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ORIGINAL ARTICLE

Is the golden ratio present in the coxal bone? An anatomical pilot study

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Abstract

The coxal bone is crucial for movement, stability, and childbirth. Although most morphometric studies estimate gender and age, ratio, correlation and index calculations, there are no studies on the golden ratios in the coxal bone. Inspired by this idea, we investigated the presence of the golden ratio in the coxal bones. In this study, 95 adult dry coxal bones were measured using a digital caliper. Morphometric measurements were conducted based on 18 identified parameters. 12 of these parameters were related to the distances between two points in various parts of the bone. New ratios were determined with those measurements. In our study, we detected a constant coefficient between the following lengths: anterior superior iliac spine (ASIS)- posterior superior iliac spine (PSIS) and anterior inferior iliac spine (AIIS)- posterior inferior iliac spine (PIIS), vertical and transverse diameters of the acetabulum (AC), ASIS-AC and AIIS-AC, PSIS-AC and PIIS-AC, ASIS-auricular surface and AIIS-auricular surface, ASIS-symphyseal surface and AIIS-symphyseal surface (respectively, 1.29, 1.05, 1.18, 2.32, 1.26, 1.32). In order to check the accuracy of this hypothesis, length of between AIIS-PIIS, transverse diameter of the acetabulum, length of between PIIS-AC, length of between AIIS-AC, shortest distance between AIIS-auricular surface, length of between AIIS-symphyseal surface were estimated with the help of new equations. We detected constant ratios between some lengths in the coxal bone. Estimated distances should be taken into account during surgical procedures to prevent complications. In this context, the constant ratios identified in our study will serve as a guide for surgeons.

Keywords Anatomy · Anthrophometry · Coxal bone · Golden ratio

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Introduction

The coxal bone, is a cornerstone of the human skeletal system, playing a key role in locomotion, stability and childbirth. Made up of three distinct bones, the intricate structure of the coxal bone forms the foundation of the pelvic girdle. At the heart of this structure is the acetabular cavity, allowing for a wide range of movements required for daily activities (DeSilva and Rosenberg 2017).

The morphology of the coxal bone has profound implications for various fields of study, from anthropology to biomechanics, medical research and forensic science. Anthropologists study the diversity of coxal morphology in different populations, providing clues to human evolution, migration patterns and adaptations to environmental challenges (Brůžek et al. 2017). Biomechanists also study the relationship between coxal bone morphology and human locomotion, examining how variations in shape and size affect gait, posture and athletic performance (Kumar and Rakshit 2020; Sangeux 2019). In the medical field, coxal bone morphometry is crucial for the diagnosis and treatment of pelvic injuries, congenital anomalies and degenerative conditions such as hip dysplasia (Wen et al. 2023). In addition, forensic scientists use coxal bone morphometry to identify individuals from skeletal remains, contributing to criminal investigations and missing person cases (Djorojevic et al. 2014; Listi and Elizabeth Bassett 2006).

The human body has long fascinated scientists, artists, and mathematicians alike, serving as a rich source of inspiration and inquiry. One of the most intriguing aspects of this fascination is the presence of the golden ratio, which is approximately 1.618 (Persaud-Sharma and O'Leary 2015). The presence of the golden ratio in the anatomical structures of living organisms has made this ratio a focal point of interest in the medical community (Aparci et al. 2016; Schwind 2011). In recent studies, various dimensions of the coxal bone and femur have been measured to determine whether the proportions in the pelvis and hip joint are in accordance with the golden ratio. A ratio close to the golden ratio has been detected in acetabular alignment and ilium and ischium proportions (Higuchi and Daisaku 2021). Also when considering the pelvis as a whole, the distances between key anatomical landmarks such as the anterior superior iliac spine, the pubic symphysis, and the ischial tuberosity exhibit golden ratio relationships (Zheng et al. 2023).

Although most morphometric studies estimate sex by creating a coxal bone database, make ratio measurements and correlations on the hip joint and overall pelvis, and calculate indexes (Adhvaryu et al. 2019; Demir et al. 2018; Güler et al. 2023; Higuchi and Daisaku 2021; Kranioti et al. 2019), there are no studies on the golden ratios in the coxal bone. In this context, this study aimed to reveal the morphometric measurements of the coxal bone and to examine whether there is a golden ratio or constant ratio relationship between these measurements.

