

ORIGINAL ARTICLE

Reliability of the talocalcaneal angle for the evaluation of hindfoot alignment[☆]



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KEYWORDS

Tarsal coalitions;
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Abstract

Introduction: Recent studies suggest that hindfoot deformity should be considered in the surgical treatment of tarsal coalitions. Many authors have used the angle between the talus and the calcaneus (TCA) for decision-making. However, its reliability has not been demonstrated and the measurement technique has not been standardized. The objective of this study was to standardize the TCA measurement technique, and to evaluate the inter and intra-observer reproducibility of the proposed technique.

Methods: The foot CT scans of a group of 30 patients between 10 and 17 years of age were analysed. Ten patients had talocalcaneal coalitions, ten calcaneonavicular coalitions and ten had no coalitions. The inter and intra-observer reproducibility of the TCA was evaluated by the intraclass correlation coefficient (ICCs). A mixed-effects ANOVA model was used to calculate the ICCs for ICC2 agreement (A, 1). This procedure was applied to the three observers (inter-observer variability), and to the test–retest of observer 1 (intra-observer variability). A two-tailed *p* value of $\leq .05$ was considered significant.

Results: The inter-observer and intra-observer agreements were excellent for the TCA. Inter-observer agreement: ICC2 (A, 1) = .95 ($p < .001$, CI 95%: .77–.93). Intra-observer agreement: ICC2 (A, 1) = .99 ($p < .001$, CI 95%: .97–.99).

Conclusion: The TCA is a reliable way to evaluate hindfoot alignment. This method of measurement, as described in this study, can be safely used for surgical planning in patients with tarsal coalitions.

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PALABRAS CLAVE

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Fiabilidad del ángulo astrágalo-calcáneo para la evaluación de la alineación del retropié**Resumen**

Introducción: Estudios recientes sugieren que en el tratamiento quirúrgico de las coaliciones tarsianas debería considerarse la deformidad del retropié. El ángulo entre el astrágalo y el calcáneo (AAC) es comúnmente utilizado para la toma de decisiones. Sin embargo, no se ha demostrado su fiabilidad ni se ha normalizado la forma de emplearlo. El objetivo de este estudio fue estandarizar la técnica de medición del AAC y evaluar la reproducibilidad inter- e intraobservador de la técnica propuesta.

Métodos: Se analizaron 30 tomografías de pie de 27 pacientes de entre 10 y 17 años de edad. Diez presentaban coaliciones calcáneo-escafoideas, 10 coaliciones astrágalo-escafoideas y 10 sin coaliciones. La reproducibilidad inter- e intraobservador del AAC fue evaluada mediante el coeficiente de correlación intraclase (ICC). Utilizamos un modelo de ANOVA de efectos mixtos para calcular los ICC para acuerdo ICC2(A,1). Este procedimiento se aplicó a los tres observadores (variabilidad interobservador) y a la prueba-reprueba del observador 1 (variabilidad intraobservador). Un valor de p a dos colas $\leq 0,05$ fue considerado como significativo.

Resultados: Los acuerdos interobservador e intraobservador fueron excelentes para el AAC. Acuerdo interobservador: ICC2(A,1)=0,95 ($p < 0,001$, IC 95%: 0,77-0,93). Acuerdo intraobservador: ICC2(A,1)=0,99 ($p < 0,001$, IC 95%: 0,97-0,99).

Conclusión: El AAC representa un medio fiable para evaluar la alineación del retropié. Este método de medición, tal cual se describe en este estudio, puede ser utilizado de forma segura para el planeamiento quirúrgico en pacientes con coaliciones tarsianas.

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Introduction

Tarsus coalitions are a frequent cause of foot pain in children and adolescents. In the majority of cases surgical treatment consists of resection of the coalition and the insertion of separating material. Several studies have underlined the need to evaluate hindfoot alignment, as this is one of the factors that would affect postoperative results.¹⁻³ It is because of this that some surgeons¹⁻⁷ have suggested foot realignment by osteotomy in the same operation or subsequently when the hindfoot has severe valgus deformity.

