Received: 30 January 2022 | Revised: 4 March 2023 | Accepted: 6 March 2023

DOI: 10.1111/vop.13090

ORIGINAL REPORT

WILEY

Prevalence and outcome of lens capsule disruption in routine canine cataract surgery: A retrospective study of 520 eyes (2012–2019)

Amy L. M. M. Andrews | **Christiane Kafarnik** | **Maria-Christine Fischer**

Queen Mother Hospital for Animals, Royal Veterinary College, Hawkshead Lane, Hatfield, AL9 7TA, United Kingdom

Correspondence
Amy L. M. M. Andrews, Queen Mother Hospital for Animals, Royal Veterinary College, Hawkshead Lane, Hatfield AL9 7TA, United Kingdom.
Email: aandrews@rvc.ac.uk

Abstract

Objective: To investigate the prevalence and surgical outcome of lens capsule disruption (LCD) in dogs undergoing cataract removal.

Animals studied: Medical records of 924 eyes undergoing phacoemulsification were analyzed retrospectively.

Procedures: Routine cataract surgeries with or without LCD were included. Any LCD other than routine anterior capsulorhexis was defined as LCD and classified according to location and etiology. Odds ratios (OR) were calculated for maintaining vision, implantation of an artificial intraocular lens (IOL), and enucleation.

Results: In total, 520 eyes were included. A LCD occurred in 145 eyes (27.8%; 145/520) and affected the posterior (85.5%; 124/145), anterior (6.2%; 9/145), and equatorial lens capsule (4.8%; 7/145) and at multiple locations (3.4%; 5/145). The etiology of the LCD was spontaneous preoperative in 41 eyes (28.3%; 41/145), accidental intraoperative in 57 eyes (39.3%; 57/145), and planned in 47 eyes (32.4%; 47/145). Disruption did not increase the odds of enucleation (OR = 1.48, 95% confidence interval [CI] 0.56–3.67; $p = .36$). The presence of LCD significantly increased the risk of losing vision 1 year post-operatively (OR = 8.17, 95% CI 1.41–84.93; $p = .007$) associated with retinal detachment. However, this was not present at 2 years follow-up or in PCCC cases at any time point. An IOL was implanted in 108 eyes (108/145; 75.2%) with LCD and in 45/47 (95.7%) eyes with a PCCC.

Conclusion: Increased surgeon awareness of possible intraoperative, accidental LCDs is important, as LCDs were relatively common and associated with increased odds for vision loss after 1 year in the present study. A prospective study investigating the causes of intraoperative, accidental LCD is warranted.

KEYWORDS

capsulorhexis, cataract surgery, dog, intraocular lens, lens capsule rupture, phacoemulsification

1 | INTRODUCTION

Lens capsule disruption (LCD) other than routine anterior capsulorhexis purposefully performed by the surgeon is a well-recognized complication associated with cataracts and their surgical management.[1] Lens capsule disruption can occur preoperatively, associated with rapid-onset of juvenile or diabetic cataracts, and/or intraoperatively.[2] Lens capsule disruption reduces the safety of in-the-bag intraocular lens (IOL) implantation and can significantly reduce the ability of IOL placement.[3] Early intraoperative identification of LCD is important to minimize the enlargement of the tear, prevent its extension to the periphery, avoid vitreal prolapse, and/or dislocation of lens fragments into the vitreous.[4]

Failure to implant an artificial IOL reduces optimal surgical success and results in hyperopia with a refractive error of 14 diopters in the canine species.[5,6] Intraocular lens placement is important to reduce the development of posterior capsular opacification.[7] Biros et al.[8] found that the implantation of an IOL was associated with a significantly lower risk for postoperative glaucoma and concluded that complications preventing IOL implantation may increase the risk of glaucoma development. There is some controversy over whether disruption of the lens capsule before or during surgery can increase the recognized risks of phacoemulsification, such as uveitis, secondary glaucoma, retinal detachment, retained lens fragments, hemorrhage, and corneal edema.[1,4,9]

