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THE CORRELATION BETWEEN FOOTPRINT MEASUREMENTS AND RADIOGRAPH OF FLATFOOT

Radiodiagnosis

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ABSTRACT

Objectives: To evaluation of the sub-arch angle from footprints in children with flatfeet, to evaluate various foot arch indexes, and to compare the results with radiographic measurements. **Methods:** The study includes Fifty-two children (age range, 2–14y) diagnosed with flatfeet. Radiographic measurements and foot shape measurements obtained. Talo-first metatarsal angle, talocalcaneal angle, talo-horizontal angle, and calcaneal angle were obtained from radiographs. Sub-arch angle, arch indexes, and long plantar angle were from foot print. **Results:** Correlations between the subarch angle and the talo-first metatarsal angle, talo-horizontal angle, and arch height were significant.there was also significant correlation between midfoot arch index and talo-horizontal angle. The forefoot arch index had no significant relationship with radiographic parameters. The talo-horizontal angle and arch height had significant relationships with the long plantar angle. Conclusions: Measurement of the subarch angle can be a useful tool in the assessment and diagnosis of flatfoot.

KEYWORDS

Flatfoot, Radiography, Footprint

INTRODUCTION

Flatfoot is a complex foot deformity that is commonly seen in clinical practice. The flatfoot deformity is characterized by a combination of a collapse of the medial longitudinal arch, foot abduction at the talonavicular joint, and hindfoot valgus (subtalar joint eversion) [1,2]. Different procedures can be used to diagnose flatfoot, such as clinical diagnosis,[3] X-ray studies,[4] and footprint analysis.[5] Footprint analysis by a pedograph is a simple, quick, cost effective, and readily available method.

There is little consensus in the literature about which parameters calculated from a footprint are highly significant[6]. However, medial longitudinal longitudinal arch (MLA) has been used as a main reference to diagnose flatfoot or to assess results after the treatment assessment[7]. The MLA is an integration of the tarsal bones and consists of the talonavicular, talocalcaneal, and naviculocuneiform joints. The main function of the MLA is to absorb the reaction shock force during ambulation[8]. Flatfeet in children are attributed to ligamentous laxity in the MLA, which results in body weight shifting to the medial side during standing and walking due to the collapsed arch of the foot. Therefore, the arch height is often used as a reference to assess foot problems[9].

There are many methods currently being used to classify MLA structures,[6,8] but the footprint is still the most popular approach to analyze and assess the MLA[10]. Many parameters from the footprint are used to assess MLA characteristics. Cavanagh and Rodgers[10] quantified the arch index and calculated the ratio of the area of the middle third to the whole toeless footprint area. Staheli et al[11] characterized the width of the foot in the area of the arch and the heel, and the ratio between these widths was called the arch index. Rao and Joseph1 obtained footprints and classified them into normal, high arched, or flat patterns using the width of the midfoot. Forriol and Pascual[12] proposed using the footprint and the Chippaux-Smirak index to analyze the changes in footprints according to age. These methods were even applied to the clinical fields for assessment of pes planus[13,14]. However, these indexes only focus on the relationship between the forefoot and midfoot. Kernozek and Ricard[15] observed the relationship between arch type and hindfoot motion. They found that the flat-arched subjects showed greater hindfoot motion. Welton[16] even proposed dynamic (walking) footprints to reflect additional information when compared with static (standing) ones. These studies frequently obtained the arch index by directly measuring the forefoot and midfoot or midfoot and hindfoot.

Conversely, some investigators stated that footprints did not often reflect the real structures of the MLA of the foot. Footprints are also used as a tool to assess the relationship with radiographic studies. Vanderwilde et al[17] set up the radiographic evaluation and established age-related normative values with various foot angles. They used radiographic anteroposterior and lateral views to compile a clinically useful reference. Saltzman et al[18] used the anthropometric measurements of MLA height, footprint calculation, and radiographic parameters of the foot to determine the correlation between these methods with interrater and intrarater reliability coefficients. They concluded that the MLA radiographic measurement is a criterion standard for assessing arch structure. Most of the radiographic measurements were found to be highly reliable in assessing foot function[19]. Kanatli et al[20] found signif- icant correlation between footprint measurement and radiographic evaluation for the MLA. The traditional method of acquiring ink footprints is a simple measure, but time-consuming, laborious, and messy. Capacitance footprint is an easier way to overcome the disadvantages of obtaining ink footprints. Foot types calculated from static (standing) footprints displayed less ability than dynamic (walking) footprints to respond to arch changes[19,21,22]. Therefore, the purpose of this study was to use a capacitance footprint to obtain a subarch angle formed by the forefoot, midfoot, and hindfoot to describe the flatfoot and to correlate the angle with radiographic measurements in a dynamic status.

