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RESEARCH ARTICLE

Ultrasonographic Assessment of Optic Nerve and Optic Nerve Sheath Diameters with Ocular Biometry in Brachycephalic versus Non-Brachycephalic Cats

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Abstract

Distinct craniofacial morphology in brachycephalic cats may alter ocular anatomy and predispose these breeds to specific ophthalmic conditions. This study evaluated the relationship between craniofacial conformation and optic nerve diameter (OND), optic nerve sheath diameter (ONSD), and ocular biometric parameters using high-resolution ultrasonography. Twenty-six clinically healthy cats were enrolled and categorized into brachycephalic and non-brachycephalic groups (n=13 per group). Comprehensive ophthalmic examinations, tonometry, and standardized ultrasonographic measurements -including axial globe length (AGL), lens thickness (LT), and vitreous chamber depth (VCD)- were performed. Although no statistically significant differences were detected between groups, several morphological tendencies emerged. Brachycephalic cats demonstrated shorter AGL and horizontal lens diameter, alongside increased anterior chamber depth and LT. Conversely, VCD appeared reduced in brachycephalic cats, potentially reflecting a more compact intraocular configuration associated with their craniofacial structure. By generating standardized ultrasonographic measurements, this study contributes to the establishment of morphology-specific reference intervals for OND and ONSD. Given the current scarcity of feline-specific normative data, these findings provide an essential preliminary framework to assist clinical diagnostics and neurological assessments in feline ophthalmology.

Keywords: Anatomic variations, Diagnostic imaging, Feline eye, Morphometry, Ocular ultrasound

Introduction

In brachycephalic cats, pronounced shortening of the skull, face, and craniofacial skeleton results in the characteristic rounded head conformation. This morphology is considered a breed-specific trait [1]. Beyond external appearance, craniofacial structure is associated with distinct anatomical alterations that may increase susceptibility to various breed-related diseases and disorders. In particular, brachycephalic breeds have been shown to be more predisposed to ocular diseases. With the growing popularity of brachycephalic cat breeds in recent years, these breed-associated ocular and respiratory conditions have gained increasing importance and warrant closer diagnostic evaluation [2-5].

Ocular ultrasonography is a fundamental, safe, and non-invasive imaging modality for the evaluation of intraocular and retrobulbar structures. This technique is indicated in a wide range of conditions, including ocular trauma, measurement of axial globe length, detection of intraocular foreign bodies, intraocular hemorrhage, lens luxation, and retinal detachment. In addition, ultrasonography provides substantial diagnostic value in cases where clinical examination of the anterior or posterior segment is limited due to opacification of the ocular media [6,7].

Another important application of ultrasonography in ophthalmology is ocular biometry. Ocular biometry is the measurement of the dimensions of the globe and its components, and measurement of axial globe length is of critical importance in the evaluation of conditions such as glaucoma, microphthalmia, macrophthalmia, phthisis bulbi, and persistent hyperplastic primary vitreous. However, information regarding normal ocular dimensions and interbreed variation in these measurements among different feline and canine breeds remains limited [8].

Among the structures of interest evaluated by ultrasonography are the optic nerve and its surrounding sheath. Measurements of optic nerve diameter [9] and optic nerve sheath diameter (ONSD) [10] have gained increasing importance in the assessment of various clinical and physiological responses, particularly in the identification of pathological processes such as intracranial hypertension. In recent years, there has been a marked increase in studies focusing on the use of non-invasive ocular ultrasonography, especially ONSD measurements, for the diagnosis and monitoring of ocular diseases in veterinary medicine [6].

This study utilized high-resolution ultrasonography to investigate the relationship between craniofacial morphology and optic nerve and optic nerve sheath diameters, as well as key ocular biometric parameters, in brachycephalic and non-brachycephalic cats. The resulting data provide objective measurements that may contribute to the current literature and support future clinical evaluations.

Material and Methods

Ethical Statement

This study was reviewed by the Ankara University Local Ethics Committee for Animal Experiments (Decision date: 18.02.2026; Decision number: 2026-04-44). The Committee determined that the study did not require formal ethical approval. Informed consent for the clinical procedures had been obtained from the animal owners at the time of presentation.