The etiology of LCD can be spontaneous, traumatic, or accidental intraoperative, and it can influence the urgency and phacoemulsification technique.[2,10,11] Spontaneous LCD is most frequently reported in rapidly progressing and intumescent diabetic cataracts and can be preoperatively diagnosed in the majority of eyes.[2] In humans, the cataract type, etiology, and stage, alongside experience and technique of the surgeon, are reported to affect the development of LCD.[12] Although the effect of surgeon's experience has not been thoroughly studied in veterinary cataract surgery, the incidence of accidental intraoperative LCD during phacoemulsification in human patients is thought to largely depend upon the experience and skill of the surgeon.[12–14] Contrary to canine patients, spontaneous lens capsule rupture in humans has not been reported in association with diabetes mellitus.[2] However, spontaneous lens capsule rupture in humans has been reported in hypermature senile cataracts and Alport's syndrome.[15,16] Alport's syndrome is an inherited disorder affecting type IV collagen resulting in clinical signs such as anterior lenticonus.[17]

A planned LCD is carried out by performing a posterior continuous curvilinear capsulorhexis (PCCC).[1,7] Planned PCCC is indicated in axial lens capsular plaques, and in young patients, in which marked lens fiber regrowth and posterior capsular opacification may occur.[7,18] A PCCC is also a recognized approach in veterinary and human medicine to manage accidental intraoperative capsular tears to prevent further tear extension during phacoemulsification.[13,19–21]

There is a paucity within the veterinary literature identifying the frequency and characteristics of LCD, with only one study having been published in the previous two decades.[3] It is essential to understand appropriate management and outcomes to provide more accurate information regarding surgical success and the long-term prognosis of vision. The present study retrospectively reports the prevalence of LCD. Furthermore, it aims to identify the odds of complications and visual outcomes following phacoemulsification, dependent on their etiology and the location of the LCD.

2 | MATERIALS AND METHODS

The clinical records were extracted for dogs that underwent phacoemulsification between April 2012 and April 2019 at the Queen Mother Hospital for Animals (QMHA). The definition used for LCD in this study was: LCD other than routine anterior capsulorhexis purposedly performed by the surgeon. Eyes were included if a routine, uncomplicated procedure had been performed with no contraindications for IOL placement and therefore classified as routine without the presence of a LCD. Eyes were included in the LCD group if a LCD occurred pre- or intraoperatively (planned PCCC or unplanned). Eyes were excluded if there was an incomplete preoperative or surgical record, or if there was recorded existence of pre- or intraoperative lens instability or luxation, a history of trauma, progressive retinal atrophy, and/or a history of corneal surgery.

The signalment, diabetic status, and duration (time of diagnosis/presentation to time of phacoemulsification) and maturity of cataract were recorded. Information from ophthalmic examinations completed before cataract surgery was used to identify clinical signs that raised suspicion of preoperative LCD, such as phacoclastic uveitis, asymmetric anterior chamber, a shift of lens suture lines, intralenticular uveal pigmentation, posterior synechia, and visible lens capsular tears. Information from an ocular ultrasound performed by a board-certified veterinary radiologist and/or veterinary radiology resident was used to determine the presence and location of preoperative LCD. The images were obtained using a 3–16-MHz (Samsung, Lysis Healthcare GmBH) linear ultrasound probe. The reports were assessed for ultrasonographic findings of LCD, including irregularity of the lens borders, discontinuation of the lens capsule, lens nucleus displacement, an increase in lens capsule echogenicity, a reduction in lens diameter, and the presence of hyperechoic and amorphous material within the vitreous protruding from the posterior lens capsule.[22,23] Information from surgical reports was used to confirm the occurrence of spontaneous preoperative LCD and to differentiate between accidental intraoperative and planned PCCC, and confirm other intraoperative complications, such as retained lens fragments and hemorrhage. Information on IOL placement was also extracted. Surgical reports were used to confirm the occurrence of postoperative complications, including: postoperative ocular hypertension (defined as >25 mmHg within 48 h), glaucoma, retinal detachment, endophthalmitis, corneal edema, decentration or dislocation of the IOL, and enucleation at any time point.[8] The medical records were used to extract information on how often clinicians assessed patients postoperatively throughout the follow-up period and how many owners complied with the recommendation to return for re-evaluation. Surgical success was categorized as the presence of postoperative vision (using the presence of the menace response), IOL placement, and an absence of enucleation reported at any time point in the postoperative period. Data from eyes with any type of LCD were compared to data from eyes with routine phacoemulsification without LCD.

