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Radiological Effects of Changes in Entry Points on the Medial Longitudinal Arch during Longitudinal Arch Lateral Projections

Dong-Hee Hong[1], Young-Cheol Joo[*2]

Sung-Jin Kim[1], Tae-Hwan Kim[1], Ji-Woo Park[1], Tae-Won Um[1], Tae-Gyeong Han[1]

[1] *Dept. of Radiology Science, Shinhan University, 95, Hoam-ro, Uijeongbu, Gyeonggi-do, 11644, Republic of Korea*

[2]*Department of Radiology, Samsung Medical Center, 81, Irwon-ro, Gangnam-gu, Seoul, 06351, Republic of Korea*

Hansound2@hanmail.net[1]

Abstract

Background/Objectives*: The flatfoot and claw-foot are diagnosed mainly by measuring the degree of cu rvature of the arch of the foot. However, if the incidence point varies, the medial arch curvature in the im age may change. This change can increase the error rate and frequency of retakes, thereby increasing the dose of radiation to the patient. The purpose of this study was to investigate the importance of using the c orrect point of incidence and effect of the point of incidence on the radiologic finding of the medial arch.*

Methods/Statistical analysis: *The GC-85A radiation generator and phantom foot and ankle were used, and heights of the incidence point were set to the plantar base, metatarsal bone, ankle bone, and ankle jo int. The phantom was located on the front side, and the central X-ray was incident in the outward and in ward directions. Five radiology students obtained a total of 40 images, ten times at each incidence point after pre-training. The statistical program SPSS was used to calculate the average and analyze the sum. I n order to express the width of the mean increase and decrease based on the change in the incidence poi nt, it was calculated by setting the reference point as the foot bone.*

Findings:*When the incidence point was changed to the plantar base, the angle between the tibia and th e first metatarsal bone changed by 3.4%; the angle between the tibia and the calcaneus pitch changed by 0.55%; the angle between the calcaneus and the first metatarsal bone changed by 0.62%; the height of th e calcaneus changed by 0.5%, the height of the longitudinal joint changed by 3.04%; the cubic bone heig ht decreased by 5.63%; the tongue bone height decreased by 2.97%; and the first medial bone height cha nged by 6.19%.*

Improvements/Applications: *Upon changing CR to the ankle joint, the talo–first metatarsal angle decre ased by 12.96%, but the calcaneal pitch angle, calcaneo–first metatarsal angle, calcaneal height, calcaneo cuboid joint height, cuboid height, cuneiform height, and first metatarsal height increased by 5.9%, 9.56%, 5.05%, 4.39%, 5.93%, 6.73%, and 16.81%, respectively. This study suggests that the effect of changes in*

the incidence point on the curvature of the medial arch is important.

Keywords: *Pes Planus, Pes Cavus, Longitudinal Arch, Center Ray*

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1. INTRODUCTION

Representative diseases due to deformities of the arch of the foot include flatfoot and claw foot. Flatfoot is a common disease that refers to deformations in which the longitudinal arch is abnormally lowered or lost. The Yao refers to the abnormally high deformation of the arch caused by plantar flexion, forefoot, foot flexion, and varus[1-2].

If the arch of the foot is deformed, the sole of the foot becomes unstable, making it difficult to withstand load, which can cause fatigue and pain of the joints.

The Health Insurance Review and Assessment Service reported that the number of patients who visited hospitals because of flatfoot increased more than twice from 9,121 in 2010 to 21,125 in 2018, and the number of patients who visited with forefoot increased from 725 in 2010 to 1,833 in 2018 [3]. Such data suggest that the number of tests for diagnosing flatfoot and claw foot may also increase.

Special inspections and radiological examination are performed for flatfoot and claw foot. Special inspections include static and dynamic foot printing, foot printing, and examination using a glass plate with a reflecting mirror. Radiological examinations include calcaneal inclination angle, talo–first metatarsal angle (Meary's angle [MA]), calcaneo–first metatarsal angle (Hibb's angle [HA]) with a longitudinal lateral projection angle, talocalcaneal angle, navicular height, etc. to determine if the measured values are within the tolerance range [1,2,4–6].

Since the flatfoot and claw foot differ in individual symptoms and the height of the medial arch, there is a difficulty in presenting a clear standard for the normal foot [1]. Therefore, the accuracy of radiological examination is important.

