STUDIES ON OCULOMETRY WITH REFERENCE TO SKULL CONFORMATION AND AGE IN DOGS

By

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CERTIFICATE

Dr. CHATTALA NAGA TRILOCHANA has satisfactorily prosecuted the course of research and that the thesis entitled **"STUDIES ON OCULOMETRY WITH REFERENCE TO SKULL CONFORMATION AND AGE IN DOGS"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any University.

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CERTIFICATE

This is to certify that the thesis entitled **"STUDIES ON OCULOMETRY WITH REFERENCE TO SKULL CONFORMATION AND AGE IN DOGS"** submitted in partial fulfilment of the requirements for the degree of **MASTER OF VETERINARY SCIENCE** of the Sri Venkateswara Veterinary University, Tirupati, is a record of bonafide research work carried out by **Miss. CHATTALA NAGA TRILOCHANA** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All assistance and help received during the course of investigation have been duly acknowledged by the author of the thesis.

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Date :
Place : **(Ch Naga Trilochna)**

DECLARATION

I, **Dr. Ch NAGA TRILOCHANA** hereby declare that the thesis entitled **“STUDIES ON OCULOMETRY WITH REFERENCE TO SKULL CONFORMATION AND AGE IN DOGS”** submitted to Sri Venkateswara Veterinary University, Tirupati for the degree of **MASTER OF VETERINARY SCIENCE** is the result of original research work done by me. I also declare that the materials contained in this thesis have not been published earlier.

Date: **(Ch NAGA TRILOCHANA)**

LIST OF SYMBOLS AND ABBREVIATIONS

%	-	Percentage
Fig.	-	Figure
Inj.	-	Injection
ml	-	Millilitre
mm	-	Millimetre
>	-	more than
<	-	less than
i.e.,		that is
et al.	:	and others
viz.,	:	namely
%	:	percent
±	;	plus or minus
mg/kg	;	milligrams per kilogram
SC	;	subcutaneously
IM	:	intramuscular
I/V	:	intravenous
etc.	:	and other similar things
®	:	trade mark
@	:	at the rate of
mm of Hg	:	millimetre of mercury
OD	:	oculus dexter (right eye)
OS	:	oculus sinister (left eye)
OU	:	oculus uterque (both eyes)

IOL	:	intraocular lens
STT	:	Schirmer´s tear test
MHz	:	Mega hertz
B-mode	:	brightness mode
A-mode	:	Amplitude mode
IOP	:	Intraocular pressure
PLR	:	pupillary light reflexes
ANOVA	:	analysis of variance
ACD	:	Anterior Chamber depth
LT	:	Lens Thickness
VCD	:	Vitreous Chamber depth
AGL	:	Axial Globe length
SE	:	Standard error

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ABSTRACT

The present work "Studies on oculometry with reference to skull conformation and age in dogs" was carried by selecting the normal eyes after assessing the eyes with general and clinical ophthalmological examination. Transcorneal direct contact for A scan and immersion method for B scan was carried under topical anesthesia in 54 dogs and yielded in good data for oculometry. Based on skull conformation (Dolichocephalic, Mesaticephalic and Brachycephalic Breeds) and age (Young (0-9 months); Middle age (1-6 years) and Old: above 7 years) dogs were divided for analysis following oculometry. On A scan, anterior chamber depth, lens thickness, vitreous chamber depth and globe axial length of right and left eyes were 3.03 ±0.10 and 3.10±0.14 ; 2.62±0.21 and 2.32±0.22 ; 14.83±0.33 and 14.96±0.31 and 20.48±0.22 and 20.49±0.22 , respectively while the measurements on B scan were 2.92±0.08 and 2.84±0.09 6.87±0.08 and 6.84±0.09 ; 8.84±0.09 and 8.86±0.08 and 19.60±0.25 and 19.52±0.26 respectively.

A and B-mode ultrasonography were easy, practical, safe and useful techniques for ocular biometry in dogs. There was a phase of growth of the ocular components in the age group of 0-9 months in all the breeds with different skull conformation. Skull size do not interfere with ocular biometry measurements in above one year aged dogs. There was no

significant difference between the ocular biometric measurements of left and right eyes, at different age. Anterior chamber length and lens thickness increased as age advances with B scan however both the values are different in A and B mode scanning procedure. A scan reveals clear axial globe length and B scan measured lens thickness, vitreous chamber depth and globe axial length with more reliability.

To conclude that the B scan procedure showed to be better as it recorded all the ocular components accurately with clear image. The A scan procedure was simple to perform and recorded globe axial length accurately and unable to record the values of lens thickness and vitreous chamber depth precisely. B scan can be a useful tool for ocular biometry due to its accuracy and the reliability with an advantage of effective role in recording the ocular components architecture for diagnosis.

CHAPTER – I

INTRODUCTION

CHAPTER I

INTRODUCTION

Ultrasound has great value in the identification and differentiation of ocular changes and also in the measurement of the eye and its tissues or structures providing additional information which allows the clinician to establish treatment and prognosis of many diseases (Gonzalez *et al.*, 2001). Ocular ultrasound was a non-invasive, painless diagnostic method and can be considered relatively inexpensive, being a relevant diagnostic tool in the veterinary routine of small animals (Andrade *et al.*, 2020). Ocular ultrasonography has become an essential technique for exploring the globe and orbit in canine practice (Mattoon and Nyland, 2015).

Indications for Ocular ultrasonography include ocular trauma, the need to measure axial length, intraocular or orbital foreign bodies or masses, intraocular haemorrhage, lens luxation, retinal detachment, and any opacity that prevents complete ophthalmoscopic examination (Rogers *et al*., 1986 and Dziezyc *et al.*, 1987). Knowledge of the ultrasonographic appearance and normal dimensions of the eye would serve as a basis for ultrasonographic examinations when ocular disease may have caused alterations in the dimensions and appearance (Bentley *et al*., 2003).

Ocular biometrics was easy to perform, safe, non-invasive and low-cost procedure that provides immediate results with excellent definition. The purpose of performing ocular biometry in dogs is to determine the axial length for calculating the power of artificial intraocular lenses or to measure the sagittal size of intraocular structures in canine glaucoma (Gilger *et al*., 1998).

Ocular biometry using A-mode ultrasonography has been performed in several studies in Veterinary ophthalmology (Schiffer *et al*., 1982, Neumann 1988, Cottrill *et al*., 1989, Gaiddon *et al*., 1991 and Ekesten1994). A-mode ultrasonography was commonly used for ocular biometric purposes, including determination of dimensions of ocular components and documentation of eye growth patterns (Hamidzada and Osuobeni, 1999).

Biometry of the globe has been undertaken with A-mode ultrasonography which was used to determine globe axial length prior to intraocular lens implantation (Gaiddon *et al*., 1991) or for research purposes (Ekesten, 1994). A-mode ultrasonography offered a one-dimensional display of echoes in a spike pattern. Time delay was required for sound waves to reach given ocular tissue interfaces. The height of spikes describes strength of echoes. The indication of an A-mode ultrasonogram was therefore to measure distance between ocular interfaces (Ngamrojanavanit *et al.*, 2019).

Diagnostic B-mode ultrasonography was a two dimensional imaging technique that can be used to determine anatomic features (Kendall and Wolfe 1990). The ophthalmic B-mode ultrasonography was used to assess periocular and retro bulbar structures (Laus *et al*., 2003 and Tovar *et al.*, 2005) in neoplasm afflictions (Baptista *et al*., 2006) and in biometry, assessing variations in size, shape and position of these structures, helping in determining the prosthesis size and intra-eye pre-surgery (Hijar, 2008).

The eyes of different breeds of dogs have different shapes, dimensions and retinal configurations (Coppinger and Coppinger, 2001). Ultrasonography was a safe, non-invasive method to evaluate the intraocular and retro bulbar tissue of opaque eyes

(Matton and Nyland, 2015). It allowed evaluation of structures such as the cornea, the anterior chamber, the iris, the ciliary body, the lens, the vitreous chamber and the posterior section of the bulbar wall (Nautrup and Tobias, 2000).

Ocular biometry is the measurement of the dimensions of the eye, its components, and their interrelationships. It is routinely performed in Veterinary ophthalmology, but there is limited information on normal eye size in different dog breeds and the correlation between eye size and breed. Hence the present work **"Studies on oculometry with reference to skull conformation and age in dogs"** was carried to arrive at the oculometry measurements due to paucity of literature and studies on this aspect with following objectives.

1. To standardize the technique of transcorneal ultrasonography for oculometry.
2. To standardize the technique of oculometry using A-mode and B-mode ultrasonography.
3. To correlate oculometry of dogs with different skull conformation.
4. To correlate the oculometry of different ages of dogs.

CHAPTER – II
REVIEW
OF
LITERATURE

CHAPTER II
REVIEW OF LITERATURE

The present work “Studies on oculometry with reference to skull conformation and age in dogs” was carried to arrive at the normal oculometry measurements reviewed under following subheads

2.1 Indications for Ocular Biometry

2.2 Anaesthesia and Positining

2.3 Ocular Ultrasonography Technique

2.4 Methods of Ocular Ultrasonography

2.5 Ocular Ultrasonographic Appearance

2.6 Ocular Biometric Measurements

2.7 Ocular Biometric variations

2.1 INDICATIONS FOR OCULAR BIOMETRY

Ekesten (1993) stated that the purpose of performing oculometry in dogs was either to determine the globe axial length for calculation of artificial intraocular lens power or to measure the sagittal size of intraocular structures in canine glaucoma.

Gilger *et al.* (1998) performed oculometry and reported that it has potential application in establishing lens power, and estimating prosthetic globe size after enucleation.

Whitcomb (2002) stated that Ocular ultrasound is a relatively easy, non-invasive diagnostic modality to evaluate for ocular abnormalities and can be used as a complement to traditional ophthalmoscopic examination. Ocular ultrasound should be performed in ocular trauma, disparity in ocular size or with any condition that impedes visualization of posterior ocular structures.

Bentley *et al.* (2003) reported that knowledge of the ultrasonographic appearance and normal dimensions of the eye would serve as a basis for ultrasonographic examinations when ocular disease may have caused alterations in the dimensions and appearance.

Brandao *et al*. (2007) stated that oculometry was useful for the assessment of abnormalities such as phthisis bulbi, microphthalmia, pseudo exophthalmia, scleral ectasia or congenital glaucoma. The authors further reported that ocular measurements these values help for monitoring the evolution of diseases, such as glaucoma and after chemical ablation of the ciliary body.

Hijar (2008) performed ocular biometry to assess variations in size, shape and position of ocular structures, helping in determining the prosthesis size and intra-eye before surgery.

Potter *et al.* (2008) reported that normal ocular biometric values serve as a basis for ultrasonographic examinations when ocular disease have caused alterations in the appearance and dimensions of intraocular structures.

Assadnassab and Fartashvand (2013) stated that oculometry was useful for assessing abnormalities such as phthisis bulbi, microphthalmia, pseudo-exophthalmia, scleral ectasia, for determining dioptric power for lens replacement following cataract, to guide the fine needle aspiration of intraocular and orbital structures, and for estimating globe size for optimal placement of encircling elements in retinal detachment repair.

Toni *et al.* (2013) reported that ocular biometry of normal eye provides reliable parameters for determination the size of ocular prostheses to be used in cases of malformation or enucleation of the opposite eye.

Audu *et al.* (2017) reported that the measurements of the normal eye can provide reliable parameters for determination of the size of eye prosthesis in cases of malformation or enucleation of the eye.

Ganesan and Ramani (2018) performed B-Mode ultrasonography in cataractous eyes and measured lens equatorial length and reported that this measurement could help to determine the desired haptic to haptic length of intraocular lens and appropriate size of capsular tension ring in order to prevent potential adverse effects during cataract surgery in dogs.

Andrade *et al.* (2020) stated that ultrasonography is an important tool for performing oculometry for globe measurements which can be used to determine intraocular or intra-orbital prosthetic size.

2.2 ANAESTHESIA AND POSITINING

Van der Woerdt *et al.* (1993) performed ocular ultrasonography in dogs by applying topical Proparacaine hydrochloride 0.5% anaesthetic drops and suggested that sedation should be avoided as it causes elevation of nictitating membrane and rotation of globe during ultrasonographic examination.

Ekesten (1994) performed A-scan ultrasonography with and without sedation. The author reported that A-scan examinations performed were both faster and easier on the sedated dogs than on unsedated dogs in lateral recumbency and further stated that sedation of patient enhances the examination procedure in A-mode ultrasonography and relieves stress and discomfort of the patients.

Paunksnis *et al.* (2001) sedated the dogs with mixture of xylazine and Imalgen intramuscularly to evaluate and measure the structures of eyes in dogs of different age by A-mode ultrasonography.

Penninck *et al.* (2001) performed A-mode and B-mode ultrasonography for biometry by instilling few drops of topical anaesthesia in the eye. The authors reported that sedation should be avoided as it leads to rotation of globe and elevation of nictitating membrane.

Williams (2004) performed B- mode ultrasonography to determine lens morphometry in normal and cataractous eyes of dogs after topical application of 0.5% amethocaine hydrochloride.

Tuntivanich *et al.* (2007) performed B-mode ultrasonography in mesaticephalic breed dogs to document the globe axial length after applying 0.5% proparacaine hydrochloride topically.

Labruyere *et al* (2008) performed B-mode ultrasonography of the eye by achieving corneal anaesthesia using0.5% proxymethacaine Hydrochloride.

Vosough *et al.* (2008) conducted three-dimensional ocular ultrasonography by sedating all the dogs under study and instilled 0.05% Tetracaine HCl eye drops to partially prevent the eye movements.

Martins *et al.* (2010) conducted lens biometry in senile cataractous eyes in dogs using A- mode and B-mode ultrasonography by positioning the dog in sternal recumbency followed by application of topical anaesthetic drops of Proxymetacaine chloride directly on the corneal surface.

Silva *et al*. (2010) studied the ocular biometry in cataractous and non cataractous eyes of English Cocker Spaniel dogs by means of A- and B-modes ultrasonography after topical administration of an anaesthetic eye drop containing 0.5% Proximetacaine chloride.

Feliciano *et al.* (2013) evaluated poodle dogs with cataract using B-mode ultrasonography for anatomical characteristics and ocular echogenicity by instilling 0.5% proxymetacaine hydrochloride topically.

Toni *et al.* (2013) performed ophthalmic ultrasound in dogs of different skull conformation by manual restraint in sternal recumbency by manually opening the eyelids and instilling anaesthetic eye drop of 0.5% Proxymetacaine hydrochloride approximately 5 minutes before the examination.

Dar *et al*. (2014) scanned the eye of dogs in sternal recumbency or sitting position with head fixations by instilling a drop of 0.5% Proparacaine eye drops without sedation or general anaesthesia as these may cause the eye to roll downward or the third eyelid to move upward making the imaging process difficult.

Tavana and Peighambarzadeh (2014) conducted B-mode ultrasonography in mixed breed dogs by sedating the dogs with xylazine and diazepam intramuscularly prior the ultrasonographic examination.

Kobashigawa *et al.* (2015) conducted A and B mode ultrasonography in adult Shih Tzu dogs under local anaesthesia using 0.5% Proparacaine hydrochloride.

Audu *et al.* (2017) performed ocular biometry by positioning the dog in sternal or lateral recumbency using B-scan without sedation or general anaesthesia and stated that it is not necessary to sedate or anaesthetize the animal in this circumstance.

Ganesan and Ramani (2018) evaluated lens equatorial length in cataractous eyes using B-mode ultrasonography without any sedation but topically anaesthesia to the eye was achieved by applying a drop of 0.5% Proparacaine at three instances with an interval of 5 minutes between each drop.

Kumar *et al.* (2018) scanned the eyes of the dogs in sternal recumbency or sitting position under corneal anaesthesia by instilling 1 to 2 drops of Proparacaine HCl 0.5% directly on cornea and that facilitated ultrasonographic examination of eye.

Silva *et al.* (2018) placed the animals in sternal recumbency and performed B-Scan to assess the eye components after desensitising the cornea of both the eyes using a drop of Proxymetacaine chloral hydrate based anaesthetic eye drops.

Tripathi *et al.* (2018) measured different intraocular echo-biometric indices in normal adult dogs restraining in sternal recumbency without general or local anaesthesia.

Hong *et al.* (2019) performed contrast-enhanced ultrasonography by positioning the dog in sternal recumbency and holding its head steady by a manual assistant for evaluation of blood perfusion in normal canine eyes under general anaesthesia.

Vali and Razhegi (2019) compared transcorneal and transpalpebral echo-biometry in Iranian mix breed dogs by performing B-mode transcorneal ultrasonography in both the eyes after administration of topical anaesthetic gel.

Andrade *et al*. (2020) performed ocular biometry in normal eyes of healthy French Bulldog dogsin sitting or in prone position after instilling a drop of 0.5% Proxymetacaine anaesthetic eye drops.

Faleiro *et al.* (2021) performed ocular biometry by direct contact technique after positioning the dogs seated or in sternal decubitus and with the help of sterile water-soluble lubricating acoustic gel between the transducer after instilling anaesthetic eye drops containing 1% tetracaine hydrochloride and 0.1% phenylephrine hydrochloride in French bulldogs of 1-6 years age.

Kovalcuka and Murniece (2020) conducted biometric examination in Latvian hunting dogs using A- mode ultrasonography under corneal anaesthesia by application of 0.5% proparacaine hydrochloride topically.

Kumawat and Jhirwal (2021) performed ultrasonography to study the intraocular structures of eyes in dogs and ultra-sonographic appearance of the globe by placing the dogs in lateral recumbency facing the head towards the ultrasound machine and examined without any sedation, analgesia or anaesthesia.

Lavanya *et al.* (2021) performed B-mode ocular ultrasonography in dogs to evaluate intraocular structures with manual restraint in sitting or standing position or sterna or lateral recumbency and corneal desensitization was achieved using topical anaesthetic, 0.5% Proparacaine hydrochloride.

Shahi *et al.* (2021) performed B-scan of the dog eyes using a 7.5-18 MHz linear probe in sternal recumbency with head towards examiner after topically anaesthetizing the cornea with 4% lignocaine gel, the transducer was placed Transcorneally after the application of coupling gel.

2.3 OCULAR ULTRASONOGRAPHY TECHNIQUE

Shammas (1984) performed A-Mode ultrasonography using corneal contact and immersion technique and reported that the corneal contact technique causes inadvertent indentation of the cornea and thus may result in inaccurate axial length measurements.

Eisenberg (1985) stated that ocular and orbital ultrasonography was a simple examination to perform and, once the clinician was familiar with the examination, a rather simple examination to interpret. The examination causes little or no stress to the animal patient and can easily be performed in a few minutes as an outpatient procedure.

Hager *et al.* (1987) performed B- Mode ultrasonography using a 7.5 MHz transducer of focal range 2-5 cm by eyelid contact method, corneal contact method and water bath offset method and reported that the corneal contact method provided superior anatomic definition of the posterior globe and extra orbital tissues, whereas the water bath method gave higher-quality images of the anterior chamber and lens.

Williams and Wilkie (1996) performed B-mode ultrasonography and reported that transcorneal technique of scanning provided superior images of the posterior segment when compared to those obtained by transpalpebral technique.

Glover and Constantinescu (1997) performed ocular ultrasonography in canines using 7.5-10 MHz transducers and reported that a 10 MHz transducer provides adequate penetration depth and resolution to visualize the anterior and posterior chambers, whereas 7.5 MHz transducer produces better penetration for visualizing retrobulbar structures.

Gonzalez *et al.* (2001) performed A-mode and B-mode transcorneal ocular ultrasonography and reported that a high frequency transducer of 7.5 or 10 MHz was required for ocular ultrasonography as only few centimetres of the tissue should be penetrated by the ultrasonic beam.

Mason *et al.* (2001) performed Real-time, B-mode ultrasonographic examination using a 7.5-MHz mechanical sector scanner by direct corneal contact method following the application of topical anaesthetic and small quantity of ultrasound coupling gel on conscious, unsedated patients positioned in sternal recumbency for the diagnosis of retro bulbar diseases of the eye in dogs.

Bentley *et al.* (2003) conducted high resolution ultrasonography and reported that transducers with frequency higher than 20MHz give greater image definition and penetration power (from 20 to 80μm), allowing the visualization and measurement of images of the anterior eye segment in dogs and cats.

Tuntivanich *et al.* (2007) conducted oculometry using B-scan in mesocephalic breed dogs using 10 MHz probe and applying the probe perpendicular to the centre of cornea using ultrasonographic coupling gel.

Labruyere *et al.* (2008) performed B-mode ultrasonography of the eye using a 10MHz phased array transducer with direct transcorneal method by application of a large amount of acoustic coupling medium, which served as a standoff pad between the transducer and the cornea to allow sufficient visualization of the entire eye.

Vosough *et al.* (2008) conducted three dimensional ultrasonography for ocular imaging in dogs with a 5-12 MHz linear transducer and measured the optical axis of eye by transpalpebral method applying acoustic gel directly to the eyelids.

Beserra *et al.* (2009) assessed dog's eye using a 5 to 8MHz frequency micro convex transductor by transpalpebral B-mode ultrasonography and reported that at this frequency corneal thickness could not be assessed.

Toni *et al.* (2013) performed oculometry using simultaneous A-mode and B-mode ultrasonography in dogs of different skull conformations using a 20MHz transducer by applying large quantities of ultrasound gel and reported that it allowed a penetration of 2-4 cm depth that is required for evaluation of the eye and identification of its internal structures.

Brunell (2014) reported that biometric A-scan of frequency 10MHz or greater optimizes the tissue scattering and axial resolution to measure the axial length of eye precisely and to differentiate between normal and abnormal tissues.

Dar *et al.* (2014) performed detailed ophthalmic examination and B-scans of the eyes by transcorneal technique using a 7.5-18 MHz linear probe and reported that it provided excellent quality real-time imaging of posterior and vitreous chambers and can be considered as a representative ultrasonogram.

Tavana and Peighambarzadeh (2014) performed B-mode ultrasonography by transcorneal technique in dogs using 7.5-10MHz linear transducer and the globe was imaged in both horizontal and vertical planes.

