Received: 5 Aug 2021 | **Accepted:** 24 Mar 2022
DOI: 10.54005/geneltip.979039

ORIGINAL ARTICLE

Investigation of Morphometric Parameters of Processus Coronoideus and Mandible in Human Dry Mandibles Between Sides

Mandibula Processus Coronoideus Morfometrik Parametrelerinin Taraflar Arası İncelenmesi

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Note

Presented as an Oral Presentation on 27-31 August 2019, 20th National Anatomy Congress-Istanbul Medipol University.

How to cite ?

Ay Keselik G, Malas MA. Investigation of Morphometric Parameters of Mandibula Processus Coronoideus Between Sides. Genel Tıp Derg. 2022; 32(3): 317-323

ABSTRACT

Aim: In our study, we aimed to determine of the relationship between mandible coronoid process and other mandible morphometric parameters in dry bones and compare these datas between the sides.
Materials and Methods: Twenty-two human mandible from our anatomy laboratory bone collection were photographed in three different ways, from 2 lateral (right and left side) and 1 posterior. Measurements were analyzied on digital images using Image J software. Morphometric parameters of coronoid process and morphometric parameters that belongs to mandibles ramus and body were compaired between both sides. Coronoid process types were hook, triangular, round and square. The parameters were compared between the two sides and correlation analysis was performed.
Results: There was no significant difference between sides in all parameters. There was a strong correlation between area of coronoid process and height of coronoid process on both sides (p <0.001). Correlation the values of the coronoid process the parameters on the right side were higher than the left side.
Conclusion: In our study, the correlation values of the parameters of the right coronoid process with each other were higher than those of the left side. However, there was no statistically significant difference between both sides. For the differences in morphometric parameter values between the coronoid process between both sides, further studies should be conducted in the developmental process up to childhood, adolescence, adult and geriatric development. Furthermore, further studies are needed to evaluate the effects of chewing side preference on coronoid process and to evaluate the differences in side/gender.

Keywords: mandible, coronoid process, morphometry, chewing side preference

ÖZ

Amaç: Çalışmamızda kuru kemiklerde mandibula processus coronoideus'u ile diğer mandibula morfometrik parametreleri arasındaki ilişkinin belirlenmesi ve bu verilerin taraflar arası karşılaştırılması amaçlanmıştır.
Gereç ve Yöntem: Anatomi laboratuvarında kemik koleksiyonuna ait 22 adet mandibula, dijital fotoğraf makinesi kullanılarak üç ayrı açıdan fotoğraflanmıştır. Dijital görüntüler üzerinde Image J yazılımı kullanılarak ölçümler yapılmıştır. Processus coronoideus morfometrik parametreleri, ramus mandibula ve corpus mandibulaya ait morfometrik parametreler belirlenmiş, processus coronoideus kanca, üçgen, yuvarlak ve kare olarak 4 ayrı şekilde tiplendirilmiştir. Parametreler taraflar arasında karşılaştırılmış ve korelasyon analizi yapılmıştır.
Bulgular: Tüm parametrelerde taraflar arasında anlamlı farklılık bulunmamıştır. Processus coronoideus tiplerinin yüzde dağılımında da taraflar arasında fark bulunmamaktadır. Her iki taraftada processus coronoideus alanı ile processus coronoideus yüksekliği arasında çok iyi derecede korelasyon bulunmaktadır (p=0.000). Sağ taraftaki processus coronoideus parametrelerinin korelasyon değerleri, sol tarafa göre daha yüksek bulunmuştur.
Sonuç: Taraflar arası processus coronoideus morfometrik parametreri çocukluk, adolesan ve erişkin olmak üzere farklı gelişim dönemlerinde yapılacak yeni çalışmalarda incelenmelidir. Ayrıca çiğneme tarafı tercihinin processus coronoideus üzerine olan etkilerinin ve taraf/cinsiyet farklılıklarının değerlendirilmesi için sağlıklı bireylerde yapılacak yeni çalışmalara ihtiyaç vardır.

