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Binsha KM
Post Graduate Student, Department of Veterinary Surgery and Radiology, NTR College of Veterinary Sciences, Sri Venkateswara Veterinary University, Tirupati, Andhra Pradesh, India

Makkena Sreenu
Associate Dean, College of Veterinary Sciences, Sri Venkateswara Veterinary University, Tirupati, Andhra Pradesh, India

NVV Harikrishna
Associate Professor, Teaching Veterinary Clinical Complex, NTR College of Veterinary Sciences, Sri Venkateswara Veterinary University, Tirupati, Andhra Pradesh, India

Manda Srinivas
Professor and Head, Department of Veterinary Gynaecology and Obstetrics, NTR College of Veterinary Sciences, Sri Venkateswara Veterinary University, Tirupati, Andhra Pradesh, India

Corresponding Author:
Binsha KM
Post Graduate Student, Department of Veterinary Surgery and Radiology, NTR College of Veterinary Sciences, Sri Venkateswara Veterinary University, Tirupati, Andhra Pradesh, India

B-mode ultrasonographic ocular biometry in cataractous dogs

Binsha KM, Makkena Sreenu, NVV Harikrishna and Manda Srinivas

Abstract
The present study was conducted to record changes in intraocular measurements in dogs affected with cataract using real time B-mode ultrasonography and comparing the change in ocular biometry with normal eyes. Transcorneal ultrasonography using excess coupling gel as standoff pad was performed by immersion technique with a 7.5 MHz sector probe. A total of 50 eyes (40%) affected with cataract were subjected to B-mode ocular ultrasonography and various ocular biometric parameters were measured. There was a significant increase ($p<0.05$) in corneal thickness in eyes affected with incipient cataract when compared to normal eyes. The intumescent cataracts have significantly reduced ($p<0.01$) anterior chamber depth and increased lens thickness ($p<0.01$) while hypermature cataract have significantly increased ($p<0.01$) anterior chamber depth, reduced lens thickness ($p<0.01$) and reduced lens equatorial length ($p<0.05$). Lenses with mature cataract and incipient cataract showed a trend towards increased lens thickness and immature cataracts demonstrated a trend towards reduced lens thickness with non significant difference.

Keywords: B-mode ultrasonography, ocular biometry, cataract, dogs

Introduction
Cataracts can be congenital, hereditary, senile, secondary to systemic diseases such as diabetes mellitus, toxic and traumatic and they can even be classified based on age of the patient (congenital, infantile, juvenile and senile), location of the opacification (capsular, subcapsular, zonular, cortical, nuclear, axial and equatorial), and with respect to appearance and stage of progression (incipient, immature, mature and hypermature) (Slatter, 1990) [34]. Vitreal degeneration and retinal detachment are common in eyes of dogs with mature or hypermature cataracts (Van der Woerdt *et al*., 1993) [42]. Cataracts can develop secondary to intraocular diseases such as glaucoma, luxation of the lens, chronic uveitis, progressive retinal atrophy, endocrine illnesses, traumas and nutritional conditions (Wilkie *et al*., 2006) [44]. Grossly in diabetic lens which develops Diabetes mellitus can cause rapid onset intumescent cataract and later will lead to rupture of lens capsule due to swelling of lens (Wilkie *et al*., 2006) [44].
Ultrasonography is an effective non-invasive diagnostic imaging technique that employs sound waves to create images of the interior of the eye. In veterinary ophthalmology, a probe with a frequency of approximately 7.5 MHz is frequently employed (Tripathi *et al*., 2018) [39] for ultrasonography. The use of B-mode ultrasound for the evaluation of eyeballs is recommended when the inside of the eye cannot be examined due to some opacification of the transparent structures of the bulb, as in corneal edema, hyphaema, cataracts, etc. It is a fast and safe technique that can be used without sedation or anaesthesia (Tramontin *et al*., 2014) [39].
In case of mature and diffuse cataract where visualization of the posterior segment of the eye is not possible, ultrasonography helps to evaluate vitreous and retinal conditions, as well as the stage of cataracts (Van der Woerdt *et al*., 1993) [42]. Ocular ultrasonography has become one of essential tool for preoperative diagnostic and prognostic tool to predict visual outcome in pets with cataract (Ganeshan and Ramani, 2018) [11].
Ocular biometry serves as a valuable tool for evaluating the standard dimensions of ocular structures and contrasting them with those observed in different ocular conditions (Whitcomb, 2002) [43]. The first study about the biometry of normal lens and cataractous lens in dogs was done by (Williams, 2004) [45] using B-mode ultrasonography. B-mode ocular biometry assist in determining the optimal haptic to haptic length of the intraocular lens and the appropriate size of the capsular tension ring in order to mitigate potential adverse effects during cataract surgery in dogs (Ganeshan and Ramani, 2018) [11].