Kobashigawa *et al.* (2015) performed simultaneous A and B mode ultrasonographic oculometry by transcorneal technique using a 20MHz probe.

Audu *et al.* (2017) performed oculometry using B-mode ultrasonography with 7.5MHz curvilinear probe at a scanning depth of 4-6 cm and each eye was viewed in a longitudinal view initially and then in transverse view to visualise the horizontal and vertical sections of eye.

Ganesan and Ramani (2018) performed B-scan by transcorneal method using 6 – 18 MHz linear transducer and the frequency band was set to maximum and viewed in transverse, longitudinal and temporal views.

Kumar *et al.* (2018) performed B- mode Ultrasonographic evaluation of eyes with linear transducer using 7.5-18 MHz probe by transcorneal and transpalpebral approaches in horizontal and vertical planes and reported that transcorneal technique was superior to transpalpebral technique but contraindicated in cases of corneal damage.

Ragab and Fathy (2018) stated that ultrasonography of the eye is a safe, rapid, non-invasive and reliable method for diagnosing most of eye affections. The authors observed that the 10 MHz probe gave excellent quality real-time images of posterior chamber and vitreous body.

Silva *et al.* (2018) assessed ocular components using B-scan with 8.5 MHz micro convex transducer by sweeping the probe in sagittal and dorsal planes and reported that only corneal thickness could not be assessed due to use of low frequency transducer.

Tripathi *et al*. (2018) performed B-mode transcorneal ultrasonography with a high end ultrasonographic machine using 2.5-7.5 MHz microconvex transducer and the scanning depth was set at 5- 9 cm. They reported that the linear probe did not allow inclusion of whole eye in one image, but it was better in obtaining detail images of cornea with different layers.

Hong *et al.* (2019) performed B-mode color Doppler ultrasonography using a 10 MHz linear transducer by transcorneal method and the depth set at 2.0 cm.

Vali and Razeghi (2019) performed B-Mode ultrasonography with 12MHz using both transcorneal and transpalpebral ultrasonographyand reported that the anterior chamber depth and lens thickness showed more values in transcorneal and transpalpebral methods respectively.

Andrade *et al*. (2020) performed ocular biometry by transcorneal technique using sterile gel as contact medium in B-mode with a 10 MHz linear probe.

Kovalcuka and Murniece (2020) performed A-scan by transcorneal ultrasonography technique using a probe of 10 MHz that is smaller than a B-mode probe and exerts less pressure on the cornea avoiding the error in the anterior chamber depth.

Faleiro *et al.* (2021) performed B-mode ocular biometry using direct contact technique with the cornea with the help of sterile water-soluble lubricating acoustic gel between the transducer and the examined eye and stated that it resulted in formation of clearer image in French bulldogs using 10 MHz frequency transducer.

Kumawat and Jhirwal (2021) performed oculometry bytranscorneal ultrasonographic technique in a sagittal plane using B-mode with high frequency sound waves i.e., a 5-14 MHz linear transducer and scanning depth kept at 4 cm to produce detailed images of eye.

2.4 METHODS OF OCULAR ULTRASONOGRAPHY

Schiffer *et al*. (1982) conducted A-mode ocular biometry in normal dogs by a ring stand technique, using a saline bath supported by a plastic membrane.

Biller and Myer (1988) conducted ultrasound scanning of superficial structures using an ultrasound standoff pad and reported that the standoff pad prevents or reduces the echo reverberations in the area of interest by placing it in the focal zone of the transducer.

Cottrill *et al. (*1989) recorded different ocular biometric indices of eye of mesaticephalic and brachycephalic dogs using A-mode and B-mode ultrasonography and opined that both the A-Scan and B-Scan ultrasonographic measurements were similar.

Kremkau (1989) performed ocular ultrasonography for diagnosis of eye disease and mentioned that the axial and lateral resolution have a significant effect on the quality of the resulting image.

Williams and Wilkie (1996) stated that application of excess coupling gel to cornea as a standoff pad while performing B-scan reduces the pressure applied with the transducer and thus anterior segment of eye can be better visualized.

Gonzalez *et al.* (2001) stated that direct contact with cornea while performing A-scan and B-scan allows the best visualization of the vitreoretinal and retrobulbar structures while the use of a standoff pad will provide the best images of the cornea and anterior chamber.

Williams (2004) stated that B-mode ultrasonography can be as accurate as A-mode biometry as Published research on A-mode and B-mode ultrasonography gave axial measurements that were not statistically significantly different.

Bedi *et al. (*2006) conducted A-mode and B-mode ocular ultrasonography in humans and stated that large amount of gel or standoff pad was used for examination of anterior chamber of eye while little amount of gel was required for posterior eye.

Hallowell and Bowen (2007) performed B-mode ultrasonography in equine eye using standoff and reported that it was useful for better visualising the cornea and anterior chamber.

Toni *et al.* (2013) conducted simultaneous A-mode and B-mode ultrasonography by immersion technique applying a large amount of ultrasound gel as a standoff pad between the eye and the transducer and stated that it allowed adequate evaluation of the anterior segment of the eye.

Mirshahi *et al.* (2014) performed B-mode oculometry in Persian cats using a large amount of contact gel on the palpebral surface as a stand-off pad to avoid near-field artefact. A surgical glove finger filled with ultrasound gel was used as probe cover and changed between cats to avoid the risk of transferring any infection.

Plummer and Resee (2014) performed A-mode and B-mode ocular ultrasonography and reported that the best possible image of the orbit and globe was produced by trans corneal technique using coupling gel as standoff medium than by transpalpebral technique or with a standoff device as they produce sound attenuation.

Mattoon and Nyland (2015) reported that A-mode ultrasonographic technique was not possible in veterinary patients as orientation of A-mode beam along the optic axis that was achieved by looking directly at a small light emitted from the centre of the transducer was necessary which was practically not possible.

Audu *et al.* (2017) performed B-mode ultrasonographic oculometry in indigenous Nigerian dogs using conductive ultrasonic gel as standoff pad and reported that it was effective and allowed adequate scanning of the anterior segment of the eye, as well as identification of its structures in all eyes.

Ganesan and Ramani (2018) conducted B-mode ultrasonography by applying sterile 2% hydroxypropyl methyl cellulose (HPMC) gel over the eye to be scanned as coupling medium to reduce artefacts.

Silva *et al*. (2018) performed B-scan and reported that carboxymethyl cellulose gel used formed a thick layer between the transducer and the cornea, permitting its complete analysis and measurement of anterior chamber depth

Ngamrojanavanit *et al.* (2019) investigated intraocular structures of canine absolute glaucomatous eyes using real time B-scan ultrasonography in accordance with the amplitude mode. Ocular biometry via closed-eye technique was performed with a 10 MHz mechanical sector probe.

Vali and Razeghi (2019) performed B-mode ultrasonography by placing Lubricating jelly on the 12 MHz transducer tip (BK Medical ultrasound machine) as a stand-off pad.

Kovalcuka and Murniece (2020) performed A-Scan biometry in normal Latvian hunting dogs and reported that there were significant differences between A- and B-modes ultrasonographic readings when different structures of the eye were evaluated.

2.5 OCULAR ULTRASONOGRAPHIC APPEARANCE

Goddard (1995) reported that the optic nerve tract showed mixed echogenic shadow from posterior margin of sclero-retinal layer on B mode ocular ultrasonography and this was likely due to orientation of the beam parallel to the nerve fibers.

Whitcomb (2002) performed B mode ultrasonography of eye and observed three fluid filled cavities (anterior chamber, posterior chamber and vitreous chamber) and an anechoic anterior and vitreous chamber in dogs

Spaulding (2008) conducted ocular ultrasonography and reported that in the normal dog eye, the anterior chamber, posterior chamber and vitreous body have anechoic appearance. The appearance of normal lens was anechoic posterior to lens and extending to the posterior aspect of globe was the vitreal body that fills the vitreous cavity. Retinal wall was hyperechoic and is not differentiated from sclera and choroid.

Audu *et al.* (2017) reported that the anterior chamber, lens capsule and vitreous chamber represent approximately 2%, 17% and 76% respectively of the entire globe area and the remainder 5% is comprised of ciliary body and muscle, suspensory ligament and posterior chamber.

Kumar *et al.* (2018) reported that anterior chamber, posterior chamber and vitreous body were visualized as anechoic on ocular ultrasonography indogs. The anterior chamber was distended with the anechoic aqueous humor, while posterior chamber was located between the posterior aspect of the lens and the ciliary body. The internal appearance of the normal lens was anechoic, while curvilinear interfaces appeared at the anterior and posterior margins of the lens, when scanned perpendicularly.

Silva *et al.* (2018) reported that the iris and the ciliary body, were presented in the lens peripheral-equatorial region, as a single structure in the sagittal cut that was triangular and echogenic in shape. The optical disc was identified on the posterior wall of the eyeball, slightly more echogenic than the wall and the optical nerve, caudal to the optical disc, and as a funnel-shaped structure, hypoechogenic in relation to the adjacent retrobulbar tissue.

Vali and Razeghi (2019) used high frequency (12 MHz), the cornea is seen as three thin distinct layers, in which the anterior and posterior layers were quite hyper echoic and the middle layer appeared anechoic.

Kumawat and Jhirwal (2021) reported that the hyper-echogenicity of the optic nerve was presumably due to orientation of the beam parallel to the nerve fibers and the highly organised, homogeneous structure of the optic nerve compared to adjacent fat.

2.6 OCULAR BIOMETRIC MEASUREMENTS

Cottrill *et al.* (1989) performed ultrasonography and biometric evaluation of eye and orbit in dogs and reported that physical measurements of anterior chamber depth were greater than the ultrasonic measurements.

Zadnik *et al.* (1992) Studied the ocular components of refraction typically neglect issues of repeatability of measurement methods or analyze method comparison/repeatability data inappropriately using correlation. The authors opined that anterior chamber depth was reliable to ±0.29 mm, lens thickness to ±0.20 mm, and vitreous chamber depth to ±0.37 mm.

Miller and Murphy (1995) studied the vision in dogs and stated that the anterior chamber depth measurement was most affected by ultrasound biometry errors due to corneal flattening by the probe.

Williams and Wilkie (1996) performed ocular ultrasonography and reported that the lens thickness, vitreous chamber depth and globe axial length in mesaticephalic breeds was 7.6mm, 8.8mm and 19.6mm and those in dolichocephalic breeds was 7.6mm, 9.6mm and 21.0mm respectively.

Hamidzada and Osuobeni (1999) stated that B mode overestimates corneal thickness and anterior chamber depth and underestimates lens thickness, vitreous chamber depth and axial globe length and further stated that A-mode and B-mode gave different readings for measurements of lens thickness, vitreous chamber depth and axial length.

Goncalves *et al*. (2000) evaluated anterior chamber depth, lens thickness, lens diameter, vitreous chamber depth and globe axial length in mixed breed of dogs and the measurements were 3.90 ± 0.70mm, 6.10 ± 1.20mm, 10.50 ± 1.00mm, 9.10 ± 0.40 mm and 18.80 ± 0.90mm respectively. The authors observed a non-significant difference between right and left eye except for anterior chamber depth.

McGreevy *et al.* (2003) observed a strong correlation exists between the distribution of retinal ganglion cells and nose length in the dog and mentioned that the dog was the most diverse species on earth, with skull length varying between 7 and 28 cm. However, eye size in dogs does not appear to vary as much. The authors stated that the radius of the canine eye varied across breeds from 9.56 to 11.57 mm and was correlated with the width and length of the skull.

Azevedo and Ranzani (2006) studied the mmeasurements of the anterior segment of the eye ball aiming to establish the ideal size of intra ocular lenses to be implanted in dogs and found no correlation between lens thickness and the weight of dogs.

Murphy et al. (2012) stated that the size of eyeball varies among breeds, but the diameter is usually approximately 20-25mm.

Boillot *et al.* (2014) conducted oculometry in Eurasier dogs and revealed that there was a significant inverse correlation between the intra ocular pressure and globe axial length i.e., a decrease in globe axial length leads to increase in IOP.

Tavana and Peighambarzadeh (2014) reported that the anterior-posterior length of the eye axis, thickness of the lens and depth of the anterior chamber in adult mixed breed dogs using B-scan were as 19.41±0.78, 5.71±0.45 and 8.63±0.35mm, respectively and no difference was detected in any ocular component measurement between the right and left eyes of the adult mixed-breed dogs.

Tokoro *et al.* (2014) recorded that the axial length, anterior chamber depth and lens thickness in normal Chihuahua using B-mode ultrasonography as 18.15 ± 0.76 mm, 2.8 ± 0.2mm, 6.6±0.2mm and 18.18 ± 0.76mm, 2.8 ± 0.2mm, 6.6 ± 0.2mm in horizontal and vertical planes respectively.

Kobashigawa *et al.* (2015) performed simultaneous A-mode and B-mode ultrasonography in Shih Tzu and reported that the globe axial length, lens thickness, anterior chamber depth and vitreous chamber depth measurements as 20.255±0.134; 6.624±0.031; 4.064±0.109 and 9.565±0.054mm, respectively.

Silva *et al.* (2018) evaluated different biometric parameters of eye using B-mode ultrasonography and stated that the globe axial length, Anterior chamber depth, lens thickness and Vitreous chamber depth of right and left eye were 1.75±0.10 and 1.73±0.11cm, 0.15 to 0.25cm and 0.13 to 0.25cm, 0.72±0.05cm and 0.73±0.04cm and 0.79 and 0.87cm, respectively.

Tripathi *et al.* (2018) performed ocular biometry and reported that the average values of globe axial length of both left and right eyes were 2.04±0.02 cm, 2.06±0.02 cm, and 1.98±0.01 cm in German shepherd, Labrador retriever, Indian mongrel dogs, respectively.

Vali and Razhegi (2019) performed trans corneal ultrasonography and obtained the of globe axial length, anterior chamber depth, lens thickness and vitreous chamber depth as 19.60±0.452, 2.99±0.242, 6.62±0.364 and 8.81±0.354 respectively in the Iranian mix breed dogs of 4±1.39 years.

Andrade *et al*. (2020) performed ocular biometry in normal eyes of healthy French Bulldog dogs and stated that axial globe length, anterior chamber depth, lens thickness and vitreous chamber depth measurements as 20.5 ± 0.6 mm, 3.8 ± 0.4mm, 7.4 ± 0.3mm and 9.4 ± 0.4mm, respectively

Kovalcuka and Murniece (2020) performed oculometry in latnavian hunting dogs using A-Scan and reported that average values of axial length, anterior chamber depth and lens thickness was 2.21±0.08 cm, 0.35±0.1 cm and 0.42±0.06 cm.

Faleiro *et al.* (2021) correlated the measurements with cephalic measurements and with body measurements and stated that the mean axial globe length, lens thickness anterior chamber depth and vitreous chamber depth as 19.51 ± 0.58 mm, 6.71 ± 0.66 mm, 2.36 ± 0.89 mm and 10.44 ± 1.32 mm, respectively. The authors also reported anon-significant difference between the parameters of male and female eye biometrics and there was no difference between the measurements of the right and left eyes. The size of the dog or skull did not interfere with the measurements of eye biometrics.

Sritrakoon *et al.* (2021) performed ocular biometry measurements using A-scan ultrasonography and reported that the average axial length were 21.54 mm OD and 21.22 mm OS.

2.7OCULAR BIOMETRIC VARIATIONS

Schiffer *et al.* (1982) performed A-mode ocular biometry and reported that males showed highly significant difference in lens thickness than in females.

Cottrill *et al.* (1989) evaluated the eyes of mesaticephalic and dolichocephalic breeds and reported that the globe axial length of dolichocephalic breeds was significantly longer than that of mesaticephalic breeds. They further stated that there was no significant difference between male and female dogs and between the right and left eyes of dolichocephalic and mesaticephalic dogs.

Gaiddon *et al.* (1991) evaluated the globe axial length of both left and right eye in dogs of various breeds, sizes and ages and stated that the mean globe axial length was 20.43 ± 1.48 mm and was not related to age or sex but was found greater in large breed dogs.

Gaiddon *et al*. (1992) stated that the axial globe length was significantly higher in large breed dogs but it did not depend on the age and sex of dog.

Zadnik *et al.* (1992) reported that anterior chamber depth measurement by ultrasonography was least reliable

Paunksnis *et al.* (2001) reported that ultrasonographic measurements of eye such as lens thickness, vitreous chamber depth and sagittal eyeball axis increased with age and also stated that the cornea was thickest in 20-day-old dogs, while thinnest in the center and thicker in the periphery of adult dogs.

Svaldeniene *et al.* (2004) opined that the dolichocephalic dog breeds had the biggest eyeball and its parts and the percentage of eye parts were similar in all dog breeds.

Boroffka (2005) assessed the intra eye structure development in both prenatal and in postnatal puppies using B-scan ultrasonography and observed that there was continuous growth of the eye depth, anterior chamber, lens and vitreous chamber both in the pre-and post natal care.

Schufelt *et al*. (2005) opined that the option of calculating the depth of the vitreous chamber by subtracting the measurements of the anterior chamber and lens from the axial length, to the detriment of the direct measurement, was carried out in order to minimize possible variations during the direct measurement.

Boroffka *et al*. (2006) recorded the intraobserver and interobserver repeatability of ocular biometric measurements obtained by means of B-mode ultrasonography in dogs and suggested that most measurements of intraocular distances and structures obtained by means of high-resolution B-mode ultrasonography have acceptable intra- and interobserver repeatability.

Tuntivanich *et al.* (2007) reported that rapid increase in Globe axial length of normal mesticephalic cross breed dogs was between two to nine weeks of age and slower up to 20 weeks of age, there after very little increase of globe axial length with age.

Berges *et al. (*2009) studied the B-mode-guided vector-A-mode versus A-mode biometry to determine axial length and intraocular lens power and suggested that the reproducibility and accuracy of AL measurements are significantly better with B-mode-guided A-mode biometry than with A-mode biometry in myopic and nonmyopic eyes.

Squarzoni (2011) performed B-mode ocular biometry in Cavalier King Charles Spaniels and reported that Males have higher measurements of length, height and head parameters than females but had no difference between ocular biometric values of male and female dogs.

Toni *et al*. (2013) reported that Skull conformation of brachycephalic dogs did not influence intraocular measurement values when compared to dolichocephalic and mesocephalic dogs but it had an influence in values of vitreous chamber and the complete length of the eye in dolichocephalic dogs when compared to mesocephalic dogs.

Mirshahi *et al.* (2014) ultrasonographic biometry of normal eyes in Persian cat and reported that globe axial length, anterior chamber depth and lens thickness had a significant positive correlation with head circumference while vitreous body had a positive correlation with age.

Chiwitt *et al.* (2017) performed ocular biometry using B-scan and CT in various breeds of dogs and reported that Eyes of large breed dogs were significantly larger than those of medium and small breed dogs ($P < 0.01$), and eyes of medium breed dogs were significantly larger than those of small breed dogs ($P < 0.01$). Eye size correlated with body weight (0.74–0.82) but not gender or skull type.

Audu *et al*. (2017) performed ocular biometry in indigenous Nigerian dogs of different ages and reported that the cornea thickness, lens thickness and ocular globe length are increased with age, in both sexes while, the anterior chamber depth and vitreous length increased initially with age from puppy to adults and then decreased slightly in older dogs.

Kumar *et al.* (2018) studied ophthalmic parameters of different dog breeds of age ranging from four month to fifteen years of either sex and stated that lens thickness differed significantly ($p < 0.05$) in Dalmatian and German shepherd breeds of dogs, Vitreous Chamber depth in Pug and Boxer showed significant difference than Labrador retriever and globe axial length in Dalmatian differed significantly than German shepherd and Labrador retriever. They further stated that all the ocular parameters increased with age.

Silva *et al.* (2018) observed positive correlation between the biometric measurements of the eyeball and the animal´s age suggesting that eye growth increases according to the age of the animal, that is, their growth.

Tripathi *et al.* (2018) reported that the average values of lens diameter and axial globe length of both the left and right eye of German shepherd dog were significantly different from Labrador retriever and Indian mongrel dogs.

Kovalcuka and Murniece (2020) reported that the mean globe axial length was 2.21±0.1 cm in normal Latvian hunting dogs and stated that the dog would be more like mesocephalic dog (1.99±1.2), but AXL was longer than that reported in dolichocephalic dogs (2.12±1.3 cm).

Faleiro *et al.* (2021) performed oculometry in French bull dogs and reported that the size of the dog or skull did not interfere with the measurements of eye biometrics.

Lavanya *et al.* (2021) conducted B-mode ocular biometry and ocular parameters like axial length of the eye, vitreous chamber depth, lens diameter and lens depth were recorded in all the dog. They repoted that these parameters differed significantly within the same group and between groups and between normal eyes and affected eyes.

CHAPTER – III
MATERIALS
AND
METHODS

Chapter III

MATERIALS AND METHODS

The present work "Studies on oculometry with reference to skull conformation and age in dogs" was carried out to record the oculometry values in dogs with different skull conformation and age groups. The materials and methods followed in this study were documented.

3.1 CLINICAL OPHTHALMIC EXAMINATION

The Present study was conducted on dogs with different skull conformation and age that were presented to the Small animal surgical outpatient ward, Department of Veterinary Surgery and Radiology, NTR College of Veterinary Science, Gannavaram from March 2022 to December 2022.

The dogs were subjected to general ophthalmological examination to detect gross lesions if any and the dogs found without any abnormalities like chemosis, corneal opacity, corneal edema, corneal ulcer, lens opacity, ocular discharges and conjunctival appearance in both the eyes were selected.

All the dogs in the present study further underwent clinical ophthalmic examination such as assessment of palpebral reflex, menace response, pupillary light reflex, tear production, fluorescein staining and intraocular pressure to rule out any concurrent diseases of the eye and to ascertain health of eye.

3.1.1 Palpebral reflex

In all the dogs to evaluate the palpebral reflex, cranial nerve V was stimulated by touching the medial or lateral canthus of both the eyes after restraining the dog in sternal recumbency /standing position (Fig 1 to 3). Complete closure of eyelids indicates normal palpebral reflex (Maggs, 2008).