Anahtar Kelimeler: mandibula, processus coronoideus, morfometri, çiğneme tarafı tercihi

Introduction

Coronoid process (CP) is the triangular part of mandible, located on the upper part of ramus of mandible, in front of condylar process (CnP) (1). The differentiation of CP in the prenatal and postnatal period is directly related to temporal muscle (TM). TM terminates on the medial and lateral aspect of CP. CP is implicit in TM in the prenatal period and in the postnatal period, it is formed in ramus of mandible together with other cranial structures (2). CP's development continues with mastication in the postnatal period (3-6). In newborn period, CP is relatively larger than ramus of mandible and is higher than the CnP (1). Functional features and dominance of TM affect development of CP in adults (7). In addition, CP is particularly associated with morphological structures on ramus of mandible, and these differ between individuals (1, 3, 7-9). Studies in literature have shown that changes in TM function and gonial angle (GA) affect CP (2, 4, 6, 7, 10, 11). It has been reported that angle of mandibular notch (AMN) formed between CP and CnP is higher in women (12) and it is wider on right side (9). CP and CnP structures are important in determining mandible asymmetry in clinical cases (13). Cardinal et al. (14) showed that in patients with unilateral crossbite, there was no difference between both sides in CnP and there was asymmetry in CP. It has been shown that changes in TM function and CP are associated with prognathism. It has been stated that the difference between the sides is greater in patients with malocclusion than in normal individuals (5). It is known that height of CP (HCP) and direction of CP can cause the trismus. It is also stated that it can narrow the gap between it and the zygomatic arc (15). Galie et al. (16) mention that in unilateral CP hyperplasia, facial deformity characterized by limited mouth opening or temporamandibular joint dysfunction can be seen due to the CP hitting to zygomatic bone. It is known that surgical treatment is beneficial in cases of CP hyperplasia (17).

In previous studies, morphometric parameters of mandible and CP were examined separately. There are few studies evaluating CP and other mandible morphometric structures together. For this reason, details of the morphometric structure of CP were determined on dry bones in our study. It was aimed to investigate the relationships between both sides CP parameters and other mandible parameters.

Materials and Methods

In our study, 22 dry mandibles that belong to the bone collection of the anatomy laboratory from our faculty and that obtained in accordance with the relevant official regulations, were used. There is no record of age and gender of the persons to whom the bones belong. Mandibles with fractures and healing after fracture were not included in the study.

The methods used in previous studies were used to determine CP and other mandible parameters (7, 9, 12, 18, 19). In our study, morphometric measurements were evaluated on digital caliper and digital images of bones. Three separate images were made using a tripod fixed digital camera (Canon EOS 800D) as posterior, right and left sides. A ruler was placed during photographing to calibrate the measurements (Figure 1). Measurements on digital images were made using Image J software (20) (Figure 2). Thickness of CP (TCP) and thickness of ramus of mandible (TRM) parameters were measured with a digital caliper.

CP related parameters (Figure 2)

Height of coronoid process (HCP): Vertical distance (f) between the highest point of CP (c) and the horizontal axis passing through the base of the coronoid process (b-d).

Base of coronoid process (BCP): Transverse distance (b-d) from the deepest point of the mandibular notch (b) to the point where the horizontal line drawn along the coronoid process cross the anterior edge of the coronoid process (d).

Thickness of coronoid process (TCP): The thickest distance between the lateral and medial surfaces of the coronoid process.

Area of coronoid process (ACP): The area determined by following the anterior and posterior edges of the coronoid process above the base of the coronoid process (b-c-d area).

Difference of ramus length between coronoid process and head of mandible (CP-HP): difference between height of coronoid process and head of mandible (e).

Angle of mandibular notch (AMN): Angle between the lines connecting the highest points of the coronoid process and head of mandible (point c-a, respectively) to the deepest point of the mandibular notch (b).

Figure 1: Lateral view from right side of mandible.

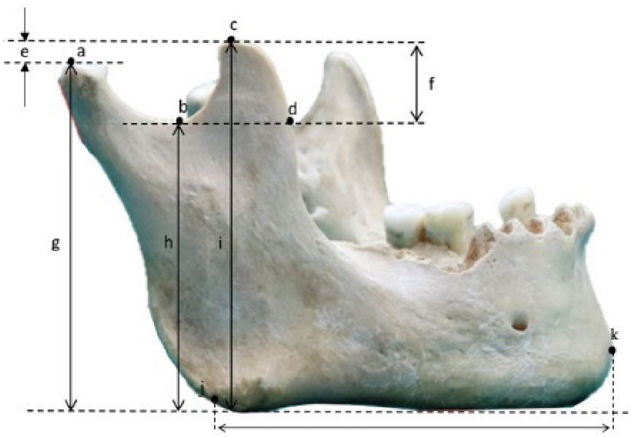

Figure 2: Obtained morphometric parameters. a: The highest point of head of mandible; b: deepest point of mandibular notch; c: the highest point of the coronoid process; d: the point where the horizontal line drawn along the coronoid process cuts the anterior edge of the coronoid process; e: difference between the height of the coronoid process and the height of head of mandible; f: vertical distance between the horizontal axis passing through the base of the coronoid process; g: vertical distance between the highest point of head of mandible and the horizontal axis passing through the base of body of mandible; h: vertical distance between the deepest point of the mandibular notch and the horizontal axis passing through the base of body of mandibula; i: vertical distance between the highest point of the coronoid process and the horizontal axis passing through the base of body of mandible; j: gonion; k: mental protuberance.

