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Analysis of common iliac artery morphometry: A computed tomography angiography study

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Abstract

The present study was conducted to create reference values of common iliac arteries (CIA) for the diagnosis of vascular diseases such as aneurysm and atherosclerosis and to contribute to preoperative evaluation and the literature for open or endovascular interventions. Abdominal computed tomography angiography (CTA) images of 299 (156 F, 143 M) patients which were taken for various reasons at Gaziantep University Faculty of Medicine Hospital between 2015 and 2023 and which met the criteria were selected. The mean age of the patients included in the study was 49.85±18.74 years. Diameter measurements were made on two-dimensional images, while length and angle measurements were made on three-dimensional images. As a result of the analysis, the mean right CIA (RCIA) anteroposterior diameter was 1.12±0.66 cm and the mean transverse diameter was 1.21±0.74 cm; while the mean left CIA (LCIA) value was 1.12±0.68 cm in the anteroposterior axis and 1.13±0.73 cm in the transverse axis. In terms of length measurements, the mean right common iliac artery (RCIA) was found as 5.63±1.61 cm and the mean LCIA was found as 6.19±1.65 cm; in angle measurements of right and left CIA with the abdominal aorta (AA), mean RCIA was found as 23.3±9.84° and mean LCIA was found as 19.66±9.18°. While a significant difference was found between genders in terms of diameter values ($p<0.05$), no difference was found in length and angle values ($p>0.05$). In terms of correlations with age, correlation was found in diameter values of both sides and RCIA angle. It is thought that morphometric measurements of the common iliac arteries will contribute to interventional radiologists, vascular surgeons and the literature.

Keywords: Common iliac artery, diameter, length, angle, computed tomography angiography

Introduction

Anatomical knowledge of vascular structures is essential for the planning and successful outcome of surgical procedures, regardless of open or endovascular interventions [1]. The anatomical structure of vascular structures changes with various diseases, age and environmental factors [1]. These changes will lead to different diseases such as atherosclerosis and aneurysm [1-3].

In patients with abdominal aortic aneurysm (AAA), endovascular aneurysm repair (EVAR) has been the most accepted treatment method [4]. The length and diameter of common iliac arteries (CIA) and its angulation with the abdominal aorta (AA) play an esential role in the success of EVAR and for choosing the appropriate stent [4,5]. In addition, since CIA separated from AA may lead to atherosclerosis formation by causing hemodynamic changes in this region due to its anatomical structure, changes in CIA morphometry may also affect the risk of developing such pathologies [3]. Although there are studies in literature on the morphometry of AA, there are few studies on CIA [1,3,4,6].

The aim of this study is to contribute to creating reference values for the diagnosis of diseases such as aneurysm and atherosclerosis and also provide helpful information to clinicians in choosing the suitable stent-graft for EVAR by researching the relationship of CIA morphometry of a population in the South of Turkey with age and gender.

Material and Methods

Patient population

This respective study was conducted by scanning the archived images of patients who had abdominal Computed tomography

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angiography (CTA) for various reasons at Gaziantep University Faculty of Medicine Hospital between 2015 and 2023. Images of ~2000 patients obtained from the archive were examined. Images with a section thickness of >5 mm, images in which the structures to be measured were not clear in three-dimensional reconstruction, images in which image quality did not allow for evaluation due to insufficient distribution of motion artefacts or contrast agent inside the artery, images of patients who were exposed to surgery and/or intervention, images of patients who were found to have trauma, aneurysm, tumour, infection in the bifurcation aorta and CIA region and images that did not have CIA in the image area were excluded. No limitations were set in the study for age and gender. A total of 299 patients, 156 women and 143 men, who met the criteria were included in the study. The measurements were made by a single researcher and the data were coded to avoid identification of patients. Ethical approval dated 03.11.2022 and numbered 2022/164 was obtained from the Ethics Committee for Non-Invasive Clinical Research of Gaziantep Islam Science and Technology University.

Obtaining and processing the images

CTA images of the patients were obtained with 64 detector VCT XTe Light Speed, General Electric, Healthcare Systems (USA). After 120 ml non-ionic contrast agent with an iodine concentration of 300 mgI/ml, 40 ml saline was injected through the median cubital vein at a rate of 4ml/sec as bolus. The images were taken by using 40 mm (64x 0.625) collimation, 0.35 seconds of rotation, a pitch value of 1, 100-120 kilovolts in X ray tube and standards of 50-600 milliampere, 0.625-4 mm detector thickness and 0.625-4 mm reconstruction interval.

