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Retrospective Cohort Study

Can immediate postoperative radiographs predict outcomes in pediatric clubfoot?

Duangjai Leeprakobboon

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Abstract

BACKGROUND

The goal of treatment for pediatric idiopathic clubfoot is to enable the patient to comfortably walk on his or her soles without pain. However, currently accepted treatment protocols are not always successful. Based on the abnormal bone alignment reported in this disease, some studies have noted a correlation between radiographic characteristics and outcome, but this correlation remains debated.

AIM

To assess the correlation between immediately postoperative radiographic parameters and functional outcomes and to identify which best predicts functional outcome.

METHODS

To predict the outcome and prevent early failure of the Ponseti's method, we used a simple radiographic method to predict outcome. Our study included newborns with idiopathic clubfoot treated with Ponseti's protocol from November 2018 to August 2022. After Achilles tenotomy and a long leg cast were applied, the surgeon obtained a single lateral radiograph. Radiographic parameters included the tibio-calcaneal angle (TiCal), talocalcaneal angle (TaCal), talofirst metatarsal angle (Ta1st) and tibiotalar angle (TiTa). During the follow-up period, the Dimeglio score and functional score were examined 1 year after surgery. Additionally, recurring events were reported. The correlation between functional score and radiographic characteristics was analyzed using sample and multiple logistic regression, and the optimal predictor was also identified.

RESULTS

In total, 54 feet received approximately 8 manipulations of casting and Achilles tenotomy at a mean age of 149 days. The average TiCal, TaCal, Ta1st, and TiTa angles were 75.24, 28.96, 7.61, and 107.31 degrees, respectively. After 12 mo of follow up, we found 66% excellent-to-good and 33.3% fair-to-poor functional

outcomes. The Dimeglio score significantly worsened in the poor outcome group (P value < 0.001). Tical and TaCal showed significant differences between each functional outcome (P value < 0.05), and the TiCal strongly correlated with outcome, with a smaller angle indicating a better outcome, each 1 degree decrease improved the functional outcome by 10 percent. The diagnostic test revealed that a TiCal angle of 70 degrees predicts an inferior functional outcome.

CONCLUSION

The TiCal, derived from lateral radiographs immediately after Achilles tenotomy, can predict functional outcome at 1 year postoperatively, justifying its use for screening patients who need very close follow-up.

Key Words: Idiopathic clubfoot; Radiograph; Functional outcome; Tenotomy; Prognostic; Tibiocalcaneal angle

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Core Tip: Idiopathic clubfoot is an abnormality of bone alignment. Current treatment strategies are associated with recurrence, which results in pain and poor quality of life. Radiography-assisted outcome prediction must be harmless in young children. The lateral tibiocalcaneal angle was directly related to functional outcomes, as a smaller angle was associated with a better outcome. A lateral tibiocalcaneal angle exceeding 70 degrees immediately after Achilles tenotomy predicted an inferior outcome.

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INTRODUCTION

Talipes equinovarus, known as idiopathic clubfoot, is a complexity inside the bone of the foot, with a birth prevalence of approximately 1-3 cases per thousand born[1,2]. The treatment goals are painlessness and a plantigrade walk. Currently, Ponseti's technique, which includes casting, Achilles tenotomy and bracing, is the accepted treatment strategy, but up to 11%-48% recurrence has been found [3-7].

However, Ponseti noted that radiography cannot predict prognosis because it is not associated with clinical appearance[8]. Nevertheless, some reports identified a significant relationship between preoperative radiographs and treatment decisions. For example, a lateral tibiocalcaneal angle > 80 degrees indicates a need for Achilles tenotomy[9]. In 2015, a retrospective study found that a preoperative dorsiflex angle > 16.6 degrees did not require reoperation and was related to recurrence [10]. Furthermore, a lateral tibiocalcaneal angle > 77 degrees and lateral talocalcaneal angle < 29 degrees at the time of brace withdrawal predicts reoperation[11].

The purposes of this study were as follows: To demonstrate the correlation between immediately postoperative radiographic parameters and functional outcome. To identify the radiographic parameter that best predicts functional outcome.