Other mandible parameters

Ramus length of the coronoid process (RLCP): The vertical distance between the highest point of the coronoid process (c) and the horizontal axis passing through the base of the body of mandible (i).

Ramus length of the mandibular notch (RLMN): the vertical distance (h) between the deepest point of the mandibular notch (b) and the horizontal axis passing through the base of the body of mandibulae.

Ramus length of head of mandible (RLHM): Vertical distance (g) between the highest point of head of mandible (a) and the horizontal axis passing through the base of body of mandible.

Thickness of ramus mandible (TRM): The thickest distance between the lateral and medial surfaces of the ramus mandible.

Gonial Angle (GA): The angle between the horizontal line tangent to the lower edge of body of mandible and the lines tangent to the posterior edge of the ramus mandible, (j: gonion)

Length of body of mandible (LBM): The distance between the vertical projections of the gonion (j) and protuberantia mentalis (k) on the horizontal line tangent to the base of body of mandible.

Bigonial Width (BgW): Transverse distance (l) between the gonions (j) of the two sides.

Typing of the coronoid process

The methods used in previous studies were used to determine CP types (9, 18). The coronoid process is typed in 4 different shape. Type 1: hook, Type 2: triangle, Type 3: round and Type 4: square

Statistical analysis

The minimum, maximum and mean values and standard deviations (SD) of the measured parameters for statistical analysis were calculated with the IBM SPSS Statistics v25 program. The percentage distribution of CP types according to the sides was determined. Sides were compared with Student's t-test. The chi-square test was used to compare the percentage distributions. Correlation between CP parameters and other mandible parameters was evaluated with Spearman correlation test (Table 4).

Ethics Committee Approval

Bone materials belonging to our laboratory were obtained in accordance with official ethical rules. Since the ethical committee requirement is not sought in noninvasive studies, no application was made to the ethics committee in our study.

Results

Arithmetic means and standard deviations for CP and other morphometric parameters of mandible are shown in Table 1. There was no significant difference between sides (Table 1).

The number of cases and the percentage distribution of CP types according to sides are shown in Table 2. No significant difference was found between sides (Table 2).

The correlation values and significance levels between CP parameters and other mandible parameters are shown in Table 3. There was a fairly strong correlation between ACP and HCP on both sides (p=0.000, Table 3). It was determined that the correlation values of the CP parameters on right sides were higher than those on the left sides. Significant correlation values were found between TCP and TRM, BCP and LBM. Significant correlation values were found between BgW and HCP and ACP (Table 3).

Correlation values of CP parameters between sides are shown in Table 4 (Table 4). A significant negative correlation was found between AMN and HCP, ACP, CP-HP and RLCP (Table 4). There is strong to fairly strong positive correlation between the same parameters on different sides (Table 4).

Table 1: Mean, standard deviation and minimum-maximum values (mm) of coronoid process and other mandible parameters

	RIGHT		LEFT	
	Mean.±SD	**Min-max**	**Mean.±SD**	**Min-max**
Coronoid process parameters				
HCP	15.88±4.11	9.25-22.64	15.84±3.65	8.52-21.86
BCP	19.87±2.53	15.47-23.96	19.01±2.11	15.49-23.92
TCP	4.04±1.01	2.71-6.04	4.07±0.97	2.44-6.14
ACP (mm^2)	160.39±48.55	74.20-258.80	161.34±44.16	82.60-248.20
CP-HP	8.46±4.07	1.89-14.91	7.32±4.51	-3.70-16.15
AMN (°)	95.35±12.60	62.63-117.31	92.99±15.01	54.91-112.79
Other mandible parameters				
RLCP	52.39±8.36	38.09-70.78	51.38±6.81	38.11-62.31
RLMN	36.29±6.52	26.42-48.43	35.73±4.93	23.96-45.00
RLHM	43.29±7.19	31.70-56.27	43.55±6.09	29.25-54.42
TRM	6.21±1.95	3.20-11.87	6.14±1.14	4.37-8.53
LBM	74.57±5.74	61.89-83.53	74.53±4.45	64.3-80.19
GA	123.55± 7.35	109.57-137.73	122.05±6.66	106.25-137.26
BgW	78.37±6.19		Min 65.39-Max 90.00	

p>0.05; No significant difference was found between sides in all parameters.