Animals and Study Design

This retrospective cohort study included 26 cats of diverse breeds, ages, and sexes presented to the Ankara University Faculty of Veterinary Medicine Animal Hospital between April 2025 and March 2026. The study population was divided into two cohorts according to craniofacial morphology: brachycephalic (n=13) and non-brachycephalic (n=13). All brachycephalic cats meeting the inclusion criteria during the study period were enrolled. An equal number of eligible non-brachycephalic cats was selected to obtain comparable group sizes.

All cats underwent a comprehensive bilateral ophthalmic examination; however, only one eye per subject was included in the data analysis to avoid statistical bias related to inter-eye correlation. The standardized ophthalmic protocol integrated direct ophthalmoscopy, slit-lamp biomicroscopy, rebound tonometry, and transcorneal ultrasonography. To ensure procedural consistency and minimize inter-observer variability, all evaluations were performed by the same two veterinary clinicians.

The intraocular structures and fundus were assessed via direct ophthalmoscopy, while the cornea, anterior chamber, and limbal regions were evaluated using slit-lamp biomicroscopy. Intraocular pressure (IOP) was quantified using a rebound tonometer (iCare® TONOVET, Finland). To prevent iatrogenic elevations in IOP, particular emphasis was placed on minimizing patient stress and avoiding any jugular compression or excessive eyelid manipulation prior to and during measurements.

For tonometric assessment, the probe was positioned perpendicular to the central cornea at a distance of approximately 4-6 mm. The tonometer automatically calculated intraocular pressure based on the rebound velocity of a single-use probe following corneal contact. Three consecutive measurements were obtained, and the mean value was recorded. During measurements, care was taken to avoid manual pressure on the globe, and the eyelids were held open with minimal contact.

Ultrasonographic Assessment of Ocular Biometry

Ocular ultrasonography was performed using an ultrasound system equipped with a high-frequency hockey-stick transducer operating at 8–18 MHz (GE Logiq S8, GE Healthcare). A topical anesthetic eye drop containing proparacaine hydrochloride (Alcaine® 0.5%, Alcon, Türkiye) was instilled into the eye a few minutes prior to the procedure. The animals were gently restrained in sternal recumbency, and a sterile, water-based ultrasound gel was applied to the probe surface. The transducer was positioned transcorneally along the visual axis to obtain standardized sagittal images *(Fig. 1)*.

Fig 1. Ocular ultrasonographic examination of a cat. The animal was restrained in sternal recumbency, and the 18 MHz linear transducer was positioned transcorneally along the visual axis using sterile water-based coupling gel to obtain standardized sagittal images

Following the acquisition of high-quality images, ocular biometric measurements were obtained based on predefined anatomical reference points. The parameters assessed included axial globe length (AGL), defined as the distance from the anterior corneal surface to the retinal layer, and horizontal lens diameter (HLD), measured as the maximal equatorial diameter of the lens along the horizontal plane. Anterior chamber depth (ACD) was determined as the distance between the posterior corneal surface and the anterior lens capsule, while lens thickness (LT) was defined as the distance between the anterior and posterior lens capsules along the visual axis. Furthermore, vitreous chamber depth (VCD) was measured as the distance from the posterior lens capsule to the retinal surface. All measurements were performed in a standardized and reproducible manner with reference to these established anatomical landmarks [11,12] *(Fig. 2)*.

Additionally, the optic nerve diameter (OND) and optic nerve sheath diameter (ONSD) were measured immediately posterior to the globe at the point where the nerve emerges from the sclera.

Ultrasonographic Assessment of Optic Nerve and Optic Nerve Sheath Diameters

Ultrasonographic evaluation of the optic nerve was performed using B-mode ultrasonography with a linear transducer operating at a frequency of 6-13 MHz. To clearly visualize the entry of the optic nerve into the globe, the transducer was rotated approximately 15° in a clockwise direction. The probe was then adjusted in dorsal and ventral directions until optimal visualization of the optic nerve was achieved. During image acquisition, the hyperechoic posterior lens capsule was used as an anatomical reference point. From the caudal aspect of the posterior lens capsule, imaging was extended over the retina toward the optic disc. Optic nerve diameter was determined by measuring the distance between the two hypoechoic outer borders of the nerve [12].

