – 22° , SD 12.7°), and poor group 35.7° (range 62° – 16° , SD 14.5°).

Talar dome flattening Graded into four grades according to Hutchins et al. [9] in the lateral view. Eight had grade 0, 23 grade 1, 14 grade 2 and five had grade 3 flattening. Chi square test was significant, indicating that the frequency distribution among various clinical grades was significant.

Spearman rank correlation coefficient showed significant correlation between the clinical scoring and the following radiological parameters: TCA in AP and lateral views, the talo-first metatarsal angle in AP and lateral views, calcaneo-fifth metatarsal angle in AP view, the tibio-calcaneal, tibio-talar angles in the lateral view, the talo-calcaneal index, and talar dome flattening.

The talo-navicular subluxation in AP view, the calcaneo-fifth metatarsal angle and the first-fifth metatarsal angle in lateral view did not show any statistically significant correlation.

Discussion

Though numerous radiological parameters have been described in the literature, the debate regarding the best parameter which can reliably assess the correction continues.

In agreement with Yamamoto and Furuya [25] and Lau et al. [11], we found a statistically significant correlation of clinical scoring with AP-TCA. In contrast to this opinion, Laaveg and Ponseti [10], Turco [23], Ono and Hyashi [14], Thompson [22] et al. found no correlation between AP-TCA and functional rating. This difference of opinion could be due to difficulties in obtaining standardised radiographs in children, inaccuracies in the measurements of radiological angles, use of different functional rating systems and differences in the patient inclusion criteria. The mean lateral TCA in a study by Laaveg and Ponseti [10] were 22.4° in feet with very good rating, 20.5° with good rating. These were comparable to values in our study. They found a very good correlation with lateral TCA. In agreement with this, Turco [23], Thompson et al. [22], Hassbeek et al. [6] and Ono and Hyashi et al. [14] also found that the lateral TCA correlated well with the functional rating and is a good indicator of the hind-foot deformity. In contrast Lau et al. [11] and Yamamoto and Furuya [25] did not find any significant correlation with lateral TCA. Our study showed a statistically significant correlation with both AP and lateral TCA. Taking into account the high standard

deviation, a definitive assignment of an angle measurement to healthy feet or clubfeet was however not possible.

TCI has been recognized as one of the very good indicators of hind-foot varus deformity by many authors [1, 4, 9]. In accordance with Beatson and Pearson [1], Hutchins et al. [9] and Porat and Kaplan [15], we also found a strong correlation of TCI with functional scoring. The difference of values among various clinical grades was significant. Lau et al. [11] found that the TCI tended to increase with functional grading; however, the difference between the groups was small and no significant correlation could be established.

Significant talo-navicular subluxation existed in only 11 feet, all of them being stage 2. The reason why we did not find a correlation between the talo-navicular subluxation and the functional scoring could be due to the fact that the number of higher-grade subluxations was less than for the milder grades (grade 0 and 1), and the milder grades are less likely to affect the function of the foot in any significant way. In contrast to our results, Hutchins et al. [9] Main and Crider [13] and Thompson et al. [22] found that the results were worse if the navicula remained medially displaced.

As an expression of fore-foot adduction, the calcaneo-fifth metatarsal angle and talo-first metatarsal angle in AP view in the case of severe deformities showed values averaging much higher than in healthy feet. The variance of these values among the Laaveg and Ponseti clinical grades was statistically significant. Herbesthofer et al. [8] and Cooper and Dietz [3] found greater average of AP-calcaneo-fifth metatarsal angle in clubfeet than the normal feet. But this correlation was not statistically significant. Ponseti [16] et al. found that talo-first metatarsal angle in AP view in clubfeet ranged from -10 to 33° , and in normal feet from -20 to 11° . The difference was statistically significant. The calcaneo-fifth metatarsal angle in AP view in the clubfeet ranged from -20 to $+20$ and in normal feet -18 to $+5^\circ$. This difference was not statistically significant.

In agreement with Uglow and Clarke [24] and Lau et al. [11], a relationship is hinted at between clinical findings and the lateral talo-first metatarsal angle as an expression of midfoot cavus. But here as well, categorisation of clubfeet according to the severity would seem to make little sense, due to high levels of standard deviation within the individual groups. Both the tibio-calcaneal and tibio-talar angles in the lateral view as a measure of the equinus deformity showed a statistically significant correlation in our study. The values averaged much higher from 55.8° in healthy feet to 91.3° in the poor group as the equinus deformity increased and the clinical scoring decreased. Reimann and Anderson [17] in their study found that the tibio-calcaneal angle showed significant correlation with functional rating. Handelsman and Soloman [7] found that

the lateral tibio-calcaneal angle provided the most reliable angle index of correction. Furthermore, they thought that serial measurement of this parameter provided an accurate guide to progress. The calcaneo-fifth metatarsal angle and the first-fifth metatarsal angle provided no significant information. Though there was a trend towards abnormal values in the feet graded as satisfactory and poor, the values were not statistically significant. In our study, 84% of our patients were found to have some degree of talar dome flattening, and the degree of flattening correlated with the functional grading, particularly the ankle movement.

Our study supports the routine use of radiography during follow-up of surgically treated clubfeet. We are of the opinion that instead of considering any one radiological parameter as the single most index of assessment of the deformity, a wide range of parameters representing each of the various deformities gives a better radiological assessment of the clubfoot as a whole.

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