Descriptive statistics and statistical analyses were performed comparing groups with and without a LCD using odds ratios (95% confidence intervals) and a one-tailed Fisher exact test. Results were considered significant with a p value < .05. The two groups were statistically compared for (1) postoperative enucleation, (2) postoperative vision (defined as the presence of menace response), and (3) implantation of an IOL.

3 | RESULTS

A total of 924 records were reviewed, and 520 eyes of 309 dogs met the inclusion criteria. The mean age ± standard deviation (SD) of the study population was 8.4 ± 3.1 years, ranging from 0.4 to 17.5 years. Sex and neuter status revealed 158/309 (51.1%) were neutered males, 24/309 (7.8%) entire males, 105/309 (34.0%) neutered females, and 22/309 (7.1%) entire females. Fifty-five breeds were represented and 44/309 (14.2%) of the dogs were crossbreeds. The Jack Russell terrier was the most represented breed, accounting for 25/309 (8.1%) of the dogs studied. Other common breeds included the West Highland White Terrier (24/309, 7.8%), Labrador retriever (22/309, 7.1%), Bichon Frise (22/309, 7.1%), and the miniature Schnauzer (20/309, 6.5%). Of the study population, 165/309 (53.4%) had concurrent diabetes mellitus. The average time ± SD from cataract diagnosis to presentation to the referral hospital was shorter in diabetic patients (108 ± 159.9 days) compared to non-diabetics (231 ± 317.6 days). The average time ± SD between diagnosis of the cataract and phacoemulsification was 205 ± 322.3 days; the group without LCD had an average of 192 ± 309.7 days and the group with LCD had an average of 241 ± 353 days. The time difference between both groups was not statistically significant (95% CI −12.923 to 110.923; p = .12). The average time ± SD from presentation to the referral hospital to phacoemulsification was shorter in diabetic patients (47 ± 56.8 days) compared to non-diabetics (76 ± 172.69 days). Surgery was performed by eight different surgeons varying from supervised residents to board-certified ophthalmologists. The eyes were operated on at varying stages of cataract progression including incipient (1/520, 0.1%), immature (222/520, 42.7%), mature (263/520, 50.6%), and hypermature (34/520, 6.5%) cataracts. There was a significant difference in the stage of cataract maturity at surgery between the groups (95% CI −0.004 to −0.236; p = .04). Phacoemulsification was most commonly performed when the cataract was mature in eyes without LCD (210/375, 56.0%) than in eyes with LCD (77/145, 53.1%). A greater proportion of hypermature cataracts underwent surgery in the LCD group (14/145, 9.7%) compared to the group without LCD (20/375, 5.3%).