3.1.2 Menace Response

In all the dogs to perform the menace response, after restraining the dog in sterna recumbency /standing position a threatening gesture was made with the hand or fingers in the direction of the eye being tested. This was done in a way that avoids creating excessive air current that can cause a false-positive response. A negative menace response may be associated with decreased vision or abnormal eyelid function (Fig 4 to 6).

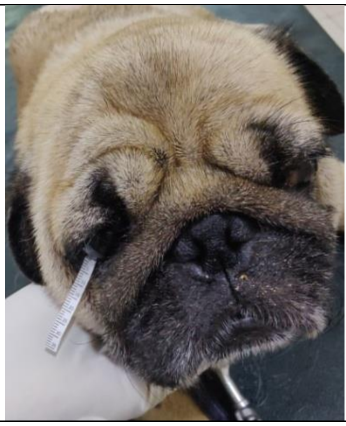
3.1.3 Pupillary light reflex

Pupillary light reflex was assessed by focussing bright light onto each eye by keeping the dog in sterna recumbency /standing position in all the dogs. Constriction of pupil in directly stimulated eye indicates normal pupillary light reflex (Fig 7).

3.1.4 Schirmer tear test

The tear production in all the dogs was assessed by performing Schirmer tear test using Schirmer tear test strips and placing this standardized sterile strip tip in the lower lateral eyelid margin for one minute. The length of strip that was wet was measured in millimetres immediately after removing strip from the conjunctival fornix. The values between 15-30 mm/minute was considered as normal (Fig 8 to10). To assure accuracy, the

	
Fig 1: Photograph showing Palpebral reflex in a Doberman Pincher Dog(Dolichocephalic skull)	Fig 2: Photograph showing Palpebral reflex in a Labrador Retriever Dog (Mesaticephalic skull)
	
Fig 3: Photograph showing Palpebral reflex in a Shih TzuDog (Brachycephalic skull)	Fig 4: Photograph showing Menace responsein Dolichocephalic breed dog.
	
Fig 5: Photograph showing Menace response in a Mesaticephalic breed dog.	Fig 6: Photograph showing Menace response in a Brachycephalic breed dog.

	
Fig 7: Photograph showing Pupillary light reflex in a Labrador Retriever Dog	Fig 8: Photograph showing Schirmer Tear Test in a Doberman Pincher Dog
	
Fig 9: Photograph showing Schirmer Tear Test in Labrador Retriever dog.	Fig 10: Photograph showing Schirmer Tear Test in a Pug dog.

Schirmer tear test was performed before applying fluorescein stain and topical anaesthetic to the eye (Maggs, 2008).

3.1.5 Fluorescein Dye Test

All the 54 dogs were evaluated for corneal ulcers by performing fluorescein dye test. The fluorescein strip was moistened with the sterile normal saline and placed in the palpebral fissure for one minute. The strip was removed and the excess stain was irrigated with normal saline. Persistence of fluorescein stain on cornea was considered as positive for Fluorescent dye test (Fig 11 to 13).

3.1.6 Intraocular Pressure (mm of Hg)

In all the dogs, the Intraocular pressure was assessed by using Tonopen (Appasamy Associates, Chennai) after instilling 0.5% Proparacaine eye drops after placing the animal in the sternal recumbency and tapping it on the corneal surface for 6 times placing the tip of Tonopen parallel to the surface of cornea, generated a value on the Tonopen. Two such readings were taken and their average value was recorded as the Intraocular pressure in mm of Hg. The values between 15-30 mm Hg was considered as normal value (Fig 14 to 16).

3.2 SELECTION OF ANIMALS

The dogs after clinical and ophthalmological examination confirmed as normal eyes were selected (54) for the study and categorized into three different groups based on skull conformation and age of animals of either sex. The oculometry was performed with both A and B scan in 54 dogs of different skull conformation and age.

Fig 11: Photograph showing Flourescien dye test in Doberman Pinscher dog.

Fig 12: Photograph showing Flourescien dye test in a Labrador Retriever Dog.

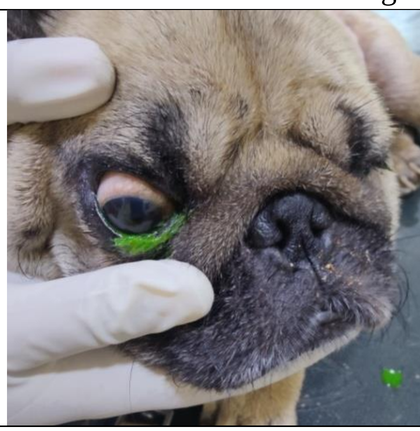


Fig 13: Photograph showing Flourescien dye test in a Pug dog.

Fig 14: Photograph showing application of Tono pen in a Doberman Pincher dog.

Fig 15: Photograph showing application of Tono pen in a Labrador Retriever Dog.

Fig 16: Photograph showing application of Tono pen in a Pug dog.

All the selected dogs (54) were categorized based on skull conformation into three groups containing 18 dogs in each group as Dolichocephalic, Mesaticephalic and Brachycephalic Breeds (Fig 17 to 19).

Based on the age the dogs were categorized in to three groups each contains 18 dogs into Young (0-9 months); Middle age (1-6 years) and Old age (above 7 years) groups to perform oculometry.

Following oculometry based on the breed and age the dogs were divided in to 3x3 groups each contains 6 dogs to analyze the data

Group	**Breed**	**A**	**B**	**C**
Group I	Dolichocephalic	0-9 months	0-9 months	0-9 months
Group II	Mesaticephalic	1-6 years	1-6 years	1-6 years
Group III	Brachycephalic	Above 7 years	Above 7 years	Above 7 years

3.3 EQUIPMENT

A-scan was done by using Appasamy A-SCAN machine which contains Display, with pencil sized transducer of 10MHz frequency and scleral cup (Fig 20).

B-Scan was done by using Prosound α6LT model ultrasound machine, (Aloka Hitachi India private limited, New Delhi-11003) with 5-13MHz frequency linear transducer and the thermal index (TI) and the mechanical index (MI) were maintained at <1 and <0.3 respectively (Fig 21).

Fig 17: Photograph showing Frontal (A) and Lateral view (B) of Dolichocephalic skull.

Fig 18: Photograph showing Frontal (A) and Lateral view (B) of Mesaticephalic skull.

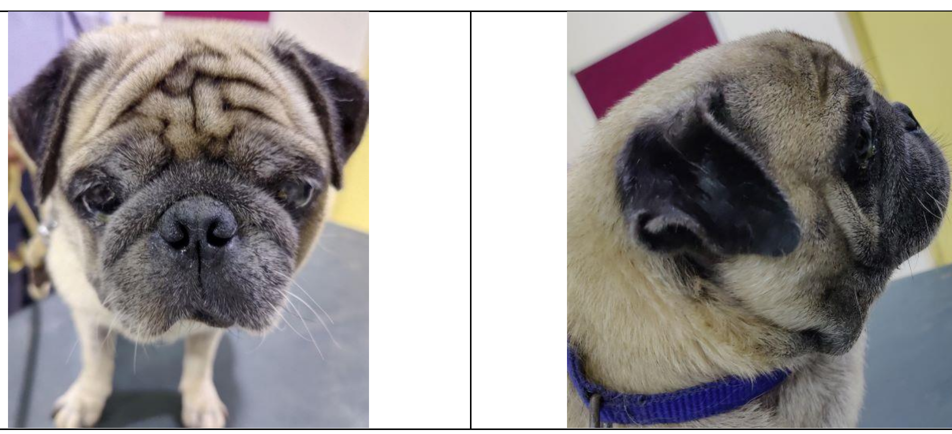


Fig 19: Photograph showing Frontal (A) and Lateral view (B) of Brachycephalic skull.

Fig 20: Photograph showing A-Scan equipment used for A mode oculometry.

Fig 21: Photograph showing Prosoundα6LTmodel ultrasound machine used for B mode oculometry.

3.4 TRANSCORNEAL OCULAR ULTRASONOGRAPHY

A preliminary examination was conducted to know the efficacy of direct contact and immersion method both in A and B mode ocular ultrasonography by trans corneal technique **(**Fig 22). To perform transcorneal ocular ultrasonography the eyes held open by an assistant and the transducer was placed on cornea either directly or with scleral cup for A mode procedure where as in B mode procedure the transducer was placed directly or via standoff gel.

All the dogs were physically restrained without sedation or general anaesthesia. The corneal anaesthesia was achieved by instilling 0.5% Proparacaine hydrochloride (Fig 23) eye drop on the cornea of the eye to be examined**.**

3.4.1 A-Mode Ocular Ultrasonography

3.4.1.1 Direct contact method

In direct contact method, the pencil sized transducer was tapped directly on to cornea without causing much pressure on cornea after restraining the dogs in sternal recumbency. The transducer was placed on the centre of cornea as it results in alignment of appropriate points of the visual axis along the ultrasonic beam to attain accurate ultrasonic values (Fig 24 to 26).

3.4.1.2 Immersion method

In immersion method, the dog was placed in the dorsal recumbency and the scleral cup was placed on the cornea. The scleral cup was infused with normal saline and the images were selected. The intraocular readings and the spikes were displayed on the screen. Five accepted readings were taken and their averages were recorded (Fig 27 to 29).

Fig 22: Photograph showing Transcorneal technique of ultrasonography in a German Shepherd dog.

Fig 23: Photograph showing topical anaesthetic 0.5% Proparacaine eye drops.

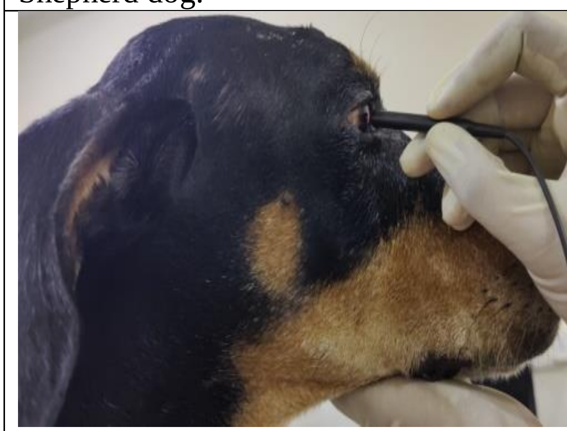


Fig 24: Photograph showing corneal contact method in A-Scan in Dolichocephalic dog.

Fig 25: Photograph showing corneal contact method in A-Scan in Mesaticephalic dog.

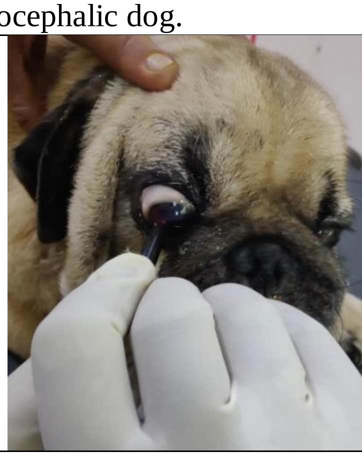


Fig 26: Photograph showing corneal contact method in A-Scan in Brachycephalic dog.

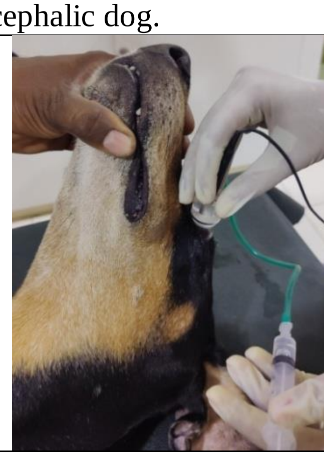


Fig 27: Photograph showing immersion method in A-Scan in Dolichocephalic dog.

	
Fig 28: Photograph showing immersion method in A-Scan in Mesaticephalic breed dog.	Fig 29: Photograph showing immersion method in A-Scan in Brachycephalic breed dog.
	
Fig 30: Photograph showing the dog in Sternal recumbency.	Fig 31:Photograph showing direct contact method in B-Scan in dolichocephalic skull.
	
Fig 32: Photograph showing direct contact method in B-Scan in mesaticephalic skull.	Fig 33: Photograph showing direct contact method in B-Scan in brachycephalic skull.

3.4.2 B-Mode Ocular Ultrasonography

The dogs were manually restrained in the sitting position or in sternal recumbency (Fig 30) and topical anaesthetic eye drops i.e., 0.5% Proparacaine hydrochloride were instilled on the cornea of eye to be examined.

3.4.2.1 Direct Contact Method

In all the dogs the eyelids were held open by the assistant and the transducer was gently placed over the cornea directly with probe head towards the medial canthus of the eye (Fig 31 to 33) and the globe was imaged in the horizontal and vertical planes. This produced a horizontal image of eye with the medial canthus towards right and the lateral canthus towards the left of the image. Care was taken not to exert pressure over the cornea and sclera with the transducer while performing ultrasonography. All the scanning images were stored in the ultrasound machine for ocular measurements and the clear and best images were selected and analysed.

3.4.2.2 Immersion Method

In all the dogs the eyelids were held open by the assistant and the linear transducer along with large quantities of ultrasound coupling gel that acts as standoff pad (Fig 34) was placed on the cornea to maintain sufficient contact area. The globe was fanned in the horizontal and vertical planes (Fig 35 and 36) placing the transducer gently over the cornea with probe head towards the medial canthus and dorsally to the eye. This resulted in a horizontal image of eye with the medial canthus towards right and the lateral canthus

Fig 34: Photograph showing coupling gel as Stand off pad on linear transducer.

Fig 35: Photograph showing B-Mode ultrasonography with probe head towards the Medial canthus.

Fig 36: Photograph showing swanning of transducer in Horizontal and vertical plane.

Fig 37: Photograph showing immersion method in B-Scan in dolichocephalic skull.

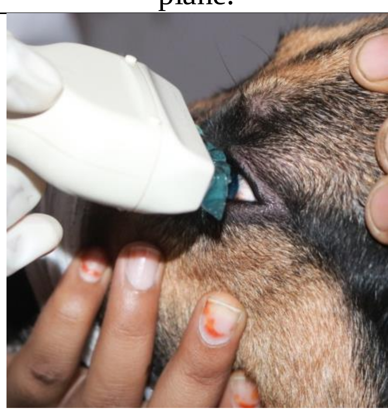


Fig 38: Photograph showing immersion method in B-Scan in mesaticephalic skull.

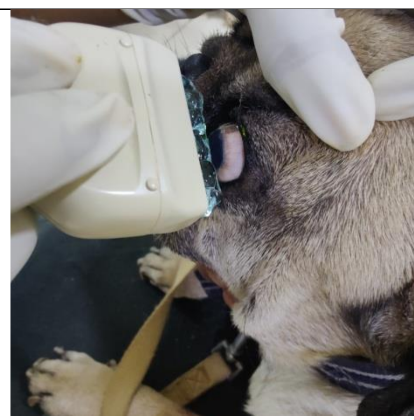


Fig 39: Photograph showing immersion method in B-Scan in brachycephalic skull.

towards the left of the image. All the scanning images were stored in the ultrasound machine for ocular measurements and the clear and best images were selected and analysed. Care was taken not to exert pressure over the cornea and sclera with the transducer while performing ultrasonography (Fig 37 to 39).

After the procedure, the eyes that undergone scanning procedure were gently cleaned using cotton wetted with sterile 0.9% sodium chloride solution to remove the excess coupling gel and the eyes were re-examined for any iatrogenic corneal lesions resulting from the examination.

After preliminary study on direct contact and immersion methods in A and B scan procedures direct contact method for A-mode and immersion method for B-mode provided better images to record ocular measurements and proceeded for further investigation.

3.5 APPEARANCE

3.5.1 A-Scan

In A-Scan, the images produced had four major peaks or spikes from the baseline which are of similar amplitude in all the dogs (Fig 40). The peaks represents Cornea, Anterior lens capsule, Posterior lens capsule and Sclero- retinal rim serially and the measurements displayed on the screen following scanning were recorded.

3.5.2 B-Scan

In the B-Scan images, near the contact area of transducer three thin distinct layers followed by an anechoic area, convex hyper-echoic line, middle anechoic area, concave hyper-echoic line, anaechoic area and concave hyperechoic structure representing cornea, anterior chamber, Anterior capsule of lens, lens, posterior lens capsule, vitreous chamber and sclera retinal rim serially (Fig 41).

3.6 INTRA OCULAR MEASUREMENTS

3.6.1 A-mode Oculometry

In all the 54 dogs following A mode ocular ultrasonography, the distances between the spikes were measured with the built-in calliperss or ruler of the ultrasound machine with less than 0.05mm standard deviation and the distances measured were Anterior chamber depth(ACD), Lens thickness(LT), Vitreous chamber depth(VCD), Globe axial length (GAL).

The Anterior chamber depth was measured as the distance between the spikes of corneal surface and the anterior lens surface, thus including the corneal thickness in the anterior chamber depth. The Lens thickness was the distance between the spikes of the anterior and posterior lens surfaces. The Vitreous chamber depth was the distance between the spikes of the posterior lens surface and retina. The Globe axial length was the sum of the corneal thickness, anterior chamber depth, lens thickness and vitreous chamber depth (Fig 42).

3.6.2 B-mode Oculometry

In all the 54 dogs following B scan ocular ultrasonography, the distance between the echoes were measured with built-in calipers of ultrasound machine. The Anterior chamber depth was measured as the distance between the caudal corneal echo and the anterior lens capsule echo, thus excluding the corneal thickness in the anterior chamber depth. The Lens thickness was measured as distance between the anterior lens capsule echo and posterior lens capsule echo. The Vitreous chamber depth was measured as distance between the posterior lens capsule echo and sclera-retinal rim echo. The Globe axial length was measured as the distance between the cranial corneal echo and the sclera-retinal rim echo (Fig 43).

3.7 STATISTICAL ANALYSIS

The data generated for each set of ocular measurements were analysed statistically using a software program IBM SPSS Statistics 26 and Microsoft excel and the values obtained were expressed as mean ± standard error.

A statistical comparison of means of different ocular parameters from different skull conformations and from different age groups (Kumar *et al.* 2018) were done using a One way analysis of variance and Duncan was used as post-hoc test. To compare the effect of breeds and the effect of age within each breed group a two way ANOVA and Duncan's post – hoc test was used. Values of $P<0.05$ and $P<0.01$ were considered as statistically significant and highly significant respectively at 95% confidence.

The mean ± standard error values of ocular measurements were obtained individually for both the eyes in order to avoid statistical dependence (Ekesten 1994) and paired T-Test was used to compare ocular parameters from right and left eye of same dog. If the P value was less than 0.05, there was a significant difference between right and left eyes.

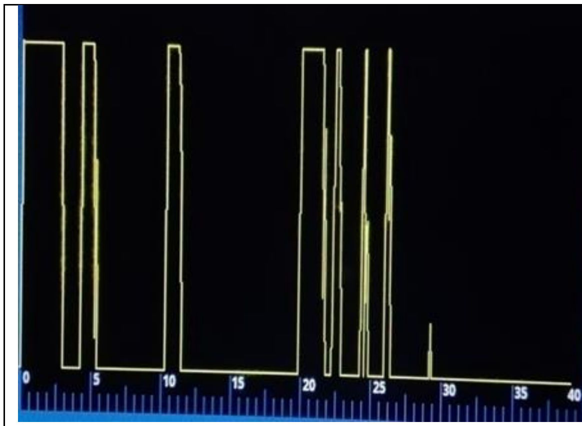


Fig 40: Photograph showing appearance of A-Scan image.

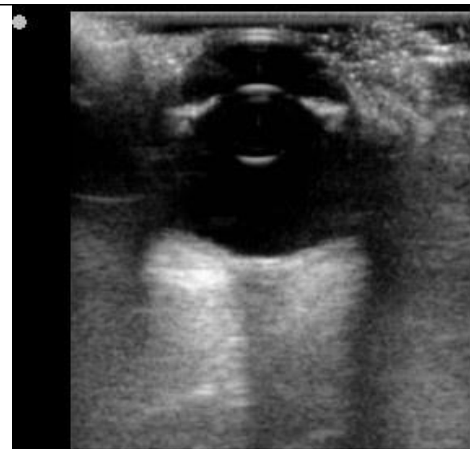


Fig 41: Photograph showing appearance ofB-Scan image.

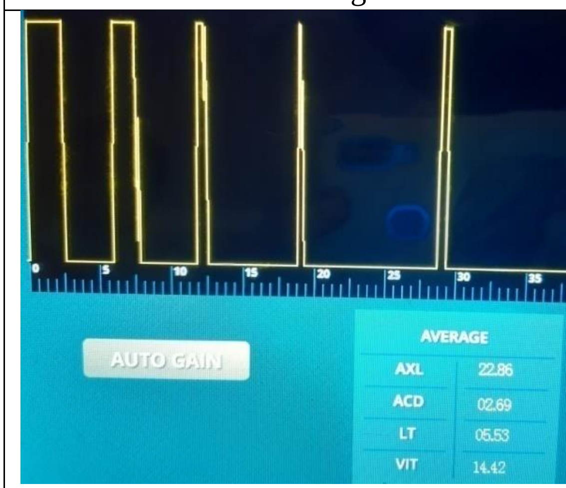


Fig 42: Photograph showing Intra ocular measurements in A-Scan.

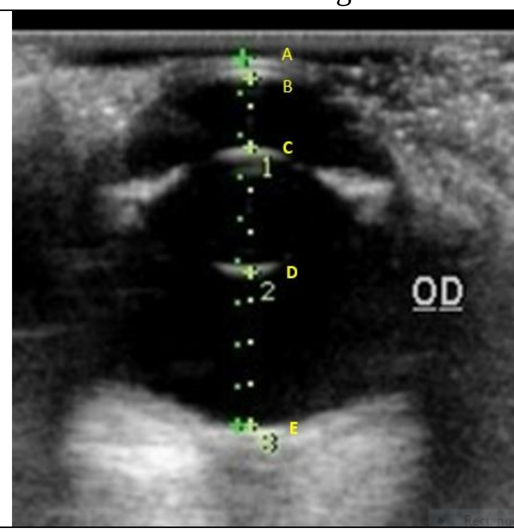


Fig 43: Photograph showing Intra ocular measurements in B-Scan. A-B Corenal thickness B-C Anterior chamber depth C-D Lens thickness D-E Vitrous chamber depth A-E Globe axial length

CHAPTER-IV
RESULTS

CHAPTER IV

RESULTS

The present work "Studies on oculometry with reference to skull conformation and age in dogs" was carried out in normal dogs to arrive oculometric values in different breeds and age dogs to serve as reference values of oculometry. The results obtained from the study were recorded and documented.