Materials and Methods

The Present study was conducted on 36 dogs of either sex of different breeds that were presented with cataract to the small animal surgical outpatient ward, Department of Veterinary Surgery and Radiology, NTR College of Veterinary Science, Gannavaram over a period of one year from October, 2022 to September, 2023. All the dogs in the present study underwent gross and detailed ophthalmic examination such as assessment of menace reflex, dazzle reflex, pupillary light reflex, tear production, fluorescein staining, intraocular pressure and slit lamp examination.

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 9). Six dogs with clinically normal eyes without any gross pathologies were also subjected to the ocular ultrasonography to compare the ocular biometry and ultrasonographic findings between the diseased and healthy normal eyes.

The dogs were manually restrained in the sitting position or in sternal recumbency and topical anaesthetic eye drops i.e., 0.5% Proparacaine hydrochloride were instilled on the cornea of eye to be examined. 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 was placed on the cornea to maintain sufficient contact area in immersion method (Fig 1). The globe was fanned in the horizontal and vertical planes 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 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. After the immersion method of scanning, the eyes were gently cleaned using cotton wetted with sterile 0.9% sodium chloride solution to remove the excess coupling gel.

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, anechoic area and concave hyperechoic structure representing cornea, anterior chamber, Anterior capsule of lens, lens, posterior lens capsule, vitreous chamber and sclera retinal rim serially were visualized

In all the dogs following B scan ocular ultrasonography, the distance between the echoes were measured in millimeters with built-in calipers of ultrasound machine. Ocular biometry was recorded by placing the cursor exactly in the center of the specified locations in order to divide each intraocular structure which was measured into exactly equal halves (Fig. 2). The biometrical parameters recorded were.

- **Corneal thickness (CT):** Distance between the two parallel curvilinear echoes of cornea
- **Aqueous chamber depth (ACD):** Distance between echoes caudal to central cornea to anterior lens capsule was recorded as aqueous chamber depth.
- **Lens depth/ Lens thickness (LT):** Distance between echoes of the anterior capsule of the lens to the posterior capsule of the lens was recorded as lens depth.
- **Lens equatorial length / Lens Diameter (LEL)**: Distance between echoes of equators of lens
- **Vitreous chamber depth (VCD):** Distance between the echoes of posterior lens capsule to the retina of the eye was recorded as vitreous depth
- **Axial globe length (AGL):** Distance between echoes of mid cornea to outermost sclera was recorded as global axial length

The obtained data of ocular biometry of different types of cataracts were analyzed by statistical software SPSS 26 using One-way analysis of variance and Duncan was used as post-hoc test. Comparison of each cataract with normal eye was done using independent two tailed students T test.

Fig 1: Photograph showing immersion method in B-Scan in Horizontal plane in a Mongrel dog.

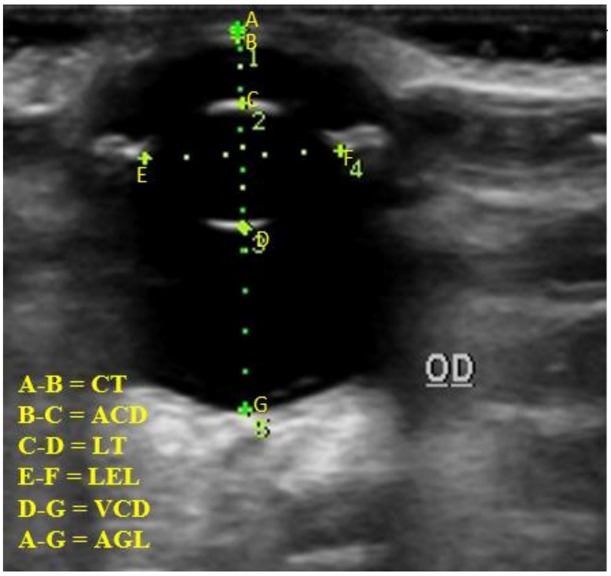

Fig 2: Photograph showing Intra ocular measurements in B-Scan of an eye.

Results and Discussion

The different stages of cataract were recorded in the present study. Among 36 dogs presented with cataract, intumescent cataract was seen in 7 (19%) dogs (4 bilateral and 3 unilateral cases), mature cataract in 12 (33%) dogs (5 bilateral and 7 unilateral), immature cataract in 12 (33%) dogs (5 bilateral and 7 unilateral), incipient cataract in 2 dogs (6%) (2 unilateral) and hypermature cataract in 3 (8%) dogs (3 unilateral). Thus, a total of 50 eyes were found affected with different types of cataracts in which intumescent cataract was seen in 11 eyes (22%), immature cataract in 17 eyes (34%), mature cataract in 17 eyes (34%), incipient cataract in 2 eyes (4%) and hypermature cataract in 3 eyes (6%). The age wise distribution of different stages of cataract was depicted in Table 1.

