DOI: https://doi.org/10.30795/jfootankle.2026.v20.2081

Original Article

Radiographic morphometric analysis of cuboid bone in asymptomatic adult feet: Reference values and anatomical parameters

Rogério de Andrade Gomes[1], Wagner Vieira da Fonseca[1], João Murilo Brandão Magalhães[1], Anderson Humberto Gomes[1], David Bastos Vieira da Fonseca[1], Thales Hott Fernandes Morais[1]

1. Hospital Francisco José Neves, Hospital da Unimed de Belo Horizonte, Belo Horizonte, MG, Brazil.

Abstract

Objectives: To establish radiographic parameters of normality of the cuboid bone and to assist in therapeutic decisions in several diseases.

Methods: Five hundred and sixteen adult patients (516 feet) aged between 18 and 70 years were selected, distributed equally between sexes and without current or previous cuboid lesions. Foot radiographs at internal oblique incidence were performed and two parameters were evaluated. The first was the measurement of the alpha angle, formed between the distal and proximal articular surfaces of the cuboid, and the second was the ratio between the length of the lateral and medial walls.

Results: Radiographic parameters were evaluated, and the results by sex and age group were divided into groups (18 to 50 and 50 to 70 years). Alpha angle values in the general population ranged from 21.6° to 49.2°, with a mean of 35.62°, and differed by sex, with male patients showing a higher angle (35.11° x 36.13°). The ratio between the walls ranged from 0.37 to 0.69, with a mean of 0.52 and no sex differences.

Conclusion: The radiographic parameters studied may help define cuboid anatomy and guide the therapeutic approach to several foot injuries.

Level of Evidence III; Radiographic Descriptive Cross-Sectional Study.

Keywords: Cuboid bone; Radiography; Anatomy; Fractures; Trauma.

Introduction

The cuboid is a medial base pyramidal-shaped bone located in the lateral region of the midfoot. The medial facet articulates with the lateral cuneiform, the proximal facet with the calcaneus, and the distal facet articulates with the base of the 4th and 5th metatarsal bones. This bone provides an important connection between the hindfoot and forefoot and contributes to dorsoplantar movement and eversion/inversion of the foot, especially adaptation to irregular surfaces[1,2].

Various pathological conditions may alter the shape and/or positioning of the cuboid. In Charcot's arthropathy, midfoot collapse can cause plantar displacement of the cuboid, sometimes below the foot support line, increasing the risk of callus formation and plantar ulceration[3]. Thus, anatomical knowledge of this bone and its relationships with other components of the foot is important for understanding these diseases and guiding the therapeutic approach.

Cuboid fractures can often be accompanied by other midfoot injuries, such as fractures and dislocations of the

Study performed at the Hospital Francisco José Neves, Hospital da Unimed de Belo Horizonte, Belo Horizonte, MG, Brazil.

Correspondence: Rogério de Andrade Gomes. Rua Aimorés 351 – 101, Funcionários, Belo Horizonte, 30140-070, MG, Brazil. **Email:** rogerioandradeg@hotmail.com. **Conflicts of interest:** none. **Source of funding:** none. **Date received:** April 27, 2026. **Date accepted:** August 12, 2026.

How to cite this article: Gomes RA, Fonseca WV, Magalhães JMB, Gomes AH, Fonseca DBV, Morais THF. Radiographic morphometric analysis of cuboid bone in asymptomatic adult feet: Reference values and anatomical parameters. J Foot Ankle. 2026;20(2):e2081.

Lisfranc joints and fractures of the navicular and metatarsal bones[4-7]. Hermel and Cohen[8] described the nutcracker fracture as an injury with a crushing pattern resulting from longitudinal compression of the lateral column of the foot through axial load with the foot in plantar flexion, with compression of the cuboid between the calcaneus and the lateral metatarsals. Other studies have shown a component of midfoot abduction, leading to compression of the lateral column and eventual injury of the medial column[4,9].

A fundamental principle of treatment is evaluating the lateral column, as shown in internal oblique incidence and tomographic studies[10-12]. Shortening of this column can occur in cuboid compression fractures, leading to biomechanical changes in the midfoot and, consequently, deformities, pain, and instability[6,13,14].