In 1994 Wilde et al. described measuring the talocalcaneal angle (TCA) using coronal tomography slices.⁸ After this description several authors^{2,3,7} have used the TCA in their decision-making. Nevertheless, the method used to measure this angle was not clearly described in the original paper, as the authors did not indicate which coronal slice should be used. Due to the anatomical characteristics of the hindfoot, if a more anterior or posterior coronal slice is used this may affect the measurement of the said angle. On the other hand, there is no information in the literature respecting the reliability of the TCA.

The aim of this study was to standardise the technique used to measure the TCA and evaluate the inter- and intra-observer reproducibility of the proposed technique.

Material and methods

A set of 30 tomographic images of the feet of 27 patients aged from 10 to 17 years old and taken in the same

institution from January 2010 to July 2016 were analysed. The subjects were selected at random from a database and divided into three groups: group A: 10 feet with talocalcaneal coalitions; group B: 10 feet with scaphoidcalcaneal coalitions; and group C: the control group (10 patients). In the latter "normal" or control group of patients tomographic imaging had usually been requested due to trauma or to evaluate juvenile osteochondritis dissecans of the talus. Patients with tarsal fusions not located between the calcaneus and the tarsal scaphoids or the tarsus and the calcaneus were excluded from the study, as were those who had been treated previously by surgery. Those patients with displaced fractures of the hindfoot and sequelae of foot or ankle fractures that may have altered the axis were excluded from the control group.

Evaluation of the images

All of the images were taken in the same institution using the same technique. The study was undertaken using Siemens Somatom Sensation tomographic imaging equipment on a support. The images were stored and analysed using version 10.2 of Kodak Carestream PACS imaging software. Three professionals evaluated the images using the relevant measuring tools of the said software. Angles were determined by using a sagittal plane slice of the foot that made it possible to observe the base of the second metatarsal bone, drawing a line that passed through 50% of the posterior subtalar joint. This slice was then translated into the coronal plane (Fig. 1A). The TCA was measured in the coronal plane, this

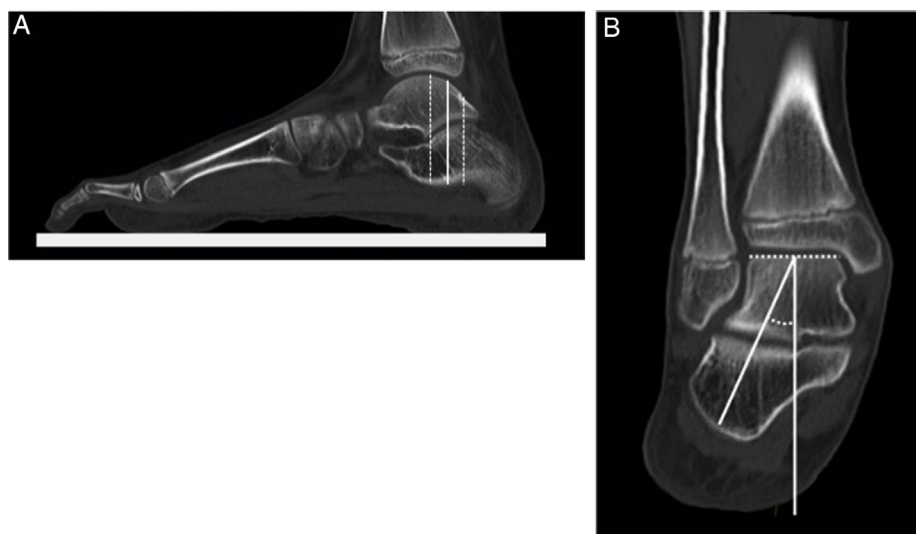


Figure 1 (A) Sagittal slice of the foot, including the base of the second metatarsal bone. A line is drawn in this slice that runs through the centre of the posterior subtalar joint. This slice was translated to the coronal plane to take the measurements. (B) Talus-calcanes angle between a line perpendicular to the talus dome and another line perpendicular to the inferior edge of the calcaneus.

being an adaptation of the angle described by Wilde et al.,⁸ and it shows the alignment of the hindfoot as a whole. This is formed between a line that is perpendicular to the tarsal dome and another line that is perpendicular to the lower edge of the calcaneus (Fig. 1B).

