

# Comparative Morphometric Study of the Hyoid Apparatus Between Brachycephalic and Non-Brachycephalic Dogs Using 3D-CT Volume Rendering

Estudio Morfométrico Comparativo del Aparato Hioideo Entre Perros Braquicéfalos y no Braquicéfalos Mediante Reconstrucción Volumétrica 3D-CT

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**SUMMARY:** The hyoid apparatus is a group of osteochondral structures located at the base of the skull that supports the root of the tongue and provides a flexible suspensory function to the larynx, stabilizing respiration, mastication, and swallowing. The aim of this study was to describe and compare the morphological and morphometrical characteristics of the normal hyoid apparatus in dogs with different skull conformations using computed tomography (CT). Records of 58 CT head dog studies were analyzed retrospectively. Several measurements (length dimensions and angles) of the hyoid bone components were obtained from three-dimensional (3D) reconstructions created from the CT images using the OsiriX software package. A significant difference was observed in the measured angles for the brachycephalic and non-brachycephalic groups ( $p < 0.05$ ), but not for the hyoid bone length dimensions. In brachycephalic skulls, the angle formed between the stylohyoid and epihyoid bone was larger, and the ceratohyoid-thyrohyoid angle was smaller than that of the non-brachycephalic groups, resulting in a short-straighter form. Evaluation of the hyoid bone on 3D CT images indicated morphometric variations in dogs with differing skull conformations.

**KEY WORDS:** Dog; CT volume rendering; Hyoid bone; Morphometric; Skull conformation.

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## INTRODUCTION

The hyoid apparatus (os hyoideum) is a group of osteochondral structures located at the base of the skull, composed of basihyoid, thyrohyoid, ceratohyoid, epihyoid, stylohyoid bones, and tympanohyoid cartilage (Evans & De Lahunta, 2013). The hyoid apparatus supports the root of the tongue and provides a flexible suspensory function to the larynx, stabilizing respiration, mastication, and swallowing (Ito *et al.*, 2012). Injuries or abnormalities of the hyoid apparatus in dogs are described after traumatic fractures or luxation, secondary to car accidents, dog bites in the ventral cervical area, strangulation by training collars or abuse, birth injury, congenital structural abnormalities such as hypoplasia or aplasia, or infiltrative neoplastic diseases (Levitt *et al.*, 1990; Kang *et al.*, 2008; Milovancev *et al.*, 2014; Gómez *et al.*, 2016; Ruth *et al.*, 2017).

Conventional radiography is a frequent imaging method used in the diagnosis of injuries of the hyoid

apparatus in dogs. However, the main disadvantage of radiography is the overlap of adjacent soft tissue structures and the consequent low-contrast resolution of the hyoid bone (Kang *et al.*, 2008). In humans, the best imaging modality for the evaluation of hyoid apparatus injuries is computed tomography (CT) (Naimo *et al.*, 2015). Computed tomography provides detailed anatomic information that is difficult to obtain with other radiographic techniques (Schwarz & Saunders, 2011). In addition, three-dimensional (3D) CT image reconstruction techniques allow for the observation of the hyoid apparatus at 360° (Aguinaga *et al.*, 2006). For reference, ultrasonography and magnetic resonance imaging methods are used for the evaluation of soft tissue structures adjacent to the hyoid apparatus, such as the muscles of the tongue, larynx cartilages, vocal folds, and thyroid gland (Aguinaga *et al.*, 2006; Penninck & d'Anjou, 2015).

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In human medicine, CT volume rendering imaging techniques have been used to describe the morphological dimensions of the hyoid apparatus, developmental changes of each bone, posttraumatic or congenital abnormalities, and postmortem sex determination (sexual dimorphism), which has been shown to be useful in forensics (Ito *et al.*, 2012; Naimo *et al.*, 2015). In veterinary medicine, 3D CT has been used to diagnose abnormalities of the hyoid apparatus and fracture/luxations of the epihyoid bone (Gómez *et al.*, 2016; de Bruyn & Hosgood, 2022).

The purpose of this study was to obtain a quantitative anatomical description with metric and a morphological analysis of the hyoid apparatus in a group of brachycephalic, mesaticephalic, and dolichocephalic dogs using 3D CT volume rendering reconstruction images.