The primary objective of this study is to create radiographic parameters of normality of the cuboid bone. The secondary objective is to report whether these parameters differ by sex and age.

Methods

The study was approved by the Institutional Review Board. Due to the retrospective study design, the written Informed Consent Form (ICF) was not required. Consent to use patients' medical record data from the private institution where the study was conducted was obtained.

Type of study

The study used an observational cross-sectional design, and radiographs were used to diagnose other conditions without a cuboid lesion. Patients with traumatic and non-traumatic forefoot injuries between 18 and 70 years of age were included. Patients with combined hindfoot injuries and previous surgeries in this segment were excluded. Patients did not receive additional radiation for this study. It was decided not to include healthy patients to avoid unnecessary radiation exposure.

Radiographic technique

The internal oblique incidence of the feet was performed with the segment supported on a platform inclined at 30° to standardize foot positioning and avoid angular variation (Figure 1). Non-weight-bearing radiographs were obtained with the foot resting on the platform, the knee flexed to 90°, and the ankle flexed to 20°. The beam was centered at the base of the 5th metatarsal, and the tube was positioned 80 cm from the foot. The decision to perform non-weight-bearing radiographs is due to the predominance of patients with traumatic injury in the study. Initially, a pilot study was conducted with 58 adult patients (58 feet), aged 18 to 77 years (mean 54 years), of both sexes with no current or previous cuboid lesions, evaluated from November 2018 to January 2019. The objective of the pilot study was to obtain statistical parameters, including estimates of standard deviation (SD), variability, and sample size. In total, the pilot study included 58 radiographs: 19 of male feet and 39 of female feet; 34 right feet and 24 left feet.

All radiographs were performed in a Siemens Multix 8 radiological set (model 7036374, Munich, Germany). The images were captured using a digital technology system, DR Shimadzu (model VIVIX-S4343VAW, Brazil). The evaluation and parameter measurements were performed in Vivace Connect MV software (version 2022.002.02.FTR, Teresópolis, Brazil).

In the radiographs, two parameters were measured: the first is the angle formed between the distal and proximal articular surfaces of the cuboid (Figure 2), which was defined by the

Figure 1. Foot radiography in internal oblique incidence on a platform with an inclination of 30° and image of the position of the foot.

Figure 2. Alpha angle measurement.

lines drawn connecting the medial-distal and lateral-distal (first line) and medial-proximal and lateral-proximal (second line) articular points, which are located outside the foot in the lateral region, named the alpha angle. The second is the ratio between the length of the lateral and medial cortical walls of the cuboid bone, which was performed by measuring the length of the lateral wall (which goes from the lateral-proximal point to the lateral-distal point of the bone) over the length of the medial wall (drawn from the medial-proximal point to the medial-distal point of the cuboid) (Figure 3). The parameters were created to obtain a more specific radiographic evaluation of the cuboid bone, with application for traumatic (especially fractures with a lateral compression pattern) and non-traumatic injuries.

The radiographs were evaluated by two orthopedists specialized in foot surgery with more than five years of experience and were recorded at two time points with a 30-day interval between evaluations.

Sample size calculation

Considering the characteristics and objectives of the study, the identification of the ideal sample was obtained through the calculations provided by Rosner[15], which accounts for the confidence interval (CI), the power of the sample, the sample size ratio, the mean, and the SD of the populations to be studied. The sample was obtained with a 90% CI. The purpose of this interval was to identify a lower sample number that was within reality. In scientific studies, 95% CI is generally used. However, 90% CI is also accepted and statistically valid. For this, the following formulas were used:

$$n_1 = \frac{(\sigma_1^2 + \sigma_2^2 / \kappa)(z_{1-\alpha/2} + z_{1-\beta})^2}{\Delta^2}$$

$$n_2 = \frac{(\kappa * \sigma_1^2 + \sigma_2^2)(z_{1-\alpha/2} + z_{1-\beta})^2}{\Delta^2}$$

n1 = sample size of group 1 (male individuals); n2 = sample size of group 2 (female individuals); α1 = standard deviation of group 1; α2 = standard deviation of group 2; □ = difference between means; □ = ratio n2/n1; $Z_1-\alpha/_2$ = two-tailed Z value, considering 95% and 90% CI; $Z_1-\beta$ = sample power.