In order to prepare for the related measurements, three-dimensional (3D) reconstructions of two -dimensional (2D) CTA images were made by using open access software program Horos v.4.0.0 (https://horosproject.org/) at the anatomy department of Gaziantep University Faculty of Medicine (Figure 1). This study was conducted with the experience and consensus of two faculty members related to the subject. While the diameter measurements of CIA were carried out in two ways as an anteroposterior and transverse axis from the proximal of CIA on 2D images (Figure 2), angles of CIA with AA and the distance from bifurcation point of AA to bifurcation point of CIA were measured on 3D images (Figure 3).

Since some programs used for angle measurement are paid applications, it is difficult for everyone to access these easily [2,7]. For angle measurements, the method used by Deveci was taken as reference in this study [8]. First the aortic bifurcation point (BAN) was determined. A circle of maximum radius was placed in the bifurcation pool to determine the origin of the right common iliac artery (RCIA) and left common iliac artery (LCIA). The maximum radius circumferential bifurcation pool was tangentially passing through 3 points as BAN, RCIA -AA vessel surface and LCIA -AA vessel surface. A circle with a maximum radius centred on this bifurcation circle was placed in the RCIA and LCIA vessel lumens. The next maximum radius circles were tangent to the centre of the first circles. The vector passing through the centre points of the first and second circles was considered as the vessel centre axis of the RCIA. The same process was applied to the LCIA. In order to determine the vessel central axis of AA, a tangential circle was drawn on the circle in the central bifurcation pool and at the same time tangential to the vessel walls of the AA. Then a second circle was drawn with its centre on this circle. The vector passing through the centre points of these two circles was considered as the vein centre axis of AA. The angle between AA's vein centre axis and the vessel central axis of RCIA was measured as the RCIA angle, while the angle between the vessel central axis of the AA and the vessel central axis of the LCIA was measured as the LCIA angle (Figure 4).

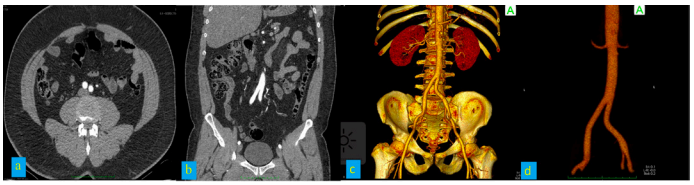

Figure 1. Conversion of two-dimensional computed tomography angiography images into 3D images. a: 2D CTA image in the transverse plane, b: 2D CTA image in the coronal plane, c: 3D reconstruction of the 2D CTA image, d: Ready-to-measure image of neighboring structures other than veins on the 3D image

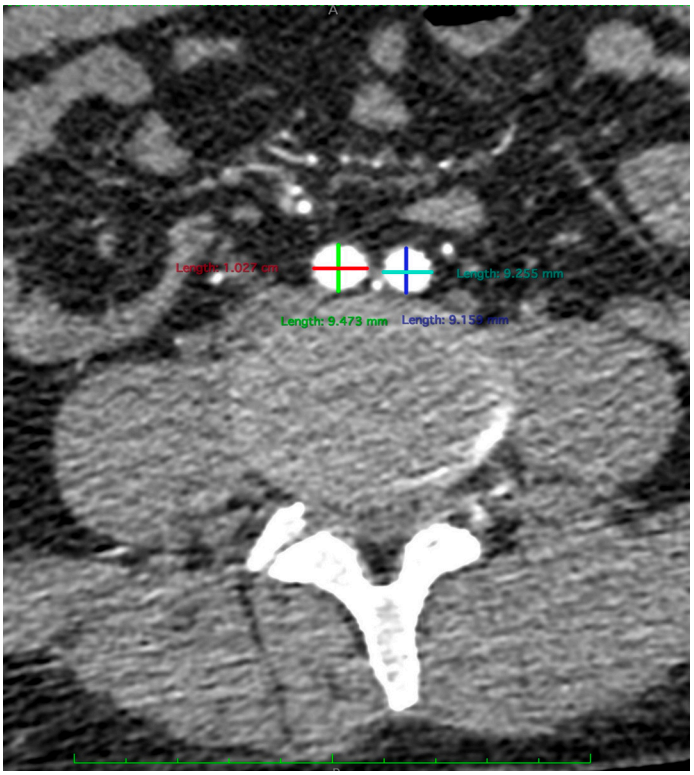

Figure 2. Measurement of the diameters of the common iliac arteries in the anteroposterior and transverse axis on two-dimensional images. Red line: transverse diameter of left common iliac artery, green line: anteroposterior diameter of left common iliac artery, turquoise line: transverse diameter of right common iliac artery, blue line: anteroposterior diameter of right common iliac artery