Materials and methods

The study was conducted on 95 adult dry coxal bones (39 left and 56 right) (51 male, 44 female) belonging to the Turkish population of unknown age. This research has been approved by the authors' affiliated institutions. Only that coxal bones with complete ossification were included in study. Sex determination in coxal bones were determined according to the presence of crista phallica. Utilized as educational materials in the Anatomy department, coxal bones stand as fixtures in the field of anatomy education. Since the measurement was conducted on dry bone, ethics approval was not required for this study.

Anthropometric measurements were conducted on all bones without distinguishing between left–right or male–female. Measurements were taken based on the 18 parameters identified in Table 1 and Fig. 1. 12 of these parameters were related to the distances between two points in various parts of the bone. To reduce the error rate, the measurements were taken twice by a single researcher and their averages were calculated. A digital caliper (Mitutoyo

Table 1 Definition of anthropometric measurements on the coxal bone

No	Measurement points
1	Maximum width of coxal bone- length of between anterior superior iliac spine (ASIS) and posterior superior iliac spine (PSIS)
2	Length of between anterior inferior iliac spine (AIIS) and posterior inferior iliac spine (PIIS)
3	Length of between anterior superior iliac spine (ASIS) and anterior inferior iliac spine (AIIS)
4	Length of between posterior superior iliac spine (PSIS) and posterior inferior iliac spine (PIIS)
5	Vertical diameter of the acetabulum (AC)
6	Transverse diameter of the acetabulum (AC)
7	Length of between posterior superior iliac spine (PSIS) and upper rim of the acetabulum (AC)
8	Length of between posterior inferior iliac spine (PIIS) and upper rim of the acetabulum (AC)
9	Length of between anterior superior iliac spine (ASIS) and upper rim of the acetabulum (AC)
10	Length of between anterior inferior iliac spine (AIIS) and upper rim of the acetabulum (AC)
11	Shortest distance between anterior superior iliac spine (ASIS) and anterior rim of auricular surface of ilium
12	Shortest distance between anterior inferior iliac spine (AIIS) and anterior rim of auricular surface of ilium
13	Height of the symphyseal surface
14	Width of the symphyseal surface
15	Length of between anterior superior iliac spine (ASIS) and upper rim of symphyseal surface
16	Length of between anterior inferior iliac spine (AIIS) and upper rim of symphyseal surface
17	Transverse diameter of the obturator foramen
18	Vertical diameter of the obturator foramen