4.1 CLINICAL OPHTHALMIC EXAMINATION

The dogs presented to the small animal surgery ward were subjected to general ophthalmic examination for gross lesions and none of the 54 dogs showed lesions like chemosis, corneal opacity, corneal edema, corneal ulcer, lens opacity, ocular discharges and conjunctival appearance in both the eyes.

All the 54 dogs in the present study underwent clinical ophthalmic examination such as assessment of palpebral reflex, menace response, pupillary light reflex, tear production, fluorescein staining and intraocular pressure and all the dogs under study well tolerated to procedures without any discomfort and post procedure complications.

4.1.1 Palpebral reflex

In all the 54 dogs, **t**he eyelid conformation and globe position were considered when interpreting the palpebral reflex. The palpebral reflex was used to evaluate eyelid sensation and function. A blink response indicates a positive palpebral reflex. Among the 54 dogs in the present study, Palpebral reflex was positive in both the eyes without any faulty conformation and globe position.

4.1.2 Menace response

The menace response was conducted to assess both the visual status and eyelid function. The eyelid conformation and globe position were considered when interpreting the menace response. To perform the menace response, a threatening gesture was made with the hand or fingers in the direction of the eye being tested. Among the 54 dogs in the present study, Menace response was positive with visual acuity in both the eyes of all the dogs.

4.1.3 Pupillary light reflex

Pupillary light reflex was assessed by focussing bright light onto each eye by keeping the dog in sternal recumbency /standing position. Constriction of pupil in directly stimulated eye indicates normal pupillary light reflex. Among the 54 dogs in the present study, Pupillary light reflex was normal in both the eyes and all the dogs tolerated the procedure without any discomfort.

4.1.4 Schirmer tear test

The Schirmer test, which measures both basal tears and reflex tear production, was the most common tear test performed in veterinary medicine. The Schirmer tear strip was bent along a preformed notch before it was removed from the package to ensure that skin oils do not interfere with the test results. The strip was placed in the medioventral to lateral third of the palpebral conjunctival fornix for one minute in all the dogs. The strip was removed from the eye, and the tear wetting was compared to a millimeter scale. In the present study, the Schirmer tear test values ranged from 17mm to 28mm in both the eyes of 54 dogs tested, which were within the normal range of the test.

4.1.5 Fluorescein dye test

All the 54 dogs were evaluated for corneal ulcers by adopting fluorescein dye test. The fluorescein strip was moistened with the sterile normal saline and placed in the palpebral fissure for one minute and the eyelids are closed to disperse the stain over the cornea, and excess stain was flushed from the eye. Persistence of fluorescein stain on cornea was considered as positive for Fluorescent dye test .There was no persistence of fluorescein stain on the cornea of both the eyes of all the 54 dogs in both the eyes examined which indicated that the dogs did not had any form of corneal ulcers .

4.1.6 Intraocular Pressure

Intraocular pressures measured by applanation tonometry (Tonopen-Appasamy Associates) in the present study yielded in satisfactory results. Instilling 0.5% Proparacaine eye drops on the cornea of both the eyes before tonometry procedure given satisfactory desensitization which was evident by calm behaviour of the dogs during procedure. The Intraocular pressure values ranged between 16 to 24 mm of Hg which were within the normal range of the test.

4.2 SELECTION OF ANIMALS

All the 54 dogs following clinical ophthalmic examination, that had normal eyes underwent oculometry by both with A mode and B mode ocular ultrasonography .To analyze the data the dogs (54) were categorized in to three groups each containing 18 dogs based on skull conformation as Dolichocephalic, Mesaticephalic and Brachycephalic Breeds.

Based on the age all the dogs (54) were categorized in to three groups each containing 18 dogs as Young age (0-9 months); Middle age (1-6 years) and Old (Above 7 years) age groups to perform oculometry.

Based on the breed and age the dogs were divided into three groups i.e., Dolichocephalic, Mesaticephalic and Brachycephalic and further divided into three groups as 0-9 months, 1-6 years and above 7 years age groups each containing six (6) dogs for interpretation.

4.3 EQUIPMENT

A-SCAN machine with pencil sized transducer of 10MHz frequency used in this study was easy to operate and the measurements appeared as spikes with display of preprogrammed ready to use values for interpretation.

B- Scan ultrasonography was done by using Prosound α6LT model ultrasound machine, (Aloka Hitachi India private limited, New Delhi-11003) with 5-13MHz frequency linear transducer which provided quality images and access for measurements from the saved data.

4.4 TRANSCORNEAL OCULAR ULTRASONOGRAPHY

4.4.1 A-Mode ocular ultrasonography

A Preliminary study was conducted on both the eyes of six dogs using Transcorneal technique. Physical restraint of the dogs in the sternal or dorsal recumbency without sedation or general anaesthesia allowed the sonographer to perform the ultrasonography without any discomfort to the dogs under study. The corneal anaesthesia was achieved by instilling 0.5% Proparacaine hydrochloride eye drops on the cornea of the eye to be examined. The results of ocular components visibility by contact method and immersion method of A and B scan were depicted in Table No: 1

4.4.1.1 Direct contact method

In the contact method, the pencil sized transducer was tapped directly on the cornea of both the eyes of 54 dogs without causing much pressure on cornea after instilling 0.5% Proparacaine hydrochloride eye drops whichwere positioned in sternal recumbency. The transducer was placed on the centre of cornea as it results in alignment of appropriate points of the visual axis along the ultrasonic beam to attain accurate ultrasonic values. In A-Scan, the direct contact method resulted in an image of spikes that do not have an appreciable cornea while anterior chamber, lens, vitreous chamber and retina were highly appreciable (Fig 44).

4.4.1.2 Immersion method

In immersion method, the transducer fixed in the sclera cup was placed on the cornea of both the eyes of 54 dogs in the dorsal recumbency and the cup was infused with normal saline. The intraocular readings and the spikes were displayed on the screen. Five accepted readings were taken and their averages were recorded.The immersion technique resulted in an image that had a highly appreciable cornea and anterior chamber when compared to contact method (Fig 45).

4.4.2 B-Mode ocular ultrasonography

A preliminary study was conducted on six dogs for both contact and immersion methods. The linear transducer was gently placed over the cornea directly after opening the

Table No 1: Visualization of intraocular structures by different techniques in transcorneal ultrasonography

Anatomical Parts	A-SCAN		B-SCAN	
	Contact	**Immersion**	**Contact**	**Immersion**
Cornea	-	++	-	++
Anterior chamber depth	+	++	+	++
Lens thickness	++	+	++	+
Vitreous chamber depth	++	+	++	+
Sclero-retinal rim	++	+	++	+

(-) not appreciable (+) appreciable (++) highly appreciable

Eye lids with probe head towards the medial canthus of the eye and the globe was imaged in the horizontal and vertical planes. Care was taken not to exert pressure over the cornea and sclera with the transducer while performing ultrasonography. All the scanning images were stored in the ultrasound machine for further investigation and the clear and best images were selected and analyzed.

4.4.2.1 Direct contact technique

In B-Scan, the contact technique resulted in an image that do not have appreciable cornea, have fairly appreciable anterior chamber, lens and highly appreciable vitreous chamber and retina (Fig 46).

4.4.2.2 Immersion technique

In immersion method, the linear transducer along with transmission gel was placed on the cornea of both the eyes of 54 dogs in the sternal recumbency and the ultrasonographic image was captured by moving the transducer in horizontal and vertical plane.

The immersion technique resulted in an image that had highly appreciable cornea, anterior chamber and lens when compared to contact method while vitreous chamber and retina were fairly appreciable (Fig 47).

After the ultrasonographic procedure in all the methods the eyes were cleaned gently using cotton wetted with sterile 0.9% sodium chloride solution to remove the excess coupling gel. None of the dogs under study showed any lesions due to scanning procedure.

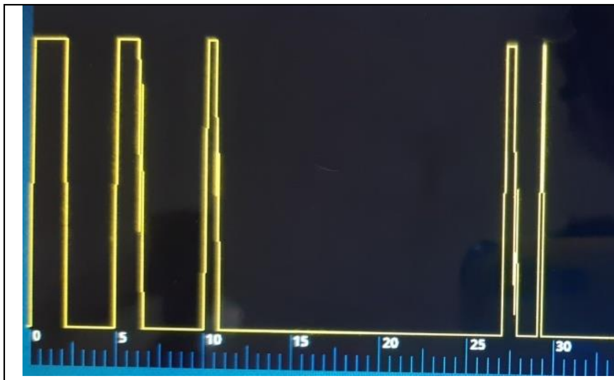


Fig. 44Image of ocular components in contact method of A-Scan

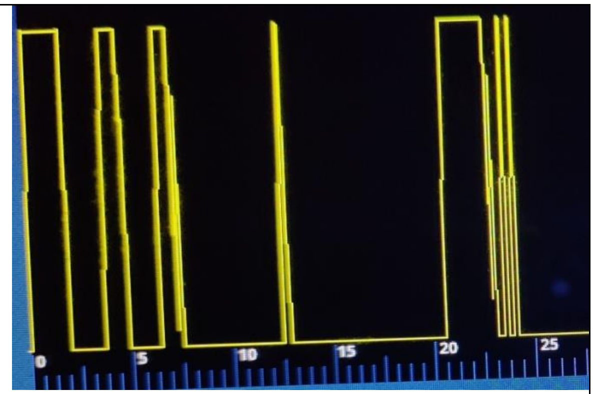


Fig. 45Image of ocular components in immersion method of A-Scan

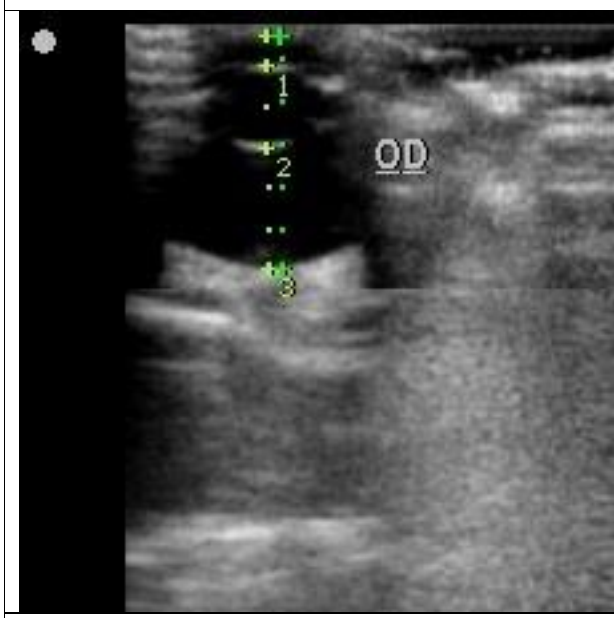


Fig. 46Image of ocular components in contact method of B-Scan

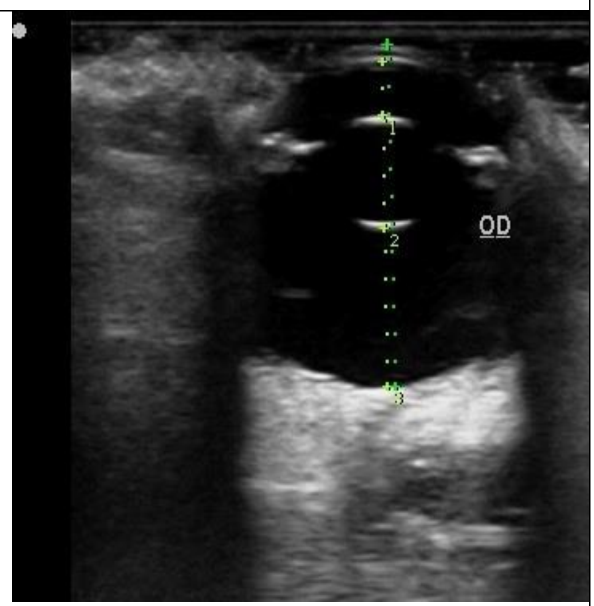


Fig. 47Image of ocular components in immersion method of B-Scan

4.5 APPEARANCE

4.5.1 A-Scan

In A-Scan, both the eyes in 54 dogs revealed four spikes which denotes Cornea, Anterior lens capsule, posterior lens capsule and Sclero- retinal rim. The space between the corneal spike and anterior lens capsule spike was anterior chamber depth, space between the anterior lens capsule spike and the posterior lens capsule spike was lens thickness while the space between the posterior lens capsule spike and retina was vitreous chamber depth.

The first spike, which is always the tallest, represents where the probe interface meets the cornea. There are then two spikes separated by a short distance, representing the anterior and posterior lens capsule. After these spikes, there is usually a flat line representing the vitreous chamber. Distal to the flat vitreous region, a series of spikes that progressively decrease in amplitude are normally seen. These represent the retina, sclera, and orbital tissues such as fat, in order.

4.5.2 B-Scan

On B-Scan imaging of the both the eyes in 54 dog, cornea was visualized as a three thin distinct layers near the contact area of transducer where the anterior and posterior corneal surfaces were parallel and hyperechoic and the middle layer was anechoic. The anterior chamber, lens nucleus and vitreous chamber appeared anechoic while the anterior and posterior lens capsules appeared as convex and concave hyperechoic lines respectively. The posterior pole of eye which includes retina, choroid and sclera appeared as concave hyperechoic structure.

4.6 OCULAR MESUREMENTS

The ocular measurements in all the 54 dogs were recorded by both A and B scan procedures and the reference range was arrived with the data obtained from the study as follows.

Following A mode oculometry, the mean ± SE values of anterior chamber depth, lens thickness, vitreous chamber depth and Globe axial length of right and left eyes in 54 dogs were 3.03 ±0.10 and 3.10±0.14; 2.62±0.21 and 2.32±0.22; 14.83±0.33 and 14.96±0.31 and 20.48±0.22 and 20.49±0.22 , respectively.

The mean ± SE values of anterior chamber depth, lens thickness, vitreous chamber depth and Globe axial length of right and left eyes in 54 dogs were 2.92±0.08 and 2.84±0.09; 6.87±0.08 and 6.84±0.09; 8.84±0.09 and 8.86±0.08 and 19.60±0.25 and 19.52±0.26, respectively on B mode oculometry.

The above data clearly showed that the anterior chamber depth values were higher in A mode when compared to the B mode. The lens thickness values recorded were higher in B mode when compared to A mode. The vitreous chamber depth and Globe axial length values were higher in A mode when compared to B mode values.

4.6.1 RIGHT vs LEFT EYE

The ACD, LT, VCD and GAL measurementson A scan of Dolichocephalic, mesaticephalic and brachycephalic breeds did not differ significantly among the right and left eyes in all the age groups. However globe axial length in dolichocephalic breed, anterior chamber depth in mesaticephalic breed and lens thickness in brachycephalic breed of 1-6 years and lens thickness in brachycephalic of above 7 years differed significantly between right and left eyes.

The ACD, LT, VCD and GAL measurements on B scan of Dolichocephalic, mesaticephalic and brachycephalic breeds did not differ significantly among the right and left eyes in all the age groups. However the globe axial length in brachycephalic breed of above 7 years differed significantly between right and left eyes (Table No 2).

4.6.2 Skull Conformation

In all the 54 dogs the ocular measurements were recorded by both A and B scan procedures (Fig 48 to 65) and the measurements as per the skull type were shown in Table No: 4 and 5.

4.6.2.1 Anterior Chamber Depth (mm)

The mean ± SE values of anterior chamber depth on A scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs were 2.87±0.15 and 3.13±0.28; 3.02±0.22 and 3.13±0.28 and 3.19±0.16 and 3.04±0.28, respectively while the values were 2.77±0.13 and 2.75±0.14; 3.15±0.16 and 3.05±0.16 and 2.84±0.14 and 2.72±0.15 on B scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs, respectively.

Table 2: A-scan Ocular measurements of right and left eyes of different age in dogs (N=54)

Age	Breed	Anterior chamber depth		Lens thickness		Vitreous chamber depth		Globe axial length	
		T value	P value	T value	P value	T value	P value	T value	P value
0-9 months	Dolichocephalic	-1.56	0.18	1.58	0.17	2.05	0.09	2.47	0.06
	Mesaticephalic	1.13	0.31	-1.18	0.29	2.18	0.08	1.75	0.14
	Brachycephalic	0.47	0.65	-1.25	0.27	1.12	0.31	0.92	0.40
1-6 years	Dolichocephalic	-0.77	0.48	1.19	0.29	-0.42	0.69	0.39	0.71
	Mesaticephalic	0.04	0.97	-0.11	0.92	-1.04	0.34	-0.63	0.55
	Brachycephalic	-0.78	0.47	1.22	0.27	-0.95	0.38	0.07	0.94
>7 years	Dolichocephalic	0.63	0.56	0.95	0.39	-1.22	0.28	0.79	0.47
	Mesaticephalic	-0.89	0.41	0.976	0.37	0.84	0.44	-1.27	0.26
	Brachycephalic	0.99	0.37	-0.39	0.72	-1.25	0.26	-3.05*	0.03

** Highly significant at 0.01% level of significance(P<0.01)

* Significant at 0.05% level of significance(P<0.05)

Table 3: B-scan Ocular measurements of right and left eyes of different age in dogs (N=54)

Age	Breed	Anterior chamber depth		Lens thickness		Vitreous chamber depth		Globe axial length	
		T value	P value	T value	P value	T value	P value	T value	P value
0-9 months	Dolichocephalic	-1.00	0.36	1.40	0.22	-1.000	0.36	1.00	0.36
	Mesaticephalic	1.51	0.19	1.05	0.34	-0.113	0.91	1.38	0.23
	Brachycephalic	1.66	0.16	1.08	0.33	0.226	0.83	1.11	0.32
1-6 years	Dolichocephalic	0.41	0.69	0.00	1.00	-1.464	0.20	-3.08*	0.03
	Mesaticephalic	7.00**	0.00	-1.39	0.22	1.464	0.20	0.59	0.58
	Brachycephalic	2.48	0.06	-3.37*	0.02	1.512	0.19	1.52	0.19
>7 years	Dolichocephalic	0.91	0.40	0.00	1.00	1.000	0.36	1.46	0.20
	Mesaticephalic	0.58	0.59	-2.08	0.09	0.415	0.69	1.60	0.17
	Brachycephalic	0.50	0.64	2.80*	0.04	-1.718	0.15	-0.96	0.38

** Highly significant at 0.01% level of significance($P<0.01$)

* Significant at 0.05% level of significance($P<0.05$)

4.6.2.2 Lens Thickness (mm)

The mean ± SE values of Lens thickness on A scan of right and left eyesin dolichocephalic, mesaticephalic and brachycephalic breed of dogs were 2.41±0.30 and 1.60±0.26; 2.99±0.41 and 2.92±0.42 and 2.36±0.37 and 2.44±0.39, respectively while the values were 7.02±0.94 and 6.94±0.11; 6.89±0.19 and 6.91±0.24 and 6.71±0.13 and 6.68±0.14 on B scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs, respectively.

There was a non-significant difference among the lens thickness, between the dogs with different skull conformation however the lens thickness of dolichocephalic breed of left eye was significantly different from lens thickness of mesaticephalic breed ($P<0.05$) on A scan. On B scan there was no significant difference among the lens thickness between the dogs with different skull conformation however the lens thickness of dolichocephalic breed was more when compared to other two skull type breeds of dogs.

4.6.2.3 Vitreous Chamber Depth (mm)

The mean ± SE values of Vitreous chamber depth on A scan of right and left eyes indolichocephalic, mesaticephalic and brachycephalic breed of dogs were 15.38±0.39 and 15.64±0.29; 14.55±0.72 and 14.58±0.67 and 14.55±0.55 and 14.66±0.59, respectively while the values were 8.74±0.14 and 8.03±0.13; 8.93±0.14 and 8.88±0.13 and 8.85±0.18 and 8.88±0.17 on B scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs, respectively.

The vitreous chamber depth was more in the dolichocephalic skull breeds when compared to other two skulls however the values are non-significant whereas on B scan the vitreous chamber depth was more in the mesaticephalic skull breeds when compared to other two skull type breeds however the values are non-significant.

4.6.2.4 Globe axial length (mm)

The mean ± SE values of globe axial length on A scan of right and left eyes indolichocephalic, mesaticephalic and brachycephalic breed of dogs were 20.75±0.26 and 20.45±0.22; 20.53±0.54 and 20.72±0.51 and 20.16±0.29 and 20.30±0.36, respectively while the values were 19.44±0.32 and 19.47±0.33; 19.87±0.55 and 19.67±0.58 and 19.49±0.41 and 19.41±0.44 on B scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs, respectively.

The globe axial length was more in the dolichocephalic skull breeds when compared to other two skull type dogs however the values are non-significant whereas on B scan the globe axial length was more in the mesaticephalic skull breeds when compared to other two skull type breeds however the values are non-significant.

In general ocular measurements in A scan revealed higher values of vitroues chamber depth and globe axial length in Dolichocephalic breeds when compared to the other two groups and the values are non-significant.

TABLE 4: Mean±SE (mm) measurements of A-Scan ocular parameters in dogs with different Skulls (N= 18)

Breed	Anterior Chamber Depth		Lens thickness		Vitreous Chamber Depth		Globe Axial Length	
	OD	OS	OD	OS	OD	OS	OD	OS
Dolichocephalic	2.87±0.15	3.13±0.28	2.41±0.30	1.60±0.26[b]	15.38±0.39	15.64±0.29	20.75±0.26	20.45±0.22
Mesaticephalic	3.02±0.22	3.13±0.18	2.99±0.41	2.92±0.42[a]	14.55±0.72	14.58±0.67	20.53±0.54	20.72±0.51
Brachycephalic	3.19±0.16	3.04±0.28	2.36±0.37	2.44±0.39[ab]	14.55±0.55	14.66±0.59	20.16±0.29	20.30±0.36
F value	0.85	0.042	0.914	3.321*	0..692	1.157	0.612	0.296
P value	0.435	0.959	0.407	0.044	0.505	0.323	0.546	0.745

* Significant at 0.05% level of significance(P<0.05)

Superscripts with different alphabets are significantly different.