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 (Gonzalez *et al.*, 2001) [13]. The B-mode probe used in the present study allowed complete evaluation of the globe which was in accordance with Audu *et al*. (2017) [2], Kumar *et al*. (2018) [18], Ganesan and Ramani (2018) [11], Silva *et al*. (2018) [32], Tripathi *et al*. (2018) [39], Vali and Razeghi (2019) [41], Andrade *et al*. (2020) [1], Faleiro *et al*. (2021) [9] and Kumawat and Jhirwal (2021) [19]. B scan procedures with topical anaesthesia using 0.5% Proparacaine hydrochloride and achieved satisfactory desensitization of the cornea to perform trans corneal 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) [42, 17].

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) [10]. Mattoon and Nyland (2002) [25], Penninck *et al*. (2001) [30], Audu *et al*. (2017) [2], Kumawat and Jhirwal (2021) [19] and Lavanya *et al*. (2021) [21] 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) [36] sedated the dogs for ocular biometry.

The corneal contact method with gel provided superior anatomic definition (Hager *et al.,* 1987) [15] and provided superior images of the posterior segment (Williams and Wilkie 1996 [46]; Mason *et al.,* 2001 [24]; Dar *et al.,* 2014; Ganesan and Ramani, 2018 [11]; Tripathi *et al.,* 2018 [39]; Andrade *et al.,* 2020 [1]; Faleiro *et al.,* 2021 [9] and Kumawat and Jhirwal, 2021) [19] 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.

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.,* 2014; Ganesan and Ramani, 2018; Andrade *et al.,* 2020; Faleiro *et al.,* 2021 and Kumawat and Jhirwal, 2021) [6, 11, 1, 9, 19]. 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) [46].

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 two 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 the anterior and vitreous chamber were anechoic in appearance as reported by Whitcomb, (2002) [43]. The cornea visualized as a thin curvilinear hyperechoic line parallel to the probe in all the dogs as reported by Paunksnis *et al.*, (2001) [29]. 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 anechoic chamber, filled with vitreous humor as observed by Spaulding (2008) [35]. 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) [43].

Twelve clinically normal eyes were subjected to the B- mode ocular ultrasonography. The mean values for corneal thickness, anterior chamber depth, lens thickness, lens equatorial length and axial globe length were measured as 0.69±0.12, 3.34±0.30, 6.64±0.25, 11.32±0.94, 9.05±0.37, 20.06±0.75 respectively.

Among the eyes affected with cataract, immature and mature cataract were found more followed by intumescent, hypermature and incipient cataract. In the present study increased echogenicity was noted on ultrasonographic examination of lens in all types of cataracts. Hyper echogenicity of the anterior and posterior capsules detected independent of the developmental stage of the cataract. There was a significant increase in the echogenicity of the lens capsule with progression of stage of the cataract as reported by Munk *et al.* (1991) [27], Diaz (2004) [8], Williams (2004) [45], Martins *et al.* (2010) [23], Barr and Gaschen (2011) [3], Ganeshan and Ramani (2018) [11], Ragab and fathy (2018) [31], Lavanya *et al.* (2021) [21] and Meena *et al.* (2023) [26]. Changes within a cataract lens create acoustic inhomogeneities, as stated by Spaulding (2008) [35].

Immature capsular cataract showed increased thickness and echogenicity of lens capsule, while lens substance was found anechoic (Fig 3). Similarly, Williams and Wilkie (1996) [46] reported that in cataract, the entire lens capsule is visualized ultrasonographically as smooth hyperechoic structure with or without intra lenticular hyperechogenicity which was evident in capsular cataract. In immature cortical cataract hyperechoic band was seen at cortex of lens and entire capsule could be apparent (Fig 4). In mature cortical cataract highly hyperechoic anterior and posterior lens cortex along with thickened capsule is appreciated (Barr and Gaschen., 2011, Dar *et al*., 2014; Ragab and Fathy., 2018) [3, 6, 31] (Fig 5). In immature nuclear cataract hyperechogenicity can see at central axis of nucleus of lens with hyperechoic lens capsule (Fig 6). In mature nuclear cataract hyperechoic lens nucleus and capsule was clearly appreciable with enhanced echogenicity at the central axis of the lens nucleus (Barr and Gaschen, 2011; Dar *et al*., 2014) [3, 6] (Fig 7). In the present study the mature cataractous lens appeared hyperechoic at the capsular, cortical, nuclear or all the three regions. In dogs with early cataract (cortical) changes had hyperechoic lines within the lens and the strong hyperechoic curvilinear line was a posterior specular reflection on the surface of the lens as observed by Dar *et al*. (2014) [6] and Ragab and Fathy (2018) [31].