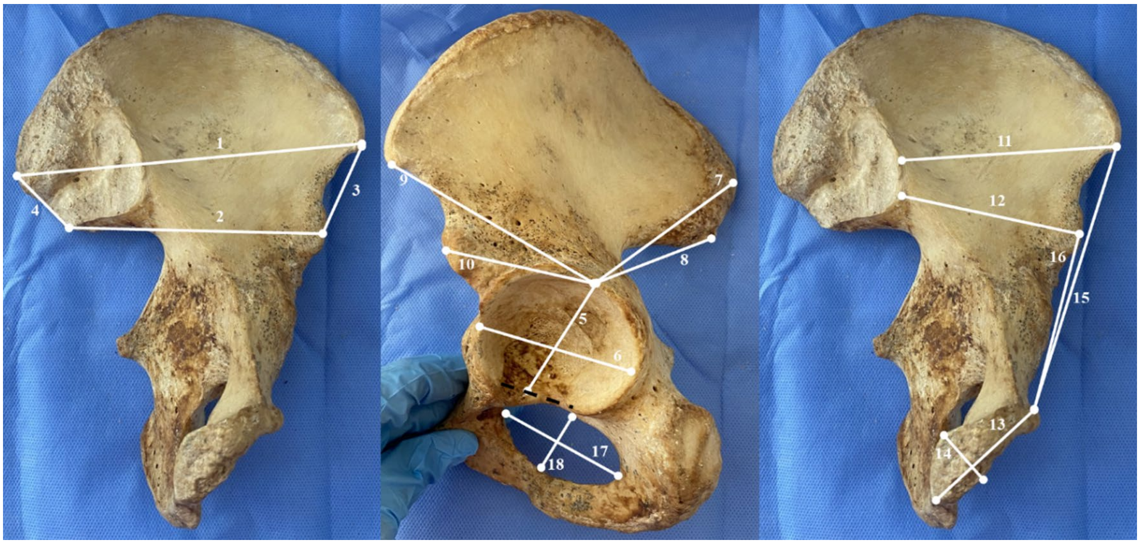

Fig. 1 Anthropometric measurements on the coxal bone

200 mm Digital Caliper, Kanagawa, Japan) with 0.01 mm (mm) precision was used for anthropometric measurements.

Statistical analysis

Histogram and Q–Q plots were used, and Shapiro–Wilk's test was applied to assess the data normality. Number (*n*) and percentage (%) were used for categorical variables. For quantitative variables, mean and standard deviation were used. Paired *t* test was used for quantitative variables in repeated pairwise comparisons. Coefficients and intervals were estimated using a simple linear regression analysis method. R 4.3.2 (www.r-project.org) software. A *p* value less than 5% was considered statistically significant.

Results

A total of 50 (52.6%) male and 45 (47.4%) female bones were included in the study. 56 (58.9%) of the bones were of right and 39 (41.1%) of left side. The mean ± standard deviation values of coxal bones used in our study are shown in Table 2.

As a result of the measurements we made from 95 coxal bones and the simple linear regression model created using the length of between ASIS-PSIS (A) to length of between AIIS-PIIS (B) ratio, vertical diameter of the acetabulum (C) to transverse diameter of the acetabulum (D) ratio, length of between PSIS and upper rim of acetabulum (E) to length of between PIIS and upper rim of acetabulum (F) ratio, length of between ASIS and upper rim of acetabulum (G) to length of between AIIS and upper rim of acetabulum (H) ratio, shortest distance between ASIS and anterior rim of auricular surface (J) to shortest distance between AIIS and anterior rim of auricular surface (K) ratio, length of between ASIS and upper rim of symphyseal surface (L) to length of between AIIS and upper rim of symphyseal surface (M) ratio shown in Table 3. The relationship between these coefficients calculated in 95 coxal bones was found to be statistically significant ($p < 0.05$) (Table 3).

In our study, we detected a constant coefficient between some length measurements obtained from the acetabulum, ASIS, AIIS, PSIS and PIIS. We calculated other measurements by accepting the average of these coefficients (1.29, 1.05, 1.18, 2.32, 1.26, 1.32 shown in Table 3) as the constant ratio. No statistically significant correlation or golden ratio was found between length of between ASIS-AIIS and length of between PSIS-PIIS, between height of the symphyseal surface and width of the symphyseal surface, between transverse diameter of the obturator foramen and vertical diameter of the obturator foramen ($p > 0.05$). No golden ratio or constant ratio was found between obturator foramen diameters, symphyseal surface height and width, lengths of between ASIS-AIIS and PSIS-PIIS.

In order to check the accuracy of this hypothesis, length of between AIIS-PIIS (B), transverse diameter of the acetabulum (D), length of between PIIS and upper rim of acetabulum (F), length of between AIIS and upper rim of acetabulum (H), shortest distance between AIIS and anterior rim of auricular surface (K), length of between AIIS and upper rim of symphyseal surface (M) were estimated with the help of Eqs. 1–6.

$$B = \frac{A}{1.29} \quad (1)$$

Table 2 The measurements of coxal bone, mean ± standard deviation (SD), minimum and maximum values (mm)