OD – RIGHT OS - LEFT

TABLE 05: Mean±SE (mm) measurements of B-Scan ocular parameters in dogs with different Skulls (N= 18)

Breed	Anterior Chamber Depth		Lens thickness		Vitreous Chamber Depth		Globe Axial Length	
	OD	OS	OD	OS	OD	OS	OD	OS
Dolichocephalic	2.77±0.13	2.75±0.14	7.02±0.94	6.94±0.11	8.74±0.14	8.03±0.13	19.44±0.32	19.47±0.33
Mesaticephalic	3.15±0.16	3.05±0.16	6.89±0.19	6.91±0.24	8.93±0.14	8.88±0.13	19.87±0.55	19.67±0.58
Brachycephalic	2.84±0.14	2.72±0.15	6.71±0.13	6.68±0.14	8.85±0.18	8.88±0.17	19.49±0.41	19.41±0.44
F value	2.01	1.40	1.13	0.66	0.36	0.04	0.28	0.09
P value	0.145	0.255	0.332	0.52	0.697	0.958	0.75	0.916

** Highly significant at 0.01% level of significance(P<0.01)
* Significant at 0.05% level of significance(P<0.05)
Superscripts with different alphabets are significantly different.
OD – RIGHT OS - LEFT

4.6.3 AGE

In all the 54 dogs the ocular measurements were recorded by both A and B scan procedures and the measurements as per the age were shown in Table No: 6 and 7.

4.6.3.1 Anterior chamber depth (mm)

The mean ± SE values of anterior chamber depth on A scan of right and left eyes in 0-9 Months, 1-6 Years and above 7 Years were 2.60±0.09 and 2.71±0.24; 3.17±0.16 and 3.39±0.16 and 3.32±0.22 and 3.19±0.30 where as the values were 2.45±0.13 and 2.38±0.14; 3.14±0.11 and 3.02±0.12 and 3.18±0.12 and 3.12±0.14 in 0-9 Months, 1-6 Years and above 7 Years age group on B scan, respectively.

The anterior chamber depth was less in 0-9 aged dogs when compared to the other two age group dogs, the difference was significant in right eye ($P<0.05$) on A scan. On B scan the anterior chamber depth was less in 0-9 aged dogs when compared to the other two aged dogs, the difference was highly significant ($P<0.01$).

4.6.3.2 Lens thickness (mm)

The mean±SE value for lens thickness of right and left eyes of age groups 0-9 Months, 1-6 Years and above 7 Years were 3.28±0.36 and 3.21±0.39; 2.35±0.35 and 1.96±0.38 and 2.14±0.34 and 1.79±0.29 where as the values were 6.46±0.18 and 6.30±0.22; 6.94±0.08 and 7.05±0.08 and 7.21±0.08 and 7.18±0.09 in 0-9 Months, 1-6 Years and above 7 Years age group on B scan, respectively.

The lens thickness was more in 0-9 months aged dogs when compared to 1-6 and above 7 years aged dogs and the difference was significant ($P<0.05$) in the left eye compared to the other two age groups. On B scan, the lens thickness was more in above 7 years aged dogs followed by 1-6 years and 0-9 months aged dogs and the difference was highly significant (P<0.01) in 0-9 months when compared to the other two age groups however the difference was non-significant between 1-6 and above 7 age group dogs.

4.6.3.3 Vitreous chamber depth (mm)

The mean± SE values for vitreous chamber depth of right and left eyes of age groups 0-9 Months, 1-6 Years and above 7 Years were 12.98±0.58 and 12.84±0.59; 15.15±0.49 and 15.38±0.32 and 16.37±0.28 and 16.67±0.19 whereas the values were 8.33±0.14 and 8.38±0.15; 9.00±0.12 and 8.94±0.10 and 9.20±0.11 and 9.27±0.08 in 0-9 Months, 1-6 Years and above 7 Years age group on B scan, respectively.

On A scan, the vitreous chamber depth, was more in above 7 years aged dogs followed by 1-6 years and 0-9 months aged dogs and the difference was highly significant (P<0.01) among all the age groups. On B scan, the vitreous chamber depth was more in above 7 years aged dogs followed by 1-6 years and 0-9 months aged dogs and the difference was highly significant (P<0.01) in 0-9 months when compared to the other two age groups however the difference was non-significant between 1-6 and above 7 age group dogs.

4.6.3.4 Globe axial length

The mean± SE values (mm) for globe axial length of right and left eyes of age groups 0-9 Months, 1-6 Years and above 7 Years were 19.10±0.31 and 18.88±0.27; 20.84±0.37 and 20.88±0.29 and 21.50±0.18 and 21.71±0.25 whereas the values were 17.92±0.44 and 17.77±0.46, 20.13±0.23 and 20.10±0.25 and 20.76±0.27 and 20.68±0.28 in 0-9 Months, 1-6 Years and above 7 Years age group on B scan, respectively.

TABLE 06: Mean±SE (mm) measurements of A-Scan ocular parameters in dogs with different Age (N= 18)

Age	Anterior Chamber Depth		Lens thickness		Vitreous Chamber Depth		Globe Axial Length	
	OD	OS	OD	OS	OD	OS	OD	OS
0-9 Months	2.60±0.09[b]	2.71±0.24	3.28±0.36	3.21±0.39[a]	12.98±0.58[b]	12.84±0.59[c]	19.10±0.31[b]	18.88±0.27[c]
1-6 Years	3.17±0.16[a]	3.39±0.16	2.35±0.35	1.96±0.38[b]	15.15±0.49[a]	15.38±0.32[b]	20.84±0.37[a]	20.88±0.29[b]
>7 years	3.32±0.22[a]	3.19±0.30	2.14±0.34	1.79±0.29[b]	16.37±0.28[a]	16.67±0.19[a]	21.50±0.18[a]	21.71±0.25[a]
F value	5.15**	2.13	2.96	4.65*	13.29**	23.46**	16.86**	28.24**
P value	0.009	0.129	0.061	0.014	0.000	0.000	0.000	0.000

** Highly significant at 0.01% level of significance(P<0.01)
* Significant at 0.05% level of significance(P<0.05)
Superscripts with different alphabets are significantly different.
OD – RIGHT OS - LEFT

TABLE 07: Mean±SE (mm) measurements of B-Scan ocular parameters in dogs with different Age (N= 18)

	Anterior Chamber Depth		Lens thickness		Vitreous Chamber Depth		Globe Axial Length	
	OD	**OS**	**OD**	**OS**	**OD**	**OS**	**OD**	**OS**
0-9 Months	2.45±0.13[b]	2.38±0.14[b]	6.46±0.18[b]	6.30±0.22[b]	8.33±0.14[b]	8.38±0.15[b]	17.92±0.44[b]	17.77±0.46[b]
1-6 Years	3.14±0.11[a]	3.02±0.12[a]	6.94±0.08[a]	7.05±0.08[a]	9.00±0.12[a]	8.94±0.10[a]	20.13±0.23[a]	20.10±0.25[a]
>7 years	3.18±0.12[a]	3.12±0.14[a]	7.21±0.08[a]	7.18±0.09[a]	9.20±0.11[a]	9.27±0.08[a]	20.76±0.27[a]	20.68±0.28[a]
F value	10.86**	8.55**	8.94**	10.37**	12.42**	14.71**	20.49**	19.79**
P value	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000

** Highly significant at 0.01% level of significance (P<0.01)
 * Significant at 0.05% level of significance (P<0.05)
Superscripts with different alphabets are significantly different.
OD – RIGHT OS - LEFT

On A scan, the, globe axial length was more in above 7 years aged dogs followed by 1-6 years and 0-9 months aged dogs and the difference was highly significant (P<0.01) among all the age groups . On B scan, the globe axial length, lens thickness was more in above 7 years aged dogs followed by 1-6 years and 0-9 months aged dogs and the difference was highly significant (P<0.01) in 0-9 months when compared to the other two age groups however the difference was non-significant between 1-6 and above 7 age group dogs.

4.6.4 BREED AND AGE

In all the 54 dogs, the ocular measurements were recorded by both A and B mode oculometry and the values were shown in table no 8 and 9.

4.6.4.1 ANTERIOR CHAMBER DEPTH (mm)

4.6.4.1.1 O-9 months age

The mean ± SE values of anterior chamber depth on A scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs between O-9 months age were 2.47±0.03 and ,3.18±0.48; 2.53±0.19 and 2.33±0.06 and 2.80±0.21 and 2.63±0.53, respectively.

The mean ± SE values of anterior chamber depth on B scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs between 0-9 months age were 2.52±0.25 and 2.55±0.28; 2.48±0.19 and 2.35±0.14 and 2.37±0.28 and 2.25±0.31, respectively.

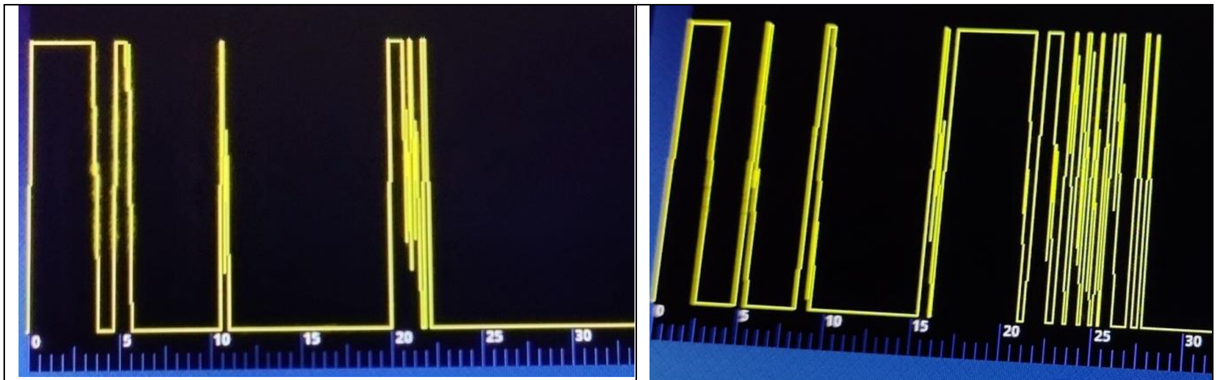


Fig No: 48 Photograph showing A-Mode Oculometric observations of right (OD) and Left (OS) eye in a three month old Great Dane (Dolichocephalic breed).

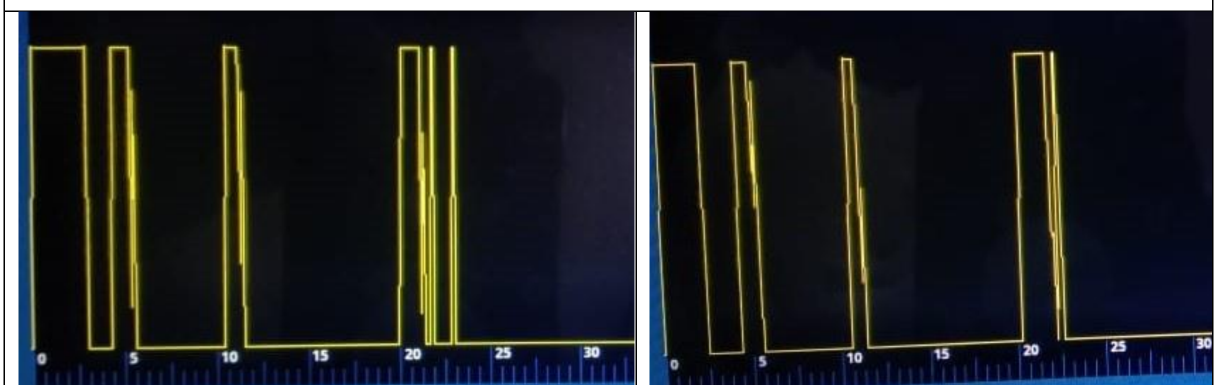


Fig No: 49 Photograph showing A-Mode Oculometric observations of right (OD) and Left (OS) eye in a one year old Doberman (Dolichocephalic breed).

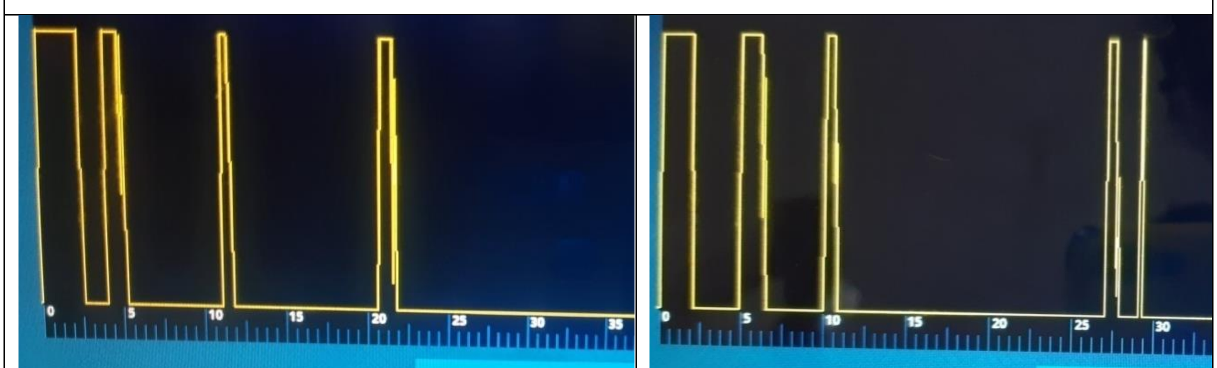


Fig No :50 Photograph showing A-Mode Oculometric observations of right (OD) and Left (OS) eye in a eight year old Dachshund (Dolichocephalic breed).

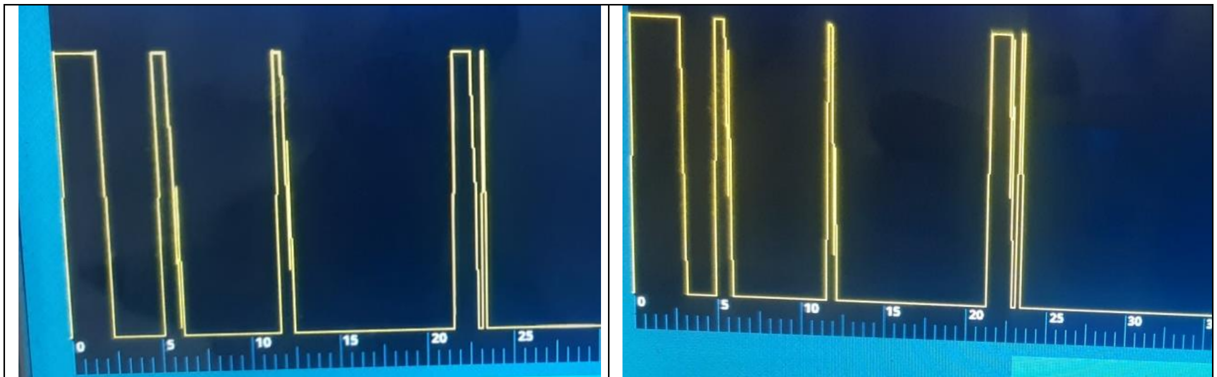


Fig No :51 Photograph showing A-Mode Oculometric observations of right (OD) and Left (OS) eye in a five month old Labrador (Mesaticephalic breed).

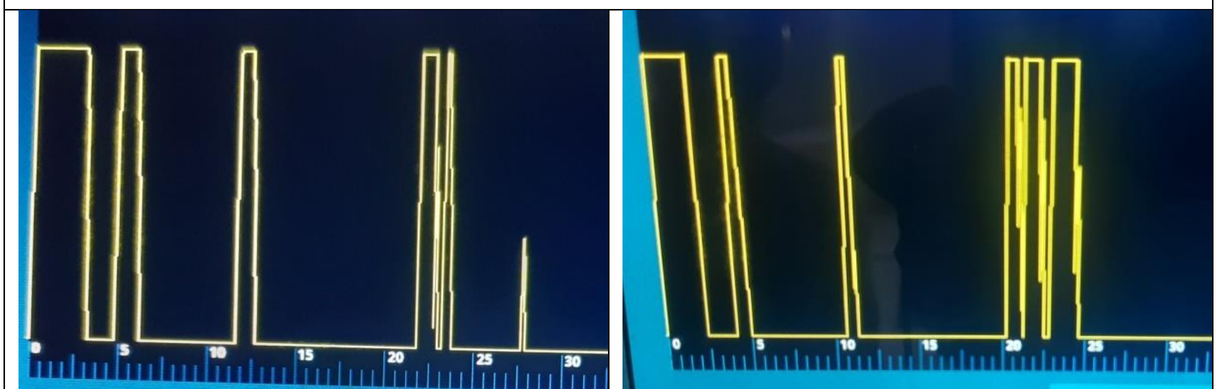


Fig No :52 Photograph showing A-Mode Oculometric observations of right (OD) and Left (OS) eye in a one year old Labrador (Mesaticephalic breed).

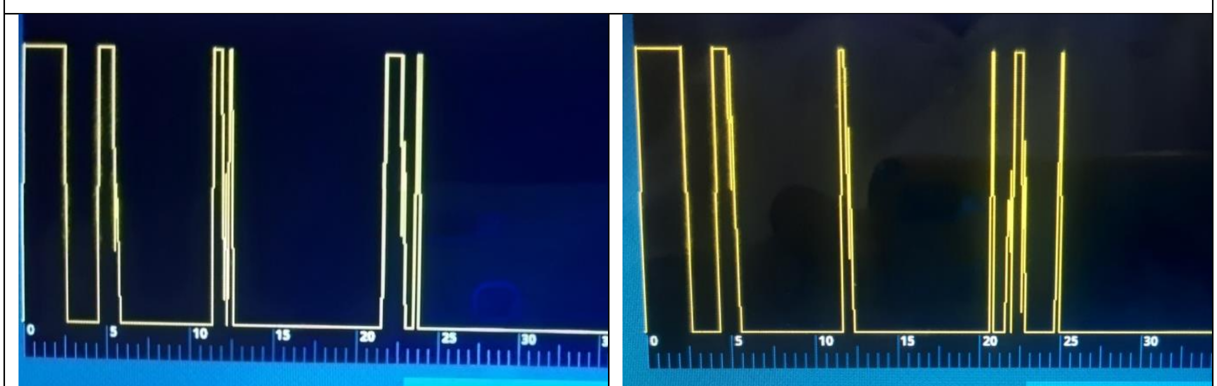


Fig No: 53 Photograph showing A-Mode Oculometric observations of right (OD) and Left (OS) eye in a seven year old Labrador (Mesaticephalic breed).

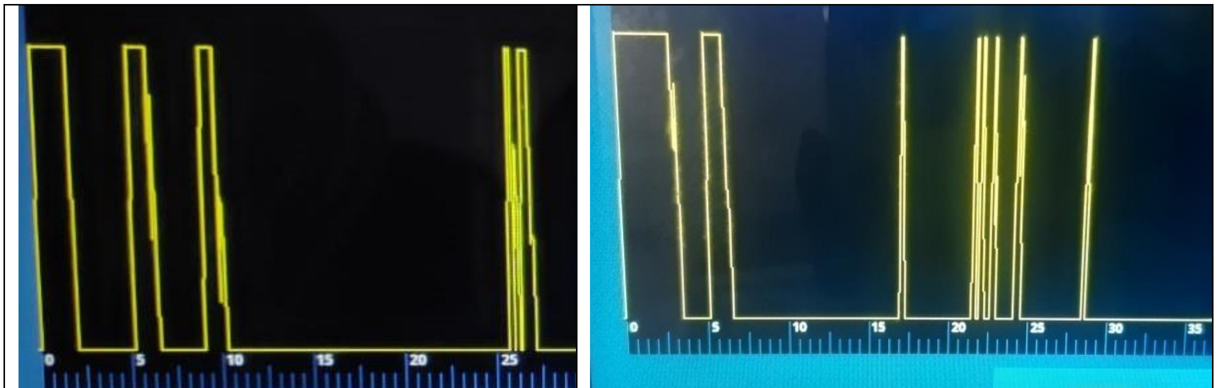


Fig No: 54 Photograph showing A-Mode Oculometric observations of right (OD) and Left (OS) eye in a Four month old Shih Tzu (Brachycephalic breed).

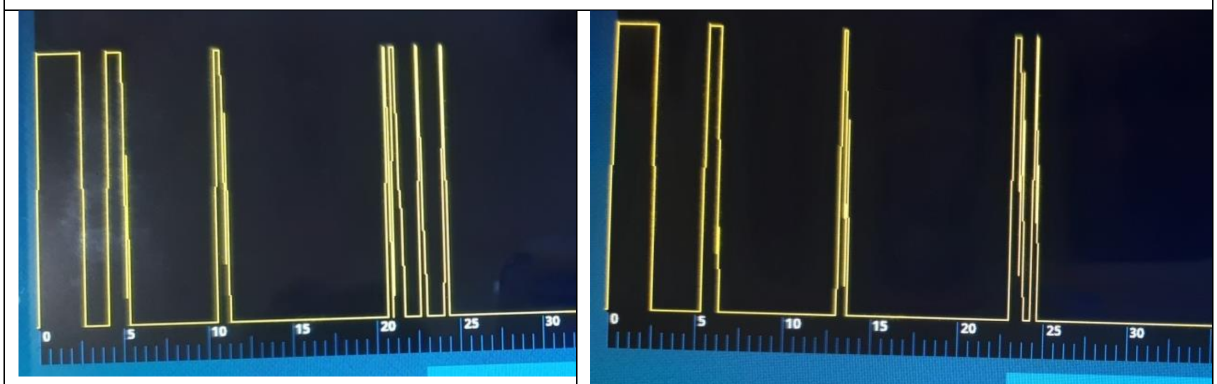
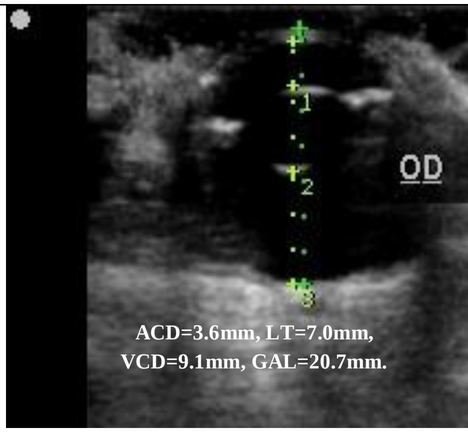


Fig No: 55 Photograph showing A-Mode Oculometric observations of right (OD) and Left (OS) eye in a Two year old Shih Tzu (Brachycephalic breed).