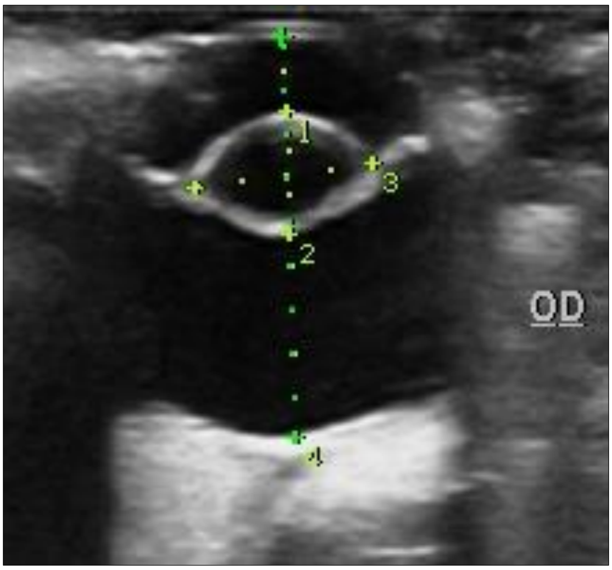

Fig 3: Sonogram showing immature capsular cataract with hyperechoic lens capsule

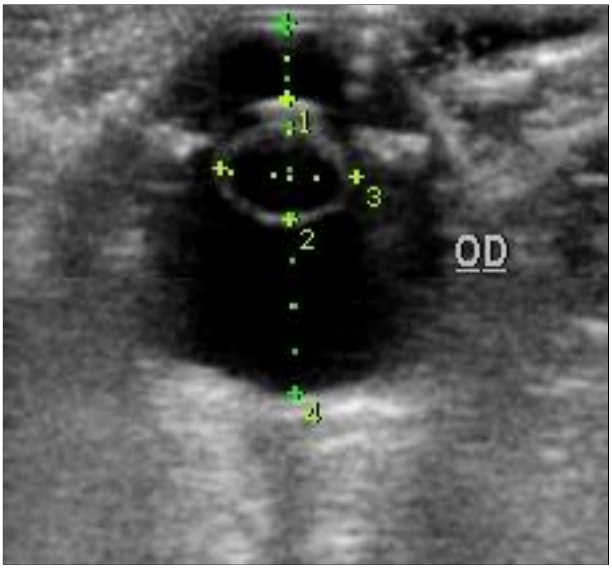

Fig 4: Sonogram showing immature cortical cataract with hyperechoic band at anterior lens cortex

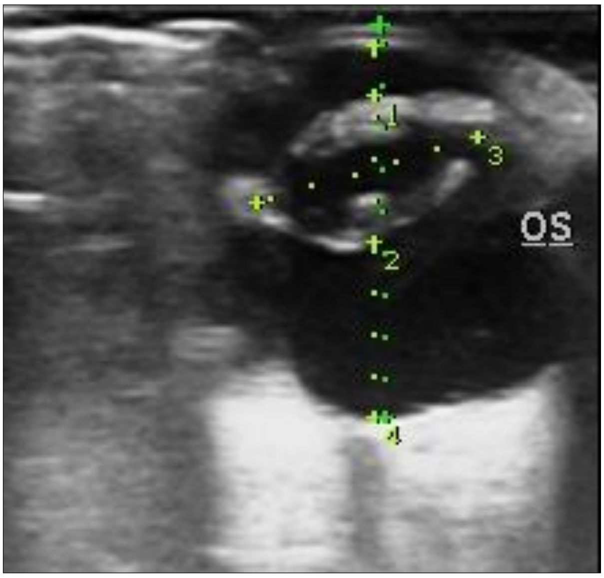

Fig 5: Sonogram showing mature cortical cataract with hyperechoic lens cortex and capsule