There were 145/520 eyes with LCD, which accounts for 27.9% of the study population. Of these, 72/145 (49.6%) had a diabetic cataract. The diabetic population had a significantly increased risk of LCD (95% CI 0.39–0.85; p = .005). Bilateral LCDs were described in 31/309 (10.0%) of dogs, of which 17/31 (54.8%) were diabetic patients. In the 83/145 (57.2%) unilateral eyes with LCD, 49/83 (59.0%) had LCD affecting the right eye and 34/83 (41.0%) affecting the left, which was statistically different (95% CI 2.80–32.08; p = .02). Of all the eyes with LCD, 47/145 (32.4%) underwent a planned PCCC (Figure 1). A PCCC accounted for 47/124 (37.9%) of all eyes with a LCD solely affecting the posterior lens capsule. The unplanned LCDs (98/145, 67.6%) comprised of 57/98 (58.2%) accidental intraoperative tears located posteriorly (41/57, 71.9%), anteriorly (9/57, 15.8%), at multiple locations (4/57, 7.0%), or equatorially (3/57, 5.3%). The remainder (41/98, 41.8%) were spontaneous preoperative LCDs located posteriorly (36/41, 87.8%), equatorially (4/41, 9.8%), or at multiple locations (1/41, 2.4%; Table 1). Spontaneous LCD was diagnosed on ophthalmic examination in 11/41 (26.8%) eyes. In a total of 2/375 (0.5%) eyes, a LCD was suspected based on the ophthalmic examination, but the surgeon could not identify a LCD intraoperatively. Spontaneous LCD was correctly diagnosed during a preoperative ocular ultrasound in 30/41 (73.1%) eyes. Five eyes (5/520,

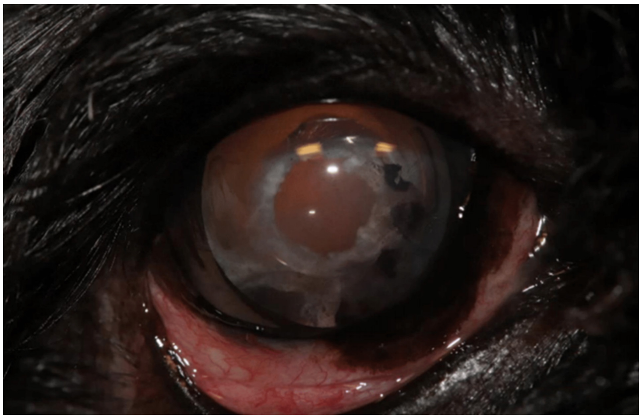

FIGURE 1 Photograph of the left eye of a dog (8 years 2-month-old, female neutered, Cockapoo) over 6 years following phacoemulsification, planned posterior continuous curvilinear capsulorhexis and implantation of a 12 mm artificial intracapsular lens implant.

1%) exhibited ultrasonographic findings suspicious of LCD; however, a LCD was not identified intraoperatively (i.e., false positive). The most consistent ultrasonographic changes suggestive of LCD were irregularity of the lens capsule and the presence of hyperechoic amorphous material within the vitreous protruding from the posterior lens capsule, which was reported in 12/25 (48.0%) and 9/25 (36.0%) eyes, respectively.

The study population had an IOL placed in 482/520 (92.7%) eyes, of which all (375/375, 100%) eyes had an IOL placed in the routine cataract surgery group (i.e., without LCD). This was significantly higher than in the group of LCDs, in which an IOL was placed in 107/145 (73.8%) eyes (OR: 0.74, $p = .039$; Table 2). Intraocular lens placement was achieved in eyes with spontaneous LCD in 18/41 (43.9%) eyes. The diabetic patients with spontaneous LCD had an IOL placed in 13/29 (44.8%) eyes. An IOL was placed in 45/47 (95.7%) eyes following a PCCC. The odds for placing an IOL following PCCC were significantly higher compared to accidental intraoperative or spontaneous preoperative LCD (OR: 0.08, $p = 1.29 \times 10^{-05}$). The odds for IOL placement were also higher for accidental intraoperative LCD compared with a spontaneous preoperative LCD (OR: 0.23, $p = 7.53 \times 10^{-5}$).

Results from postoperative examinations were not available for all time points due to a lack of owner compliance with recommended follow-up examinations. The median follow-up time in the routine group was 286 days (range 0–2253 days) and 283 days (range 7–1982 days) in the LCD group which was not significantly different. A postoperative ophthalmic examination was performed on 430/520 (82.7%) eyes at 3 months, 350/520 (67.3%) at 6 months, 248/520 (47.7%) at 1 year and 113/520 (21.7%) at 2 years. Follow-up of the routine group was 306/375

TABLE 1 Classification of lens capsule disruption (LCD) location and type in 145/520 dogs that underwent phacoemulsification (n = number of eyes).