Fig No: 56 Photograph showing A-Mode Oculometric observations of right (OD) and Left (OS) eye in a seven year old pug (Brachycephalic breed).



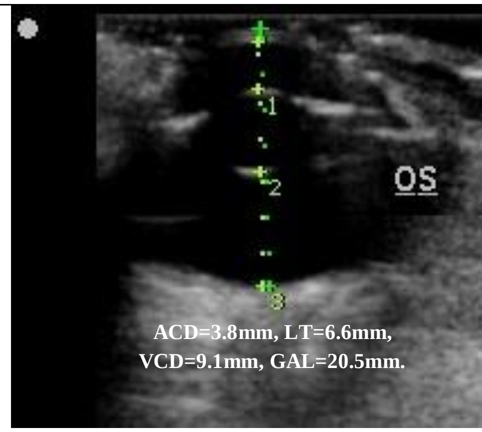
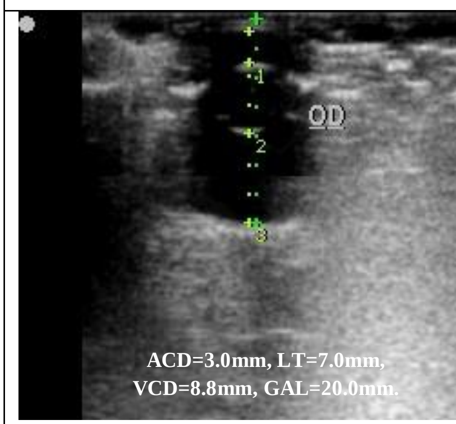


Fig No: 57 Photograph showing B-Mode Oculometric observations of right (OD) and Left (OS) eye in a Nine month old Doberman (Dolichocephalic breed).



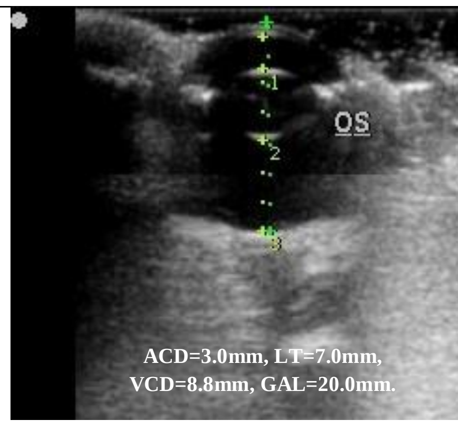
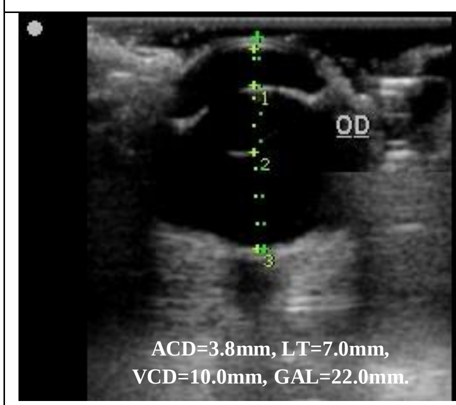


Fig No: 58 Photograph showing B-Mode Oculometric observations of right (OD) and Left (OS) eye in a Five Year old Dachshund (Dolichocephalic breed).



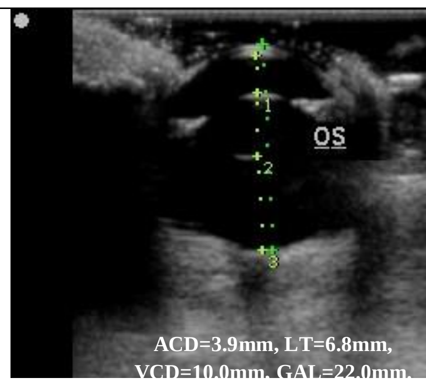
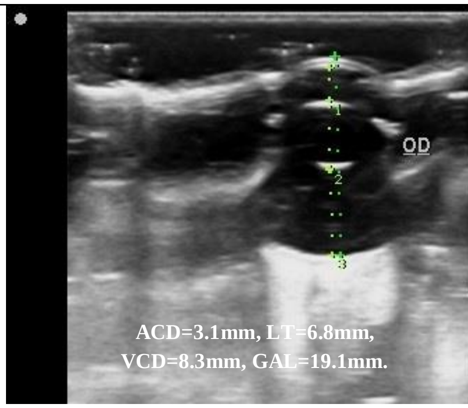


Fig No: 59 Photograph showing B-Mode Oculometric observations of right (OD) and Left (OS) eye in an Eight Year old Doberman (Dolichocephalic breed).



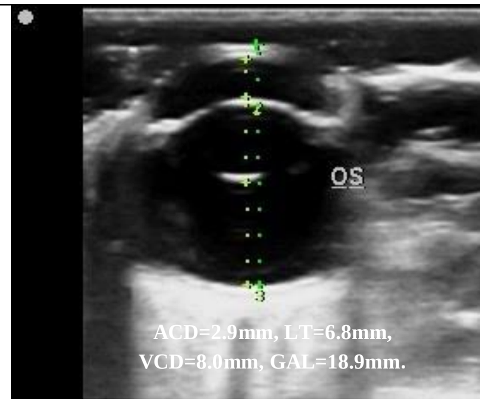
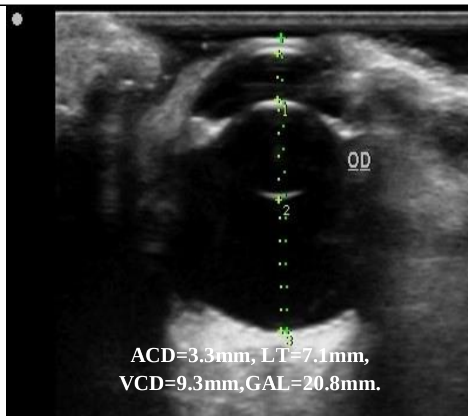


Fig No: 60 Photograph showing B-Mode Oculometric observations of right (OD) and Left (OS) eye in a Five month old Labrador (Mesaticephalic breed).



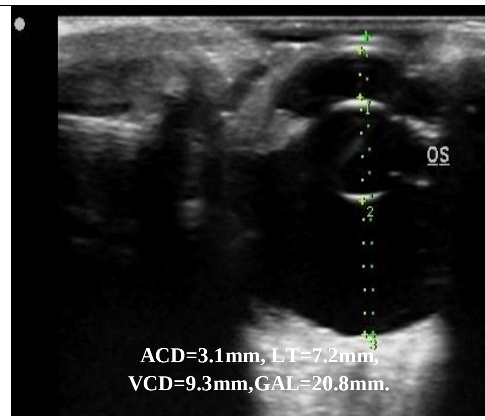
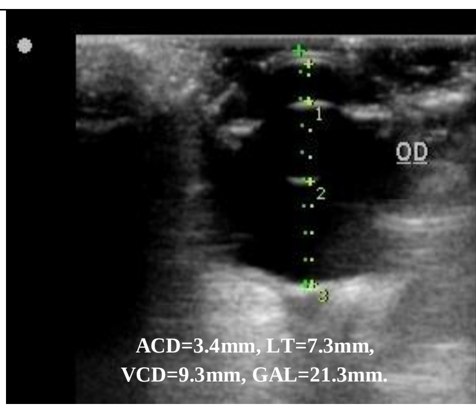


Fig No: 61 Photograph showing B-Mode Oculometric observations of right (OD) and Left (OS) eye in a One year old Labrador (Mesaticephalic breed).



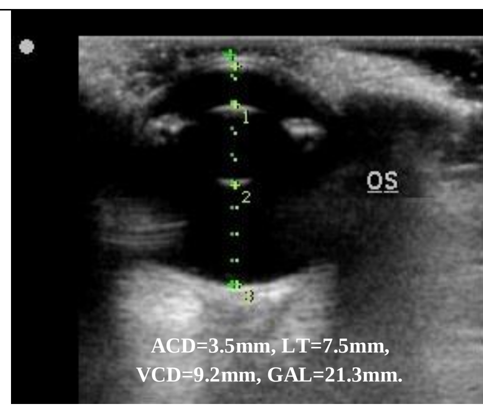


Fig No: 62 Photograph showing B-Mode Oculometric observations of right (OD) and Left (OS) eye in a Seven year old Labrador (Mesaticephalic breed).

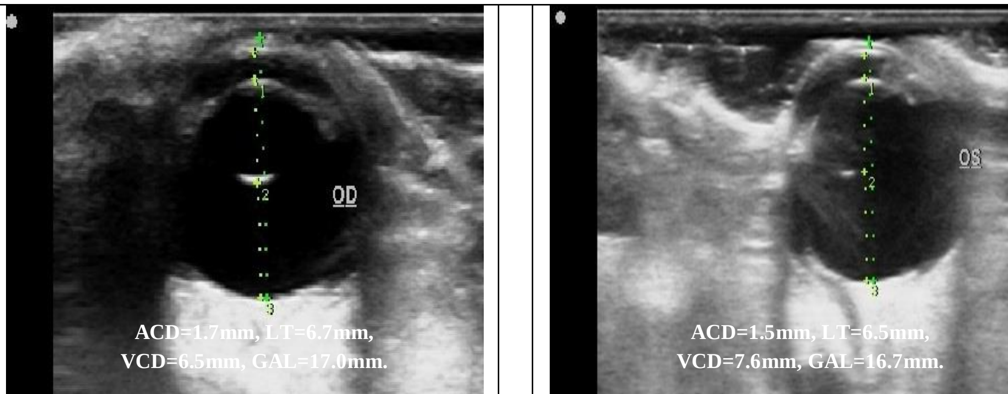


Fig No: 63 Photograph showing B-Mode Oculometric observations of right (OD) and Left (OS) eye in a Four month old Shih Tzu (Brachycephalic breed).

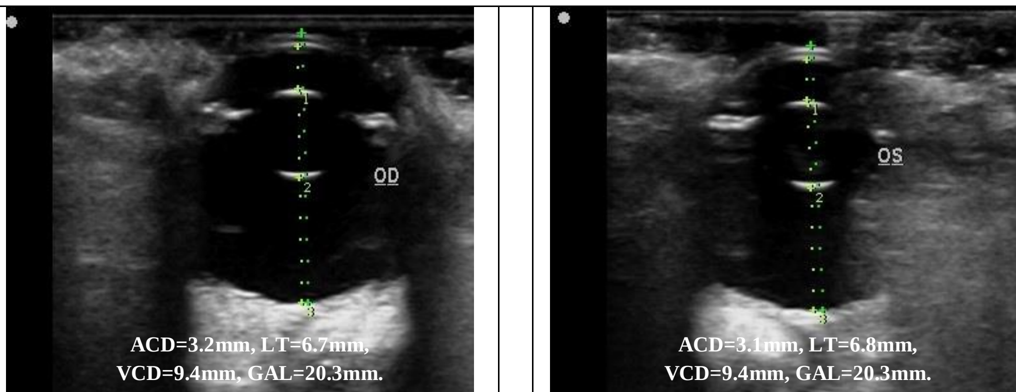


Fig No: 64 Photograph showing B-Mode Oculometric observations of right (OD) and Left (OS) eye in a Two Year old Shih Tzu (Brachycephalic breed).

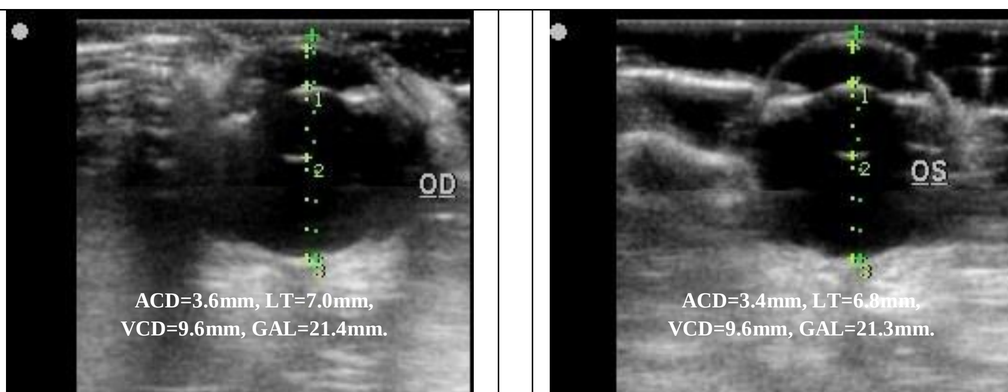


Fig No: 65 Photograph showing B-Mode Oculometric observations of right (OD) and Left (OS) eye in a Seven Year old Pug (Brachycephalic breed).

4.6.4.1.2 1-6 Years age

The mean ± SE values of anterior chamber depth on A scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs between 1-6 years age were 3.09±0.33 and 3.57±0.39; 3.29±0.29 and 3.28±0.18 and 3.12±0.23 and 3.34±0.24, respectively.

The mean ± SE values of anterior chamber depth on B scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs between 1-6 years age were 3.02±0.17 and 3.00±0.16; 3.45±0.23 and 3.33±0.22 and 2.95±0.16 and 2.73±0.21, respectively.

4.6.4.1.3 Above 7 years age

The mean ± SE values of anterior chamber depth on A scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs in above 7 years age were 3.04±0.28 and 2.63±0.55; 3.23±0.54 and 3.79±0.29 and 3.68±0.29 and 3.15±0.64, respectively.

The mean ± SE values of anterior chamber depth on B scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs in above 7 years age were 2.80±0.21 and 2.70±0.27; 3.53±0.18 and 3.47±0.25 and 3.22±0.14 and 3.18±0.12, respectively.

Among age groups of all breeds the right eye anterior chamber depth showed significant difference at 0-9 month’s age when compared to other two age groups. However the values showed non-significant difference among breeds at any age on A scan.

Among age groups of all breeds the right eye anterior chamber depth showed highly significant difference ($P<0.01$) at 0-9 months age when compared to other two age groups. However the values showed non-significant difference among breeds at any age on A scan.

Among age groups of all breeds the right and left eye anterior chamber depth showed highly significant difference ($P<0.01$) at 0-9 months age when compared to other two age groups. However the values showed non-significant difference among breeds at any age on B scan.

4.6.4.2 LENS THICKNESS (mm)

4.6.4.2.1 O-9 month's age

The mean ± SE values of lens thickness on A scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs between O-9 months age were 2.58±0.12 and 1.72±0.43; 3.53±0.75 and 3.80±0.64 and 3.71±0.78 and 4.11±0.57, respectively.

The mean ± SE values of lens thickness depth on B scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs between 0-9 months age were 6.97±0.20 and 6.73±0.26; 6.02±0.33 and 5.83±0.49 and 6.40±0.33 and 6.33±0.37, respectively.

4.6.4.2.2 1-6 years age

The mean ± SE values of lens thickness on A scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs between 1-6 years age were 1.93±0.60 and 1.15±0.41 and 3.33±0.74 and 3.34±0.79 and 1.79±0.25 and 1.38±0.31, respectively.

The mean ± SE values of lens thickness on B scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs between 1-6 years age were 7.08±0.14 and 7.08±0.13; 7.13±0.09 and 7.30±0.07 and 6.62±0.09 and 6.78±0.11, respectively.

4.6.4.2.3 Above 7 years age

The mean ± SE values of Lens thickness on A scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs in above 7 years age were 2.71±0.70 and 1.93±0.53; 2.11±0.60 and 1.61±0.48 and 1.69±0.55 and 1.84±0.58, respectively.

The mean ± SE values of lens thickness on B scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs in above 7 years age were 7.00±0.17 and 7.00±0.14; 7.52±0.09 and 7.60±0.08 and 7.12±0.08 and 6.93±0.06, respectively.

Among age groups of all breeds the left eye lens thickness showed highly significant difference (P<0.01) at 0-9 months age when compared to other two age groups. However the values showed non-significant difference among breeds at any age on A scan.

Among age groups of all breeds the right and left eye lens thickness showed highly significant difference (P<0.01) at 0-9 months age when compared to other two age groups. However the values showed non-significant difference among breeds at any age on B scan.

4.6.4.3 Vitreous chamber depth (mm)

4.6.4.3.1 O-9 months age

The mean ± SE values of Vitreous chamber depthon A scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs between O-9 months age were 15.12±0.22 and 15.01±0.25; 12.08±1.22 and 11.95±1.20 and 11.74±0.73 and 11.56±0.77, respectively

The mean ± SE values of Vitreous chamber depth on B scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs between 0-9 months age were 8.42±0.20 and 8.58±0.20; 8.33±0.22 and 8.35±0.19 and 8.23±0.35 and 8.20±0.38, respectively.

4.6.4.3.2 1-6 years age

The mean ± SE values of Vitreous chamber depth on A scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs between 1-6 years age were 15.25±0.99 and 15.43±0.58; 14.49±1.15 and 14.90±0.78 and 15.67±0.28 and 15.79±0.19, respectively.

The mean ± SE values of Vitreous chamber depth on B scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs between 1-6 years age were 8.63±0.26 and 8.73±0.26; 9.05±0.18 and 8.90±0.13 and 9.32±0.10 and 9.18±0.09, respectively.

4.6.4.3.3 Above 7 years age

The mean ± SE values of Vitreous chamber depthon A scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs in above 7 years age were 15.76±0.73 and 16.46±0.49; 17.10±0.19 and 16.89±0.16 and 16.24±0.21 and 16.64±0.27, respectively .

The mean ± SE values of Vitreous chamber depthon B scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs in above 7 years age 9.18±0.18 and 9.17±0.18; 9.42±0.10 and 9.40±0.09 and 9.00±0.27 and 9.25±0.16, respectively.

Among age groups of all breeds the left and right eye vitreous chamberdepth showed highly significant difference ($P<0.01$) at 0-9 months age when compared to other two age groups. However the values showed non-significant difference among breeds at any age on A scan.

Among age groups of all breeds the right and left eye vitreous chamber depth showed highly significant difference ($P<0.01$) at 0-9 months age when compared to other two age groups. However the values showed non-significant difference among breeds at any age on B scan.

4.6.4.4 Globe Axial length (mm)

4.6.4.4 .1 O-9 months age

The mean ± SE values of Globe axial length on A scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs between O-9 months age were 20.33±0.33 and 19.89±0.16; 18.25±0.47 and 18.20±0.45 and 18.73±0.42 and 18.56±0.45, respectively.

The mean ± SE values of Globe axial length on B scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs between 0-9 months age were 18.52±0.57 and 18.48±0.55; 17.18±0.83 and 16.88±0.85 and 18.07±0.91 and 17.93±0.96, respectively.

4.6.4.4.2 1-6 years age

The mean ± SE values of Globe axial length on A scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs between 1-6 years age were 20.47±0.55 and 20.36±0.56; 21.33±1.02 and 21.59±0.65 and 20.71±0.12 and 20.69±0.14, respectively.

The mean ± SE values of Globe axial length on B scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs between 1-6 years age were 19.85±0.41 and 20.07±0.43; 20.73±0.32 and 20.70±0.32 and 19.80±0.41 and 19.55±0.48, respectively.

4.6.4.4.3 Above 7 years age

The mean ± SE values of Globe axial length on A scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dogs in above 7 years age were 21.45±0.38 and 21.09±0.49; 22.01±0.25 and 22.39±0.33 and 21.03±0.22 and 21.64±0.31, respectively .

The mean ± SE values of Globe axial length on B scan of right and left eyes in dolichocephalic, mesaticephalic and brachycephalic breed of dog in above 7 years age 19.97±0.54 and 19.87±0.59; 21.70±0.31 and 21.43±0.45 and 20.62±0.23 and 20.75±0.17, respectively.

Among age groups of all breeds the left and right eye globe axial length showed highly significant difference (P<0.01) at 0-9 months age when compared to other two age groups. However the values showed non-significant difference among breeds at any age on A scan.

Among age groups of all breeds the right and left eye globe axial length showed highly significant difference (P<0.01) at 0-9 months age when compared to other two age groups. However the values showed non-significant difference among breeds at any age on B scan.

The Anterior chamber depth measurements showed slightly higher on A scan when compared to B scan measurements indicating the role of corneal thickness inclusion while calculating the measurements in A scan as these are preprogrammed values on the other hand the measurements of anterior chamber depth in B scan are manually measured by excluding the corneal thickness.

The lens thickness measurements showed lower values on A scan when compared to B scan measurements indicating the underestimation of these values on A scan and its reliability on the other hand the measurements of lens thickness in B scan showing the normal values.

TABLE 08: Mean±SE (mm) measurements of A-Scan ocular parameters in dogs with different skull conformation and age (N=6).