Table 2: Types of coronoid processes (n) (%)

Side	Hook	Triangular	Round	Square	Total
Right	5 (%23)	5 (%23)	9 (%41)	3 (%13)	22 (100)
Left	5 (%23)	7 (%32)	9 (%41)	1 (%4)	22 (100)
Total	10 (%23)	12 (%27)	18 (%41)	4 (%9)	44 (100)

*Percentage distribution was made according to horizontal axis; p>0.05; There is no difference between the sides.

Table 3: Relationship between ipsilateral CP and other mandible parameters (r: correlation coefficients)

		HCP	BCP	TCP	ACP	CP-HP	AMN	RLCP	RLMN	RLHM	TRM	LBM	GA
HCP	Right	1											
	Left	1											
BCP	Right	0.30	1										
	Left	0.00	1										
TCP	Right	0.33	0.09	1									
	Left	0.15	-0.10	1									
ACP	Right	0.90**	0.54**	0.25	1								
	Left	0.90**	0.28	0.06	1								
CP-HP	Right	0.96**	0.34	0.26	0.91**	1							
	Left	0.88**	0.21	-0.03	0.84**	1							
AMN	Right	-0.77**	-0.05	-0.17	-0.63**	-0.75**	1						
	Left	-0.77**	0.37	-0.25	-0.60**	-0.53**	1						
RLCP	Right	0.73**	0.21	0.29	0.64**	0.60**	-0.71**	1					
	Left	0.66**	0.01	0.34	0.57**	0.47*	-0.70**	1					
RLMN	Right	0.30	0.10	0.27	0.25	0.17	-0.42	0.81**	1				
	Left	0.20	0.01	0.32	0.14	-0.00	-0.40	0.86**	1				
RLHM	Right	0.30	0.11	0.26	0.22	0.15	-0.40	0.82**	0.97**	1			
	Left	0.05	-0.12	0.36	0.01	-0.21	-0.40	0.72**	0.91**	1			
TRM	Right	-0.05	0.26	0.58**	0.02	-0.05	0.21	0.11	0.22	0.20	1		
	Left	0.02	0.07	0.34	0.05	0.01	-0.08	0.29	0.39	0.33	1		
LBM	Right	0.17	0.45*	0.12	0.27	0.10	0.00	0.39	0.53*	0.59**	0.21	1	
	Left	-0.05	0.52*	-0.07	0.03	-0.06	0.03	0.45*	0.63**	0.54**	0.05	1	
GA	Right	-0.21	0.04	-0.28	-0.12	-0.18	0.31	-0.54**	-0.67**	-0.65**	-0.30	-0.31	1
	Left	-0.11	0.38	-0.34	0.01	0.14	0.40	-0.55**	-0.65**	-0.75**	-0.18	-0.11	1
BgW	Right	0.44*	0.36	0.02	0.52*	0.41	-0.27	0.42*	0.38	0.34	0.05	0.50*	-0.14
	Left	0.52*	0.26	0.24	0.46*	0.34	-0.36	0.52*	0.34	0.27	0.82	0.40	-0.17

*: p<0.05; **: p<0.01; ***: While calculating the correlation relations of the parameters: right sides were compared with right sides parameters, left sides were compared with left sides parameters. BgW: Bigonial Width, RLHM: Ramus length of head of mandible, LBM: Body of mandible length, GA: Gonial Angle of Mandible, AMN: Angle of mandibular notch, RLMN: Ramus length of the mandibular notch, ACP: Area of coronoid process, CP-HP: Difference of ramus length between coronoid process and head of mandible, TCP: Thickness of coronoid process, RLCP: Ramus length of the coronoid process, BCP: Base of coronoid process, HCP: Height of coronoid process, TRM: Thickness of ramus of mandible.