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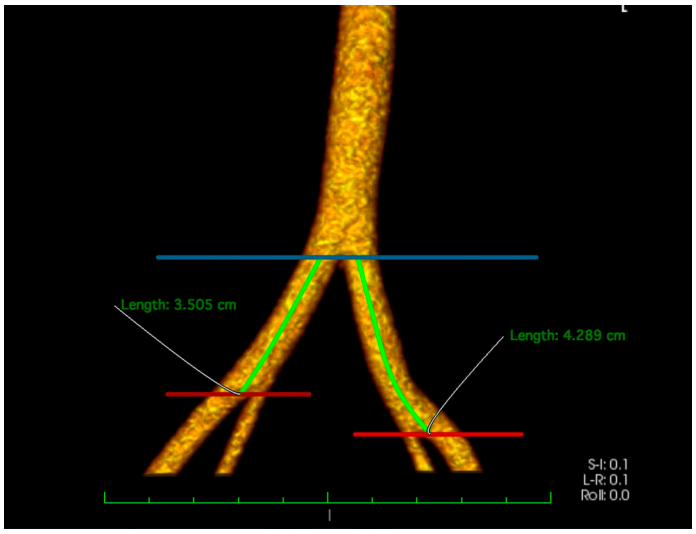

Figure 3. Length measurement on three-dimensional reconstructions of the common iliac arteries

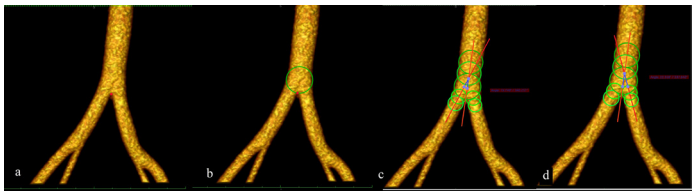

Figure 4. Angle measurement on three-dimensional reconstructions of the right and left common iliac arteries. a: determining the bifurcation point, b: placing the first circle in the bifurcation pool, c: measuring the right common iliac artery angle by determining the central axes of the abdominal aorta and right common iliac artery, d: determining the centreline of the abdominal aorta and left common iliac artery and measuring the left common iliac artery angle

Statistical analysis

Descriptive statistics of the data obtained from the study were shown with mean and standard deviation for numerical variables, and with frequency and percentage analysis for categorical variables. The normality distribution test of CIA measurements was analysed with the Shapiro Wilk test. In the comparison of these variables according to categorical variables, independent samples t-test/Mann-Whitney U test were used for categorical variables containing two groups. In addition to these, the differences between categorical variables were tested with Chi-square analysis. The correlations between numerical variables were tested with Pearson correlation analysis (parametric values) Spearman correlation (non-parametric values) analysis. The analyses were made with SPSS 22.0 (IBM Corp., Armonk, NY) program and a significance level of $p<0.05$ was used.

Results

In this study which was conducted on the images of 299 individuals (F:156, M:143), age range was 5-89, while mean age was 49.85±18.74. In the right CIA (RCIA) measurements, mean anteroposterior diameter was found to be 1.12±0.66 cm, while mean transverse diameter was found as 1.21±0.74 cm (Table 1). When diameter values were compared in terms of gender, diameter values of men were found to be statistically significantly higher than those of women ($p<0.05$) (Table 2). Mean left CIA (LCIA) diameter values were found as 1.12±0.68 cm in the anteroposterior axis and as 1.13±0.73 cm in the transverse axis (Table 1). When evaluated in terms of gender, statistically significant difference was found in men when compared with women (Table 2). In length measurements, while mean RCIA was found as 5.63±1.61 cm, mean LCIA was found as 6.19±1.65 cm (Table 1). No significant difference was found when analysed in terms of gender ($p>0.05$) (Table 2).