Measurements	Mean ± SD	Min–max
Length of between ASIS-PSIS	151.56 ± 9.50	126.4–170.7
Length of between AIIS-PIIS	116.98 ± 7.36	97.7–129.6
Length of between ASIS-AIIS	42.18 ± 4.55	33.2–52.4
Length of between PSIS-PIIS	34.72 ± 6.23	22.3–47.6
Vertical diameter of the AC	52.98 ± 3.78	45.6–62.7
Transverse diameter of the AC	49.61 ± 3.59	43.3–59.0
Length of between PSIS and upper rim of AC	113.38 ± 13.10	78.1–141.9
Length of between PIIS and upper rim of AC	94.66 ± 11.02	65.1–118.9
Length of between ASIS and upper rim of AC	62.43 ± 6.08	46.2–76.3
Length of between AIIS and upper rim of AC	26.95 ± 2.61	19.9–33.0
Shortest distance between ASIS and anterior rim of auricular surface	92.53 ± 6.77	77.7–106.2
Shortest distance between AIIS and anterior rim of auricular surface	70.36 ± 5.32	58.9–81.3
Height of the symphyseal surface	31.66 ± 4.05	20.4–45.9
Width of the symphyseal surface	13.30 ± 2.20	8.1–18.7
Length of between ASIS and upper rim of symphyseal surface	135.39 ± 9.77	98.1–165.8
Length of between AIIS and upper rim of symphyseal surface	102.61 ± 7.42	76.0–125.2
Transverse diameter of the obturator foramen	45.48 ± 3.94	37.0–55.1
Vertical diameter of the obturator foramen	35.71 ± 3.33	28.4–44.0

ASIS anterior superior iliac spine, *PSIS* posterior superior iliac spine, *AC* acetabulum, *AIIS* anterior inferior iliac spine, *PIIS* posterior inferior iliac spine

Table 3 Results of simple linear regression analysis

Variables	Coefficient (95%CI)	*p*
Length of between ASIS-PSIS		
β_0	1.36 (−1.01/3.72)	0.259
β_1 (Length of between AIIS-PIIS)	1.29 (1.25/1.32)	<0.001
Vertical diameter of the AC		
β_0	0.80 (0.04/1.56)	0.039
β_1 (Transverse diameter of the AC)	1.05 (1.03/1.07)	<0.001
Length of between PSIS and upper rim of AC		
β_0	1.47 (−0.84/3.78)	0.209
β_1 (Length of between PIIS and upper rim of AC)	1.18 (1.16/1.21)	<0.001
Length of between ASIS and upper rim of AC		
β_0	−0.13 (−1.19/0.92)	0.802
β_1 (Length of between AIIS and upper rim of AC)	2.32 (2.28/2.36)	<0.001
Shortest distance between ASIS and anterior rim of auricular surface		
β_0	3.82 (1.33/6.32)	0.003
β_1 (Shortest distance between AIIS and anterior rim of auricular surface)	1.26 (1.23/1.30)	<0.001
Length of between ASIS and upper rim of symphyseal surface		
β_0	−1.55 (−3.53/0.26)	0.092
β_1 (Length of between AIIS and upper rim of symphyseal surface)	1.32 (1.29/1.33)	<0.001

ASIS anterior superior iliac spine, *PSIS* posterior superior iliac spine, *AC* acetabulum, *AIIS* anterior inferior iliac spine, *PIIS* posterior inferior iliac spine, β_0 constant coefficient, β_1 slope coefficient, *CI* confidence interval

$$D = \frac{C}{1.05} \quad (2)$$

$$F = \frac{E}{1.18} \quad (3)$$

$$H = \frac{G}{2.32} \quad (4)$$

$$K = \frac{J}{1.26} \quad (5)$$

$$M = \frac{L}{1.32} \quad (6)$$

There was no statistically significant difference between the measured (observed values) length of between AIIS-PIIS and estimated length of between AIIS-PIIS, between the observed and predicted values length of between PIIS and upper rim of acetabulum, between the observed and predicted the length of between AIIS and upper rim of symphyseal surface of pubis ($p > 0.05$) (Table 4).

Discussion

Traffic accidents and falling from heights often result in pelvic injuries and fractures due to high-energy trauma. Knowing the morphometric properties of the hip in the treatment of pelvic injuries is of great importance as it is useful in determining the dimensions of the hip replacement surgery or surgical technique and materials to be used (Rommens et al. 2010). The morphology of the human coxal bone makes it interesting from an anatomical, anthropological and forensic perspective. There are no studies on the golden ratios in the coxal bone. In this context present study is unique in that it shows golden ratios between morphometric measurements of the coxal bone. In our study, we detected a constant coefficient (1.29, 1.05, 1.18, 2.32, 1.26, 1.32) between some length measurements obtained from the acetabulum, ASIS, AIIS, PSIS and PIIS.