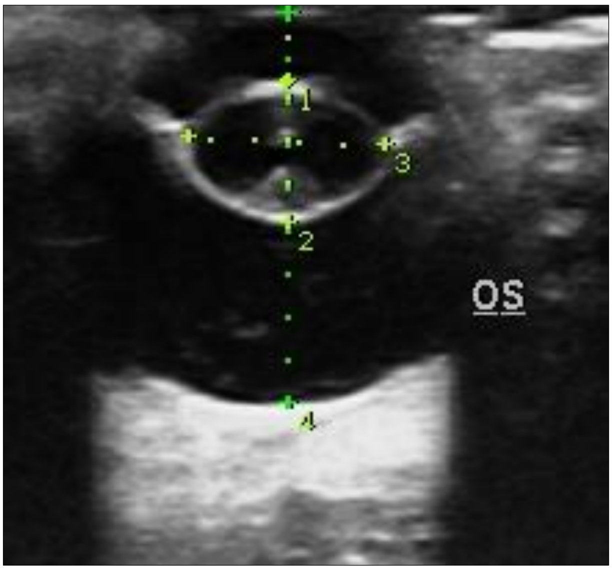

Fig 6: Sonogram showing immature nuclear cataract

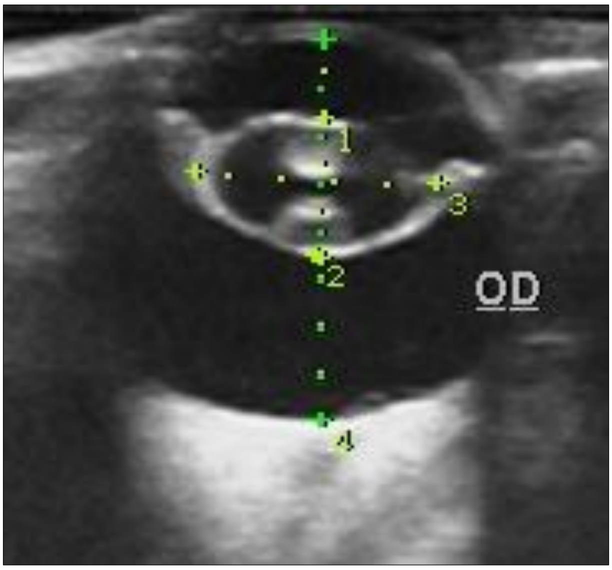

Fig 7: Sonogram showing mature nuclear cataract. Note the hyperechoic lens nucleus in its central axis

In eyes affected with mature cataract vitreous degeneration was seen as hyperechoic changes or opacification in the vitreous chamber along with hyperechoic ciliary body as two white triangular structures on equator of the lens suggestive of lens induced uveitis (Fig 8). Similarly, the relationship between cataract and vitreous degeneration was discussed in previous studies by Van der Woerdt *et al.* (1993) [42], Gonzalez *et al.* (2001) [13], Valentini *et al*. (2010) [40], Park *et al*. (2015) [28] and Krishnan *et al*. (2020) [16]. Ultrasonography was a valuable tool to evaluate vitreous and retinal conditions, as well as the stage of cataracts in mature cataract which occluding the visualization of posterior segment of eye (Van der Woerdt *et al.*, 1993) [42]. Vitreous degeneration and retinal detachment were more seen in eyes with hypermature cataract and were less common in eyes with immature cataract as reported by Gonzalez *et al.* (2001) [13], Dar *et al.* (2014) [6] and Ragab and Fathy (2018) [31].

In the present study, Hypermature cataract showed increase in echogenicity of lens capsule or nucleus or both with more thickening of lens capsule, mostly anterior lens capsule and irregularity in the contour of lens capsule (Dar *et al.*, 2014 and Barr and Gaschen., 2011) [6, 3]. This can be due to proteolysis of cortex and leakage of lens protein via capsule causing thickening and wrinkling of anterior capsule as reported by Davidson and Nelms (1999) [2]. Lens depth was found decreased in all eyes with hypermature cataract and hyperechoic thicker ciliary body was appreciated in all eyes with hypermature cataract suggestive of lens induced uveitis (Fig 9).

Intumescent cataract showed only hyperechoic lens capsule in the central axis of eye in immature stage and increased echogenicity in both capsule and nucleus in mature stage. There was a severe increase in lens depth and lens appeared almost globular in all eyes affected with intumescent cataract (Fig 10 and 11). Similar findings were reported by Williams (2004) [45], Barr and Gaschen (2011) [3] and Ganeshan and Ramani (2018) [11] where they found increase in lens volume in diabetic cataracts.

One case of intumescent cataract showed loss of contour of the lens capsule posteriorly and lenticular tissue was visible adjacent to the capsule suggestive of rupture of lens posteriorly (Fig 12) as reported by Williams (2004) [45] and Gould and McLellan (2014) [14] in diabetic cataracts which draw water into the lens leading intumescence or swelling of lens and later rupture.