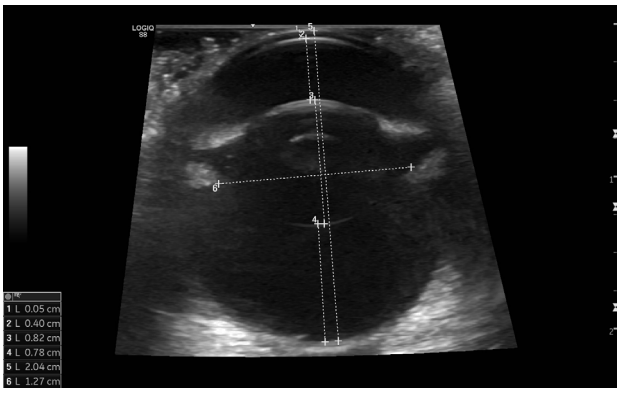

Fig 2. Ultrasonographic image of the feline eye illustrating ocular biometric measurements based on predefined anatomical landmarks. The numbered markers correspond to specific structures measured on the image as follows: 1, corneal thickness (CT); 2, anterior chamber depth (ACD); 3, lens thickness (LT); 4, vitreous chamber depth (VCD); 5, axial globe length (AGL); and 6, horizontal lens diameter (HLD). Axial globe length (AGL), anterior chamber depth (ACD), lens thickness (LT), horizontal lens diameter (HLD), and vitreous chamber depth (VCD) are indicated

Color Doppler ultrasonography was employed to differentiate the optic nerve from surrounding tissues and vascular structures. During ultrasonographic assessment, a transverse projection was used to identify the angle at which the optic nerve sheath was most clearly visualized. The images obtained at this optimal projection were recorded, and measurements were subsequently performed on the sections in which the nerve appeared at its maximum width.

All ultrasonographic recordings were standardized in the transverse plane at a gain setting of 60 dB. A generous amount of ultrasound gel was applied to the transducer, which was then gently placed on the superior aspect of the globe using a contact corneal technique. Transverse sections of the globe were sequentially scanned by fanning and sliding the transducer until the orbit and optic nerve were clearly visualized. The image in which the optic nerve appeared most clearly and at its maximum width was frozen, and diametric measurements were obtained. The same procedure was subsequently repeated for the contralateral eye. Video recordings of each examination were saved and archived for further evaluation.

All ocular ultrasonographic videos were independently reviewed by two investigators. The optic nerve was identified as a slightly curved hypoechoic band located caudal to the globe, whereas the optic nerve sheath (ONS) was defined as the hyperechoic bands flanking the optic nerve on either side. The outer boundaries of the hyperechoic bands farthest from the optic nerve were used as reference points for measuring the optic nerve sheath diameter (ONSD), which was assessed 3 mm caudal to the optic disc with the measurement line oriented perpendicular to the longitudinal axis of the optic nerve [13] *(Fig. 3)*. This 3-mm distance was determined by drawing a straight line parallel to the longitudinal axis of the optic nerve in the caudal direction from the optic disc. Upon completion of the ultrasonographic assessments, the eyes were gently irrigated with sterile saline solution.

Statistical Analysis

Descriptive statistics were calculated for all variables. Categorical variables were presented as frequencies (n) and percentages (%), while continuous variables were expressed as mean ± standard deviation (SD), median, and interquartile range (Q1-Q3), as appropriate. The normality of continuous variables was assessed using the Shapiro-Wilk test. Comparisons between brachycephalic and non-brachycephalic groups were performed using the independent samples t-test for