Statistical analysis

Continuous variables were examined to analyse their normalcy, and they are shown as an average (\pm SD). Statistical analysis was carried out using the SPSS V 16.0 program (SPSS Inc., Chicago, IL). Three observers measured 30 tomographic images of the foot and then one observer measured 30 tomographic images on two different occasions within a 4-week period. We use a mixed effect ANOVA model to calculate the intraclass correlation coefficients (ICC) for ICC2 (A, 1) agreement. This procedure was applied to the three observers (inter-observer variability) and observer 1 test-retest (intra-observers variability). A two-tailed p value $\leq .05$ was considered to be significant.

Results

Thirty tomographic images of the feet of 27 patients (16 male) were analysed. Fifteen were of the right foot, 9 were of the left foot and 3 were bilateral. The average age of the patients was 12.2 years old (range: 10–17 years old).

Inter-observer and intra-observer agreement was excellent for the TCA, as is shown in Table 1.

Discussion

Tarsal coalitions are a major cause of rigid valgus flat feet in paediatric patients. Surgery is indicated in cases that

Table 1 Inter- and intra-observer variability.

Analysis	ICC2 (A, 1)	p^*
Inter-observer	.95 (.77–.93)	<.001
Intra-observer	.99 (.97–.99)	<.001

* Mixed effects.

present with symptoms and do not respond to conservative treatment. Surgical treatment of this pathology has evolved significantly over recent decades. After the first description of triple arthrodesis for the treatment of this pathology, its indication has progressed to include resection of the coalition and the insertion of soft tissues.^{9–11} Although resection is able to restore mobility and eliminate pain in patients with an aligned foot, there is controversy regarding the treatment of coalitions that include associated valgus deformity. Due to this some authors^{5,7,11} consider that surgical treatment should not be based solely on the size and resectability of the coalition, as it should also take hindfoot alignment into account. Some studies suggest that simple resection gives poor results when severe valgus deformity is $>16^\circ$, according to Mosca and Bevan³ and Wilde et al.,⁸ or $>21^\circ$ according to Luhmann and Schoenecker.² A recent study¹² also suggests the surgical reconstruction of flat feet associated with the resection of a calcaneus-scapheids coalition, as it considers that resection alone does not give rise to a substantial improvement in foot biomechanics. Although this angle has been widely used,^{2–7} to date the inter- and intra-observer margin of error associated with it has not been evaluated. As the treatment of patients with tarsal coalitions is based on hindfoot alignment among other factors, exact measurement of this angle is crucial for decision-making by the treating doctor.

In this study, we evaluate a group of patients with both most frequent types of tarsal coalition, with a third coalition-free group as the control. We standardise measurement of the TCA by using individuals in all three groups. We decided to use the coronal slice that passes through the centre of the posterior face of the calcaneus because we consider it to be the zone that best represents hindfoot alignment. We also decided to use the axis of both bones (as described originally) rather than the superior dome of the tarsus and the inferior part of the calcaneus, as we believe the latter has greater variation. We use these parameters to evaluate inter- and intra-observer variability in measuring the TCA. This evaluation gave excellent and reproducible results, making reliable evaluation of hindfoot valgus possible.

Our study has some limitations that should be described. The measurements were taken by three paediatric orthopaedic doctors with experience in this pathology. It is possible that the high level of reliability observed in this study may not be reproduced by less experienced doctors. Another limitation concerns the technique used to obtain images. The images were obtained using tomographic imaging equipment on a support, and not on a support with offloading. This may lead to underestimation of the angles obtained, although in theory this would not affect reproducibility. The aim of this study was restricted to evaluating the reliability of measurements rather than obtaining normal values for each group. The values obtained for the TCA in this study are offered solely as a reference to describe the differences between the different observations. A larger study would be required to determine the normal values of the TCA in patients with tarsal coalitions. In spite of these limitations we believe this study to be original, as it standardises and validates measurement of the TCA.

To conclude, the TCA is a reliable means of evaluating hindfoot alignment. This method of measuring, as described in this study, may be used with surety when considering surgery for patients with tarsal coalitions.

Level of evidence

Level of evidence III (diagnostic study).

Conflict of interests

The authors have no conflict of interests to declare.

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