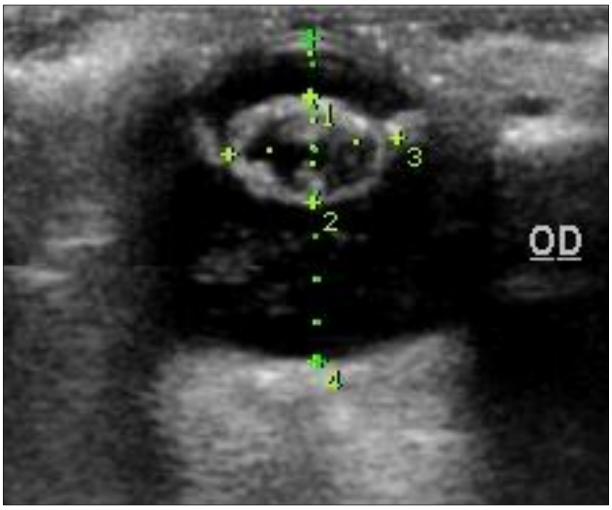

Fig 8: Sonogram showing mature cataract with vitreous degeneration and uveitis

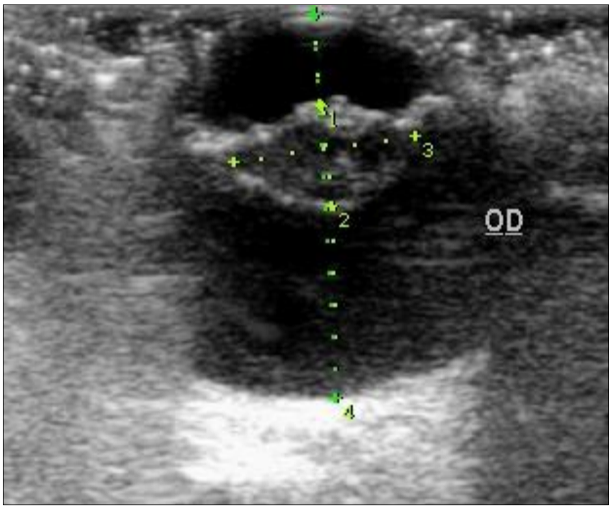

Fig 9: Sonogram showing decreased lens thickness and increased anterior chamber depth in hypermature cataract with thickened anterior lens capsule

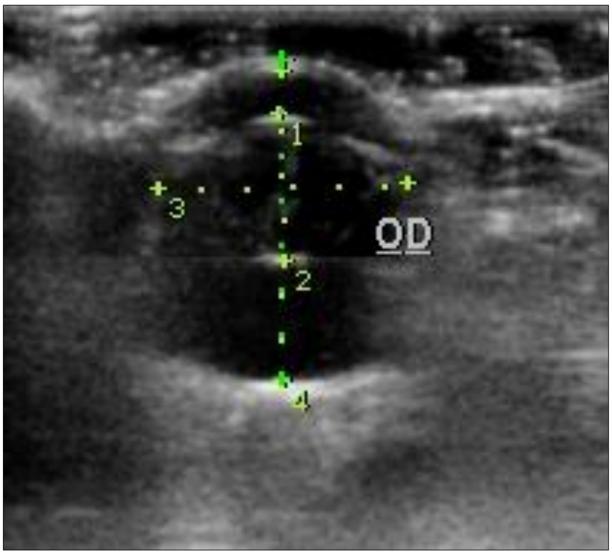

Fig 10: Sonogram showing increased lens thickness and decreased anterior chamber depth in immature intumescent cataract. Note the lens appeared globular

Fig 11: Sonogram showing increased lens thickness and decreased anterior chamber depth in mature intumescent cataract

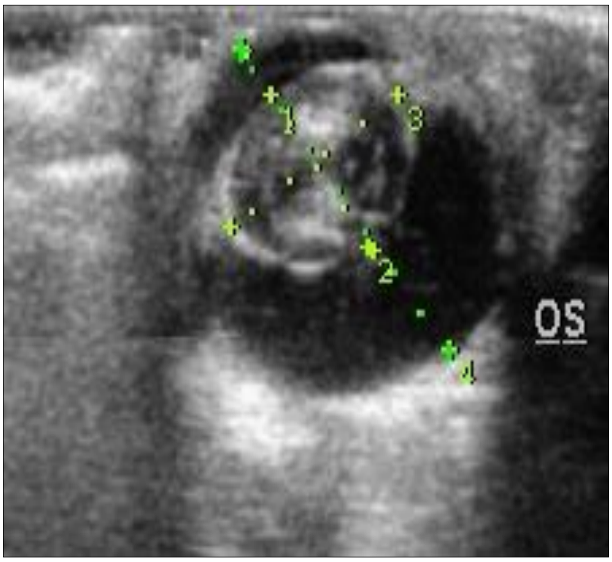

Fig 12: Sonogram showing lenticular rupture in diabetic cataract. Note the loss in contour of posterior lens capsule at its central axis with dispersed lenticular material

Eyes affected with cataract were subjected to B-mode ultrasonographic ocular biometric studies. The ocular biometry of different parameters measured in cataractous eyes were shown in Table 2.