METHOD

All paediatric patients of both sexes, who can walk without support (2-14 yr.) and who are otherwise clinically asymptomatic was included in the study. The exclusion criterion were

a) Symptomatic feet;
b) Old history of trauma to foot;
c)Neuromuscular abnormalities e.g
polio/cp/meningomyelocele/myopathies/neuropathies;
d) Patients with apparent lower limb alignment abnormalities e.g. knock knee etc. and
e) Patients not willing to participate in study.

This was open study. All children visiting ortho OPD for some reasons other than foot problems and children from surrounding 03 schools were screened and included.

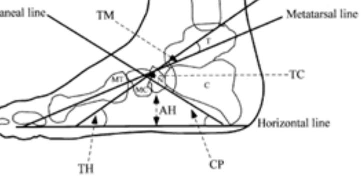

Fig 1. Template for radiographic measurements of the medial longitudinal arch, calculated on lateral radiography. Abbreviations: AH, arch height; C, calcaneus; CP, calcaneal pitch angle; MC, medial cuneiform bone; MT, metatarsal bone; N, navicular bone; T, talus; TC,

talocalcaneal angle; TH, talo-horizontal angle; TM, talo-first metatarsal angle.

Radiographic Parameters

From the lateral radiograph, we obtained 5 parameters to describe the MLA (fig 1) [22]. For data analysis, the angles were also measured with 4 lines[22,23]: (1) talar line: a longitudinal line was determined by the middle points in cortices of the talus; (2) calcaneal line: a target line was drawn along the inferior surface of the calcaneus; (3) metatarsal line: a line was determined by the middle points of superior and inferior cortices of the metatarsal bone; and (4) horizontal line: a line was connected from the fifth metatarsal bone to the inferior process of the calcaneus. From these 4 lines, the following parameters were obtained: (1) talo-first metatarsal angle: a measure of the forefoot and the hindfoot, which becomes wider in the flat foot; (2) talocalcaneal angle: the angle is used to identify the hindfoot with increased valgus heel angle because increased angles are found during valgus angulation; (3) talo-horizontal angle: the angle is obtained to demonstrate the talar inclination; (4) calcaneal pitch angle: an angle that is introduced to describe calcaneal inclination, which is decreased in flatfoot; and (5) arch height: height is defined from the inferior tubercle of the navicular bone to the horizontal line.

Geometric Parameters of the Foot

Static weight bearing podogram of both feet were taken on plain white paper on a levelled surface.the name of subject and enrolment number was written on right upper cover of thde paper.subject and enrolment number was written on right upper cover of the paper.subjects was instructed to stand motin less with weighgt center over both feet and eyes focusd straight a head for even weight distribution .once in position for approximately 2 second ,the foot was removed carefully from print. (fig 2). Two tangent lines were drawn along the lateral and medial margin of the foot. The 4 points (A, A=, B, B=) were defined and the forefoot and heel width were also measured. The 2 lines met to form the long plantar angle. The most lateral point of the border of the medial midfoot (O) made 2 tangents and contacted the forefoot and the hindfoot at 2 points, respectively (C, D). The 3 points O, C, and D formed the subarch angle. A tangent was drawn from point A toward the great toe in contact with point H. The hallux angle was then defined by the 2 lines AH and AB. The narrowest part of the arch was defined as the midfoot length (L). The 2 arch indexes, forefoot arch index (equal to L/A A=) and midfoot arch index (equal to L/B B=), were also defined.

Data Analysis

We calculated mean values and standard deviations (SDs) for all dependent parameters. The relationship between the right and left feet was compared with paired t test. Tomine whether the geometric parameters could be used to assess the flatfeet, the correlation between geometric parameters and radiographic data were analyzed with Pearson correlation coefficients.A significance level of P less than .05 was used for all analyses.

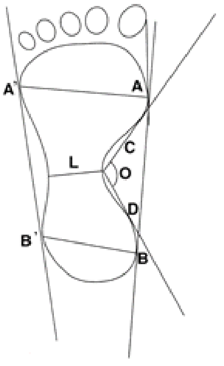

Fig 2. The geometric parameters were determined with the EMED ST-4 system. Subarch angle (equal to COD, A, A=, B, B=) defined over the forefoot and heel width, forefoot arch index (equal to L/A A=), midfoot arch index (equal to L/B B=), and long plantar angle determined by AB and A= B=.