Parameter	AGE	OD			OS		
		Dolichocephalic	**Mesaticephalic**	**Brachycephalic**	**Dolichocephalic**	**Mesaticephalic**	**Brachycephalic**
Anterior chamber depth	0-9 Months	2.47±0.03^{b}	2.53±0.19^{b}	2.80±0.21^{b}	3.18±0.48	2.33±0.06	2.63±0.53
	1-6 years	3.09±0.33^{a}	3.29±0.29^{a}	3.12±0.23^{a}	3.57±0.39	3.28±0.18	3.34±0.24
	7 and above	3.04±0.28^{a}	3.23±0.54^{a}	3.68±0.29^{a}	2.63±0.55	3.79±0.29	3.15±0.64
Lens thickness	0-9 Months	2.58±0.12	3.53±0.75	3.71±0.78	1.72±0.43^{a}	3.80±0.64^{a}	4.11±0.57^{a}
	1-6 years	1.93±0.60	3.33±0.74	1.79±0.25	1.15±0.41^{b}	3.34±0.79^{b}	1.38±0.31^{b}
	7 and above	2.71±0.70	2.11±0.60	1.69±0.55	1.93±0.53^{b}	1.61±0.48^{b}	1.84±0.58^{b}
Vitreous chamber depth	0-9 Months	15.12±0.22^{b}	12.08±1.22^{b}	11.74±0.73^{b}	15.01±0.25^{c}	11.95±1.20^{c}	11.56±0.77^{c}
	1-6 years	15.25±0.99^{a}	14.49±1.15^{a}	15.67±0.28^{a}	15.43±0.58^{b}	14.90±0.78^{b}	15.79±0.19^{b}
	7 and above	15.76±0.73^{a}	17.10±0.19^{a}	16.24±0.21^{a}	16.46±0.49^{a}	16.89±0.16^{a}	16.64±0.27^{a}
Globe axial length	0-9 Months	20.33±0.33^{b}	18.25±0.47^{b}	18.73±0.42^{b}	19.89±0.16^{c}	18.20±0.45^{c}	18.56±0.45^{c}
	1-6 years	20.47±0.55^{a}	21.33±1.02^{a}	20.71±0.12^{a}	20.36±0.56^{b}	21.59±0.65^{b}	20.69±0.14^{b}
	7 and above	21.45±0.38^{a}	22.01±0.25^{a}	21.03±0.22^{a}	21.09±0.49^{a}	22.39±0.33^{a}	21.64±0.31^{a}

Means with different superscripts in a column of each parameter differ significantly (P<O.O1)

OD – RIGHT OS - LEFT

TABLE 09: Mean±SE (mm) measurements ofB-Scan ocular parameters in dogs with different skull conformation and age (N=6).

Parameter	AGE	OD			OS		
		Dolichocephalic	**Mesaticephalic**	**Brachycephalic**	**Dolichocephalic**	**Mesaticephalic**	**Brachycephalic**
Anterior chamber depth	0-9 Months	2.52 ± 0.25^{b}	2.48 ± 0.19^{b}	2.37 ± 0.28^{b}	2.55 ± 0.28^{b}	2.35 ± 0.14^{b}	2.25 ± 0.31^{b}
	1-6 years	3.02 ± 0.17^{a}	3.45 ± 0.23^{a}	2.95 ± 0.16^{a}	3.00 ± 0.16^{a}	3.33 ± 0.22^{a}	2.73 ± 0.21^{a}
	7 and above	2.80 ± 0.21^{a}	3.53 ± 0.18^{a}	3.22 ± 0.14^{a}	2.70 ± 0.27^{a}	3.47 ± 0.25^{a}	3.18 ± 0.12^{a}
Lens thickness	0-9 Months	6.97 ± 0.20^{b}	6.02 ± 0.33^{b}	6.40 ± 0.33^{b}	6.73 ± 0.26^{b}	5.83 ± 0.49^{b}	6.33 ± 0.37^{b}
	1-6 years	7.08 ± 0.14^{a}	7.13 ± 0.09^{a}	6.62 ± 0.09^{a}	7.08 ± 0.13^{a}	7.30 ± 0.07^{a}	6.78 ± 0.11^{a}
	7 and above	7.00 ± 0.17^{a}	7.52 ± 0.09^{a}	7.12 ± 0.08^{a}	7.00 ± 0.14^{a}	7.60 ± 0.08^{a}	6.93 ± 0.06^{a}
Vitreous chamber depth	0-9 Months	8.42 ± 0.20^{b}	8.33 ± 0.22^{b}	8.23 ± 0.35^{b}	8.58 ± 0.20^{b}	8.35 ± 0.19^{b}	8.20 ± 0.38^{b}
	1-6 years	8.63 ± 0.26^{a}	9.05 ± 0.18^{a}	9.32 ± 0.10^{a}	8.73 ± 0.26^{a}	8.90 ± 0.13^{a}	9.18 ± 0.09^{a}
	7 and above	9.18 ± 0.18^{a}	9.42 ± 0.10^{a}	9.00 ± 0.27^{a}	9.17 ± 0.18^{a}	9.40 ± 0.09^{a}	9.25 ± 0.16^{a}
Globe axial length	0-9 Month	18.52 ± 0.57^{b}	17.18 ± 0.83^{b}	18.07 ± 0.91^{b}	18.48 ± 0.55^{b}	16.88 ± 0.85^{b}	17.93 ± 0.96^{b}
	1-6 years	19.85 ± 0.41^{a}	20.73 ± 0.32^{a}	19.80 ± 0.41^{a}	20.07 ± 0.43^{a}	20.70 ± 0.32^{a}	19.55 ± 0.48^{a}
	7 and above	19.97 ± 0.54^{a}	21.70 ± 0.31^{a}	20.62 ± 0.23^{a}	19.87 ± 0.59^{a}	21.43 ± 0.45^{a}	20.75 ± 0.17^{a}

Means with different superscripts in a column of each parameter differ significantly (P<O.O1)

OD – RIGHT OS - LEFT

In the present study Vitroues chamber depth and Globe axial length measurements showed higher values on A scan when compared to B scan measurements indicating the over estimation of these values on A scan where as these measurements in B scan showing the normal values.

The anterior chamber depth, lens thickness and vitreous chamber depth values together in A-mode showed almost the equal value of the Globe axial length while these values together in B-mode showed lesser value than the globe axial length in the present study.

The excess measurement recorded in the globe axial length with B mode when compared to A-mode clearly attributes to the additive effect of thickness of cornea to anterior chamber depth with B scan measurements.

The B-mode oculometry showed to be better as it recorded all the parameters accurately with clear image even though the A scan procedure was simple to perform and recorded Globe axial length accurately. However the A scan was unable to record the values of lens thickness and vitreous chamber depth precisely .

CHAPTER – V
DISCUSSION

Chapter V

DISCUSSION

The present work on Studies on oculometry with reference to skull conformation and age in dogs was carried out to record the reference values of oculometry in normal eyes of dogs of different skull conformation and age. The findings of the present study were discussed.

The assessment of eye for its health in all the dogs of the present study was carried and the methodology applied for it served the purpose of selecting the dogs to record oculometric measurements. The initial examination of the eye should assess symmetry, conformation, and gross lesions; the eye should be viewed from 2–3 feet away, in good light, and with minimal restraint of the head as opined by Moore (2001). Gelatt (1991) suggested that gross abnormalities like chemosis, corneal opacity, corneal edema, corneal ulcer, lens opacity, ocular discharges and conjunctival appearance can be identified with naked eye examination for the assessment eye health as recorded in the present study.

A complete ophthalmic examination includes an evaluation of all areas of eye and orbit, the motility and position of the globes, the extra ocular and the intraocular structures as suggested by Moore (2001) and same pattern was followed in the present study. Baseline tests like the Schirmer tear test, fluorescein dye test, tonometry and vision testing were carried as per the methods adopted by Gelatt (1991).

In the present study, clinical ophthalmic examination was carried to screen the eyes for any abnormalities in all the dogs and found them without any concurrent eye diseases. Among the 54 dogs examined, the Palpebral reflex was normal in all without any visual imparity. The eyelid conformation and globe position were considered when interpreting the palpebral reflex. To evaluate the palpebral reflex, cranial nerve V was stimulated by touching the medial or lateral canthus. A blink response indicates a positive palpebral reflex (Moore, 2001).

Menace response in present study was positive in all the eyes of dogs with visual acuity. The menace response was used to assess both the visual status and eyelid function. A positive menace response requires a clear optic media, a functioning retina, and intact cranial nerves II (optic nerve) and VII (facial nerve) (Moore, 2001) as observed in the present study.

Among the 54 dogs, pupillary light reflex (PLR) was normal in both the eyes. The interpretation of the PLR requires an understanding of the neurologic reflex as well as other potential confounding factors which stimulate the smooth muscles of the iris sphincter muscle to cause pupil contraction. The neural arc being tested has an afferent arm, which includes the retina, optic nerve, optic chiasm, optic tract, pretectal area, and the parasympathetic nucleus of cranial nerve (CN) III, where there is a synapse with the pupillomotor fibres of CN III (oculomotor nerve), which stimulate the smooth muscles of the iris sphincter muscle to cause pupil contraction (Moore, 2001).

The Schirmer test, which measures both basal tears and reflex tear production, was the most common tear test performed in Dogs. The Schirmer tear test values were within the normal range i.e., 17mm to 28mm in all the 54 dogs of the present study which was in an agreement with Moore (2001) in normal eyes.

There was no persistence of fluorescein stain on the cornea of both the eyes in all the 54 dogs examined indicating the absence of corneal ulcers as reported by Moore (2001) Fluorescein stain was water soluble, the stain does not penetrate the intact hydrophobic corneal epithelium. If an epithelial defect is present, the hydrophilic corneal stroma stains green. Although the edges of deep stromal defects can take up stain, deep corneal defects that extend to the level of Descemet's membrane do not stain (Moore, 2001). To assure accuracy, the Schirmer tear test was performed before applying fluorescein stain and topical anaesthetic to the eye as reported by Maggs (2008).

Among 54 dogs of the present study, the intra ocular pressure ranged from 16 mm of Hg to 24 mm of Hg. The applanation tonometry (Tonopen) was considered as the method of choice for measuring intraocular pressures as in the present study because of its ease of use and accuracy. The tonometer was gently touched to the central cornea six times until the Tono-Pen indicates that measurements have been recorded as suggested by Mattoon and Nyland (2015).

Ocular ultrasonography has become an essential technique for exploring the globe and orbit even though, clinical examination of the eye usually provides enough information to reach an ophthalmic diagnosis. Ocular Ultrasonography may provide additional information especially useful in eyes with opaque ocular media. (Gonzalez *et al.,* 2001). In the present study the dogs with normal eyes were undergone both A mode and B mode ocular ultrasonography and the ocular biometric measurements were recorded. The equipment required to perform ocular ultrasonography includes an ultrasound machine with an appropriate transducer, sterile acoustic coupling gel and a topical ophthalmic anaesthetic (Williams and Wilkie,1996).

In the present study an A-Scan machine with pencil sized transducer of 10MHz frequency and B-Scan with 5-13MHz frequency linear transducer yielded in clear images as reported by Silva *et al.*, (2010) and Kumar (2018). Transducers are available in a wide range of frequencies, however, a 7.5- or 10-MHz probe was recommended for ocular ultrasonography and the axial and lateral resolution have a significant effect on the quality of the resulting image (Kremkau, 1989).

A 10-MHz transducer provides superior resolution but less depth of penetration than does a 7.5- MHz transducer as reported by Mattoon and Nyland (1995). The transducer with 10MHz for A scan recorded clear images in the present study as observed by Brunell (2014); Kobashigawa *et al*., (2015) and Kovalcuka and Murniece (2020); Andrade *et al*., (2020); Faleiro *et al.*, (2021)and Kumawat and Jhirwal (2021). The B-mode probe used in the present study allowed complete evaluation of the globe which was in accordance with Audu *et al*., (2017); Kumar *et al*., (2018); Ganesan and Ramani(2018); Silva *et al*., (2018); Tripathi*et al*., (2018) ; Vali and Razeghi (2019); Andrade *et al*., (2020); Faleiro *et al.*, (2021) and Kumawat and Jhirwal (2021) .

In the present study Ocular biometry was performed by A and B scan procedures without sedation and topical anaesthesia with 0.5% Proparacaine hydrochloride and achieved satisfactory desensitization of the cornea to perform transcorneal ocular ultrasonography in all the eyes. Similar anaesthetic regimen was also adopted by earlier workers and achieved sufficient desensitization long enough for the scanning procedure (Van der Woerdt *et al.*, 1993 and Kumar, 2012).

All the dogs in the present study were restrained in either sternal or lateral recumbency for ocular ultrasonography as so reported by Boroffka (2006). Sedation or anaesthesia of the canine patient is often used during ocular biometry, but it has been proposed that ocular biometry can be performed without anaesthesia or sedation (Gaiddon *et al*., 1991). Dogs without sedation allowed adequate evaluation of the eye globe, avoided rotation of eye ball and upward movement of third eyelid which were reported as the common problems faced in sedated or general anesthetized and closed eyelids (Penninck *et al*., 2001 and Dar *et al*., 2014) while, light sedation considerably increases the accuracy of ocular biometrics, in addition to making the examination faster and easier to be performed (Ekesten, 1994).

Mattoon and Nyland (1995); Penninck *et al*., *(*2001); Audu *et al*., (2017); Kumawat and Jhirwal (2021) and Lavanya *et al*., (2021) opined that Sedation should be avoided because it may cause elevation of the nictitating membrane and rotation of the globe, thus interfering with thorough examination. On the contrary, Tavana and Peighambarzadeh (2014) sedated the dogs for oculometry. Ekesten (1994) reported that oculometry was faster and easier on the sedated dogs and relieves stress and discomfort of the patients. A-scan ultrasonography was performed with and without sedation by Ekesten (1993) whereas Paunksnis *et al*., (2001) sedated the dogs.

Topical anaesthesia with 0.5% Proparacaine hydrochloride was the common agent instilled by majority of the workers to desensitize the cornea (Van der Woerdt *et al*., 1993; Tuntivanich *et al*., 2007; Dar *et al*., 2014; Kobashigawa *et al*., 2015; Kumar *et al*., 2018; Ganesan and Ramani 2018; Kovalcuka and Murniece 2020). Many topical agents were used for corneal desensitization for B-mode ultrasonography like 0.5% amethocaine hydrochloride (Williams, 2004); 0.5% Proxymethacaine (Labruyere *et al*., 2008; Toni *et al*., 2013; Feliciano *et al*., 2013; Silva *et al*., 2018 and Andrade *et al.,* 2020); topical anaesthetic gel (Vali and Razhegi, 2019); 1% Tetracaine hydrochloride and 0.1% phenylephrine hydrochloride (Faleiro *et al.,* 2021) and 5% tetracaine hydrochloride (Sritrakoon *et al.,* 2021) and 4% lignocaine gel (Shahi *et al.,* 2021) with satisfactory results. Both A-mode and B-mode ultrasonography was performed under topical anesthesia by Penninck *et al.,* (2001); Silva *et al.,* (2010) and Martins *et al.,* (2010) with Proxymethacaine.

In the present study trans corneal contact method and immersion method were compared to test the accurate measurements with both A and B scan procedures. In A-Scan, the direct contact method resulted in an image of spikes that do not have an appreciable cornea whereas, the immersion method resulted in an image of spike that had a highly appreciable cornea with similar ocular measurements. As both methods are relevant to take ocular measuments as the present study includes measurements without corneal thickness hence direct contact method was performed in all the dogs for oculometry.

Transcorneal approach of B mode in the present study given clear and sharper images of the anterior and posterior segment of the eyes which was also reported by Labruyere *et al.* (2008) and Toni *et al. (*2013). The corneal contact method with gel provided superior anatomic definition (Hager *et al.,* 1987) and provided superior images of the posterior segment (Williams and Wilkie 1996; Mason *et al.,* 2001; Dar *et al.,* 2013; Plummer and Resee 2014; Kobashigawa *et al.,* 2015; Ganesan and Ramani, 2018; Tripathi *et al.,* 2018; Kovalcuka and Murniece 2020; Andrade *et al.,* 2020; Farreiro *et al.,* 2021 and Kumawat and Jhirwal, 2021) as observed in the present study. On the contrary, Shammas (1984) reported that the corneal contact method causes inadvertent indentation of the cornea and thus may result in inaccurate axial length measurements.

Ultrasound can be performed using the direct contact or immersion method. Hager *et al.* (1987) compared direct corneal contact, on closed eyelids, and over a small balloon filled with water techniques for ultrasound examination and concluded that the direct corneal contact method allows superior anatomical definition of the posterior segment and orbital tissues. Care was taken not to exert pressure over the cornea and sclera with the transducer while performing ultrasonography as followed by the earlier workers (Dar *et al.,* 2013; Ganesan and Ramani, 2018; Kovalcuka and Murniece 2020; Andrade *et al.,* 2021; Farreiro *et al.,* 2021 and Kumawat and Jhirwal, 2021.)

Sterile coupling gel facilitates transmission of sound from the transducer into the optic tissue; therefore, a layer of sterile coupling gel was placed between the patient and the transducer (Williams and Wilkie, 1996). Applying the transducer directly to the gel coated cornea provides a better image of the posterior globe and retrobulbar tissue than does transpalpebral ultrasonography (Hager *et al,* 1987). Applying excess sterile coupling gel to the cornea and decrease the pressure applied with the transducer, thus allowing the gel to act as a stand-off (Cottrill *et al,* 1989).

Ocular ultrasonography was performed in dogs with ring stand technique (Schiffer *et al*,1982); Standoff pad (Biller and Myer 1988; Gonzalez *et al.,* 2001 ; Bedi *et.al*, 2006; Plummer and Resee, 2014); coupling gel to cornea as a standoff pad (Williams and Wilkie, 1996 ; Toni *et al.,* 2013; Audu *et al.,* 2017; Vali and Razeghi 2019) ; 2% Hydroxypropyl methyl cellulose (HPMC) gel (Ganesan and Ramani,2018); Carboxymethyl cellulose gel without standoff (Cottrill *et al.*1989 and Silva *et al.,* 2018).

The direct contact method and immersion method performed in the present study with A and B scan, respectively given better quality images. Visualization of the anterior segment can be improved with the use of a stand-off pad or additional coupling gel (Williams and Wilkie, 1996). Many parameters in the anterior segment may be lost in the near-field reverberation artefact and a standoff can be used to avoid this problem (Goddard, 1995).

After examination, each eye was gently flushed with eyewash or sterile saline to remove the coupling gel and associated debris as reported by Williams and Wilkie, (1996) and rinsed with sterile 0.9% sodium chloride solution as suggested by Martins *et al.,* (2010) to prevent the corneal irritation (Kealy and McAllister, 2000 and Maggs, 2008). The eyes were re-examined for the identification of iatrogenic corneal lesions resulting from the examination as advised by Martins *et al.,* (2010). In the present study no iatrogenic corneal lesions were noticed from the examination and this was in accordance with Goncalves *et al.,* (2000). The use of conductive gel enables more reliable images and measurements and provides better contact of the transducer with the surface of the cornea, with minimal indentation over the bulb (Faleiro *et al*, 2021).

In the present study, on A-Scan, four spikes were noticed which denotes Cornea, Anterior lens capsule, Posterior lens capsule and Sclero- retinal rim. The space between the corneal spike and anterior lens capsule spike was anterior chamber depth, space between the anterior lens capsule spike and the posterior lens capsule spike was lens thickness while the space between the posterior lens capsule spike and retina was vitreous chamber depth. A-mode ocular biometry in normal dogs was performed by Schiffer *et al.* (1982) and Cottrill *et al. (*1989). Mattoon and Nyland (2015) reported that in A-mode ultrasonographic technique was not possible in veterinary patients as orientation of A-mode beam along the optic axis that was achieved by looking directly at a small light emitted from the centre of the transducer was necessary which was practically not possible but, this problem was not arrived in the present study.

Diagnostic B-mode ultrasonography is a two-dimensional imaging technique that can be used to determine anatomic features. In the B-Scan images, cornea could be visualized as three thin distinct hyperechoic layers near the contact area of transducer where the anterior and posterior corneal surfaces were parallel and hyperechoic and the middle layer was anechoic. The anterior chamber, lens nucleus and vitreous chamber appeared anechoic while the anterior and posterior lens capsules appeared as convex and concave hyperechoic lines respectively and allowed for the measurements clearly.

In the present study on B mode ultrasonographic imaging three fluid filled cavities (anterior chamber, posterior chamber and vitreous chamber) were visualized and the anterior and Vitreous chamber were anechoic in appearance as reported by Whitcomb, (2002). The cornea visualized as a thin curvilinear hyperechoic line parallel to the probe in all the dogs as reported by Paunksnis *et al.,* (2001). Anterior chamber appeared anechoic which was filled with aqueous humor and bordered anteriorly by the cornea, laterally and medially by iris and ciliary body and posteriorly the anterior capsule of the lens. The lens appeared anechoic in normal eyes with curvilinear anterior and posterior capsules being echogenic. Under the posterior margin of the lens, vitreous body was seen as an anechogenic chamber, filled with vitreous humor as observed by Spaulding (2008). Vitreous was bordered anteriorly by posterior capsule of the lens and posteriorly by posterior wall of the eye ball. At the posterior wall of the eye ball, the optic disc could be imaged as a thick hyperechoic structure which was evidently more echogenic than adjacent structures (Whitcomb, 2002).

Ocular ultrasound is an important tool for performing ocular biometrics for globe measurements which can be used to determine intraocular or intraorbital prosthetic size. These measurements are helpful in calculating appropriate intraocular lens (Toni *et al.*, 2013; Boillot *et al.*, 2014 and Kobashigawa *et al.*, 2015). Several studies of ocular biometry have been described in dogs, such as Beagles (Boroffka *et al*, 2006), Shih Tzus (Kobashigawa *et al*, 2015), Eurasier dogs (Boillot *et al*, 2014), brachycephalic dogs (Toni *et al*, 2013) and mesocephalic and dolichocephalic dogs (Cottrill *et al*, 1989 and Chiwitt *et al*, 2017).

The indications for the Ocular biometry include to determine the globe axial length for calculation of artificial intraocular lens power or to measure the sagittal size of intraocular structures in canine glaucoma. (Ekesten, 1994;Gilger *et al.,* 1998 and Ganesan and Ramani 2018). Gilger *et al.* (1998); Toni *et al.* (2013); Audu *et al.* (2017) and Andrade *et al.* (2020) performed oculometry and reported that it has potential application in establishing lens power, and estimating prosthetic globe size after enucleation. On the contrary Brandao *et al.* (2007), Potter *et al.* (2008) and Assadnassab and Fartashvand (2013) suggested that the oculometry values help for monitoring the evolution of diseases. Hijar (2008) assessed the variations in size, shape and position of eye structures, with oculometry while Toni *et al.*(2013) opined that oculometry helps in in determining the prosthesis size and intra-eye before surgery. Bentley *et al.* (2003) reported that knowledge of the ultrasonographic appearance and normal dimensions of the eye would serve as a basis for ultrasonographic examinations when ocular disease may have caused alterations in the dimensions and appearance.