The mean ± SE values of corneal thickness in eyes affected with intumescent, mature, immature, incipient and hypermature cataract were 0.92±0.18; 0.91±0.20; 0.83±0.24; 1.05±0.21 and 0.73±0.20 mm respectively. The study findings revealed that there was a significant increase (p<0.05) in the mean value of corneal thickness in eyes affected with incipient cataract when compared to normal eyes. There was no literature support regarding change in corneal thickness in incipient cataract.

Table 1: Age wise distribution of dogs affected with different types of cataracts in dogs

Age	Intumescent cataract	Mature cataract	Immature cataract	Incipient cataract	Hypermature cataract	Overall
0 – 1 Year	1(14%)	1(9%)	1(9%)	-	-	3(8%)
1 – 7 Year	4(57%)	7(58%)	7(58%)	2(100%)	2(67%)	22(61%)
>7 Year	2(29%)	4(33%)	4(33%)	-	1(33%)	11(31%)
Total	7(100%)	12(100%)	12(100%)	2(100%)	3(100%)	36(100%)

Table 2: Comparison of mean±SE (in mm) ocular biometric measurements between eyes affected with cataract (n=50) and healthy normal eyes (n=12)

Variable	Intumescent cataract (n=11)	Mature cataract (n=17)	Immature cataract (n=17)	Incipient cataract (n=2)	Hypermature cataract (n=3)	Normal eyes (n=12)	p value
Corneal thickness	0.92±0.18	0.91± 0.20	0.83±0.24	1.05^{b}± 0.21	0.73±0.20	0.69^{a}±0.12	0.028*
Anterior chamber depth	2.51^{a}±0.48	3.55±0.77	3.50±0.52	3.0 ±0.28	4.20^{c}±0.62	3.34^{b}±0.30	0.000**
Lens thickness	8.77^{c}±0.62	6.84^{b} ±1.03	6.56^{b}±0.61	6.80^{b}±0.28	5.53^{a}±0.29	6.64^{b}±0.25	0.000**
Lens equatorial length	11.07±1.59	10.47±1.20	9.99±1.29	10.45±1.90	9.47^{a}±0.40	11.32^{b}±0.94	0.047*
Vitreous chamber depth	7.88±2.67	8.82±1.10	8.83±0.85	8.45±0.07	9.67±0.59	9.05±0.37	0.271
Axial globe length	18.76±1.30	19.49±1.56	19.06±0.88	18.95±0.64	19.70±0.56	20.06±0.75	0.120

The mean ± SE values of anterior chamber depth in eyes affected with intumescent, mature, immature, incipient and hypermature cataract were 2.51±0.48; 3.55±0.77; 3.50±0.52; 3.0±0.28 and 4.20±0.62 mm respectively.

There was a high significant difference (p<0.01) in values of anterior chamber depth in eyes affected with intumescent cataract and hypermature cataract when compared with normal eyes and other types of cataracts. While, there was no significant difference in anterior chamber depth among immature, mature and incipient cataract and between these cataractous groups and normal eyes.

In the present study anterior chamber depth varied significantly among different types of cataract and normal eyes. When compared to a normal eye (3.34^{b}±0.30), intumescent cataracts (2.51^{a}±0.48), have significantly reduced anterior chamber depth (p<0.01) and hypermature cataract (4.20^{c}±0.62) have significantly increased anterior chamber depth (p<0.01). There was no significant difference in anterior chamber depth in eyes affected with mature (3.55±0.77), immature (3.50±0.52) and incipient cataract (3.0±0.28) when compared to normal eyes (3.34 ± 0.30) as reported by Ganeshan and Ramani (2018) [11].

The mean ± SE values of lens thickness in eyes affected with intumescent, mature, immature, incipient and hypermature cataract were 8.77±0.62; 6.84±1.03; 6.56±0.61; 6.80±0.28 and 5.53±0.29 mm respectively.

The study findings revealed that there was high significant difference (p<0.01) in values of lens thickness in eyes affected with intumescent cataract when compared with normal eyes and other cataracts. There was a high significant difference (p<0.01) in values of lens thickness in eyes affected with hypermature cataract when compared with normal eyes and other types of cataracts. There was no significant difference in lens thickness in eyes affected with immature, mature and incipient cataract when compared to normal eyes. Also, there was no significant difference in lens thickness between these three types of cataracts.