Since X-rays are transmitted through a three-dimensional body and projected as a planar image, a distorted image may be generated because of a center ray (CR) through which radiation is transmitted and a transmission direction. Overlooking these effects and failing to observe the exact point of incidence in simple radiographs can change the radiological measurements, leading to an increase in the error rate and increased patient's radiation dose with retake.

In this study, we investigated the effect of changes in the incidence point on the image anatomy of the medial arch curvature during longitudinal arch lateral projections. Establishing the point of incidence is recommended.

2. MATERIAL AND METHODS

2.1. Materials

This study was conducted on phantom foot and ankle (RS116T, California, USA).

2.2. Methods

2.2.1. Equipment

The X-ray generator used was GC 85A (Samsung Electronics, Korea). Image measurements were obtained on a Centricity DICOM Viewer (GE Medical Systems).

2.2.2. Methods

(1) Phantom position and image acquisition method

The phantom was positioned in the true lateral position, and central X-rays were incident in the medial direction (lateromedial [LM]) from the outside of the phantom.

In figure 1, changes in the height of the incident point of the central X-ray were set to the facies plantares, metatarsal bones, malleolus, and ankle joints. For an accurate incidence, anatomical indices were marked by attaching a marker to the three points except for the facies plantares.

Photographs were acquired in the order of facies plantares, metatarsal bones, malleolus, and ankle joints.

For image acquisition, a total of 40 images were acquired ten times at each incident point.

The shooting conditions were set to 55 kVp of tube voltage, 100 mAs of tube current, and 100 cm of source–image receptor distance.

The collimator was set to include all phantoms at 12.6″–13.8″.

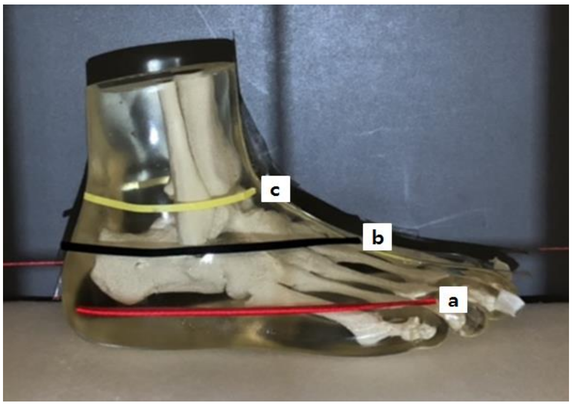

Fig. 1. Foot Phantom which is marked with tapes on center rays. ‘a’ is attached on metatarsal bone level, ‘b’ is attached on malleolus level ‘c’ is attached on ankle joint level.

(2) Image measuring method

In figure 2, imaging measurements were obtained five times at different intervals each day to ensure that the five radiology students did not affect each other's readings after prior training.

In this study, the following radiological indices were recorded for the observation of the change in the value of the image.

1. MA: Angle between the talus axis and the first metatarsal axis
2. Calcaneal pitch angle (CPA): Angle between the lower edge of the calcaneus and the floor
3. HA: Angle between the calcaneal axis and the first metatarsal axis
4. Calcaneus height (CCH): Vertically lowered from the calcaneus
5. Calcaneocuboid joint height (CJH): Vertically lowered from the cubic joint

6. Cuboid height (CBH): Vertically lowered from the cube
7. Cuneiform height (CNH): Height lowered from the tongue
8. First metatarsal height (1st MH): Height from the floor to the first metatarsal bone

(3) Data analysis method

In figure 3, values measured by five researchers were presented as descriptive statistics. The reliability of the measured values for each investigator was analyzed using the intraclass correlation coefficient (ICC). For reference, ICC ranges from 0 (no correlation) to 1 (exact match), with 0.00 to 0.39 indicating poor, 0.40 to 0.74 indicating moderate, and 0.75 to 1.00 indicating excellent.

Changes in the measurement index value based on changes in the central X-ray incidence point was analyzed by the mean sum of the measured values.

The mean comparison analysis was performed with one-way ANOVA, and Duncan was used for the post-hoc analysis.

The statistical program used was SPSS (version 22.0, SPSS, Chicago, IL, USA), and the significance level α was set to 0.05. A p-value less than 0.05 was considered statistically significant.