## MATERIAL AND METHOD

A random selection of 58 head CT scan studies of dogs was obtained from the medical database of the Veterinary Hospital at Universidad Austral de Chile. The CT studies were reviewed retrospectively. The CT scan used for this study was a fourth-generation CT scanner (Picker PQ 6000; Picker International, Cleveland, OH). The inclusion criteria included adult dogs (> 1 year) with complete visualization of the hyoid apparatus and the absence of any pathologic condition, trauma or surgery at the neck area or any presence of metal artifacts that could disturb the visual quality of the CT images. All CT examinations were performed under general inhalatory anesthesia with the dog positioned in sternal recumbency with the forelimbs extended and the head extended in neutral position on the CT table.

Three-dimensional CT reconstruction images of the hyoid apparatus were created from each study using the OsiriX® software package (version 3.9.2; OsiriX Foundation, Geneva, Switzerland). The software was used for identification and measurements of the hyoid apparatus structures. Image acquisition consisted of 2 mm slices, 512 x 512 matrix using 130 kV and 50 mAs exposure factors, which were reconstructed into 2-mm slices with 2-mm intervals. Length measurements (mm) were performed along the longitudinal axis of each component (right and left bones) of the hyoid apparatus on 3D CT images. Measurements were done using a preset 3D filter displaying bone in color with a window level range of 116 - 541. Hyoid measurements included the distance between the tips of the stylohyoid, epihyoid, ceratohyoid and thyrohyoid (Fig. 1A). Basihyoid measurement included the distance between the left and right borders (Fig. 1B). Additionally, the 3D CT reconstruction images were also used for angle measurements between hyoid components and the calculation of the cephalic index. The angles formed between the various hyoid bones (stylohyoid-epihyoid, epihyoid-ceratohyoid, ceratohyoid-thyrohyoid, and basihyoid-ceratohyoid) were measured. The cephalic index was calculated as (skull width/skull length) x 100. CT images were recorded and evaluated three times by a single observer to ensure precision and reliability of the data, avoiding inter-observer variability.

The cephalic index (CI) was used to compare the hyoids from skulls of different morphologies. CIs have traditionally been sorted into three distinct skull categories: dolichocephalic, mesaticephalic and brachycephalic, based on skull shape or by simple subjective sorting (often at the breed level) (Georgevsky *et al.*, 2014). However, as the CI

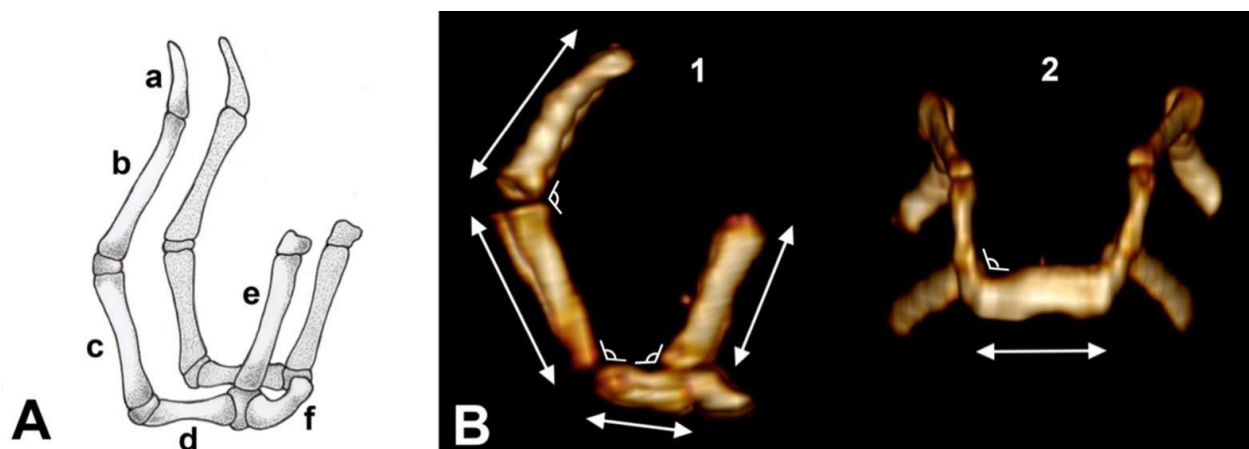


Fig. 1. (A) Diagram of canine hyoid bone (lateral view). a, Tympanohyoid; b, Stylohyoid; c, Epihyoid; d, Ceratohyoid; e, Thyrohyoid; f, Basihyoid. (B) Measurement points in the 3D CT reconstruction image of the normal canine hyoid apparatus. Lateral view (1): Double-headed arrows correspond to the length of the Stylohyoid, Epihyoid, Ceratohyoid and Thyrohyoid; (∩) Angles between the Stylohyoid-Epihyoid, Epihyoid-Ceratohyoid and Ceratohyoid-Thyrohyoid. Rostro-caudal view (2): Double-headed arrows correspond to the length of Basihyoid; (∩) Angles between Basihyoid-Ceratohyoid.