When the angulations of right and left CIA with AA were examined, mean RCIA was measured as 23.3±9.84°, while mean LCIA was measured as 19.66±9.18° (Table 1). While RCIA angle was found to be statistically significantly higher in women when compared with men ($p<0.05$), no difference was found between genders in LCIA angle ($p>0.05$) (Table 2).

Table 1. Average values of diameter, angle and length measurements of common iliac arteries

Parameters	N	Mean±SD	Min-Max
RCIA diameter a-p (cm)	298	1.12±0.66	(0.397-7.695)
RCIA diameter t (cm)	298	1.21±0.74	(0.436-8.719)
LCIA diameter a-p (cm)	299	1.12±0.68	(0.326-7.928)
LCIA diameter t (cm)	299	1.13±0.73	(0.407-8.661)
RCIA length (cm)	292	5.63±1.61	(1.868-9.826)
LCIA length (cm)	292	6.19±1.65	(1.719-12.29)
RCIA angle (°)	297	23.3±9.84	(3.903-96.087)
LCIA angle (°)	297	19.66±9.18	(0.314 -54.986)

N: number; SD: standart deviation; Min: minimum; Max: maximum, RCIA: right common iliac artery, LCIA: left common iliac artery, a-p: anteroposterior, t: transvers

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Table 2. Distribution of diameter, angle and length measurements of common iliac arteries by gender

	Female		Male		p
	Mean±SD	Median (Min-Max)	Mean±SD	Median (Min-Max)	
RCIA diameter a-p (cm)	1.11±0.74	0.97 (0.88-1.13)	1.14±0.57	1.08 (0.95-1.19)	0.001*‡
RCIA diameter t (cm)	1.19±0.79	1.05 (0.92-1.25)	1.24±0.68	1.17 (1-1.36)	0.001*‡
LCIA diameter a-p (cm)	1.11±0.75	1 (0.88-1.13)	1.13±0.6	1.06 (0.95-1.21)	0.002*‡
LCIA diameter t (cm)	1.12±0.82	0.99 (0.88-1.16)	1.14±0.62	1.08 (0.96-1.23)	0.001*‡
RCIA length (cm)	5.54±1.67	5.38 (4.21-6.82)	5.72±1.53	5.73 (4.55-6.76)	0.357§
LCIA length (cm)	6.15±1.77	6.08 (4.91-7.4)	6.23±1.53	6.33 (5.17-7.1)	0.668‡
RCIA angle (°)	24.58±9.6	23.01 (17.47-30.68)	21.9±9.93	20.67 (16.61-26.33)	0.010*‡
LCIA angle (°)	19.19±9.48	18.86 (12.65-25.53)	20.18±8.85	19.44 (14.72-24.84)	0.443‡

*p<0,05; ‡Mann-Whitney U test, §Student's t-test; SD: standart deviation, min: minimum, max: maximum, a-p: anteroposterior, t: transvers, RCIA: right common iliac artery, LCIA: left common iliac artery

When the correlation of diameter, angle and length values with age was examined, while both anteroposterior and transverse axis values of RCIA and LCIA diameters and RCIA angle showed a positive, low, statistically significant correlation ($p<0.05$; $0.2<r<0.4$), LCIA transverse diameter was found to show very weak positive correlation with age ($p<0.05$; $0<r<0.2$) (Table 3). When correlations were made among the morphometric measurements, a very high level of positive correlation was found between RCIA diameter values and LCIA diameter values ($p<0.05$; $0.8<r<1$). A high positive significant correlation was found between RCIA length and LCIA length ($p<0.05$; $0.6<r<0,8$). While a weak negative significant correlation was found between RCIA angle and LCIA angle ($p<0.05$; $0.2<r<0.4$), LCIA angle was found to have a negative and weak correlation with RCIA ($p<0.05$; $0.2<r<0.4$), a negative and very weak correlation was found with LCIA length ($p<0.05$; $0<r<0.2$) (Table 3).