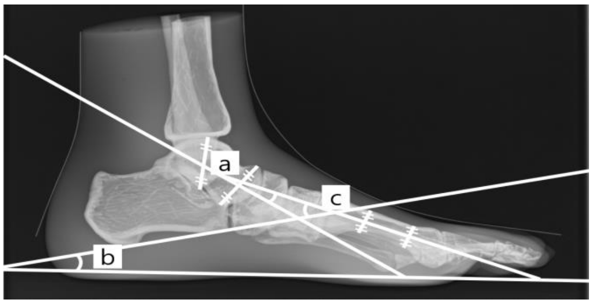

Fig. 2. Radiographic parameters are shown on longitudinal arch view
'a' is MA which is an angle between long axis of talus and long axis of 1st metatarsal, 'b' is CPA which is an angle between calcaneous and facies plantares, 'c' is HA which is an angle between calcaneous and 1st metatarsal.

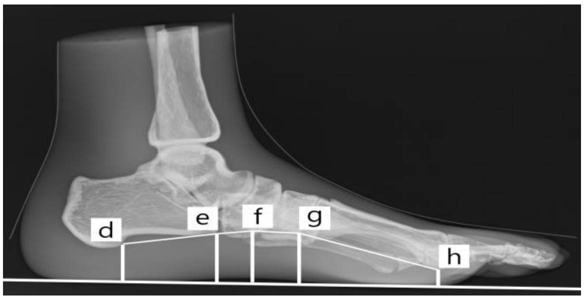

Fig. 3. Radiographic parameters are shown on longitudinal arch view

'd' is CCH which is a height from calcaneous to facies plantares, 'e' is CJH which is a height from calcaneocuboid joint to facies plantares, 'f' is CBH which is a height from cuboid to facies plantares, 'g' is CNH which is a height from cuneiform to facies plantares, 'h' is 1st MH which is a height from 1st metatarsal bone to facies plantares.

3. RESULTS

3.1. Descriptive statistics and reliability analysis results of MA, CPA, and HA based on changes in CR

Inter-measurement measurements of MA, CPA, and HA based on changes in CR are as follows:

MA was measured to be 12.02°~14.58° for the CR facies plantares, 12.72°~15.10° for the metatarsal bone, 10.96°~13.78° for the malleolus, and 11.92°~12.74° for the ankle joint.

CPA was 11.54°~13.08° for the CR facies plantares, 11.10°~13.42° for the metatarsal bone, 12.10°~13.84° for the malleolus, and 12.92°~14.54° for the ankle joint.

HA was 28.22°~32.77° for the CR facies plantares, 28.40°~32.88° for the metatarsal bone, 28.80°~33.41° for the malleolus, and 30.60°~34.64° for the ankle joint.

The inter-observer ICC for the three angles was 0.754, showing excellent results (Table 1).

3.2. Descriptive statistics and reliability analysis results among CCH, CJH, CBH, CNH, and 1st MH based on changes in CR

Inter-measurement measurements at CCH, CJH, CBH, CNH, and 1st MH based on changes in CR are as follows.

CCH was measured to be 1.91~2.02 □ for the facies plantares, 1.91~2.08 □ for the metatarsal bone, 2.00~2.13 □ for the malleolus, and 2.00~2.15 □ for the ankle joint.

CJH was 2.58~2.96 □ for the facies plantares, 2.61~3.13 □ for the metatarsal bone, 2.61~3.16 □ for the malleolus, and 2.58~3.32 □ for the ankle joint.

CBH was 2.60~3.16 □ for the facies plantares, 2.99~3.36 □ for the metatarsal bone, 3.09~3.56 □ for the malleolus, and 3.04~3.68 □ for the ankle joint.

CNH ranged from 2.61 to 3.03 cm for the facies plantares, 2.61 to 3.09 cm for the metatarsal bone, 2.53 to 3.24 cm for the malleolus, and 2.55 to 3.69 cm for the ankle joint.

Lastly, 1st MH was measured to be 1.03~1.08 □ for the facies plantares, 1.10~1.15 □ for the metatarsal bone, 1.19~1.31 □ for the malleolus, and 1.26~1.43 □ for the ankle joint.

The inter-observer ICC for each height was 0.920, showing excellent results (Table 2).

3.3. Results of the mean comparison analysis of radiological indicators based on changes in CR

The mean MA was 13.78° ± 1.29° for the CR facies plantares, 14.27° ± 1.76° for the metatarsal bones, 12.51° ± 1.65° for the malleolus, and 12.42° ± 0.96° for the ankle joint. There was a statistically significant difference in the mean values, but after the post-hoc test, the facies plantares and metatarsal bones were in the same group, and the malleolus and ankle joint were classified in the same group.