During surgical procedures, ASIS is frequently utilized to estimate the center of the femoral head and evaluate limb alignment (Hooper et al. 2005). A constant ratio of 1.29 (1.25–1.32) was calculated between ASIS-PSIS as maximum width of ilium or width of coxal bone and AIIS-PIIS in our study. The study of Güler et al. (2023) of 95 coxal bones, found the mean value of length of between ASIS-PSIS left coxal bones as 153.45 ± 11.38 mm, and the average value of length of between AIIS-PIIS of the same bones as 120.29 ± 8.90 mm. The ratio between these two lengths is 1.28. The same ratio was calculated as 1.30 in Demir et al. (2018)'s study (ASIS-PSIS: 153.22 ± 9.96 mm; AIIS-PIIS: 117.51 ± 7.70 mm), and it appears to these rates in both studies are within the confidence interval specified in our study.

The atypical morphology of AIIS is being more frequently recognised as a cause of symptomatic extra-articular hip impingement (Amar et al. 2013). Demir et al. (2018) measured the ASIS-AIIS value as 41.46 ± 5.02 mm, Sako et al. (2021) measured it as 41.0 ± 4.5 mm in patients with developmental hip dysplasia and 40.0 ± 4.6 mm in the healthy group, and Güler et al. (2023) measured it as 45.58 ± 4.43 mm in the right side and 44.51 ± 3.39 mm in the left side. Our results were found to be higher than other results except Güler et al. (2023). Lakshmi et al. (2014) measured the length of PSIS-PIIS value as 28.84 ± 6.8 mm, and Güler et al. (2023) measured it as 33.01 ± 5.62 mm in the right side and 34.84 ± 9.01 mm in the left side. In our study, this length was measured as 34.72 ± 6.23 mm, similar to Güler et al.'s (2023) measurement results on the left coxa. No constant ratio was found between ASIS-AIIS and PSIS-PIIS in our study. In the surgery of avulsion fractures, particularly those involving the ASIS and AIIS, occur due to the sudden and forceful contraction of muscles, these ratios are of significant importance.

Table 4 Descriptive statistics of variables and group comparisons

Variables	Observed		Prediction		p
	$\overline{X} \pm \sigma$	95%CI	$\overline{X} \pm \sigma$	95%CI	
Length of between AIIS-PIIS	116.98 ± 7.36	115.47–118.47	116.90 ± 7.31	115.44–118.44	0.166
Transverse diameter of the acetabulum	49.61 ± 3.59	48.93–50.36	49.51 ± 3.54	48.84–50.23	<0.001
Length of between PIIS and upper rim of acetabulum	94.66 ± 11.02	92.41–96.90	94.48 ± 10.91	92.23–96.74	0.106
Length of between AIIS and upper rim of acetabulum	26.95 ± 2.61	26.44–27.49	27.14 ± 2.64	26.61–27.69	<0.001
Shortest distance between AIIS and anterior rim of auricular surface of ilium	70.36 ± 5.32	69.30–71.52	70.10 ± 5.13	69.08–71.23	<0.001
Length of between AIIS and upper rim of symphyseal surface of pubis	102.61 ± 7.42	101.06–104.14	102.61 ± 7.52	101.05–104.14	0.991

$\overline{X}$ mean, σ standard deviation, *CI* confidence interval of mean

The acetabulum varies in shape, width, depth and diameter. Minor anatomical variations in the shape of the acetabulum and joint congruences are frequently observed (Ülkir and Ilgaz 2023). A constant ratio of 1.05(1.03/1.07) was calculated between vertical and transverse diameter of the AC in present study. Ülkir and Ilgaz (2023) measured the vertical diameter of the AC as 52.21 ± 3.52 mm and the transverse diameter of the AC as 50.67 ± 3.12 mm in 57 coxal bones. The ratio between these two diameters is 1.03 and it can be seen that it is within the confidence interval specified in our study. In the 3D computed tomography study conducted by Djorojevic et al. (2014) on 150 individuals, vertical diameter of the AC and horizontal diameter of the AC values of males as 54.00 ± 3.44 mm and 52.53 ± 3.57 mm, and 46.65 ± 2.68 mm and 45.60 ± 2.70 mm for females, respectively. The ratio between these two diameters is 1.03 in male and it can be seen that it is within the confidence interval specified in our study. This ratio in female was found very close to the confidence interval (1.02). In other studies conducted on the acetabulum from different populations, it was determined that the ratio between vertical and transverse AC diameter was within the confidence interval we determined (Djorojevic et al. 2014; Taşci et al. 2023; Tripathi and Gajbhiye 2022; Ülkir and Ilgaz 2023; Ukoha et al. 2014).