is a continuous variable with no sharply separable thresholds, its value can vary over a wide range, even within a breed (McGreevy *et al.*, 2013). We decided to carry out our analysis from two points of view.

1. According to CI, skulls were classified as brachycephalic (CI >0.80), mesaticephalic (between CI 0.80–0.55), and dolichocephalic (CI <0.55), following a traditional established classification (Cañete & Bravo, 2017). Once the skulls were classified, the lengths and angles of the hyoid bones were compared between the skull types.
2. The CI was examined as a continuous variable across all skulls using correlation analysis. To determine the correlation between CI and the length and angles of the hyoid bones.

In addition, measurements of the length of individual hyoid components were standardized before the comparative analysis. Adjustment allowed us to compare dimensions between different skull sizes. The standardized adjustment ratio was calculated with average dimensions of the hyoid bone of the right and left side/skull length x 10. A high correlation (greater than 0.9) between skull length and long bone length has been described (Alpak *et al.*, 2004), indicating that the length of the head is proportional to the body size. A high positive correlation between skull length and all the hyoid bones was observed in our study (stylohyoid R= 0.86, epihyoid R= 0.85, ceratohyoid R= 0.88, basihyoid R= 0.93, thyrohyoid R= 0.9), indicating that it is a good variable for standardized comparison.

The mean value and standard deviation for each measurement in each group were calculated. For comparisons of hyoid bones of the 3 skull types, a comparative analysis of variance (1-way ANOVA) with Tukey's multiple comparison post hoc test was performed. Pearson correlation was used to determine the correlation between CI and the length and angles of hyoid bones. All statistical data analysis was performed using RStudio®

Table I. Mean and standard deviation of the length (cm) of the hyoid apparatus components in brachycephalic (n=7), mesaticephalic (n=42) and dolichocephalic (n=9) dog skull conformations measured from 3D reconstruction CT images.

	Length (cm) hyoid bones		
	Brachycephalic n=7	Mesaticephalic n=42	Dolichocephalic n=9
Stylohyoid	1.67 ± 0.30	1.78 ± 0.48	2.22 ± 0.34
Epihyoid	1.60 ± 0.36	1.74 ± 0.59	2.07 ± 0.59
Ceratohyoid	0.82 ± 0.22	0.93 ± 0.31	1.24 ± 0.34
Basihyoid	1.70 ± 0.34	1.82 ± 0.50	2.28 ± 0.51
Thyrohyoid	1.65 ± 0.36	1.75 ± 0.51	2.27 ± 0.38

software (R Core Team (2014), Vienna, Austria). A p value <0.05 was considered statistically significant.

## RESULTS

The dogs' age range varied between 1 and 20 years. A total of 58 CT studies of the head were randomly selected. Individual IC values of dogs in the present study ranged between 48 and 108.7, with the lowest ICs for dolichocephalic and the highest ICs for brachiocephalic dogs. From these 58 dogs, three groups of dogs were arbitrarily defined based on their CI: brachycephalic (n=7), mesaticephalic (n=42) and dolichocephalic (n=9). Brachiocephalic dogs included English bulldogs (2), French bulldogs (1), Boxers (2) and Pekingese (2). Mesaticephalic dogs included Poodle (7), Pointer (1), Argentinian Dogo (1), Fox terrier (1), German shepherd (1), Schnauzer (1), Dachshund (1), Yorkshire (2), Labrador retriever (2), mixed Boxer (2) and mixed breed (22). Dolichocephalic dogs included Doberman pinscher (1), Labrador retriever (1), German shepherd (1) Golden retriever (1), Fox terrier (1), Poodle (1) and mixed breed (3). The overlapping of breeds between the mesaticephalic and dolichocephalic groups confirms that a strict cut classification associated with the cephalic index is difficult, since there are wide intrabreed variations.