The first report on the use of ultrasound in veterinary ophthalmology was made by Rubin and Koch (1968), when only the A-mode was used in the evaluation of eyes of dogs with opacities of transparent media. Schiffer *et al*, (1982) performed a biometric study of the eyes of dogs, using A-mode ultrasonography to determine the normal pattern of axial length of eyes. It is extremely important to know the dimensions of the normal ocular components of different canine breeds, and in different age groups, so that the diagnosis of congenital abnormalities of the eyeball, such as microphthalmia, nanophthalmos and congenital glaucoma, is possible (Andrade *et al.* 2020).

Several studies were carried out to determine the ultrasonographic appearance of normal dog eyes (Hager et al., 1987 and Cottrill *et al.*, 1989). Ocular biometry can be performed using ultrasound, both A-mode (one-dimensional) and B-mode (two-dimensional), partial coherence interferometry, tomography and magnetic resonance imaging. Although the A-mode allows more accurate ocular biometry (Hamidzada and Osuobeni, 1999), the B-mode also proved to be useful for this purpose (Cottrill *et al.*, 1989 and Boroffka *et al.*, 2006).

In the present study in all age groups, the ocular components of different breeds did not differ significantly between the left and right eyes which was with an agreement with Schiffer *et al*, 1982; Gaiddon *et al*, 1991; Paunksnis *et al*, 2001; Williams 2004; Boroffka *et al*, 2006 and Beserra *et al*, 2009).

In the present study, the measurements of anterior chamber depth of right and left eyes were 3.03 ±0.10 and 3.10±0.14 on A scan and 2.92±0.08 and 2.84±0.09 on B scan, respectively. There was a non-significant difference among the anterior chamber depth, between the dogs with different skull conformation on both the scanning procedures however the B scan values recorded less when compared to A scan except with left eye of the mesaticephalic breed dogs,

The earlier authors reported the anterior chamber depth measurement as 4.19 ± 0.28 mm (Ekesten, 1994); 4.95 ± 0.45 mm (Schiffer *et al*, 1982) and 3.4 ± 1.04 mm, (Silva, 2018) whereas Cottrill *et al*. (1989) recorded values as 3.6 ± 0.7 mmin mesocephalic dogs and 3.8 ± 1.0 mm in dolichocephalic dogs.These measurements are smaller than those described in previous studies compared to the present study. This difference might have occurred due to the different age between the breeds included in the present study whereas the previous authors performed the studies in specific breed or in adult dogs. Cottrill *et al*. (1989) suggest a positive relationship between anterior chamber depth and snout length, thus justifying such low values. Zadnik *et al*, (1992) reported that anterior chamber depth measurement by ultrasonography was least reliable. The measurement most affected by ultrasound biometry errors due to corneal flattening by the probe, (Miller and Murphy, 1995) whereas, the anterior chamber measurements performed in sedated dogs were significantly greater than carried out in non-sedated dogs (Ekesten, 1994).

During the measurements, constant efforts were made in order to minimize the corneal flattening caused by the transducer. The depth of the anterior chamber may be related to the size of the dog and the shape of the skull, but it must be taken into account that this measurement was not very reliable. Ekesten and Torrang (1995) found that lens thickness increased with age in Samoyeds, leading to a shallow anterior chamber. Depression of the corneal surface by the ultrasound probe may result in underestimation of the axial length of the eye and the depth of the anterior chamber (Ekesten 1994).

In the present study the measurements of lens thickness of right and left eyes were 2.62±0.21 and 2.32±0.22 on A scan and 6.87±0.08 and 6.84±0.09 on B scan respectively. There was no significant difference among the lens thickness, both on A and B scan between the dogs with different skull conformation. The recorded values are higher on B scan when compared to A scan which denoting the reliability of the B scan to image the Lens. The lens thickness of dolichocephalic breed of left eye was significantly different from lens thickness of mesaticephalic breed (P<0.05 on A scan while, the lens thickness of dolichocephalic breed was more when compared to other two breeds of dogs.

The previous authors reported lens thickness as 7.14 ± 0.3 mm in mesocephalic dogs (Schiffer et al., 1982) ; 7.6 ± 0.5 mm in mesocephalic dogs (Cottrill et al., 1989); 4.7 to 6.8 mm in mesocephalic dogs (Paunksnis *et al*, 2001) and 7.06 ± 0.48 mm in English Cocker Spaniel dogs (Silva, 2009). The observations with B scan in the present study were in accordance with the findings of Beserra *et al.* (2009) who stated that there was no relationship between lens length and skull size while, Zadnik *et al.* (1992) reported that thickness of the lens by ultrasonography was the most reliable measurement.

The values found for lens thickness were smaller than the previous authors, may be related to the shape of their skulls.These measurements are smaller than those described in previous studies compared to the present study. This difference might have occurred due to the different age between the breeds included in the present study whereas the previous authors performed the studies in specific breed or in adult dogs. Beserra et al., (2009) related ocular biometry data with the skull size of mongrel dogs and the lens thickness was the only measurement that did not show a positive relationship with skull size. Azevedo and Ranzani (2006) found no correlation between lens thickness and the weight of dogs. On the contrary (Zadnik *et.al*, 1992) showed that the most reliable measurement among ocular measurements. Ekesten (1994) found that lens thickness increased with age in Samoyeds, leading to a shallow anterior chamber.

In the present study measurements of Vitreous chamber depth of right and left eyes were 14.83±0.33 and 14.96±0.31 on A scan and 8.84±0.09 and 8.86±0.08 on B scan respectively. In the present study, the vitreous chamber depth values recorded were more in the dolichocephalic skull breeds when compared to other two skulls however the values are non-significant Whereas on B scan the vitreous chamber depth value was more in the mesaticephalic skull breeds when compared to other two skull breeds however the values are non-significant as reported by Cottrill *et al*. (1989).

The previous authors reported vitreous chamber depth were 8.91 ± 0.30 mm in adult mesocephalic dogs (Cottrill *et al*., 1989); 8.8 ± 0.7 mm in dolichocephalic dogs(Cottrill et al., 1989). On the other hand, mesocephalic dogs weighing between 18 and 27 Kg presented greater measures of vitreous chamber depth, of 9.51 ± 0.31 mm (Schiffer *et al*., 1982) on the contrary Zadnik *et al*. (1992) showed that the least reliable are the depth of the vitreous chambers as reported in the present study with A scan.

In the present study the measurements of Globe axial length right and left eyes were 20.48±0.22 and 20.49±0.22 on A scan and 19.60±0.25 and 19.52±0.26 on B scan, respectively. In the present study, the globe axial length was more in the dolichocephalic skull breeds on A scan when compared to other two skulls however the values are non-significant whereas, on B scan the globe axial length was more in the mesaticephalic skull breeds when compared to other two skull breeds however the values are non-significant might be due to different age groups in the present study whereas the previous authors performed the studies in specific breed or in adult dogs. Murphy *et al* ., (2012) stated that the size of the eyeball varies among breeds, but the diameter was usually approximately 20 to 22 mm. while McGreevy et ., (2003) recorded that the radius of the canine eye varied across breeds from 9.56 to 11.57 mm and was correlated with the width and length of the skull.

The mean axial length in adult dogs was 18.8 ± 0.9 mm in mongrel dogs (Goncalves *et al*., 2000); 21.2 ± 1.3 mm in dolichocephalic dogs and 19.9 ± 1.2 mm in mesocephalic dogs (Cottrill et al., 1989); 21.60 ± 0.77 mm in A mode in mongrel dogs (Schiffer et al., 1982); 20.43 ± 1.48 mm in different breeds (Gaiddon *et al*., 1991) whereas the same authors reported that small sized dogs with 19.53 ± 1.35 mm; medium-sized ones with 20.14 ± 0.81 mm and large-sized ones with 21.89 ± 1.08 mm of mean axial length.

According to the skull conformation ocular measurements showed variation as reported by some earlier workers on oculometry. Beserra *et al*., (2009) studied the relationship between measures of the fronto-occipital and bizygomatic distances of the skull of mongrel dogs and demonstrated a significantly positive relationship between the values. It has been demonstrated that dolichocephalic dogs have greater axial length and greater depth of anterior and vitreous chambers than mesocephalic ones (Cottrill et al., 1989). Gaiddon *et al*., (1991) concluded that large dogs had eyes with relatively greater axial length with A-mode ultrasonography. In mixed breed, measurements of axial length, depth of the anterior chamber and vitreous chamber showed a positive correlation with the measurements of the skull (Beserra *et al*., 2009). The ocular measurements among the skull type showed the variation but not significant in the present study which may be due to the inclusion of different age groups between the breeds whereas the previous authors performed the studies in specific breed or in adult dogs.

According to the age, on A scan the vitreous chamber depth , globe axial length was more in above 7 years aged dogs and the difference was highly significant ($P<0.01$) among the groups. The lens thickness was more in 0-9 months aged dogs followed by 1-6 and above 7 years aged dogs. The anterior chamber depth was less in 0-9 aged dogs when compared to the other two aged dogs, the difference was significant in right eye ($P<0.05$). On B scan The vitreous chamber depth, globe axial length, lens thickness was more in above 7 years aged dogs and the difference was highly significant ($P<0.01$) in 0-9 months. The anterior chamber depth was less in 0-9 aged dogs when compared to the other two aged dogs, the difference was highly significant ($P<0.01$).The variations may be due to the inclusion of different age groups between the breeds whereas the previous authors performed the studies in specific breed or in adult dogs.

Dogs' eyes are not completely developed at birth, and continue to develop until 2 or 3 months of age, when they reach full functionality (Aguirre, 1972). Despite the A-mode being more accurate for performing ocular biometry (Hamidzada and Osuobeni,

1999) However, the B-mode biometrics showed to be efficient and there was a difference in the measurements performed by the two modes as mentioned by Hamidzada and Osuobeni, (1999). Paunksnis *et al*., (2001) demonstrated that axial length, lens thickness and vitreous chamber depth increase with age while the lens thickness showed less values in the present study.

In the present study, with the exception of the measurement of the depth of the anterior chamber the other ocular biometrics correlated moderately or strongly with the size variables of the dogs, suggesting that ocular growth follows the growth of the individual (Ekesten, 1995; Boroffka, 2005 and Tuntivanich *et al*., 2007).The anterior chamber and lens showed rapid growth until the fourth month of life and then reached a plateau (Ekesten and Torrang 1995). The lens showed slow growth until the 12th month and the depth of the vitreous chamber and axial length showed a rapid increase until 4 months of age, a slow increase until 9 months of age, and then a plateau. There was a phase of rapid growth for all parameters in young dogs (Ekesten, 1995; Boroffka, 2005 and Tuntivanich *et al*., 2007). The same pattern was observed in the present study with both A and B scan procedures evidence by the measurements recorded in the young age group on the other hand aged dogs showed slight changes might due to the age related changes in the ocular components.

Cottrill *et al*., (1989) compared B-mode ocular biometry and direct measurement of enucleated eyes in dogs, and all direct measurements were significantly greater than the measurements performed with B-mode ultrasound, which may have been caused by corneal indentation during the ultrasound examination.The factors can potentially affect the accuracy of the measurements, such as, probe alignment along the optical axis of the bulb (Berges *et al*., 1998), compression of the bulb by the probe (Ekesten, 1994) and differences in velocity of sound (Cottrill *et al*., 1989). During the performance of the ocular biometry, the probe must be aligned with the axial axis of the bulb, in order to obtain the greatest measurement of the axial length. Proper identification of the anterior surface of the cornea, the anterior and posterior capsules of the lens and the vitreoretinal interface is of paramount importance for the accurate measurement of ocular distances (Boroffka *et al*., 2006).

In the present study, all measurements with B mode were performed after perfect alignment of the cornea, anterior and posterior capsules and vitreoretinal interface the average between repeated measurements can be used in order to approximate the real value.Placing the transducer with minimum pressure on cornea and taking the average values of six contacts with A scan were followed to nullify the effects of indentation.

The reason for carrying out this study was to investigate the agreement between A- and B-mode ultrasonography for measurement of intraocular distances. The results of the study are potentially useful in determining whether B-mode ultrasonography can be used to measure intraocular distances when it is not possible to do so with A-mode. B mode Ultrasonography was used routinely for evaluation of the eye whereas, A-mode ultrasonography was commonly used for ocular biometric purposes, including determination of dimensions of ocular components and documentation of eye growth patterns (Kendall and Wolfe, 1990).

A-scans are one-dimensional displays in which returning echoes are reflected as vertical spikes from a baseline. Spacing between the spikes depends on the time it takes for the sound beam to reach the interface and for the echo to return to the transducer. Schiffer *et al*. (1982) first described anterior chamber, lens thickness, vitreal chamber, and overall axial lengthmeasurements. Ocular biometry using A-scan ultrasonography has been performed in several studies in veterinary ophthalmology (Schiffer *et al*., 1982, Neumann 1988, Cottrill *et al*., 1989, Gaiddon *et al*., 1991, Ekesten 1994). A-mode ocular biometry depends on measuring the distance between unambiguously identifiable echo spikes reflected from the boundary between ocular tissues (Hamidzada and Osuobeni 1999). It is generally accepted that A-mode ultrasonography is more accurate than B-mode in measuring intraocular dimensions. Consequently, A-mode ultrasonography is the procedure of choice in ocular biometry while B-mode ultrasonography is used principally for diagnostic purposes.

B scan is the primary modality for determining lesion topography- location and configuration of the lesion through oscillating A-scan that passes through a cross-section of tissue. Both A-scan and B-scan ultrasonography has been used for ocular biometry in euthanized dogs and it was found that the results were similar (Cottrill *et al*., 1989). It has been stated that A-scan is more accurate than B-scan for measuring intraocular distances and two methods are more likely to give different readings for measurements of lens thickness, vitreous chamber depth and axial length. (Hamidzada and Osuobeni, 1999) as observed in the present study.

In the present study, the Anterior chamber depth measurements showed slightly higher on A scan when compared to B scan measurements indicating the role of corneal thickness inclusion while calculating the measurements in A scan as these are preprogrammed values on the other hand the measurements of anterior chamber depth in B scan are manually measured by excluding the corneal thickness.

The lens thickness measurements showed lower values on A scan when compared to B scan measurements indicating the underestimation of these values on A scan and its reliability on the other hand the measurements of lens thickness in B scan showing the normal values. The Vitreous chamber depth and Globe axial length measurements showed higher values on A scan when compared to B scan measurements indicating the over estimation of these values on A scan where as these measurements in B scan showing the normal values.

The anterior chamber depth, lens thickness and vitreous chamber depth values together in A-mode showed almost the equal value of the Globe axial length while these values together in B-mode showed lesser value than the globe axial length in the present study. The excess measurement recorded in the globe axial length with B mode when compared to A-mode clearly attributes to the additive effect of thickness of cornea to anterior chamber depth with B scan measurements.

The B-mode oculometry showed to be better as it recorded all the parameters accurately with clear image even though the A scan procedure was simple to perform and recorded Globe axial length accurately however the A scan was unable to record the values of lens thickness and vitreous chamber depth precisely .

The option of calculating the depth of the vitreous chamber by subtracting the measurements of the anterior chamber and lens from the axial length, to the detriment of the direct measurement, was carried out in order to minimize possible variations during the direct measurement (Schufelt *et al.*, 2005). Zadnik *et al.*, (1992) reported that the measurement of the lens was the most reliable, followed by the measurement of the axial length and, finally, the measurement of anterior chamber depth was the least reliable as observed in the present study.

To conclude the present study A and B-mode ultrasonography were easy, practical, safe and useful techniques for ocular biometry in dogs. There was a phase of growth of the ocular components in the age group of 0-9 in all the breeds with different skull conformation. The anterior chamber depth, lens thickness and vitreous chamber depth values together in A scan showing almost the equal value of the Globe axial length while the same in B scan showed lesser value than the Globe axial length in the present study.

Skull size did not interfere with ocular biometry measurements in above one-year aged dogs. There was no significant difference between the ocular biometric measurements of left and right eyes in any age group. Lens thickness increased as age advances with B scan however both the values are different in A and B mode scanning procedure. A scan reveals clear axial globe length and B scan measured lens thickness, vitreous chamber depth and globe axial length with more reliability. The B scan procedure showed to be better as it recorded all the parameters accurately with clear image even though the A scan procedure was simple to perform and recorded Globe axial length accurately and unable to record the values of lens thickness and vitreous chamber depth precisely. Hence B scan can be a useful tool for ocular biometry due to its accuracy and the reliability with an advantage of effective role in recording the ocular components architecture for diagnosis.

CHAPTER – VI
SUMMARY

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SUMMARY

The present work "Studies on oculometry with reference to skull conformation and age in dogs" was carried and the data pertaining to the study was here with summarized.

- The dogs presented to the small animal clinic were screened for their eye health after gross examination and ophthalmic examination to include in the study.

- All the dogs (54) underwent clinical ophthalmic examination such as assessment of palpebral reflex, menace response, pupillary light reflex, tear production, fluorescein staining and intraocular pressure to ascertain the health of the eye.

- A pencil sized transducer of 10MHz frequency for A-mode and a 5-13MHz frequency linear transducer was utilized for B-mode ocular biometry by restraining the dog in sternal recumbency.

- Transcorneal ultrasonography by direct contact in A-mode and immersion method in B-modewas done without causing much pressure on cornea after instilling 0.5% Proparacaine hydrochloride eye drop to achieve corneal desensitization.

- A comparison was made between direct contact and immersion methods in both A scan and B scan procedures to identify the accurate scanning procedure for oculometry.

- In A-Scan, the direct contact method resulted in an image of spikes that do not have an appreciable cornea while anterior chamber, lens, vitreous chamber and retina were highly appreciable.

- The immersion technique in B scan resulted in an image that had highly appreciable cornea, anterior chamber, lens, vitreous chamber and retina. The linear transducer along with ultrasound coupling gel served as standoff pad.

- Care was taken not to exert pressure over the cornea and sclera with the transducer while performing ultrasonography.

- Sterile 0.9% sodium chloride solution was used, to remove the excess coupling gel after the scanning to avoid any iatrogenic corneal lesions.

- In A-mode, transcorneal direct contact method showed four spikes of image denotes Cornea, Anterior lens capsule, Posterior lens capsule and Sclero- retinal rim.

- In B-mode images, cornea could be visualized as a three thin distinct hyperechoic layers near the contact area of transducer where the anterior and posterior corneal surfaces were parallel and hyperechoic and the middle layer was anechoic.

- To analyze the data the dogs were categorized in to three groups each contains 18 dogs based on skull conformation in to as Dolichocephalic, Mesaticephalic and Brachycephalic Breeds.

- Based on the age the dogs were categorized in to three groups each contains 18 dogs into Young (0-9 months); Middle age (1-6 years) and Old: above 7 years aged groups to perform oculometry.

- Based on the breed and age the dogs were divided in to 3x3 groups each contains 6 dogs to compare the skull conformation and age of the dogs

- A-mode oculometry revealed that, the mean ± SE values of anterior chamber depth. lens thickness, vitreous chamber depth and Globe axial length of right and left eyes in 54 dogs were 3.03 ±0.10 and 3.10±0.14 ; 2.62±0.21 and 2.32±0.22 ; 14.83±0.33 and 14.96±0.31 and 20.48±0.22 and 20.49±0.22 , respectively .

- B-mode oculometry revealed that, the mean ± SE values of anterior chamber depth , lens thickness, vitreous chamber depth and Globe axial length of right and left eyes in 54 dogs were 2.92±0.08 and 2.84±0.09; 6.87±0.08 and 6.84±0.09; 8.84±0.09 and 8.86±0.08 and 19.60±0.25 and 19.52±0.26, respectively.

- The ACD, LT, VCD and GAL of Left and right eyes measurements on both A and B scan of Dolichocephalic, Mesaticephalic and Brachycephalic breeds did not differ significantly.

- There was a non-significant difference among the anterior chamber depth, between the dogs with different skull conformation on both the scanning procedures however the B-mode measurements were less when compared to A-mode except with left eye of the mesaticephalic breed dogs.

- Vitroues chamber depth and Globe axial length measurements showed higher values on A scan when compared to B scan measurements indicating the over estimation of these values on A scan where as these measurements in B scan showing the normal values.

- The anterior chamber depth, lens thickness and vitreous chamber depth values together in A-mode showed almost the equal value of the Globe axial length while these values together in B-mode showed lesser value than the globe axial length.

- The excess measurement recorded in the globe axial length with B mode when compared to A-mode clearly attributes to the additive effect of thickness of cornea to anterior chamber depth with B-mode measurements.

- The B-mode oculometry showed to be better as it recorded all the parameters accurately with clear image even though the A-Scan procedure was simple to perform and recorded Globe axial length accurately however the A scan was unable to record the values of lens thickness and vitreous chamber depth precisely.

- A and B-mode ultrasonography were easy, practical, safe and useful techniques for ocular biometry in dogs.

To conclude the present study, there was a phase of growth of the ocular components in the age group of 0-9 in all the breeds with different skull conformation. The anterior chamber depth, lens thickness and vitreous chamber depth values together in A-mode showing almost the equal value of the Globe axial length while the same in B-mode showed lesser value than the Globe axial length. Skull size did not interfere with ocular biometry measurements in above one-year aged dogs. There was no significant difference between the ocular biometric measurements of left and right eyes in any age group. Lens thickness increased as age advances with B-mode however both the values are different in A and B mode scanning procedure.

A-scan reveals clear axial globe length and B-scan measured lens thickness, vitreous chamber depth and globe axial length with more reliability. The B-scan procedure showed to be better as it recorded all the parameters accurately with clear image even though the A-scan procedure was simple to perform and recorded Globe axial length accurately and unable to record the values of lens thickness and vitreous chamber depth precisely. Hence B-scan can be a useful tool for ocular biometry due to its accuracy and the reliability with an advantage of effective role in recording the ocular components architecture for diagnosis.

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