The length of between PSIS and upper rim of AC is important for certain surgical procedures such as intra iliac anchor fixation and screw placement (Berry et al. 2001). In the study by Berry et al. (2001), investigated the length of between PSIS and the upper rim of the AC in 120 males and females between the ages of 20–79, it was calculated as 128.2 ± 6.8 mm and 124.9 ± 7.1 mm in males and females, respectively. Sako et al. (2021) measured PSIS-AC as 113.3 ± 5.9 mm in patients with developmental hip dysplasia and 113.7 ± 6.3 mm in the healthy group. Demir et al. (2018) calculated this length as an average of 106.24 ± 12.63 mm. In this study, PSIS-AC length (113.38 ± 13.10 mm) was found to be lower than the values of Berry et al. (2001), higher than the values of Demir et al. (2018), and similar to the values of Sako et al. (2021). There is only one study in the literature that measures length of the between PIIS and upper rim of AC. Sako et al. (2021) reported PIIS-AC length as 87.7 ± 7.2 mm in patients with developmental hip dysplasia and 86.8 ± 8.4 mm in the healthy group. This length was found to be higher than Sako et al.'s (2021) in our study (94.66 ± 11.02 mm). Although a constant ratio of 1.18 (1.16–1.21) was calculated between PSIS-AC and PIIS-AC in our study, it was determined that this ratio in Sako et al.'s (2021) study was not within the confidence interval we determined. The differences in the results of the studies are likely due to the use of different measurement techniques and racial variations.

To delineate the intricate anatomical characteristics of acetabular dysplasia, it is crucial to assess for any abnormalities in the ilium and acetabulum, as well as their specific locations (Sako et al. 2021). While the length of between ASIS and upper rim of AC in our study was similar to Demir et al. (2018) (60.30 ± 5.46 mm), it was found to be significantly lower than that of Sako et al. (2021) (patients: 84.3 ± 5.3 mm; healthy: 86.7 ± 5.6 mm). In our study, length of between AIIS and upper rim of AC was measured as 26.95 ± 2.61 mm. In a study evaluating the morphology of the AIIS in relation to the acetabular rim in 10 human cadaver pelvises using CT images, the AIIS-AC length was measured as 20.5 ± 3.80 mm (Schindler et al. 2017). In the study conducted by Amar et al. (2013), the distance between the AIIS and the acetabular rim was 21.8 mm. This length in our study was found to be longer than other studies. Although a constant ratio of 2.32 (2.28–2.36) was calculated between ASIS-AC and AIIS-AC in our study, no study was found with this ratio and confidence interval.

The Ranawat triangle method is one of the most commonly used techniques with pelvic radiographs to estimate the true acetabulum and anatomical hip joint center in the anteroposterior plane. Although it is used to determine the actual location of the acetabulum during prosthetic surgeries several studies have reported that this method exhibits considerable deviation from the anatomical hip joint center (Fujii et al. 2021). As an alternative to the Ranawat triangle used in the anteroposterior plane, the ratios we identified between ASIS-AC and AIIS-AC, and between PSIS-AC and PIIS-AC, could provide guidance for the positioning of prosthetics in surgical procedures in sagittal plane.

Similar to Demir et al. (2018) (93.40 ± 6.25), the shortest distance between ASIS and anterior rim of auricular surface in our study was calculated as 92.53 ± 6.77 mm. Sex estimation is made using the shortest distance between AIIS and anterior rim of auricular surface, defined as spino-auricular length (Brůžek et al. 2017). Brůžek et al. (2017), in their study on 2040 coxas, reported spino-auricular length as 74.7 ± 6.7 mm in male, 74.3 ± 6.3 mm in female. The study of Demir et al. (2018) reported the shortest distance between AIIS and anterior rim of auricular surface as 71.67 ± 4.52 mm. This length in our study (70.36 ± 5.32) was measured lower than other studies (Brůžek et al. 2017; Demir et al. 2018). A constant ratio of 1.26 (1.23–1.30) was calculated between ASIS-auricular surface and AIIS-auricular surface in our study. In the study by Demir et al. (2018), the same ratio was calculated as 1.30, and it was found to be within the confidence interval determined in our study.