The mean CPA was 12.46° ± 0.71° for the CR facies plantares, 12.53° ± 1.02° for the metatarsal bones, 12.96° ± 0.86° for the malleolus, and 13.71° ± 0.73° for the ankle joint. Each mean value was statistically significant, and all were classified into individual groups in the post-hoc test results.

The mean HA was 30.25° ± 1.91° for the CR facies plantares, 30.44° ± 1.79° for the metatarsal bones, 31.97° ± 1.80° for the malleolus, and 33.35° ± 1.69° for the ankle joint. There was a statistically significant difference in the mean values, but after the post-hoc test, the facies plantares and metatarsal bones were classified into the same group, and the malleolus and ankle joint were classified into different groups.

The mean CCH was 1.97 ± 0.04 cm in the CR facies plantares, 1.98 ± 0.08 cm in the metatarsal bones, 2.03 ± 0.08 cm in the malleolus, and 2.08 ± 0.10 cm in the ankle joint. There was a statistically significant difference in the mean values, but after the post-hoc test, the facies plantares and metatarsal bones were classified into the same group, and the malleolus and ankle joint were classified into the same group.

The mean CJH was 2.87 ± 1.15 cm for the CR facies plantares, 2.96 ± 0.19 cm for the metatarsal bones, 3.00 ± 0.21 cm for the malleolus, and 3.09 ± 0.28 cm for the ankle joint. There was a statistically significant difference in the mean values, but after the post-hoc test, the facies plantares and metatarsal bones were classified into the same group, and the malleolus and ankle joint were classified into different groups.

The mean CBH was 3.02 ± 0.23 cm for the CR facies plantares, 3.20 ± 0.19 cm for the metatarsal bones, 3.28 ± 0.21 cm for the malleolus, and 3.39 ± 0.22 cm for the ankle joint. There was a statistically significant difference in each mean value, and all points were classified into individual groups.

The mean CNH was 2.92 ± 0.16 cm in the CR facies plantares, 2.97 ± 0.19 cm in the metatarsal bones, 3.06 ± 0.28 cm in the malleolus, and 3.17 ± 0.43 cm in the ankle joint. There was a statistically significant difference in the mean values, but after the post-hoc test, the facies plantares and metatarsal bones were classified into the same group, and the malleolus and ankle joint were classified into the same group.

The mean 1st MH was 1.06 ± 0.03 □ for the CR facies plantares, 1.13 ± 0.06 □ for the metatarsal bones, 1.25 ± 0.07 □ for the malleolus, and 1.32 ± 0.09 □ for the ankle joint. There was a statistically significant difference in each mean value, and all points were classified into separate groups after the post-hoc test (Table

Table 1. Descriptive statistics on measurements of MA, CPA and HA according to the change of CR and results of intraclass correlation

radiological index	Center Ray	measure	n	mean±SD(°)	min	max	ICC*
MA	facies plantares	measure 1	5	14.30±0.67	13.50	15.20	0.754
		measure 2		14.58±0.88	13.40	15.40	
		measure 3		14.58±0.88	13.40	15.40	
		measure 4		13.44±0.74	12.50	14.20	
		measure 5		12.02±1.24	10.40	13.20	
	metatarsal bone	measure 1		14.44±0.72	13.40	15.10	
		measure 2		14.54±2.35	11.80	17.00	
		measure 3		14.54±2.35	11.80	17.00	
		measure 4		15.10±0.8	14.20	16.10	
		measure 5		12.72±1.53	10.70	14.10	
	malleolus	measure 1		10.96±0.75	10.10	11.90	
		measure 2		13.78±1.87	11.80	16.60	
		measure 3		13.78±1.87	11.80	16.60	
		measure 4		12.16±0.89	10.90	13.10	
		measure 5		11.86±0.56	11.30	12.50	
	ankle joint	measure 1		12.74±0.62	11.90	13.50	
		measure 2		12.70±1.24	11.40	14.50	
		measure 3		12.70±1.24	11.40	14.50	
		measure 4		12.06±0.43	11.50	12.50	
		measure 5		11.92±1.05	10.30	13.10	
CPA	facies plantares	measure 1		11.54±0.48	10.80	12.10	
		measure 2		13.08±0.23	12.80	13.30	
		measure 3		12.76±0.26	12.40	13.10	
		measure 4		11.98±0.57	11.20	12.80	
		measure 5		12.92±0.40	12.50	13.50	
	metatarsal bone	measure 1		11.10±0.21	10.90	11.40	
		measure 2		13.20±0.27	12.80	13.50	
		measure 3		13.00±0.93	12.20	14.20	