Table 3. Correlation of diameter, angle, length values of common iliac arteries with age and each other

		Age	RCIA diameter a-p	LCIA diameter a-p	LCIA diameter t	RCIA length	LCIA length	RCIA angle	LCIA angle
RCIA diameter a-p	r	0.405	.972**	.976**	.960**	.113	.064	.062	.049
	p	0.001	.000	.000	.000	.055	.273	.285	.399
RCIA diameter t	r	0.400	1	.973**	.962**	.096	.053	.072	.036
	p	0.001*		.000	.000	.103	.367	.215	.533
LCIA diameter a-p	r	0.334	.973**	1	.977**	.096	.019	.039	.057
	p	0.001	.000		.000	.102	.743	.501	.325
LCIA diameter t	r	0.180	.962**	.977**	1	.098	.010	.021	.078
	p	0.002*	.000	.000		.096	.866	.720	.179
RCIA length	r	0.075	.096	.096	.098	1	.640**	.066	-.283**
	p	0.203	.103	.102	.096		.000	.261	.000
LCIA length	r	0.086	.053	.019	.010	.640**	1	-.013	-.149*
	p	0.145	.367	.743	.866	.000		.820	.011
RCIA angle	r	0.291	.072	.039	.021	.066	-.013	1	-.292**
	p	0.001*	.215	.501	.720	.261	.820		.000
LCIA angle	r	-0.057	.036	.057	.078	-.283**	-.149*	-.292**	1
	p	0.328	.533	.325	.179	.000	.011	.000	

RCIA: right common iliac artery; LCIA: left common iliac artery, a-p: anteroposterior, t: transvers

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Discussion

While cadavers or computed tomography (CT) are often used to determine the morphological and morphometric features of vascular structures, the ultrasonography (US) method is also used [1,3-6,9,10].

It is important to evaluate CIA diameter since it is considered as one of the causes of vascular diseases such as aortic aneurysm, aortic dissection and atherosclerosis [9]. There is no predetermined diameter value for a definitive diagnosis in CIA aneurysm [2]. Although there are different interpretations in the literature, experts may have an idea about the aneurysm threshold if reference values are determined for each population for individuals who do not have arterial diseases. In a study examining the morphometry of AA and CIA in Ethiopian population, it was found that mean RCIA diameter was 1.10±0.16 cm in anteroposterior axis and 1.12±0.16 cm in transverse axis, mean LCIA diameter was 1.09±0.16 cm in anteroposterior axis and 1.10±0.15 cm in the transverse axis and it was reported that diameter values of both sides were positively correlated with age, there was statistically significant difference between genders and the values were higher in men when compared with women [9]. In a study conducted to determine the CIA reference diameter of Korean population, it was found that mean RCIA diameter was 1.19 cm, while mean LCIA diameter was 1.27 cm and RCIA diameter was higher in men, with higher diameters measured as the age increased [11]. In a study conducted on Chinese population, while mean RCIA diameter was 9.77±1.75 mm and LCIA diameter was 9.65±1.76 mm in male patients, mean RCIA diameter was 8.59±1.31 mm and LCIA diameter was 8.45±1.28 mm in female patients [4]. In another study, in measurements made on Chinese population who were older than 45 years of age, mean RCIA diameter was 10.76 mm and mean LCIA diameter was 10.41 mm in proximal [12]. In a study examining the anatomy of CIA with US, it was reported that mean CIA diameter was 10.1±2.0 mm in men and 9.2±1.3 mm in women and no significant difference was found in terms of gender [10]. In a study in which CIA diameters were measured from 3 different planes and a mean value was obtained in Saudi population, mean RCIA diameter was found as 0.90 cm and mean LCIA diameter was found as 0.88 cm and no difference was reported between genders [13]. In a study conducted on cadavers in aorta iliac region, it was reported that mean RCIA diameter was 9.91±1.86 mm, while mean LCIA diameter was 9.22±2.44 mm, and there were no significant differences between genders in the right and left sides [14]. In a study conducted on a healthy population on the anatomy of aorta iliac region, mean RCIA diameter was reported as 10.49±1.85 mm and mean LCIA diameter was reported as a 10.36±1.81 mm; however, the midpoint of CIA was taken as reference as the diameter measurement point [15]. In studies on pediatric populations, Munk et al. have observed that the vascular diameter in males up to the age of 16 is significantly larger than that in females [16]. In a study measuring diameter from the narrowest point of common iliac arteries on angiography images of hyperlipidaemia patients, mean RCIA diameter was found as 8.9 mm, while mean LCIA diameter was found as 8.6 mm [17]. Our results are not in parallel with the results of Saudi population. In this study, mean RCIA anteroposterior diameter was found as 1.12±0.66 cm, and mean RCIA transverse diameter was found as 1.21±0.74 cm, while mean LICA diameter was found as 1.12±0.68 cm in anteroposterior axis and as 1.13±0.73 cm in transverse axis, showing results similar to literature. A significant difference between genders was also found in our study.