MATERIALS AND METHODS

Population

This work was a retrospective cohort study conducted from November 2018 to August 2022. Any newborn patient who was diagnosed with idiopathic clubfoot was included. Exclusion criteria included syndromic clubfoot, recurrent cases and patients who had received previous treatment. All patients underwent weekly manipulation of their feet according to the Ponseti technique, followed by Achilles tendon tenotomy and long leg cast application. Immediately after this procedure, the surgeon took one radiograph of the lateral foot and ankle.

Radiography and clinical parameters

In an attempt to predict the outcome and prevent early failure of the Ponseti's method, we used a simple radiographic method to predict outcome because radiographic postoperative studies are lacking

and radiographic assessment is not associated with disadvantages[12].

Radiographic parameters included the tibio calcaneal angle (TiCal), talocalcaneal angle (TaCal), talofirst metatarsal angle (Ta1st) and tibiotalar angle (TiTa) (Figure 1). Foot characteristics were evaluated according to the Dimeglio classification, and functional scores were assessed 1 year after surgery, as described by Ponseti, and interpreted as follows: A total score < 70, 70-79, 80-89, and 90-100 represents poor, fair, good, and excellent outcomes, respectively[13]. Additionally, recurring events were reported if further surgery was needed. Data were analyzed by 2 observers, a fourth-year resident orthopedic training and pediatric orthopedic surgeon, and interrater reliability was confirmed using the kappa statistic.

Statistical analysis

All statistical analyses were performed using STATA 11 statistical software (Stata Corp., College Station, TX, United States). The chi-squared test and Fisher's exact test were used to assess independence between two dichotomous variables. The chi-squared test was applied under the assumption that the sample was large. When more than 20 percent of cells had expected frequencies < 5, the Fisher's exact test was run for small-sized samples. The two-sample *t*-test was used to compare the mean of continuous variables, and the Mann-Whitney U test was used when the variable did not have a normal distribution. Logistic regression by using a penalized maximum likelihood estimation method was used to determine factors associated with functional scores, *P* value < 0.05 was considered statistically significant and the magnitude of association was shown as crude odds ratios (OR), adjusted OR, and 95% confidence intervals (CI).

RESULTS

The study included 54 feet from 35 newborn patients with clubfoot. All feet received manipulation, and a long leg cast was applied approximately 8 times on average. Then, the Achilles tenotomy procedure was performed at an average age of 149 days. Immediately after surgery and cast application, we obtained radiographs and found that the average TiCal, TaCal, Ta1st, and TiTa angles were 75.24, 28.96, 7.61, and 107.31 degrees, respectively. After the last cast was removed, the brace protocol was utilized as usual, and the Dimeglio score significantly worsened in the poor outcome group (*P* value < 0.001), which was clearly evident 6 mo postoperatively. After 12 mo of follow up, 24% of cases required further surgery, 66% of cases had an excellent-to-good functional outcome and 33.3% of cases had a fair-to-poor functional outcomes. Demographic data did not significantly differ between groups, as shown in Table 1.

Table 2 presents the significant differences in the Tical and TaCal angles between each functional outcome (*P* value < 0.05), and the TiCal angle was strongly predictive of outcome, as shown in Table 3. Furthermore, the study shows that a lower TiCal angle corresponded to a better outcome, with an adjusted odds ratio of 0.90 (0.83-0.99). Specifically, each 1 degree decrease improved the functional outcome by 10 percent. The diagnostic test revealed that a TiCal angle of 70 degrees predicts an inferior functional outcome, with 88.9% sensitivity, 41.7% specificity, and 0.56 ROC area (95% CI: 0.42-0.70).

DISCUSSION

Idiopathic clubfoot is the most common multifactorial irreducible foot problem in newborns[2,14]. To date, the Ponseti protocol is widely utilized to treat this condition, in which the deformity is corrected sequentially by Achilles tenotomy and a brace is applied. However, a previous study showed a 33%-41% rate of recurrence[15,16]. Clubfoot is pathogenically characterized by abnormal bone alignment and abnormal radiographic features compared with normal feet, including bony abnormalities from incorrect treatment, whereas radiographic features from correct treatment are obviously better than pre-treatment[17,18].

This study found a correlation between radiographic data, lateral tibio calcaneal and talocalcaneal angles derived immediately postoperation, and functional outcomes at the 12 mo follow-up. This finding is in agreement with a previous report that supports the use of radiographs for treatment guidance, especially in residual deformity correction, such as complete subtalar release or postero-medial release procedures[19-21].