Table I shows the absolute data of length measurements (cm) of hyoid bones from 58 dogs. An increase in the length of the hyoid bones from brachycephalic – mesaticephalic – dolichocephalic is observed. These values were influenced by breed, as the brachycephalic and dolichocephalic breeds include mainly small and large dogs, respectively. In addition, the heterogeneity of the sizes of the mixed dogs that were part of the 3 groups also contributed to this variation, which required that the original data be standardized to be able to compare them.

In standardized data, statistically significant differences were observed in the length of the hyoid bones with respect to the type of skull. In summary, the hyoid bones (stylohyoid, epihyoid, basihyoid, thyrohyoid) of brachycephalic dogs were larger in relation to the length of their head compared to the mesaticephalic and dolichocephalic skulls (Table II). However, no differences were observed in the ceratohyoid bone, which maintained a similar proportion regardless of the shape of the skull (brachycephalic 0.69±0.16, mesaticephalic 0.61±0.1 and dolichocephalic 0.6±0.07; p=0.179).

The evaluation of the data as continuous variables is presented in Table III. All hyoid bones

Table II. Mean and standard deviation of standardized length of the hyoid apparatus components in brachycephalic (n=7), mesaticephalic (n=42) and dolichocephalic (n=9) dog skull conformations.

	Standardized length			p
	Brachycephalic n=7	Mesaticephalic n=42	Dolichocephalic n=9	
Stylohyoid	1.41 ± 0.23 a	1.17 ± 0.24	1.09 ± 0.12 a	0.007
Epihyoid	1.34 ± 0.18 ab	1.14 ± 0.19 b	1.00 ± 0.16 a	0.002
Ceratohyoid	0.69 ± 0.16	0.61 ± 0.10	0.60 ± 0.07	0.179
Basihyoid	1.42 ± 0.15 ab	1.22 ± 0.10 bc	1.10 ± 0.12 ac	<0.001
Thyrohyoid	1.38 ± 0.16 ab	1.13 ± 0.26 b	1.11 ± 0.09 a	0.005

Table III. Relationship between the cephalic index (CI) and standardized length of hyoid bones in 58 dogs.

	Coefficient of correlation	
	R	p
Stylohyoid	0.49	< 0.001
Epihyoid	0.44	< 0.001
Ceratohyoid	0.26	0.05
Basihyoid	0.68	< 0.001
Thyrohyoid	0.30	0.020

had positive correlations between the CI and standardized length of each bone, indicating that the CI increases as the length of the hyoid bones is longer proportional to the length of the skull. Its correlations ranged from low to strong depending on the bone (Table III). Ceratohyoid and thyrohyoid bones showed low correlation (R=0.29 and R=0.3, respectively). Stylohyoid and epihyoid showed moderate correlations (R=0.49 and R=0.44, respectively). For

the basihyoid bone, a strong correlation was determined (R=0.68), indicating that in dogs with a brachycephalic-type skull (highest IC), the hyoid apparatus is wider, considering the transverse position of this bone in the hyoid apparatus.

Evaluation of the angles showed that brachycephalic dogs had a different conformation of hyoid apparatus bones compared with the non-brachycephalic groups. Specifically, they had greater angle values in the stylohyoid-epihyoid, epihyoid-ceratohyoid and basihyoid-ceratohyoid joints and lower angle values in the ceratohyoid-thyrohyoid joint (Table IV), indicating a straighter conformation of the hyoid apparatus (Fig. 2A).



Fig. 2. Rostrolateral view of a 3D CT reconstruction image of the normal hyoid apparatus of a brachycephalic skull (A) and non-brachycephalic skull conformation (B). Notice the wide angles between different hyoid bone components in brachiocephalic dogs in relation to non-brachycephalic dogs.

The analysis of angles as continuous variables (Table V) is consistent with our previous results. The correlation between CI and angles showed moderate positive correlations for stylohyoid-epihyoid (R=0.46) and epihyoid-ceratohyoid (R=0.52) and a strong positive correlation for basihyoid-ceratohyoid (R=0.73). These correlations indicate that the higher the CI, the greater the angles described for brachycephalic-type dogs. On the other hand, the ceratohyoid-thyrohyoid angle showed a moderate negative correlation, indicating that in dogs with higher CI (brachycephalic-type dogs), this angle is more closed, resulting in a shorter hyoid apparatus in the lateral view, as observed in Figure 2A.