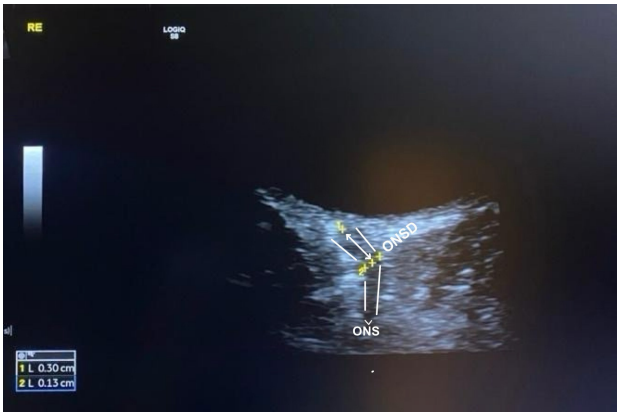

Fig 3. Ultrasonographic image of the feline optic nerve illustrating the measurement of optic nerve sheath diameter (ONSD). The optic nerve appears as a hypoechoic band, flanked by hyperechoic borders representing the optic nerve sheath (ONS). ONSD was measured 3 mm caudal to the optic disc, using the outer margins of the hyperechoic sheath as reference points, with the measurement line oriented perpendicular to the longitudinal axis of the optic nerve. Labels indicating ONS and ONSD are shown on the image

normally distributed variables and the Mann-Whitney U test for non-normally distributed variables. A criterion of $P<0.05$ was used for all statistical comparisons. All statistical analyses were conducted using SPSS 30.0 software package.

Results

The cats were classified into two groups according to craniofacial morphology: brachycephalic (n=13) and non-brachycephalic (n=13). Overall, 13 cats (50.0%) were mixed-breed, while the remaining cats comprised British Shorthair (34.62%, n=9), Scottish Fold (11.54%, n=3), and Chinchilla (3.85%, n=1). The brachycephalic group consisted of British Shorthair, Scottish Fold, and Chinchilla cats, whereas the non-brachycephalic group comprised exclusively mixed-breed cats.

Regarding sex distribution, male cats were predominant in the overall study population 76.92% (n=20), while females represented 23.08% (n=6). Evaluation based on neutering status showed that 61.54% (n=16) of the cats were neutered, and 38.46% (n=10) were intact. This distribution was similar in both craniofacial morphology groups.

The mean age was 2.58±2.77 years in the brachycephalic group and 4.49±4.51 years in the non-brachycephalic group, with no significant difference between the groups (P=0.147). Statistical analysis revealed no significant correlations between age and any of the evaluated ocular biometric parameters (P>0.05). Specifically, neither the optic nerve diameter (OND) nor the optic nerve sheath diameter (ONSD) demonstrated age-dependent variations. A marginal positive trend was observed only between age and vitreous chamber depth (VCD) (P=0.061)

In terms of the eyes examined, the left eyes accounted for 53.85% (n=14) and the right eyes for 46.15% (n=12). The distribution of the eye side did not differ significantly between the brachycephalic and non-brachycephalic groups. The mean intraocular pressure (IOP) was 21.46±4.54 mmHg in brachycephalic cats and 23.23±3.19 mmHg in non-brachycephalic cats. Although the brachycephalic group exhibited numerically lower mean IOP values, no statistically significant difference was observed between the two craniofacial morphologies (P>0.05).

Ocular Biometric Findings

The ultrasonographic evaluation of ocular biometry revealed distinct morphological trends between skull types, although none of the measured parameters demonstrated statistically significant differences (P>0.05). Axial globe length (AGL) was numerically shorter in brachycephalic cats (18.89±2.33 mm) compared with non-brachycephalic cats (19.45±0.98 mm). Similarly, brachycephalic group showed slightly reduced vitreous chamber depth (VCD) (7.85±0.66 mm) and horizontal lens diameter (HLD) (11.13±1.21 mm) relative to the non-brachycephalic group (8.22±0.86 mm and 11.39±0.95 mm, respectively).

In contrast, the anterior chamber depth (ACD) and lens thickness (LT) were found to be marginally higher in the brachycephalic group. The mean ACD was 3.60±0.60 mm in brachycephalic cats versus 3.32±0.43 mm in non-brachycephalic cats, while the LT followed a similar trend with 7.95±0.75 mm and 7.75±0.83 mm, respectively. Detailed biometric results and statistical comparisons are summarized in *Table 1* and *Fig. 4*.

Optic Nerve and Optic Nerve Sheath Findings

Ultrasonographically, the optic nerve was identified as a slender, slightly curved hypoechoic structure posterior to the globe, surrounded by retrobulbar adipose tissue and musculature *(Fig. 5)*. The assessment of the optic nerve diameter (OND) revealed a notable trend toward higher values in brachycephalic cats (1.65±0.38 mm) compared to non-brachycephalic cats (1.43±0.12 mm), approaching but not reaching statistical significance (P=0.080).