The tibio calcaneal angle was the most reliable feature for predicting outcome in the present study, as a smaller angle predicted a better outcome based on the plantigrade ability. We found that a cutoff point of > 70 degrees could predict fair-to-poor functional outcome at walking age with 88.9% sensitivity, similar to the equinus position, which results in a poor quality of life. Similarly, previous studies recommended using this angle to predict risk of relapse and decide the surgical type, such as Achilles tenotomy, soft tissue release, and even reconstructive procedures for recurrent clubfoot, to improve functional outcome, but these studies investigated older children[8,10,11,22,23]. Additionally, a close relationship of clinical and talocalcaneal and talo-1st metatarsal angles was found in some studies[17,24,

Table 1 Demographic data for the excellent/good and fair/poor functional groups

| Demographic data | Excellent and good group (n = 36) | Fair and poor group (n = 18) | Mean different (95%CI) | P value |
|--------------------------------|-----------------------------------|------------------------------|------------------------|---------------------|
| Male, n (%) | 26 (72.22) | 11 (61.11) | - | 0.407 ^b |
| Number of casts | 8.69 (3.05) | 8.33 (3.39) | -0.36 (-2.19, 1.47) | 0.6950 ^a |
| Age at tenotomy (d), mean (SD) | 144 (53.52) | 161.55 (69.11) | 17.55 (-16.66, 51.77) | 0.3081 ^a |
| Brace compliance, n (%) | 29 (80.56) | 17 (94.44) | - | 0.245 ^c |

^aIndependent samples *t* test.^bPearson chi square test.^cFisher's exact test. SD: Standard error.**Table 2 Mean range of each radiographic angle in clubfeet patients after surgery in lateral view**

| Angle | Excellent and good group, mean (SD) | Fair and poor group, mean (SD) | Mean different (95%CI) | P value ^a |
|----------------------------|-------------------------------------|--------------------------------|------------------------|----------------------|
| Tibiocalcaneal angle | 72.55 (10.36) | 80.61 (7.76) | 8.05 (2.49, 13.61) | 0.0053 |
| Talocalcaneal angle | 31.66 (11.92) | 23.55 (12.00) | -8.11 (-15.03, -1.18) | 0.0225 |
| Talofirst metatarsal angle | 7.72 (7.83) | 7.38 (5.23) | -0.33 (-4.44, 3.77) | 0.8713 |
| Tibiotalar angle | 107.72 (11.73) | 106.50 (15.53) | -1.22 (-8.80, 6.36) | 0.7478 |

^aIndependent samples *t* test.**Table 3 Correlation of radiographic parameters and functional outcomes**

| Angle | Functional score, excellent and good group (n = 36), fair and poor group (n = 18) | | |
|----------------------------|---|-----------------------------|----------------------|
| | Crude odds ratio (95%CI) ^a | Adjusted odds ratio (95%CI) | P value ^b |
| Tibiocalcaneal angle | 0.90 (0.84-0.97) | 0.90 (0.83-0.99) | 0.031 |
| Talocalcaneal angle | 1.06 (1.00-1.12) | 1.04 (0.97-1.11) | 0.199 |
| Talofirst metatarsal angle | 1.00 (0.92-1.09) | 0.99 (0.89-1.10) | 0.916 |
| Tibiotalar angle | 1.00 (0.96-1.05) | 1.01 (0.95-1.07) | 0.707 |

^aSimple logistic regression.^bMultiple logistic regression. CI: Confidence interval.