Table IV. Mean and standard deviation of angles between the hyoid apparatus component in brachycephalic (n =7), mesaticephalic (n=42) and dolichocephalic (n=9) dog skull conformations measured from 3D reconstruction CT images.

Angle	Brachycephalic n=7			Mesaticephalic n=42			Dolichocephalic n=9			p
	Mean	SD	Significance	Mean	SD	Significance	Mean	SD	Significance	
Stylohyoid-Epihyoid	153.8	± 17.9	a	129.1	± 18.3	a	133.3	± 13.5		0.005
Epihyoid-Ceratohyoid	132.1	± 22.5	ab	101.8	± 18.1	b	91.8	± 23.9	a	<0.001
Ceratohyoid-Thyrohyoid	84.9	± 27.4	ab	129.0	± 17.2	a	127.1	± 24.7	b	<0.001
Basihyoid-Ceratohyoid	119.5	± 19.3	ab	91.7	± 10.5	a	87.6	± 6.9	b	<0.001

Structural abnormalities in the hyoid apparatus were detected in 27.58 % of the animals (16/58). Abnormalities included asymmetry, irregular shape, fusion between hyoid bones, and fracture or absence of hyoid bones (Fig. 3). Structural abnormalities were described in 57.14 % (4/7) of cases in the brachycephalic group, with 28.57 % (2/7) corresponding to size asymmetry, 28.57 % (2/7) to irregular shape and 14.28 % (1/7) to fracture of one bone. Abnormalities were observed in 26.19 % (11/42) of mesaticephalic dogs, with 9.52 % (4/42) corresponding to bone fusion, 9.52 % (4/42) corresponding to size asymmetry, 4.76 % (2/42) to irregular shape, 2.38 % (1/42) to absence of some bones and 4.76 % (2/42) to fracture. Finally, 11.11 % (1/9) of cases with abnormalities were observed in the dolichocephalic group, which corresponded to size asymmetry of one bone.



Fig. 3. Lateral view of 3D CT reconstruction images of mesaticephalic hyoid apparatus with abnormal anatomic conformation. (A) White arrow indicates the presence of an additional ossification connecting the left epihyoid and thyrohyoid bones. (B) White arrow indicates fusion between the stylohyoid and epihyoid bones.

Table V. Relationship between cephalic index (CI) and angles of hyoid bones.

	Coefficient of correlation	
	R	P
Stylohyoid-Epihyoid	0.46	<0.001
Epihyoid-Ceratohyoid	0.52	<0.001
Ceratohyoid-Thyrohyoid	-0.58	<0.001
Basihyoid-Ceratohyoid	0.73	<0.001

## DISCUSSION

This study described the morphological features and morphometric dimensions of the hyoid apparatus in a group of brachycephalic, mesaticephalic, and dolichocephalic dogs using 3D CT reconstruction images. Although the morphological characteristics for these 3 types of skulls are widely recognized, it is not possible to establish clear limits between each of them, so comparisons between groups will only allow general approximations. Therefore, data analysis as continuous variables was added in this study, as has been established in several related studies (Hussein *et al.*, 2012; McGreevy *et al.*, 2013; Bognár *et al.*, 2021).

Plotsky *et al.* (2016) measured the length of the bones of the hyoid apparatus from 74 Portuguese water dog cadavers and showed greater values compared to brachycephalic and mesaticephalic dogs of the present study. In the dolichocephalic group, the values of the hyoid bones were similar, which could be mainly associated with the larger body size of the dolichocephalic group, similar to the body size of the Portuguese Water Dog (Plotsky *et al.*, 2016). However, both studies are not fully comparable due to the high variability of the physical attributes of the dog breeds included in our study and the technique used for measuring. Plotsky *et al.* (2016) obtained measurements directly from

cadavers compared to an indirect measurement technique utilizing 3D CT volume rendering reconstruction images in the present manuscript. Another factor that may affect the accuracy of measurements in CT morphometric studies is the selected soft tissue window level (Nieman *et al.*, 2003) since the cartilage between the components of the hyoid apparatus could alter the long axis measurement of each hyoid bone. However, measurements of hyoid bones using 3D CT imaging are simple, have high resolution and can be used effectively in medical studies (Ito *et al.*, 2012). Previous studies demonstrated the precision and accuracy of 3D-CT surface rendered images of different craniometric anatomical measurements in humans (Cavalcanti *et al.*, 2004).