The mean optic nerve sheath diameter (ONSD) was 2.99±0.51 mm (median: 3.00 mm; range: 2.60-3.30) in the brachycephalic group and 2.92±0.47 mm (median: 2.70 mm; range: 2.70-3.20) in the non-brachycephalic group. No statistically significant difference was detected in ONSD values between the two craniofacial morphologies (P=0.752).

Table 1. Comparison of ocular biometric parameters between brachycephalic and non-brachycephalic cats

Ocular Parameter (mm)	Brachycephalic Group		Non-brachycephalic Group		P
	Mean ± SD	Median (Q1-Q3)	Mean ± SD	Median (Q1-Q3)	
AGL	18.89±2.33	19.20 (19.00-19.90)	19.45±0.98	19.70 (19.50-20.00)	0.396
HLD	11.13±1.21	11.40 (10.50-11.70)	11.39±0.95	11.30 (10.70-12.00)	0.557
ACD	3.60±0.60	3.50 (3.20-4.10)	3.32±0.43	3.40 (2.90-3.60)	0.188
LT	7.95±0.75	8.10 (7.40-8.50)	7.75±0.83	7.70 (7.30-8.20)	0.526
VCD	7.85±0.66	7.80 (7.50-8.30)	8.22±0.86	8.10 (7.50-8.70)	0.222
ONSD	2.99±0.51	3.00 (2.60-3.30)	2.92±0.47	2.70 (2.70-3.20)	0.752
OND	1.65±0.38	1.60 (1.40-1.70)	1.43±0.12	1.50 (1.30-1.50)	0.080

OND, optic nerve diameter; ONSD, optic nerve sheath diameter; SD, standard deviation; AGL, axial globe length; HLD, horizontal lens diameter; ACD, anterior chamber depth; LT, lens thickness; VCD, vitreous chamber depth. A criterion of P<0.05 was used for all statistical comparisons. Data analysis was conducted using SPSS 30 software package

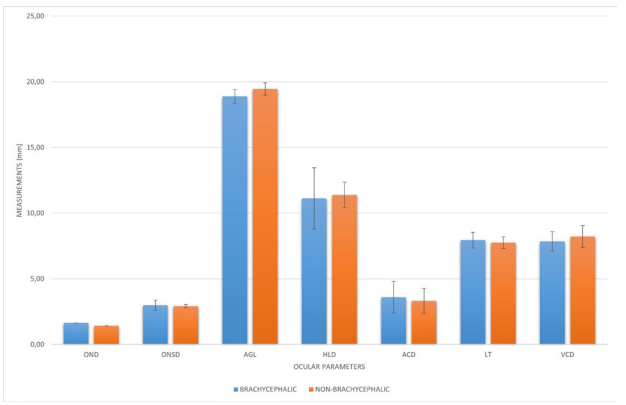

Fig 4. Comparison of ocular biometric parameters between brachycephalic and non-brachycephalic cats. Bars represent mean values, and error bars indicate the standard deviation (SD). OND, optic nerve diameter; ONSD, optic nerve sheath diameter; AGL, axial globe length; HLD, horizontal lens diameter; ACD, anterior chamber depth; LT, lens thickness; VCD, vitreous chamber depth. All measurements are expressed in millimeters. No statistically significant differences were observed between the two groups for any parameter (P>0.05)

Discussion

In feline medicine, biometric evaluation enables quantitative assessment of both anterior and posterior segment structures along the axial globe length. While both A-mode and B-mode ultrasonography are conventionally used to measure parameters such as corneal thickness, anterior chamber depth, lens thickness, equatorial lens diameter, vitreous chamber depth, and total axial length, B-mode remains the preferred modality for evaluating the posterior segment, including the retina-choroid-sclera complex [14].