Some studies show that foot shape can change with aging, especially in relation to forefoot width[16] and the fall of the longitudinal arch[17]. Thus, the parameters were measured in both sexes and in two age groups (18 to 50 years and 51 to 70 years). This division was based on changes observed in the study by Ansuategui Echeita et al.[16], who showed changes in foot shape after the sixth decade of life.

The sample included 516 patients, equally distributed between males and females (258 patients in each group), and the images were obtained from radiographs taken between June 2022 and January 2023.

Statistical analysis

Initially, an exploratory analysis was performed using the Shapiro-Wilk test to assess whether the data follow a continuous distribution. Given the parametric nature of these data, measures of central tendency were reported as the mean, SD, minimum, and maximum. For categorical variables, measures of frequency (n) and percentage (%) were calculated for each category. No multivariate analysis was performed for this study.

Reliability was evaluated through intra- and interobserver comparisons at 30-day intervals to ensure the consistency and stability of the data obtained. To evaluate intra- and interobserver agreement, the Intraclass Correlation Coefficient (ICC) was used. Two statistical models were used: the intraclass correlation coefficient for absolute agreement (ICC-AA) to assess absolute agreement between measurements, and the intraclass correlation coefficient for consistency (ICC-C) to estimate agreement consistency between raters and between the two assessment time points.

For intraobserver agreement (between the first and second evaluations of each evaluator), the two-way mixed effects ICC was used. For interobserver agreement (using the means of each evaluator), the two-way random effects ICC was adopted. In both situations, the interpretation of the ICC values was obtained according to Koo and Li[18], with ICC values < 0.5 being considered of poor agreement, reasonable/moderate agreement ICC between 0.51 and 0.75, good agreement between 0.76 and 0.90, and excellent agreement ICC > 0.91. In addition to the ICC, intra- and interobserver metrics of the alpha angle and cuboid ratio were compared to each other using an unpaired t-test. All statistical analyses were performed using STATA® software (version 14.0, Stata Corporation, College Station, TX, USA), with a significance level of 5% ($p < 0.05$).

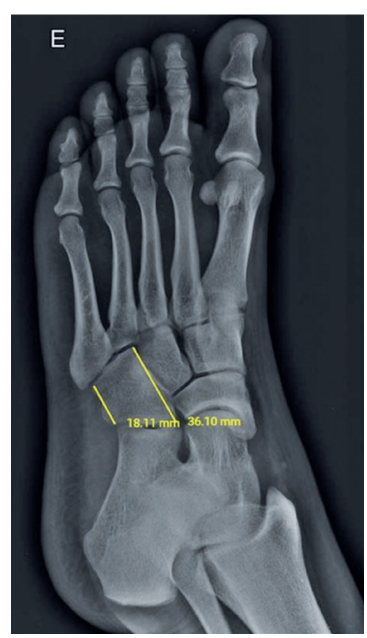

Figure 3. Ratio between the lengths of the lateral and medial walls of the cuboid.

Comparative analyses were performed to identify significant differences between patients by sex and age group. For this, the unpaired t-test (for two-by-two comparisons between the means obtained) and the Chi-square test (for comparisons between frequencies) were performed. In all analyses performed, the differences obtained were considered statistically significant when the p-value was less than 0.05 ($p < 0.05$). Statistical analyses were performed using the STATA® program (version 14.0, Stata Corporation, College Station, TX, USA).

Results

A total of 516 foot radiographs from patients treated at a private hospital in Belo Horizonte, Minas Gerais, Brazil, were analyzed. The mean patient age was 46.14 years (±14.00), and the most prevalent characteristics were age up to 50 years and the left side, corresponding to 57.75% and 50.97%, respectively. Considering the alpha angle measurements, the mean obtained from the 516 patients was 35.62° (± 4.23°), with a mean ratio of 0.52° (± 0.06°) (Table 1).