Comparatively, in the mesaticephalic and dolichocephalic groups, a more similar hyoid apparatus conformation was observed, with smaller angles between the stylohyoid-epihyoid, epihyoid-ceratohyoid and ceratohyoid-thyrohyoid bones in comparison with the brachycephalic group (Fig. 2). In addition, the brachycephalic skulls in the present study showed that the ceratohyoid-thyroid angle was smaller than that of the non-brachycephalic groups, resulting overall in a shorter hyoid bone (anteroposteriorly) and straighter form. Similarly, a

recent CT study described morphological differences in the hyoid apparatus in French Bulldogs and mesaticephalic dogs (de Bruyn & Hosgood, 2022). French Bulldogs had a more curved and thickened basihyoid bone than mesaticephalic dogs (de Bruyn & Hosgood, 2022). No other studies regarding the angles of the hyoid apparatus in dogs are present in the literature. However, Ito *et al.* (2012) described a complete morphological study of the human hyoid apparatus using 3D CT reconstruction images. They measured the angle between the basihyoid and thyrohyoid bones, as they are the ossified components of the human hyoid apparatus. The study revealed significantly higher angles in females (Ito *et al.*, 2012).

The standardized length of the bones showed a statistically significant pattern for all the bones of the hyoid apparatus (except the ceratohyoid). Longer bones for the brachycephalic group compared to the non-brachiocephalic group were proportional to the length of the animal's head. It was associated with positive correlations between the length of the bones and the CI, mainly highlighted for the basihyoid bone, which indicates that the brachiocephalic group has a slightly larger and wider hyoid apparatus than the other types of the skull. In contrast, the ceratohyoid bone was characterized as a bone that did not vary in length among the three groups.

Hyoid apparatus abnormalities were observed in 27.58 % of the analyzed CT images (57.14 % brachicephalic, 26.9 % mesaticephalic and 11.11 % dolicocephalic). These abnormalities included asymmetry, fracture, irregular shape and fusion or absence of hyoid bones. Interestingly, a high percentage of abnormalities was observed, proportionally higher for brachycephalic dogs, which is expected since brachycephalic dogs are characterized by alterations at the level of the upper airways; however, the other cranial conformations of dogs also presented developmental abnormalities. Therefore, findings of this type of abnormality without association with signs could be considered fortuitous and within the normal range of morphology. A case report described congenital abnormalities in a 7-month-old male French Bulldog including fused stylohyoid and epihyoid bones, absence of the ceratohyoid bone and an acutely curved and thickened basihyoid bone (de Bruyn & Hosgood, 2022). Bilateral structural abnormalities of the hyoid apparatus and right aplasia have been previously diagnosed using 3D reconstruction in a 5-year-old female Miniature Poodle (Kang *et al.*, 2008). A retrospective CT study of 293 dogs and 100 cats identified incidental findings of hyoid fractures or luxation in 3.1 % of dogs but not in cats, and congenital abnormalities were not reported (Ruth *et al.*, 2017). In our study regarding fracture findings, a slightly higher percentage was identified 5.17 % (3/58). Naimo *et al.* (2015) described

age-related changes in the human hyoid apparatus, which included abnormalities such as unilateral fusion of synchondrosis, asymmetric shape, absence of lesser cornua, and anomalous connection between greater cornua and the lamina of the thyroid cartilage. Bilateral and unilateral absence of the cornua was reported in 1,5 % and 7 % of the individuals, respectively (Naimo *et al.*, 2015).

Brachycephalic dogs typically have anatomical characteristics that predispose them to brachycephalic obstructive airway syndrome (BOAS), such as a short-wide head, short snouts, thick surrounding soft tissues in the neck, elongated soft palate, everted lateral saccules of the larynx, narrowed rima glottidis, bigger tongue size than oral cavity, less mobility of the tongue, and collapse of the larynx and trachea (Kraimer & Dupré, 2022). The form of the hyoid apparatus could possibly contribute to BOAS, ventrally displacing the larynx, thereby constraining the nasal and pharyngeal spaces by tongue crowding. This structural conformation would naturally exert pressure on the hyoid apparatus to maintain effective breathing, eating, swallowing, and vocalizing, resulting in the modification of the length of the constituents of the hyoid apparatus (Plotsky *et al.*, 2016).