Ultrasonographic studies have reported a positive association between eyeball length and age in cats, particularly during early developmental stages [11]. In the present study, no significant relationship was observed between age and the evaluated biometric parameters (P>0.05). This finding may be related to the predominance of adult cats in the study population, in which ocular

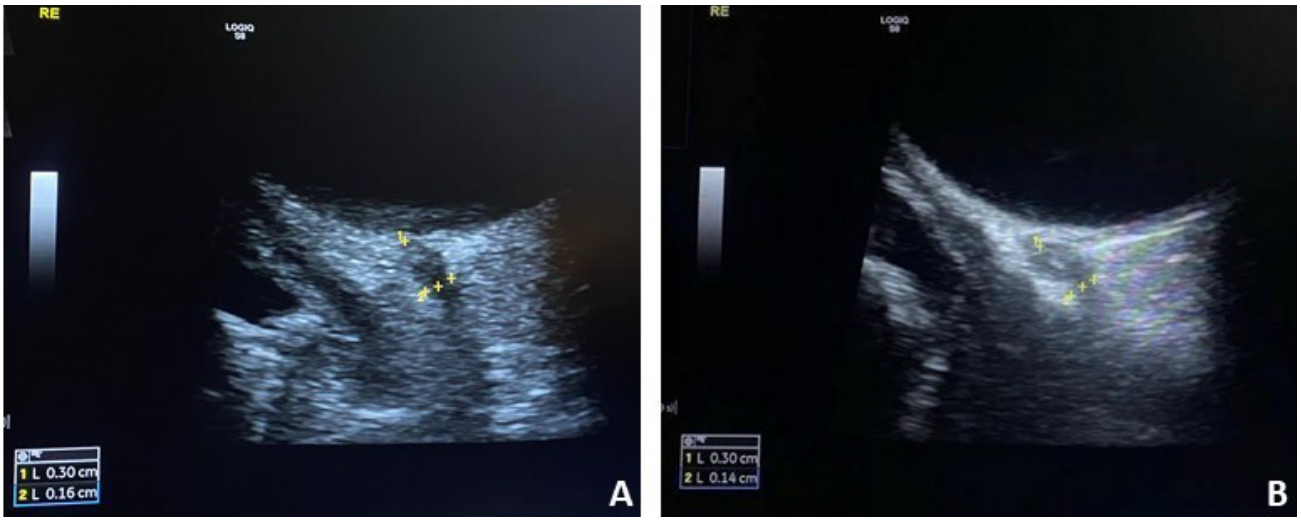

Fig 5. Representative B-mode ultrasonographic images of the optic nerve and optic nerve sheath in a brachycephalic **(A)** and a non-brachycephalic **(B)** cat. **(A)** A 3-year-old male British Shorthair, **(B)** a 4-year-old male mixed-breed cat. The optic nerve appears as a slender, slightly curved hypoechoic structure posterior to the globe, surrounded by retrobulbar adipose tissue and musculature. Calipers (+) indicate the site of optic nerve sheath diameter measurement

growth is likely already complete. Therefore, age-related biometric variation may have been less evident in this cohort. Overall, these results suggest that the observed differences in ocular biometry are more likely associated with craniofacial morphology rather than age-dependent physiological growth.

Ultrasonographic ocular biometric measurements play a crucial role in identifying anatomical differences across breeds. Previous studies have demonstrated a positive association between cranial dimensions and globe size, and have also highlighted the role of head type in shaping ocular morphology [7,11]. In particular, brachycephalic cats tend to exhibit wider globes than non-brachycephalic individuals [11]. Collectively, these findings suggest that variations in cranial morphology, body conformation, and ocular biometry may occur even within the same breed, underscoring the need for breed- and head-type–specific biometric evaluations and reference intervals to improve the early and accurate diagnosis of ocular diseases.

In the present study, although differences in ocular biometric parameters did not reach statistical significance, distinct morphological trends were observed between head types. Specifically, horizontal lens length tended to be lower in brachycephalic cats, whereas anterior chamber depth and lens thickness appeared higher, accompanied by a reduced vitreous chamber depth. These findings suggest that cranial conformation may be associated with globe morphology and the spatial arrangement of intraocular structures, although this interpretation should be considered in the context of the study's limitations. These findings suggest a relatively more compact orbital and intraocular configuration in brachycephalic cats.