		measure 4		11.94±0.61	11.10	12.80	
		measure 5		13.42±0.33	12.91	13.82	
	malleolus	measure 1		12.10±0.57	11.20	12.60	
		measure 2		13.08±0.30	12.70	13.50	
		measure 3		13.84±0.29	13.50	14.20	
		measure 4		12.12±0.27	11.90	12.50	
		measure 5		13.66±0.71	12.63	14.58	
	ankle joint	measure 1		13.46±0.24	13.20	13.70	
		measure 2		14.20±0.19	14.00	14.50	
		measure 3		14.54±0.60	13.60	15.00	
		measure 4		12.92±0.61	12.10	13.80	
		measure 5		13.46±0.54	12.73	14.07	
HA	facies plantares	measure 1		28.22±0.48	27.80	29.00	
		measure 2		30.58±0.36	30.20	31.10	
		measure 3		31.48±0.76	30.70	32.50	
		measure 4		28.22±0.61	27.50	28.90	
		measure 5		32.77±0.65	31.87	33.66	
	metatarsal bone	measure 1		29.34±1.30	28.20	31.50	
		measure 2		30.26±0.29	30.00	30.70	
		measure 3		31.34±0.68	30.50	32.00	
		measure 4		28.40±1.21	27.10	29.90	
		measure 5		32.88±0.59	32.09	33.55	
	malleolus	measure 1		32.12±0.37	31.60	32.60	
		measure 2		32.34±0.36	31.90	32.80	
		measure 3		33.16±0.92	32.00	34.00	
		measure 4		28.80±0.82	27.90	29.90	
		measure 5		33.41±0.68	32.67	34.15	
	ankle joint	measure 1		34.64±0.33	34.30	35.10	
		measure 2		34.16±0.18	33.90	34.40	
		measure 3		33.44±0.4	33.10	34.10	
		measure 4		30.60±1.50	29.10	33.00	
		measure 5		33.90±1.34	32.52	36.08	

1. MA is an angle between long axis of talus and long axis of first metatarsal. CPA is an angle between calcaneous and facies plantares. HA is an angle between calcaneous and 1st metatarsal
2. SD: Standard Deviation 3. *is the Intraclass correlation coefficient.

Table 2. Descriptive statistics on measurments of CCH, CJH, CBH, CNH, 1st MH according to the change of CR and results of intraclass correlation

radiological index	Center Ray	measure	n	mean±SD(°)	min	max	ICC*
CCH	facies plantares	measure 1	5	2.02±0.24	1.98	2.04	0.920
		measure 2		1.96±0.04	1.91	2.01	
		measure 3		1.91±0.01	1.90	1.93	
		measure 4		2.01±0.02	1.98	2.03	
		measure 5		1.96±0.13	1.95	1.98	
	metatarsal bone	measure 1		2.08±0.52	2.02	2.15	
		measure 2		1.97±0.04	1.92	2.01	
		measure 3		1.91±0.10	1.80	2.03	
		measure 4		2.01±0.05	1.98	2.10	
		measure 5		1.95±0.03	1.93	1.99	
	malleolus	measure 1		2.02±0.06	1.96	2.10	
		measure 2		2.13±0.08	2.00	2.23	
		measure 3		2.01±0.1	1.90	2.15	
		measure 4		2.00±0.02	1.98	2.02	
		measure 5		2.02±0.01	2.00	2.02	
	ankle joint	measure 1		2.15±0.04	2.10	2.20	
		measure 2		2.03±0.05	1.98	2.10	
		measure 3		2.00±0.08	1.89	2.09	
		measure 4		2.14±0.15	2.04	2.40	
		measure 5		2.08±0.04	2.03	2.13	
CJH	facies plantares	measure 1		2.95±0.06	2.87	3.02	
		measure 2		2.95±0.04	2.91	3.01	
		measure 3		2.92±0.05	2.84	2.98	
		measure 4		2.96±0.04	2.89	2.99	