In the present study, lens thickness varied significantly among different types of cataract and normal eyes. When compared to a normal lens (6.64±0.25), intumescent cataracts (8.77±0.62), have significantly increased lens thickness (p<0.01) and hypermature cataract (5.53±0.29) have significantly decreased lens thickness (p<0.01) although lenses with mature cataract (6.84±1.03) and incipient cataract (6.80±0.28) showed a trend towards increased lens thickness, and immature cataracts (6.56±0.61) demonstrated a trend toward reduced thickness. But there was no significant difference in lens thickness in eyes affected with mature, immature and incipient cataract, when compared to normal eyes. Similar findings were reported by Williams (2004) [45], Barr and Gaschen (2011) [3], Martins *et al.* (2010) [23], Ganesan and Ramani (2018) [11] for the axial lens thickness and anterior chamber depth in diabetic cataractous eyes and Davidson and Nelms (1999) [2], Gellat (2013) [12], Gould and McLellan (2014) [14] and Lavanya *et al.* (2021) [21] for hypermature cataract. While, Lavanya (2021) [21] reported a non-significant increase in lens thickness in mature cataract when compared to normal eyes as seen in the present study.

In previous studies, diabetic cataracts showed significantly increased lens thickness and lenses with mature cataracts showed a trend towards increased axial thickness, and immature cataracts demonstrated a trend toward reduced thickness. Anterior chamber depth was significantly reduced in eyes with diabetic cataract from normal eyes, eyes with immature cataract and eyes with mature cataract as reported by Williams (2004) [45]. Diabetic cataractous lens was larger, compared to mature cataract. Lens with immature cataract were smaller in dimension than those with mature and diabetic cataracts as reported by Martins *et al.* (2010) [23].

The increase in lens thickness in intumescent cataract could be due to the defective glucose metabolism in diabetes and accumulation of sorbitol in the lens which draw water into the lens leading to increase in lens volume (intumescence). The increase in the lens depth will cause decrease in anterior chamber depth in this cataract as opined by Gellat (2013) [12], Gould and McLellan (2014) [14].

The decrease in lens thickness in hypermature cataract could be due to the release of enzymes from the lens fibers due to advanced stage of cataract causing proteolysis notably in the cortex. The lysis of proteins and loss of fluid by the lens capsule induce a reduction in volume of lens. This reduction in depth of lens causes relative increase in anterior chamber depth. Similar statement was opined by Slatter (1990) [34], Davidson and Nelms (1999) [2], Gellat (2013) [12] and Gould and McLellan (2014) [14]. In contrary to present study Silva *et al*. (2010) [33] reported there was no discernible variation in the ocular biometric values between normal and cataractous lens.

The mean ± SE values of lens equatorial length in eyes affected with intumescent, mature, immature, incipient and hypermature cataract were 11.07±1.59; 10.47±1.20; 9.99 ±1.29; 10.45 ±1.90 and 9.47±0.40 mm respectively.

There was a significant difference (p<0.05) in values of lens equatorial length between eyes affected with hypermature cataract and normal eyes. When compared to normal eyes (11.32^b ±0.94), lens affected with hypermature cataract (9.47^a ±0.40) has significantly reduced lens equatorial length (P<0.05). This can be due to shrinkage and reduction in volume of lens in hypermature cataract due to lysis of proteins and loss of fluid by the lens capsule as reported by Davidson and Nelms (1999) [2]. There was no significant difference in LEL between eyes affected with other type of cataracts and healthy normal eyes.

The mean ± SE values of vitreous chamber depth in eyes affected with intumescent, mature, immature, incipient and hypermature cataract were 7.88±2.67; 8.82±1.10; 8.83±0.85; 8.45±0.07 and 9.67±0.59 mm respectively.

There was no significant difference in the values of vitreous chamber depth between eyes affected with cataract and normal eyes. Similarly, Martins *et al.* (2010) [23] evaluated the length of the eye, anterior chamber, lens, and vitreous of dogs with immature, mature, and diabetic senile cataract, using B-mode ultrasonography and found there was no alternation in size of vitreous in senile cataracts as found in the present study.

The mean ± SE values of axial globe length in eyes affected with intumescent, mature, immature, incipient and hypermature cataract were 18.76±1.30, 19.49±1.56, 19.06±0.88, 18.95±0.64 and 19.70±0.56 mm respectively.

There was no significant difference in the values of axial globe length between eyes affected with cataract and normal eyes as reported by Williams (2004) [45]. In contrary to the present study Lavanya (2021) [21] stated that there was significant difference in the axial length of the eyes with mature cataract when compared with that of immature and hypermature cataracts in the left and right eyes (p< 0.05).

Conclusion

It was concluded that there was a significant increase (p<0.05) in corneal thickness in eyes affected with incipient cataract when compared to normal eyes. The intumescent cataracts have significantly (p<0.01) reduced anterior chamber depth and significantly increased lens thickness while hypermature cataract have significantly (p<0.01) increased anterior chamber depth, significantly reduced lens thickness (p<0.01) and significantly reduced lens equatorial length (p<0.05).

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