The data showed that the female population had a higher mean age than the male population (49.74 versus 42.54 years, respectively) (p = 0.000). In the male population, the most frequent age group was younger patients (up to 50 years old: 70.93%), while in the female population, patients ≥ 51 years were the most prevalent (55.43%). The difference between the percentages in each age group was significant (p = 0.000).

The metrics obtained in the alpha angle (°), measured by evaluators 1 (A1) and 2 (A2) in the male and female populations show that, for males, A1 had a mean of 36.13° (± 4.42°) in the first evaluation and 36.34° (± 3.99°) in the second evaluation, with no statistically significant difference between the time points (p = 0.567), indicating good intraobserver agreement. A2 also showed similar means between the two evaluations (36.26° ± 4.38° and 36.03° ± 4.58°), with p = 0.562, reinforcing intraobserver agreement. The interobserver comparison between A1 and A2 showed no significant differences between sexes ($p > 0.05$), indicating high agreement between evaluators.

For the cuboid bone morphometric ratio, results by sex showed that, for male patients, A1 produced identical means in the two evaluations (0.52 ± 0.06 and 0.52 ± 0.05), with no statistically significant difference (p = 0.920), indicating high intraobserver stability. A2 also showed identical means (0.53 ± 0.05 in both evaluations), with p = 0.467, confirming measurement consistency. Among female patients, the mean values were 0.53 ± 0.05 in the two evaluations performed by A1 (p = 0.688) (Figure 3B) and identical for A2 (0.53 ± 0.05), with p = 0.238 (Figure 4B). The interobserver comparison between A1 and A2 showed no significant differences in either sex ($p > 0.05$), indicating high agreement between evaluators.

Table 2 presents a general comparison between female and male patients, including age, age group, laterality, and measures of the alpha angle and the ratio of the lateral to medial walls of the cuboid bone.

Table 1. Characterization of the overall study population (n = 516)

General population (n = 516)		
Age (years)		
Mean	46.14	
± SD	14.00	
Min - Max	18 - 70	
Age group	n	%
Up to 50 years	298	57.75
≥ 51 years	218	42.25
Sex		
Female	258	50.00
Male	258	50.00
Laterality		
Right	253	49.03
Left	263	50.97
Alfa angle (°)		
Mean	35.62	
± SD	4.23	
Min - Max	21.6 - 49.2	
Ratio		
Mean	0.52	
± SD	0.06	
Min - Max	0.37 - 0.69	

SD: Standard deviation; Min: Minimum value; Max: Maximum value; n: Absolute frequency; %: Percentage.

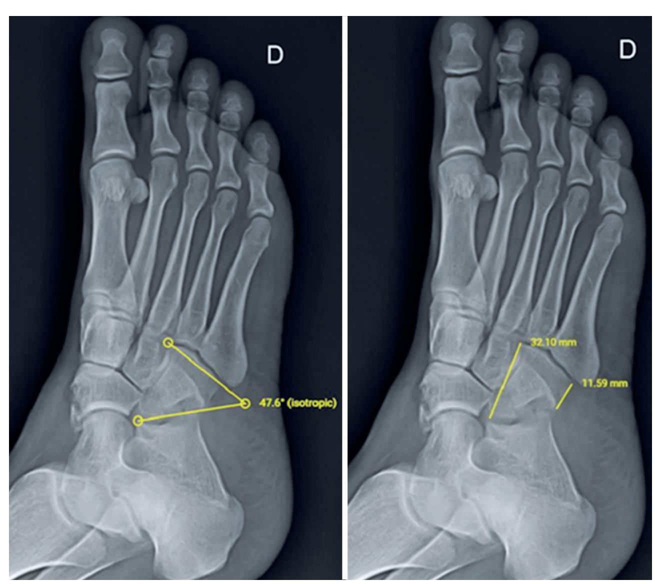

Figure 4. Radiographs with fracture-impaction of the cuboid. Alpha angle = 47.6° and cortical ratio = 0.36°.