Table 4: Correlation relationship between right and left sides CP and mandible parameters (r: correlation coefficients)

Left Right	HCP	BCP	TCP	ACP	CP-HP	AMN	RLCP	RLMN	RLHM	TRM	LBM	GA	BgW
HCP	0.81**	-0.16	0.19	0.74**	0.59**	-0.81**	0.49*	0.10	0.10	-0.05	-0.09	-0.19	0.36
BCP	0. 29	0.60**	0.02	0.46*	0.41	-0.09	0.15	-0.01	-0.08	0.09	0.28	0.27	0.36
TCP	0. 14	-0.17	0.71**	0.17	-0.03	-0.25	0.09	0.26	0.30	0.41	-0.07	-0.29	0.02
ACP	0.80**	0.13	0.14	0.86**	0.65**	-0.66**	0.47*	0.08	0.03	-0.01	-0.03	-0.07	0.52*
CP-HP	0.83**	*0.07	0.17	0.78**	0.68**	-.75**	0.43*	0.01	-0.01	-0.05	-0.16	-0.14	0.41
AMN	-0.76**	0.18	-0.15	-0.66**	-0.58**	0.91**	-0.63**	-0.32	-0.28	0.03	-0.01	0.26	-0.27
RLCP	0.57**	-0.19	0.32	.047*	0.29	-.82**	0.71**	0.55**	0.59**	0.29	0.15	-0.44*	0.42*
RLMN	0.24	-0.13	0.40	0.13	0.00	-0.56**	0.79**	0.87**	0.85**	0.30	0.46*	-0.60**	0.37
RLHM	0.19	-0.15	0.35	0.10	-0.04	-0.57**	0.74**	0.83**	0.89**	0.30	0.46*	-0.61**	0.34
TRM	-0.12	0.18	0.53*	-0.04	-0.03	0.08	0.10	0.21	0.20	0.76**	-0.02	-0.14	0.05
LBM	0.03	0.27	-0.03	0.13	-0.07	-0.14	0.44*	0.56**	0.61**	0.31	0.68**	-0.33	0.50*
GA	-0.18	0.09	-0.40	-0.07	-0.04	0.37	-0.62**	-0.67**	-0.68**	-0.26	-0.21	0.83**	-0.13
BgW	0.52*	0.26	0.24	0.46*	0.34	-0.36	0.52*	0.34	0.27	0.05	0.40	-0.17	1

* : p<0.05; **: p<0.01. AMN: Angle of mandibular notch, RLMN: Ramus length of mandibular notch, ACP: Area of coronoid process, CP-HP: Difference of ramus length between coronoid process and head of mandible, TCP: Thickness of coronoid process, RLCP: Ramus length of the coronoid process, BCP: Base of coronoid process, HCP: Height of coronoid process.

Table 5: Average values of CP parameters in the literature (mm)

					HCP		BCP		TCP		ACP		CP-HP		AMN	
Article	Tear	n	Method	Country	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Our study	2019	22	Dry Bone	Turkey	15.88	15.84	19.87	19.01	40.40	40.77	160.39	161.34	8.46	7.32	95.35°	92.99°
Kasat and Bhuiyan (18)	2016	100	Dry Bone	India	18.2	18.0	19.3	19.1								
Çorumlu* (27)	2016	1	Dry Bone	Turkey	25	20										
Aragao et al. (12)	2014	85	Dry Bone	Brazil											Men: 97.3°	
											Women: 101.2°					
Bakırcı et al. (9)	2013	97	Dry Bone	Contemporary Turkey			200		222		194	221			99.1°	94.9°
				Byzantine							101.0°	98.9°				
Chauhan and Dixit* (28)	2011	1	Dry Bone	India	24	26										
					Edentulous: 63.5											

* studies of hyperplasia

Table 6: Types of CP in the literature

					Triangle		Hook		Round		Square		Others	
Article	Year	n	Method	Country	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Our study	2019	22	Dry bone	Turkey	23	32	23	23	41	41	13	4		
Kasat et al. (18)	2016	100	Dry bone	India	23.5		54.5		18.5		0.5		3	
Quadri et al. (30)	2016	200	Dry bone	India	Men: 72.2		Men: 25.2		Men: 2.6					
					Women: 51.1		Women: 44.9		Women: 4.1					
Bakırcı et al. (9)	2013	97	Dry bone	Contemporary Turkey	20	21.4	60	64.2	20	14.28				
				Byzantine	17.9	13.6	66.6	61.4	15.4	25				
Isaac et al. (32)	2001	157	Dry bone	India	52	46	26	29	22	25				

Discussion

Mandible is one of the viscerocranium bones that have functional importance in mastication function. In previous clinical studies, it has been shown that CP is affected in TM functions (2, 4-7, 10, 11). It is also known that CP differs between genders and in clinical problems (13-15).