RESULT

There was no significant difference in geometric parameters (P_.05) between the subjects' right and left feet when using the paired samples t test. Therefore, only the right foot of each subject was selected for assessing the correlation between geometric parameters and the radiographic measurements.

Table:3 Correlation of Radiographic Parameters With Subarch Angle, Midfoot Arch Index, and Forefoot Arch Index (N_52)

Parameters*	Subarch angle		Mid foot arch index		Forefoot arch index	
	r	p	r	p	r	p
TM	0.66	<0.0001	0.19	0.17	0.39	<0.004
TH	0.54	<0.00056	0.43	<0.001	0.22	0.11
TC	0.16	0.25	0.08	0.57	-0.22	0.11
CP	0.24	0.08	0.22	0.11	-0.29	<0.03
AH	0.60	<0.00001	0.32	<0.02	-0.22	0.11

Table:4 Correlation of Radiographic Parameters With Subarch Angle and Long Plantar Angle (N=52)

Parameter	Subarch angle		Long plantar angle	
	r	p	r	p
TM	0.66	<0.00001	0.31	<0.02
TH	0.54	<0.00036	0.41	<0.002
TC	0.16	0.25	0.34	<0.013
CP	0.24	0.08	0.21	0.13
AH	0.60	<0.00001	-0.63	<0.00001

DISCUSSION

The navicular tubercle of the MLA has been considered the best anthropometric parameter and has been taken as an important indicator of foot structures[24,25]. The subarch angle is determined by forefoot, midfoot, and hindfoot parameters in the footprint. The most lateral point of the border of the midfoot (O in fig 2) is nearest to the reflectional point in the surface of the tarsal epicenter[26], which locates at the center of the calcaneal-cuboid articulation. The subarch angle may best show changes in the foot over the plantar surface, although there are many methods to describe arch height using the footprint. The subarch angle formed by the first metatarsal and the heel bone (C, D) are also reflected in the forefoot and hindfoot area that embraces all the skeletal structure of the foot's main arch (ie, MLA). Because we know the flatfoot is characterized by forefoot abduction, a decrease in height of the MLA or hindfoot valgus may quantify a diagnosis of flatfoot. The subarch angle had a high correlation with variable radiographic parameters. The talo-first metatarsal angle has been used to describe the inclination of the talus[22,23]. The talo-horizontal angle represents the medial and plantar-ward movement of the talus. The angle becomes increasingly positive in subjects with flatfeet. When sagging at the naviculocuneiform joint occurs, the navicular bone slides downward with an increasingly negative value. The subarch angle correlated well with the angle of talo-first metatarsal angle and the talo-horizontal angle, as well as the arch height (see table 3).

The results showed that the subarch angle is most suitable to characterize the behavior of the MLA. The vertical height of Therefore, the subarch angle can be regarded as the most representative measurement of the MLA from the anatomic point of view.

The calcaneal pitch angle describes the alignment of the hindfoot, and is decreased in subjects with flatfeet. The talocalcaneal angle also demonstrates the angle changes of the hindfoot. These 2 parameters, however, have no significant relationships with subarch angle. Cobey and Sella[27] showed that the measurement of the talocalcaneal angle alone was not representative and could not be reproducible. Saltzman et al[18] also reported lower correlation of the calcaneal pitch angle with the MLA. Midfoot arch index has been widely used for evaluating and describing flatfeet, Igbigbi and Msamati[28] used the methods of measuring the footprint described by Cavanagh[29] and stated that the footprint ratio was a prediction of flatfoot in an indigenous Malawian population. In this study, there were no significant correlations between the radiographic parameters and the midfoot arch. However, some midfoot arch measurements obtained with a static method made significant correlations with radiographic parameters,[24,19] which differed from our study. The forefoot arch index, however, revealed no significant correlation with the parameters of the radiographic findings in our study. . Foot placement (long plantar) angle and arch type was used to assess hindfoot motion[15]. The long plantar angle, but not the arch type, was a significant prediction of maximum subtalar pronation. In this study, a significantly negative relationship between the long plantar angle and decreased arch height was found. The long plantar angle exhibited a high correlation with the arch height as that of the sub-arch angle (r__.63 vs r__.60); however, the other radiographic parameter showed no significant correlations. The measurements of sub-arch angle obtained from footprint analyses are simple, available, reliable, and easily transported electronically.

CONCLUSIONS

Subarch angle correlated highly to measurements obtained from radiographs and can be repeated in the EMED system. It can significantly reflect the major component of foot measurement, MLA, which is formed by forefoot, midfoot, and hindfoot. Therefore, the measurement of the subarch angle can be a useful tool in the assessment and diagnosis of flatfoot.

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