		measure 5		2.58±0.02	2.56	2.60	
	metatarsal bone	measure 1		3.13±0.07	3.04	3.22	
		measure 2		3.06±0.48	2.99	3.12	
		measure 3		3.03±0.08	2.93	3.13	
		measure 4		2.97±0.05	2.88	3.00	
		measure 5		2.61±0.02	2.57	2.63	
	malleolus	measure 1		3.16±0.05	3.10	3.23	
		measure 2		3.06±0.04	3.02	3.12	
		measure 3		3.14±0.06	3.06	3.20	
		measure 4		3.00±0.11	2.92	3.20	
		measure 5		2.61±0.03	2.57	2.64	
	ankle joint	measure 1		3.32±0.10	3.18	3.45	
		measure 2		3.13±0.04	3.08	3.18	
		measure 3		3.18±0.07	3.11	3.26	
		measure 4		3.24±0.15	3.10	3.40	
		measure 5		2.58±0.03	2.54	2.61	
CBH	facies plantares	measure 1		3.13±0.06	3.04	3.21	
		measure 2		3.07±0.03	3.04	3.12	
		measure 3		3.12±0.18	3.00	3.44	
		measure 4		3.16±0.10	3.01	3.25	
		measure 5		2.60±0.17	2.59	2.63	
	metatarsal bone	measure 1		3.36±0.09	3.27	3.50	
		measure 2		3.25±0.06	3.19	3.34	
		measure 3		3.34±0.23	3.05	3.69	
		measure 4		3.04±0.05	3.00	3.11	
		measure 5		2.99±0.05	2.92	3.04	
	malleolus	measure 1		3.49±0.78	3.40	3.60	
		measure 2		3.11±0.03	3.06	3.15	
		measure 3		3.56±0..04	3.50	3.60	
		measure 4		3.16±0.11	3.02	3.31	
		measure 5		3.09±0.03	3.07	3.13	
	ankle joint	measure 1		3.68±0.04	3.64	3.74	

		measure 2		3.43±0.04	3.38	3.48	
		measure 3		3.50±0.08	3.38	3.57	
		measure 4		3.34±0.08	3.23	3.43	
		measure 5		3.04±0.05	2.96	3.08	

Table 3. Results of ANOVA on means of Radiologic Indicators According to CR Change

radiological index	Center Ray	n	mean±SD	min	max	F	p*
MA	facies plantares	25	13.78±1.29^{a}	10.40	15.40	10.111	0.001
	metatarsal bone		14.27±1.76^{a}	10.70	17.00		
	malleolus		12.51±1.65^{b}	10.10	16.60		
	ankle joint		12.42±0.96^{b}	10.30	14.50		
CPA	facies plantares		12.46±0.71^{a}	10.80	13.50	11.787	0.001
	metatarsal bone		12.53±1.02^{ab}	10.90	14.20		
	malleolus		12.96±0.86^{b}	11.20	14.58		
	ankle joint		13.71±0.73^{c}	12.10	15.00		
HA	facies plantares		30.25±1.91^{a}	27.50	33.66	16.223	0.001
	metatarsal bone		30.44±1.79^{a}	27.10	33.55		
	malleolus		31.97±1.80^{b}	27.90	34.15		
	ankle joint		33.35±1.69^{c}	29.10	36.08		
CCH	facies plantares		1.97±0.04^{a}	1.90	2.04	9.768	0.001
	metatarsal bone		1.98±0.08^{a}	1.80	2.15		
	malleolus		2.03±0.08^{b}	1.90	2.23		
	ankle joint		2.08±0.10^{b}	1.89	2.40		
CJH	facies plantares		2.87±1.15^{a}	2.56	3.02	4.384	0.006
	metatarsal bone		2.96±0.19^{a}	2.57	3.22		
	malleolus		3.00±0.21^{ab}	2.57	3.23		
	ankle joint		3.09±0.28^{b}	2.54	3.45		
CBH	facies plantares		3.02±0.23^{a}	2.59	3.44	13.898	0.001
	metatarsal bone		3.20±0.19^{b}	2.92	3.69		
	malleolus		3.28±0.21^{bc}	3.02	3.60		
	ankle joint		3.39±0.22^{c}	2.96	3.74		