Axial globe length and vitreous chamber depth were lower in brachycephalic cats than in non-brachycephalic cats, although these differences did not reach statistical significance. This trend may be related to the shallow orbital conformation characteristic of brachycephalic phenotypes, potentially affecting globe configuration along the sagittal axis. Previous studies across brachycephalic species have reported associations between craniofacial conformation, reduced orbital space, and alterations in posterior segment biometry, supporting the concept that head morphology plays a key role in shaping ocular dimensions [11,15,16]. These findings suggest that morphology-related anatomical variation may contribute to the biometric pattern observed in our cohort, although they should be interpreted within the context of the study's limitations.

Studies in dogs have demonstrated that head morphology, particularly in brachycephalic individuals, may affect the angle of the optic nerve within the orbit and the tension of the optic nerve sheath, with these anatomical variations representing important determinants of optic nerve sheath diameter (ONSD) measurements [10,13]. In contrast, data on the relationship between brachycephaly and optic nerve anatomy or ONSD in cats remain limited.

In the present study, optic nerve diameter (OND) tended to be higher in brachycephalic cats, whereas no statistically significant difference in ONSD was detected between the groups. Although brachycephalic cranial conformation could theoretically increase ONSD by reducing orbital volume and confining the optic nerve within a more restricted space, our findings do not support a clear effect in this regard. This may indicate that ONSD is maintained within relatively stable physiological limits despite variations in head morphology, or that ultrasonographic assessment may lack the sensitivity to detect subtle structural differences. Consequently, the extent to which ONSD reflects craniofacial conformation in brachycephalic cats warrants further investigation using larger cohorts and advanced imaging modalities.

The sigmoid structure of the optic nerve in dogs and cats, together with the plexiform arrangement of cilioretinal arteries, renders the optic nerve head anatomically heterogeneous [17]. In cats, retinal veins do not converge centrally within the optic nerve head but instead course parallel to the arteries and exit laterally, further complicating the clear delineation of optic disc boundaries. These species-specific anatomical features may affect ultrasonographic OND and ONSD measurements by limiting the identification of consistent anatomical landmarks [10]. Therefore, the absence of a measurable ONSD difference associated with head morphology in brachycephalic cats may reflect both true morphological similarity and the limited sensitivity of ultrasonographic assessment in detecting subtle structural variations.

As this was a retrospective study, the sample size was determined by the number of eligible cases identified during the study period, which limited the number of animals available for inclusion. As a result, an a priori power analysis could not be performed, and the study may have been underpowered to detect small differences between groups. In addition, the single-center design and the unequal distribution of breeds and sexes should be taken into account when interpreting the generalizability of the results. It is also worth noting that the brachycephalic group consisted mainly of British Shorthair and Scottish Fold cats. Although both breeds are generally classified as brachycephalic in the veterinary literature, their craniofacial conformation is less pronounced than that of some other brachycephalic breeds. Therefore, further studies including cats with more marked brachycephalic features would be useful to better assess the generalizability of the present findings.

In conclusion, the ocular biometric measurements obtained in this study addresses an existing gap in the literature regarding the ultrasonographic characterization of the optic nerve and nerve sheath diameter in cats. The concentration of existing research primarily on dogs and large animal species has left species-specific normative data for cats relatively limited. The data derived from our study contribute to a better understanding of optic nerve morphology in brachycephalic cats, aiming to enhance the accuracy of diagnostic interpretations in critical clinical evaluations such as intracranial hypertension. These standardized ultrasonographic measurements performed on healthy cats underscore the importance of developing head-type-specific reference intervals and provide a robust morphological foundation for future clinical and diagnostic research.

Declarations

Availability of Data and Materials: The data that support the findings of this study are available on request from the corresponding author (İE).

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Ethical Statement: This study was reviewed by the Ankara University Local Ethics Committee for Animal Experiments (Decision date: 18.02.2026; Decision number: 2026-04-44).

Competing Interest: The authors declare that there is no conflict of interest.

Declaration of Generative Artificial Intelligence (AI): **The authors** declare that the article, tables and figures were not written/created by AI and AI-assisted Technologies.

Authors' Contributions: YS: Conceptualization, data curation, methodology, writing-original draft. BT: Data curation, formal analysis, writing-review and editing. İE: Investigation, writing-review and editing, supervision.

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