Other carnivore species, such as cats, have similar hyoid apparatus morphology compared to dogs. However, some of the big large cats (lion, tiger, jaguar, leopard and snow leopard) have an epihyoid component that is an elastic ligament (Weissengruber *et al.*, 2002). Differences in the epihyoid component are correlated with differences in vocal repertoires: cats with an elastic epihyoid are able to roar but not purr, while species with a completely ossified hyoid are able to purr but not roar (Weissengruber *et al.*, 2002). In the present study, all the structures of the hyoid apparatus were completely ossified. However, the straight hyoid apparatus conformation may contribute to the particular vocalization of brachycephalic dogs.

Radiography is the primary and most available imaging technique used to observe bony structures in human and veterinary medicine (Grant & Griffin, 2019). Radiography is usually the first imaging technique employed to evaluate traumatic hyoid lesions (fracture or luxation) in small animals (Levitt *et al.*, 1990). However, hyoid abnormalities cannot always be completely assessed by radiography. The use of CT images in small animals has allowed the diagnosis of specific congenital, structural, or traumatic lesions of the hyoid apparatus, as well as neoplastic diseases (Kang *et al.*, 2008). In the present study, hyoid apparatus abnormalities, such as the presence of an extra bone between the epihyoid and thyrohyoid bones, could be a congenital abnormality or associated with structural changes due to aging.

In human hyoid studies, CT imaging techniques are used to describe gender differences, age-related changes and to analyze the cause of lesions, which is important in forensic medicine (Ito *et al.*, 2012; Naimo *et al.*, 2015). Two-dimensional imaging of the hyoid apparatus does not allow adequate measurement of width, angle of inclination, volume or assessment of degree of ossification (Cotter *et al.*, 2015). In the present report, CT studies stored in the database of our Veterinary Hospital were randomly analyzed. Classification by gender, age or specific breed was difficult. However, differences by skull conformation were observed.

Limitations of the present report include the retrospective nature of the study, initial CT evaluation obtained with slightly different protocols, bias associated with evaluation for a single observer, small sample size and not including all the skull conformation breeds. Despite these limitations, 3D CT examinations allow us to adequately assess the measurements and morphology of the hyoid apparatus. Further studies are needed to evaluate other breeds (not included in the present study) and sex differences.

## CONCLUSIONS

In conclusion, brachycephalic dogs had a different anatomic conformation of the hyoid apparatus compared to mesaticephalic and dolichocephalic dogs. These findings suggest that morphological and morphometric variations should be included in brachiocephalic morphological features. Additionally, 3D CT provides adequate visualization of all components of the hyoid apparatus and is useful in the diagnosis of structural lesions. The results obtained in this study may serve as a reference for future hyoid research in dogs.

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**KANI, Y.; GÓMEZ, M.; MIERES, M.; PÉREZ, B. & GUTIÉRREZ, J. C.** Estudio morfométrico comparativo del aparato hioides entre perros braquicefalos y no braquicefalos mediante reconstrucción volumétrica 3D por TC. *Int. J. Morphol.*, 44(2):443-450, 2026.

**RESUMEN:** El aparato hioides es un grupo de estructuras osteocondrales ubicadas en la base del cráneo que sostiene la raíz de la lengua y proporciona una función suspensoria flexible a la laringe, estabilizando la respiración, la masticación y la deglución. El objetivo de este estudio fue describir y comparar las características morfológicas y morfométricas del aparato hioides normal en perros con diferentes conformaciones craneales mediante

tomografía computarizada (TC). Se analizaron retrospectivamente los registros de 58 estudios de TC craneal en perros. Se obtuvieron diversas mediciones (longitud y ángulo) de los componentes del hueso hioides a partir de reconstrucciones tridimensionales (3D) creadas a partir de imágenes de tomografía computarizada (TC) utilizando el software OsiriX. Se observó una diferencia significativa en los ángulos medidos entre los grupos braquicefálico y no braquicefálico ( $p < 0,05$ ), pero no en las dimensiones de longitud del hueso hioides. En los cráneos braquicefálicos, el ángulo formado entre el estilohioideo y el epihioideo era mayor, y el ángulo ceratohioideo-tirohioideo era menor que en los grupos no braquicefálicos, lo que resulta en una forma más corta y recta. La evaluación del hueso hioides en imágenes de TC 3D indicó variaciones morfométricas en perros con diferentes conformaciones craneales.

**PALABRAS CLAVE:** Perro; Reconstrucción volumétrica por TC; Hueso hioides; Morfometría; Conformación craneal.

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