Franklin et al. (2014) measured height of the symphyseal surface as 35.7 ± 4.65 mm in male and 31.56 ± 3.57 mm in female in 400 pelvic multi-slice computed tomography scans. In Djorojevic et al.'s study (2014), both height of the symphyseal surface (male: 40.32 ± 5.10 mm, female: 37.14 ± 4.33 mm) and width of the symphyseal surface (male: 17.56 ± 2.90 mm, female: 16.79 ± 3.20 mm) were found to be higher in male than in female. Our results regarding the symphyseal surface were found to be lower than other studies. Also, a constant ratio between the height and width of the symphysis surface could not be determined in our study.

The mid-inguinal point holds significance as a surgical landmark, marking the midpoint along an imaginary line connecting the ASIS and pubic symphysis. The symphyseal surface of pubis joins with the corresponding surface of the opposite pubis, forming the pubic symphysis (Wobser et al. 2024). A constant ratio of 1.32 (1.29–1.33) was calculated between ASIS-symphyseal surface and AIIS-symphyseal surface in our study. In the study by Demir et al. (208), the same ratio was calculated as 1.29, and it was found to be within the confidence interval determined in our study.

Romão et al. (2020) reported the transverse diameter of the obturator foramen in 60 coxas as 45.95 ± 4.21 in the right side, 47.00 ± 3.98 in the left side, and the vertical diameter of the obturator foramen as 31.34 ± 3.56 in the right side and 30.42 ± 2.82 in the left side. In our study, the transverse diameter of the obturator foramen (45.48 ± 3.94 mm) was found to be very similar to that reported by Romão et al. (2020), while the vertical diameter of the obturator foramen (35.71 ± 3.33 mm) was found to be higher.

The knowledge of morphometric measurements related to the hip bone is indispensable, given its applications in specimen identification, the treatment of pelvic fractures and sex determination using skeletal remains. The golden or constant ratios' occurrence in the coxal bone highlights the intersection of mathematics, biology, and aesthetics in human anatomy. As studies continue, our understanding of these proportions will not only enhance our appreciation of human anatomy but also inform practical applications in orthopedic research and joint surgery.

Our study was conducted on 95 coxal bones. Therefore, it should be treated as a pilot study. We investigated the relationship between some lengths in the coxal bone and detected some constant ratios. We calculated and compared the ratios we determined using the average values of the studies in the literature. Orthopedic and plastic surgeons should consider safe pathways and estimated distances during surgical procedures to prevent complications in implant and hip prosthesis surgeries. In this context, the constant ratios identified in our study will serve as a guide for surgeons.

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Author contributions Conceptualization: Burcu Kamaşak Arpaçay; Data curation: Burcu Kamaşak Arpaçay, Burak Oğuzhan Karapınar; Formal analysis: Burcu Kamaşak Arpaçay, Burak Oğuzhan Karapınar, Funda İpekten; Project administration: Burcu Kamaşak Arpaçay, Hatice Güler; Supervision: Hatice Güler, Mehtap Nisari; Writing—original draft: Burcu Kamaşak Arpaçay, Burak Oğuzhan Karapınar, Funda İpekten; Writing—review and editing: Burcu Kamaşak Arpaçay, Hatice Güler, Mehtap Nisari. All authors have read and final approved of the manuscript being submitted.

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Data availability The data that support the findings of this study are available on request from the corresponding author.

Declarations

Conflict of interest All authors (Burcu Kamaşak Arpaçay, Burak Oğuzhan Karapınar, Hatice Güler, Funda İpekten, Mehtap Nisari) declare that they have no conflict of interest.

Ethical approval This study was conducted on dry coxal bones; it is among the studies that do not require ethics committee approval.

Informed consent Not applicable.

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