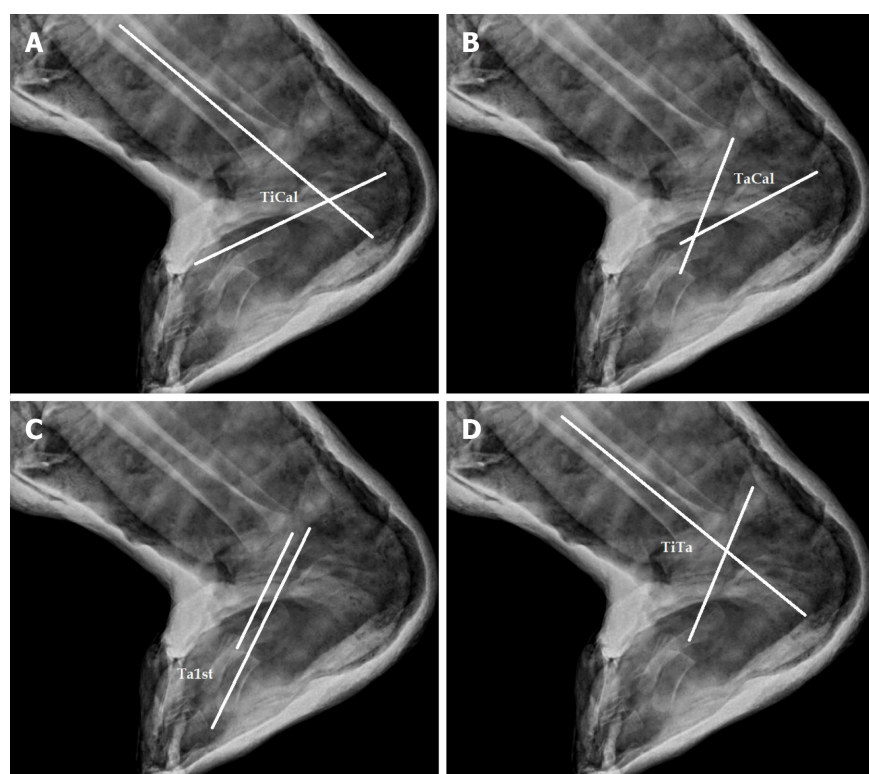
25].

Although a later study from 2017 discovered that radiographic abnormalities are not indicative of clinical abnormalities and that the Ponseti method can improve foot shape but cannot correct bone deformities, the treatment protocol needs to be based on various data sources[8,26]. Radiography is a criterion to screen patients who need very close follow-up.

This study has the following strengths: (1) We used functional outcome as the end result instead of recurrence because recurrence is a subjective assessment that the surgeon utilizes to determine whether to perform additional interventions; (2) We analyzed only ossified bone to provide more accurate results; and (3) We based our analysis on one lateral view radiograph, which is harmless to patients, as shown in a previous study[12].

Limitations of the study

The small sample analyzed in this study precludes large effect sizes between groups. Furthermore, we calculated the angle based on only ossified bone in a small child for accuracy reasons. Consequently, we may lack information from other nonossified bone.



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Figure 1 Radiographic angles. A: The tibiocalcaneal angle was defined as the angle between the axis of the tibia and the axis of the calcaneus; B: The talocalcaneal angle was defined as the angle between the talus axis and the calcaneus axis; C: Talofirst metatarsal angle was defined as the angle between the axis of the talus and the axis of the 1st metatarsal bone; D: The tibiotalar angle was defined as the angle between the axis of the tibia and the axis of the talus.

CONCLUSION

The tibiocalcaneal angle, derived from lateral radiographs immediately after Achilles tenotomy and casting, can predict functional outcome at 1 year postoperatively and provide a sufficient rationale for screening patients who need very close follow-up.

ARTICLE HIGHLIGHTS

Research background

Idiopathic clubfoot is an abnormal bone alignment and there are currently failure cases resulting from the currently acceptable treatment protocol. Postoperative radiographs are expected to predict outcomes beginning at the prewalking age.

Research motivation

To predict the outcome and early prevention in cases that may fail with Ponseti's method, considering the lack of radiographic postoperative studies and almost none of the disadvantages of radiation taken once, we decided to use the simple radiographic method for outcome prediction.

Research objectives

To assess the correlation between immediately postoperative radiographic parameters and functional outcomes.

Research methods

Patients with idiopathic clubfoot were assessed for radiographic parameters immediately postoperatively, and functional scores were assessed at follow-up.

Research results

The tibiocalcaneal and talocalcaneal angles showed significant differences between each functional outcome, and the tibiocalcaneal angle had a strong effect, with a smaller angle seeming better.

Research conclusions

The tibiocalcaneal angle, derived from lateral radiographs immediately after Achilles tenotomy and cast, can predict functional outcome at 1 year postoperatively.

Research perspectives

A larger population and long-term follow-up of 5 to 10 years would provide a better correlation of the radiographic parameters and functional outcomes.

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