Mandibular cartilage provides primary ossification in the mandible, while a secondary ossification center is present in the CP (8). At the beginning of the prenatal period, the height of ramus of mandible increases more than LBM, and the rate of increase becomes equal towards the end (19). The relationship between mandible and TM begins in the prenatal period and continues in the postnatal period (2, 4, 6, 7, 10, 11). The increase in tone in TM attached to CP causes an increase in HCP and a forward bending of CP. the TM is removed in the postnatal period, the CP loses its upward and posterior slope. It has also been reported that HCP is decreased in edentulous patients (4, 6, 7).

It has been reported in the literature that chewing side preference (CSP) is associated with the dominant cerebral hemisphere (21-25). According to Diernberger (22), it prefers right side on 64%. In a study examining lateralization in bite hardness, it was reported that right side was preferred 63.6% in hard foods and 57.9% in soft foods (23). According to Lee et al. (25), although dominance is effective in side preference, it has no effect on chewing efficiency. On the other hand, there are also studies showing that CSP is not associated with the dominant hemisphere (26).

The CP data in previous studies on CP morphometry and the data obtained in our study are shown in Table 5. It is seen that HCP measurements of our study have a lower mean than hyperplasia cases (27, 28) and dry bone datas of Kasat (18). According to Torisu (7), BCP increases due to the increase in the activity of the anterior part of the TM. According to another study performed in dry mandibles, ACP was shown to be wider on the left (9). According to our study, it was observed that BCP was approximately 1 mm higher on right side (Table 1). The fact that right side CP parameters are larger than left supports existence of dominance.

Bakırcı et al. (9) observed that AMN values in dry mandibles of contemporary and Byzantine periods were close to the average of AMN values in our study. Aragao et al. (12) stated that AMN is higher in women.

In a study conducted in the Indian population, CP was bilaterally higher than CPn in 3 mandibles (18). In our study, except for 1 case, CP was bilaterally higher than CnP in 21 cases (in our study, it was shown by the CP-HP parameter). CP-HP was found higher on right side than left. However, this difference is not statistically significant (Table 1).

Kasai et al. (29) examined 31 cadavers in their study and compared RLCP with dentated and edentulous individuals. RLCP found 68 mm in toothed individuals and 63 mm in edentulous individuals. These values are higher than our data.

CP typing results are listed in Table 6 together with the studies in the literature. According to the study of Bakırcı et al., hook type has the highest percentage. In different studies conducted in India, the rate of triangle type is higher (30-32). On the contrary, in the study of Kasat and Bhuiyan (18), it is stated that the frequency of hook type is high. However, in our study, the most common type is round. Quadri et al. (30) stated that hook type is more common in women than men, but result is not sufficient because gender distribution is not equal.

Mandibular notch is also grouped in the literature. According to study of Ishwarkumar et al. (33) mandibular notch could be round, wide, curved, triangular and rectangular. Round shaped mandibular notch was recorded as the most common type with 44.2% in both genders.

TCP increase in patients with CP hyperplasia. It has also been shown that there is early contact between zygomatic arc and CP (10). It may cause trismus due to an increase in HCP or a change in CP direction (10). It has been reported that physical therapy is not beneficial in cases of CP hyperplasia, but surgical treatment is possible (17). It has been reported that early surgical treatment is beneficial in improving morphology and function (16). HCP differs between sides in pediatric patients with unilateral posterior crossbite.

According to asymmetry evaluation in individuals, CnP was not found asymmetrical, and CP was found asymmetric (14).

According to literature, GA decreases with advancing age and increases in edentulous patients (34). The morphometric parameters of the mandible have difference in individuals with low GA (35, 36). In our study, no significant relationship was found between GA and CP values.

The correlation values of right CP parameters among themselves are higher than those of left side (Table 3). While there was a strong positive correlation between TCP and TRM on right side, this relationship was not found on left side. According to the previous literature, this is thought to support right dominance in CSP (22, 23). The same parameters on different sides show strong positive correlation (Table 4).

Conclusion: Our study for CP morphometry is pioneering. However, the age and sex information of bones is unknown. It is known that morphometry of mandible varies with age. In order to determine more appropriate clinical approaches, developmental examination of CP in childhood, adolescence, adulthood and geriatric period is required. In addition, new studies in healthy individuals are needed to evaluate the effects of CSP on CP and side and sex differences.

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