Tables 3 and 4 show comparative analyses by age group and sex. No significant differences were observed between patients in the age groups up to 50 years and ≥ 51 years, regardless of sex, considering laterality, alpha angle, and ratio ($p > 0.05$).

Table 2. A general comparative analysis between female and male patients, considering age, age groups, laterality and measures of the alpha angle and the ratio of the lateral and medial walls of the cuboid bone

	Female (n = 258)		Male (n = 258)		p-value
Age (years)					
Mean	49.74		42.54		
± SD	13.54		13.53		**0.000**^{*T}
Min - Max	18 - 70		18 - 70		
Age group	n	%	n	%	
Up to 50 years	115	44.57	183	70.93	**0.000**^{*Q}
≥ 51 years	143	55.43	75	29.07	
Laterality					
Right	118	45.74	135	52.33	0.134^{Q}
Left	140	54.26	123	47.67	
Alfa angle (°)					
Mean	35.11		36.13		
± SD	3.97		4.42		**0.006**^{*T}
Min - Max	21.6 - 44.4		22 - 49.2		
Ratio					
Mean	0.53		0.52		
± SD	0.05		0.06		0.236^{T}
Min - Max	0.4 - 0.66		0.37 - 0.69		

SD: Standard deviation; Min: Minimum value; Max: Maximum value; n: Absolute frequency; %: Percentage.
*: Significant difference ($p < 0.05$); T: Unpaired t-test; Q: Chi-square test.

Table 3. Comparative analysis between female patients, considering the age group

	Female population				
	Up to 50 years (n = 115)		≥ 51 years (n = 143)		p-value
Laterality	n	%	n	%	
Right	48	41.74	70	48.95	0.248^{Q}
Left	67	58.26	73	51.05	
Alfa angle (°)					
Mean	35.05		35.17		
± SD	4.08		3.90		0.811^{T}
Min - Max	24.5 - 44.4		21.6 - 42.0		
Ratio					
Mean	0.53		0.52		
± SD	0.05		0.06		0.417^{T}
Min - Max	0.4 - 0.64		0.41 - 0.66		

n: Absolute frequency; %: Percentage; T: Unpaired t-test; Q: Chi-square test.

Table 5 presents the comparative analyses within each age group by sex. The alpha angle in the age group up to 50 years was the only significant variable in the comparisons

Table 4. Comparative analysis between male patients, considering the age group

	Male population				
	Up to 50 years (n = 183)		≥ 51 years (n = 75)		p-value
Laterality	n	%	n	%	
Right	95	51.91	40	53.33	0.836^{Q}
Left	88	48.09	35	46.67	
Alfa angle (°)					
Mean	36.47		35.30		
± SD	4.43		4.31		0.052^{T}
Min - Max	23 - 48.5		22 - 49.2		
Ratio					
Mean	0.52		0.53		
± SD	0.06		0.06		0.126^{T}
Min - Max	0.37 - 0.66		0.4 - 0.69		

n: Absolute frequency; %: Percentage; T: Unpaired t-test; Q: Chi-square test.

Table 5. Comparative analysis of the age group, considering the sex of the patients

	Age group up to 50 years				
	Female (n = 115)		Male (n = 183)		p-value
Laterality	n	%	n	%	
Right	48	41.74	95	51.91	0.087^{Q}
Left	67	58.26	88	48.09	
Alfa angle (°)					
Mean	35.05		36.47		
± SD	4.08		4.43		**0.006**^{*T}
Min - Max	24.5 - 44.4		23 - 48.5		
Ratio					
Mean	0.53		0.52		
± SD	0.05		0.06		0.063^{T}
Min - Max	0.4 - 0.64		0.37 - 0.6		
	Age group ≥ 51 years				
	Female (n = 143)		Male (n = 75)		p-value
Laterality	n	%	n	%	
Right	70	48.95	40	53.33	0.539^{Q}
Left	73	51.05	35	46.67	
Alfa angle (°)					
Mean	35.17		35.30		
± SD	3.90		4.31		0.822^{Q}
Min - Max	21.6 - 42		22 - 49.2		
Ratio					
Mean	0.52		0.53		
± SD	0.06		0.06		0.510^{Q}
Min - Max	0.41 - 0.66		0.4 - 0.69		

n: Absolute frequency; %: Percentage.
*: Significant difference ($p < 0.05$); T: Unpaired t-test; Q: Chi-square test.

performed ($p < 0.05$). The results showed that male patients aged up to 50 years had higher means than females in the same age group (36.47° versus 35.05°, respectively) ($p = 0.006$). No significant difference was reported regarding the age group ≥ 51 years ($p > 0.05$).