CNH	facies plantares		2.92±0.16[a]	2.56	3.06	3.766	0.013
	metatarsal bone		2.97±0.19[a]	2.55	3.14		
	malleolus		3.06±0.28[ab]	2.50	3.40		
	ankle joint		3.17±0.43[b]	2.24	3.94		
1st MH	facies plantares		1.06±0.03[a]	1.01	1.12	83.277	0.001
	metatarsal bone		1.13±0.06[b]	1.01	1.29		
	malleolus		1.25±0.07[c]	1.14	1.36		
	ankle joint		1.32±0.09[d]	1.05	1.51		

1. MA is an angle between long axis of talus and long axis of first metatarsal. CPA is an angle between calcaneous and facies plantares. HA is an angle between calcaneous and 1st metatarsal ,CCH: Calcaneus Height, CJH: Calcaneocuboid Joint Height, CBH: Cuboid Height,
CNH: Cuneiform Height, 1st MH: 1st Metatarsal Height
2. SD: Standard Deviation
**p*-value by one way ANOVA, post-hoc by Duncan

4. DISCUSSION

In order to measure the medial calf of the foot, indirect examinations, such as foot prints and photographs, and direct examinations, such as anthropometric examination, ultrasound examination, and radiographs, are used. The double-foot test is not only effective but also requires special equipment to evaluate changes in the width or width of the foot print [5][7].

According to Cobey and Sella, the height of the arch obtained on a foot scan differs from that on a simple radiograph. Anthropometric methods can be less reliable because anatomical reference points are not clearly set, and ultrasound is expensive compared to other tests [5]. In comparison, the simple radiographic examination is relatively inexpensive, and the frequency of examination is higher compared to the aforementioned examinations owing to the advantage of the image of the medial calf skeleton being clearer and more reliable compared to other examinations.

However, the simple radiographic examination has a limitation in that a three-dimensional object must be represented in a two-dimensional plane. Therefore, image distortion occurs easily because of the change in the inspection method [6-9]. Image distortion can lead to errors in the diagnosis. The incident angle and CR are important conditions for obtaining highly reproducible images.

The foot arch largely comprises four types of bone: the metatarsal bones, columnar bones, calcaneus and cubic bone. To measure the curvature of the arch, the angle between the long axis of the metatarsal bone and the long axis of the metatarsal bone, angle between the long axis of the metatarsal bone and the long axis of the calcaneus, or angle between the valley of the calcaneus and the ground can be measured. This can be determined by the height as well. Therefore, in this study, we measured CCH, CJH, CBH, CNH, and 1st MH to evaluate the association between MA, CPA, and HA, which are commonly used for diagno sing squamous foot and foot [3,10].

According to the results of this study, upon changing CR to the sole of the foot, MA, CPA, HA, CCH, CJH, CBH, CNH, and 1st MH decreased by 3.4%, 0.55%, 0.66%, 0.5%, 3.04%, 5.63%, 2.97%, and 6.19 %, respectively. Upon changing CR to the ankle joint, MA decreased by 12.96%, but CPA, HA, CCH, CJ H, CBH, CNH, and 1st MH increased by 5.9%, 9.56%, 5.05%, 4.39%, 5.93%, 6.73%, and 16.81%, respec tively. Therefore, it can be seen that changing CR affects the curvature of the medial arch. Therefore, if in correct CR points are set during foot disease examination because of a deformed arch, incorrect test result s can be provided to the medical staff.

In general, the flatfoot and urina foot tests are performed by a simple standing radiograph to check the c hanged alignment of the foot and ankle bone according to the weight load. This change was not reflected in the present study using the phantom foot. However, it does not have a direct effect on the results, and t he reliability assessment reveals that the measured value may vary depending on the CR.

In future studies, patients with weight-bearing conditions should be included to determine whether chang es in CR are sufficiently effective on the diagnosis of foot diseases because of medial calf deformities.

Most previous studies focused on changes in the image according to the angle of incidence while studies on changes in the radiological index according to the incident point are insufficient. Radiologists should av oid testing methods that reduce reproducibility to help doctors make accurate diagnoses. This study may se rve as reference for future studies on similar subjects in other tests.

5. Conclusion

The purpose of this study was to investigate the effect of changes in the incidence point on the image d epending on anatomical changes of the medial arch curvature as well as to recommend the correct CR sett ing.

As CR increased from the plantar base to the ankle joint, the mean MA increased with the base of the foot bone and decreased. As this increased, the mean value increased, and the difference was statistically s ignificant.

These results infer the effect of changes in CR on the medial arch curvature and that the incorrect setti ng of CR could lead to an incorrect diagnosis of the flatfoot and claw foot.

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