CIA lengths should be known by interventional radiologists and vascular surgeries for choosing suitable stents and grafts and for the success of EVAR [4,18]. The anatomy of the iliac artery often poses a significant challenge during EVAR repair, hence a careful preoperative assessment of the iliac system is crucial for providing optimal patient care [19]. Deswal et al. reported CIA lengths as 56.49±17.82 mm on the right and 53.75±18.25 mm on the left and reported no differences between genders [14]. In a study examining the sinuosity of CIA, both the straight distance and the actual intravascular distance of CIA were measured. According to the results, the actual length of the vessel measured according to the centreline was reported as LCIA 53.6±19.2 mm, RCIA 52.9±18.8 mm in patients with aneurysm, while it was reported as LCIA 48.7±15.7 mm, RCIA 45.9±15.7 mm in patients who did not have aneurysm, stating that the central length of CIA did not change with age, while the straight length measured from the outside was negatively correlated with age [7]. In a study conducted on cadaver, mean LCIA length was found as 6.12±1.79 cm, while mean RCIA length was found as 6.03±1.61 cm and no difference between genders was found on both sides [6]. In a study they conducted on Turkish population, Ekingen et al. (20) found mean RCIA length as 59.43±1.69 mm and mean LCIA length as 62.07±1.77 mm and they reported that there were no differences between genders [20]. In the present study mean RCIA length was found as 5.63±1.61 cm and mean LCIA length was found as 6.19±1.65 cm, showing similar results to the results found in studies of Ekingen et al., Deswal et al. and Panagouli et al., while the results were not in parallel with the length results of individuals who did not have aneurysm in a study conducted by Song et al. Since anatomic structures of the Far east society are reported as lower than those of Western societies, we believe that the different results found in the measurements of our study and Song et al.'s study are due to differences in population or measurement methods [4,15,21].

In diseases clogging the vessel lumen such as atherosclerosis, the angulation of vessels is an important factor [14]. Studies examining the CIA morphometry mostly measured the aortic bifurcation angulation [1,2,22]. However, there are few studies measuring the CIA exit angulation of two sides separately according to AA. In a study conducted on cadavers, the angle of the aortic bifurcation and the exit angles of the CIA were measured separately, and mean RCIA angle was reported as 27.24±7.65°, while mean LCIA angle was 22.92±7.01° [14]. In a study conducted by using a method roughly similar to the

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measurement technique of this study, Semedby reported mean RCIA angle as 19.5° and mean LCIA angle as 17.9° [17]. In a study analysing the hemodynamic characteristics of the aorta iliac region, a similar method was used to measure the right and left common iliac artery angles and RCIA angle was reported as 26.7±9.5°, while LCIA angle was reported as 15.6±8.1° [23]. In the present study, mean RCIA angle was found as 23.3±9.84°, while mean LCIA angle was found as 19.66±9.18°. The results found are lower than the results of Deswal et al. and higher than those of Semedby. We can say that this difference is due to the difference in materials and measurement methods.

There have been limited morphometric studies on the diameter, angle, and distances of the iliac arteries, hence further comparisons could not be made.

Limitations

It was applied to individuals who applied to the hospital with any complaint but did not have any pathology in terms of abdominal aorta and common iliac arteries. It can also be performed and compared in patients with pathology in the iliac vessels.

Since this study was designed as a retrospective, demographic information and the presence of any other disease that could affect the morphometry of the common iliac arteries could not be obtained.

Conclusion

Diameter, angle and length measurements of CIA were performed in the present study. As a result of the data found, difference in terms of gender was found only in diameter values. In the correlation of parameters with age, only diameter results were found to have a weak correlation with age. This information can contribute to creating a reference value for the Turkish population. When the close relationship of pathologies such as aneurysm and atherosclerosis with these morphological values is considered, these data may help interventional radiologists and vascular surgeries. We believe that clinicians should pay attention to this information in the diagnosis and preoperative assessment of arterial diseases and choosing patient specific stent-graft.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
Permission was taken from Gaziantep İslam Science and Technology University Non-interventional Clinical Research Ethics Committee before starting the study (Decision number: 164.20.08).

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