Although no significant results were identified, in male patients (Table 5), the p-value for the alpha angle was borderline ($p = 0.052$), indicating a trend toward a higher mean value in male patients aged up to 50 years. These results corroborate the findings shown in Table 2, in which male patients had a higher mean alpha angle than female patients.

Discussion

This study aimed to establish two radiographic parameters to characterize the normal radiographic anatomy of the cuboid bone. The first was the angle formed between the distal and proximal articular surfaces of this bone, with its apex located lateral to the foot (alpha angle). The second radiographic parameter was the relationship between the length of the lateral and medial cortices of the cuboid. Regarding the alpha angle, male patients had a slightly higher mean angle than female patients (36.13° versus 35.11°). However, this difference has little clinical relevance due to its very small effect size. No differences were observed by laterality or ratio. No significant differences were found between patients in the age groups up to 50 years and ≥ 51 years, regardless of sex, based on injury laterality, alpha angle, and ratio.

Radiographic anatomy has long been widely studied across all areas of orthopedics, defining parameters of normality and helping professionals understand diseases and their treatments. The Böhler[19] and Gissane[20] angles in calcaneal fracture, the metatarsophalangeal angle of the first joint in the hallux valgus, and the calcaneal inclination angle (pitch) are examples of the importance of such measurements, which assist in disease characterization, therapeutic indication, and postoperative follow-up. In addition, many other orthopedic problems are treated using angle measurements and radiographic anatomical relationships, such as distal radius fractures and patellofemoral instability.

The literature focuses on radiographic studies of the normal foot, seeking to define measures of positioning (height)[21] and the relationship of the cuboid with the lateral column. Steel et al.[21] measured the height of the upper point of the cuboid to the ground on lateral radiography with support to characterize the shape of the longitudinal arc. However, parameters of normality in frontal evaluation remain scarce. One of the few parameters described is the calcaneocuboid angle, which can be used to evaluate lateral column alignment, with deviations greater than 5° indicating forefoot abduction deformity[22]. Fracture patterns with lateral joint compression (nutcracker) can lead to loss of the pyramidal shape and collapse of the lateral column, with consequent forefoot abduction and alteration of this angle.

Changes in cuboid morphology may result from articular impaction fractures involving either the distal articular surface with the metatarsals or the calcaneal articular surface, as shown in Figure 4, altering the shape of the bone and leading to flattening of the lateral portion of the cuboid.

Deformation after crushing the cuboid may have an unfavorable course, leading to arthrosis and deformity in forefoot abduction.

Another clinical condition that can occur with changes in cuboid position and shape is Charcot's arthropathy, a disorder that often causes plantar displacement of the bone and severe hindfoot deformity (Figure 5). This condition is predisposing to plantar ulceration and osteomyelitis, and presents a higher risk of amputations and mortality[23].

The cuboid is a midfoot bone that contributes most to plantar/dorsal flexion[24], providing an expressive range of motion in the sagittal plane with the lateral metatarsals, an essential movement for adapting the foot to irregular surfaces. Loss of movement in the calcaneal-cuboid joint or cuboid-lateral metatarsal bones can lead to stiffness of the lateral column and translate into poor tolerance when walking on inclined or irregular surfaces[25].

In addition to its dynamic importance, the cuboid is also fundamental for the static function of the foot, as it is the main supporter of the lateral column. Shortening of the lateral column results in forefoot abduction and flatfoot, associated or not with valgus[6,11,13,14]. These biomechanical changes culminate in a mechanical dysfunction of the entire foot. To compensate for these forefoot deformities, the hindfoot (calcaneus) everts, also resulting in frontal-plane changes[13].

Figure 5. Radiographs of the foot with Charcot's arthropathy.

The literature offers few studies on the radiographic anatomy of the cuboid, and even fewer provide references to define the degree of lateral impaction after fractures or to guide restoration of normality after surgical treatment. Mihalich and Early[26] recommend surgical treatment for cases of lateral column shortening, but do not define the size of this shortening. Bradshaw[27] indicates surgical treatment when lateral column shortening exceeds 2 mm. Yu et al.[28] also consider this shortening value in the surgical indication of cuboid compression fractures.

Shortening measurements in mm may be affected by technical factors, such as tube distance and foot size, which can lead to misinterpretation and inappropriate therapeutic indication.

One limitation of this study is that the values obtained were not correlated with hindfoot alignment. Therefore, it cannot be stated whether foot varus or valgus affects the shape of the cuboid. Similarly, the elevated or lowered position of the cuboid in cavus and flat feet may alter the position of the bone, leading to different angular values and wall-length measurements.

Another issue was the CI adopted. Scientific studies generally use a 95% CI. However, 90% CI is also accepted and statistically valid. The purpose of this interval was to identify a lower sample size that was within reality.

Another limitation is how the parameters were evaluated in the perioperative study. It was performed with measurements from a goniometer and a ruler, unlike the preoperative evaluation (done with computerized software), which could introduce divergence between measurements due to the lower accuracy of manual measurement. Another issue relates to the radiographic method of evaluating the parameters. Non-weight-bearing radiographs were performed (most patients presented with traumatic injury), which could be addressed in a future study by applying analysis under weight-bearing conditions.

The alpha angle and the latero-medial cortical relationship are radiographic parameters for evaluating the lateral column and can be used intraoperatively as criteria for reducing fractures and correcting cuboidal height. In addition to studying fractures and their correction, these parameters may be useful in investigating other diseases that affect cuboid positioning, such as Charcot's arthropathy and clubfoot.

The alpha angle and the latero-medial cortical relationship are radiographic parameters for evaluating the lateral column and can be used intraoperatively as criteria for reducing fractures and correcting cuboid height. In addition to studying fractures and their correction, these parameters may be useful in investigating other diseases that affect cuboid positioning, such as Charcot's arthropathy and clubfoot.

The strength of this study was expanding methods for better anatomical analysis of the cuboid bone by creating radiographic parameters that are easy to perform and reproducible.

Conclusion

Two radiographic parameters of the cuboid bone were defined at the oblique incidence at 30°: the alpha angle, with a mean of 35.62°, and the ratio of the lateral and medial cortices of the cuboid, with a mean of 0.52°. There was no difference in the alpha angle and the ratio in relation to sex and age, except for the angle between sexes in the age group from 18 to 50 years.

Authors' contributions: Each author contributed individually and significantly to the development of this article: GRA *(https://orcid.org/0000-0003-3056-9401) and THFM *(https://orcid.org/0009-0002-4972-6446) Wrote the article and data collection; FWV *(https://orcid.org/0000-0001-8087-8435) Participated in the review process; MJMB *(https://orcid.org/0000-0002-4224-8149) Interpreted the results of the study; GAH *(https://orcid.org/0000-0002-3644-4928) Data collection and interpreted the results of the study; FDBV *(https://orcid.org/0000-0001-8158-3129) Formatting of the article and bibliographic review. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID) iD.

References

1. Elftman H. The transverse tarsal joint and its control. Clin Orthop. 1960;16:41-6.
2. Ouzounian TJ, Shereff MJ. In vitro determination of midfoot motion. Foot Ankle. 1989;10(3):140-6.
3. Meyr AJ, Sebag JA. Relationship of Cuboid Height to Plantar Ulceration and Other Radiographic Parameters in Midfoot Charcot Neuroarthropathy. J Foot Ankle Surg. 2017;56(4):748-55.
4. Ceroni D, De Rosa V, De Coulon G, Kaelin A. Cuboid nutcracker fracture due to horseback riding in children case series and review of the literature. J Pediatr Orthop. 2007;27(5):557-61.
5. Harma S, Dhillon MS, Sharma G, John R. Nutcracker cuboid fractures are never isolated injuries. J Foot Ankle Surg (Asia-Pacific). 2014;1(1):9-11.
6. Lucerna A, Espinosa J, Butler N, Wenke A, Caltabiano N. Nutcracker cuboid fracture: A case report and review. Case Rep Emerg Med. 2018;2018:3804642.
7. Sangeorzan BJ, Swiontkowski MF. Displaced fractures of the cuboid. J Bone Joint Sur Br. 1990;72(3):376-8.
8. Hermel MB, Gershon-Cohen J. The nutcracker fracture of the cuboid by indirect violence. Radiology. 1953;60(6):850-4.

9. Hunter JC, Sangeorzan BJ. A nutcracker fracture: cuboid fracture with an associated avulsion fracture of the tarsal navicular. AJR Am J Roentgenol. 1996;166(4):888.
10. Miller SR, Handzel C. Isolated cuboid fracture: A rare occurrence. J Am Podiat Med Assoc. 2001;91(2):85-8.
11. Attinger CE, Evans KK, Bulan E, Blume P, Cooper P. Angiosomes of the foot and ankle and clinical implications for limb salvage: reconstruction, incisions, and revascularization. Plast Reconstr Surg. 2006;117(7 Suppl):261S-293S.
12. Werber M, Locher S. Reconstruction of the cuboid in compression fractures: Short to midterm results in 12 patients. Foot Ankle Intern. 2002;23(11):1008-13.
13. Borrelli J Jr, De S, VanPelt M. Fracture of the cuboid. J Am Acad Orthop Surg. 2012;20(7):472-7.
14. Yu G, Yu T, Yang Y, Yuan F. Old nutcracker fracture of cuboid. Indian J Orthop. 2013;47(3):310-2.
15. Rosner B. Fundamentos de Bioestatística. São Paulo: Cengage Learning; 2018.
16. Ansuategui Echeita J, Hijmans JM, Smits S, Van der Woude LH, Postema K. Age-related differences in women's foot shape. Maturitas. 2016;94:64-9.
17. Scott G, Menz HB, Newcombe L. Age-related differences in foot structure and function. Gait Posture. 2007;26(1):68-75.
18. Koo TK, Li MY A guideline of selecting and reporting intraclass correlation coefficients for reliability research. J Chiropr Med. 2016;15(2):155-63.
19. Böhler L. Diagnosis, pathology, and treatment of fractures of the os calcis. J Bone Joint Surg Am. 1931;13(1):75-89.
20. Gissane W. Proceedings of the British Orthopedic Association. J Bone Joint Surg Am. 1947;29:254-5.
21. Steel MW 3rd, Johnson KA, DeWitz MA, Ilstrup DM. Radiographic measurements of the normal adult foot. Foot Ankle. 1980;1(3):151-8.
22. Sanner WH. Foot segmental relationships and bone morphology. In: Christman RA. (ed). Foot and ankle radiology. Churchill Livingstone; 2003. p.272-302.
23. Yammine K, Boulos K, Assi C, Hayek F. Amputation and mortality frequencies associated with diabetic Charcot foot arthropathy: a meta-analysis. Foot Ankle Surg. 2022;28(8):1170-6.
24. Clements JR, Dijour F, Leong W. Surgical management navicular and cuboid fractures. Clin Podiatr Med Surg. 2018;35(2):145-59.
25. Rammelt S, Zwipp H, Hansen S. Posttraumatic reconstruction of the foot and ankle. In: Browner BD, Jupiter J, Krettek C, Anderson PA. Skeletal trauma. Elsevier Saunders; 2019. p. 2641-90.
26. Mihalich RM, Early JS. Management of cuboid crush injuries. Foot Ankle Clin. 2006;11(1):121-6, ix.
27. Bradshaw CL. Navicular and cuboid fractures. Clin Podiatr Med Surg. 2024;41(3):425-35.
28. Yu G, Yu T, Yang Y, Li B, Yuan F, Zhou J. Nutcracker fracture of the cuboid: management and results. Acta Orthop Belg. 2012;78(2):216-9.