Classification of LCD	*n*	% of the total study population	Stage of cataract (*n*)			
			Incipient	Immature	Mature	Hypermature
Planned posterior continuous curvilinear capsulorhexis	47	9.1	0	19	20	8
Accidental intraoperative, posterior	41	7.9	1	17	21	2
Spontaneous posterior	36	6.9	0	11	24	1
Accidental intraoperative, anterior	9	1.7	0	1	6	2
Spontaneous equatorial	4	0.8	0	1	3	0
Accidental intraoperative, multiple	4	0.8	0	3	1	0
Accidental intraoperative, equatorial	3	0.6	0	1	2	0
Spontaneous, multiple	1	0.2	0	0	1	0

Note: The number of eyes at each cataract stage for each classification of LCD.

TABLE 2 A comparison of outcomes between cataract surgery with and without lens capsule disruption (LCD).

	Without LCD	With LCD	Odds ratio	*p* value
Placement of intraocular lens[a]	100% (375/375)	73.8% (107/145)	0.7	.039
Vision				
3 months	97.7% (299/307)	93.5% (115/123)	2.6	.086
6 months	96.5% (245/254)	89.6% (89/96)	2.1	.153
1 year[a]	98.9% (176/178)	91.4% (64/70)	8.2	.007
2 years	97.5% (79/81)	87.5% (28/32)	5.5	.053
Enucleation	4.2% (16/375)	6% (9/145)	1.5	.364

[a]Indicates statistical significance (p value < .05).

(81.6%) eyes at 3 months, 253/375 (67.5%) at 6 months, 178/375 (47.5%) at 1 year, and 81/375 (21.6%) at 2 years. Follow-up of the LCD group was 123/145 (84.8%) eyes at 3 months, 96/145 (66.2%) at 6 months, 70/145 (48.3%) at 1 year, and 32/145 (22.1%) at 2 years. Postoperative vision assessment was carried out by clinicians through the assessment of menace response as part of the ophthalmic exam. There was no significant difference in maintenance of vision between different types of LCD up to 6 months postoperatively or after 2 years. There were significantly higher odds of vision retention in eyes without LCD than in eyes with LCD at year one postoperatively (OR: 8.17, $p = .007$), with a trend of vision retention (OR: 5.5, $p = .053$) after 2 years (Table 2). Loss of vision in the LCD group within the first year after cataract surgery was associated with retinal detachment and occurred in seven eyes affected by unplanned LCD. There was no significant difference between the incidence of enucleation following surgery with or without LCD ($p = .36$; Table 2). Corneal edema, postoperative hypertension, and glaucoma were the most common complications reported, with no significant difference between the groups with or without LCD when analyzing the postoperative examinations collectively (Figure 2).

4 | DISCUSSION

4.1 | Prevalence of lens capsule disruption

To the author's knowledge, this is the only study in the last decade on canine lens capsule disruption investigating its prevalence, visual outcome, and associated complications depending on location and etiology. There are no studies of human patients identifying the prevalence of lens capsule disruption (LCD) as defined in the current study. However, human studies that have looked at the disruption of the posterior capsule are more abundant.[21,24–27]

The current study revealed a higher prevalence of posterior LCD compared to a canine study by Johnstone and Ward[3] which reported it in 13.5% (33/244) of the eyes included, while the number of PCCC in both studies was similar. A study in human patients reported performing a PCCC prophylactically to avoid post-phacoemulsification posterior capsule opacification in 96% of patients.[28] Planned PCCC in human subjects has been reported to be useful during the intraoperative management of accidental, posterior capsular tears and the removal of posterior capsular opacification, and has been described as "advantageous" in the cataract surgery of uveitic and pediatric cataracts.[28–30] However, performing a planned PCCC in human subjects in the presence of an intact posterior capsule is seen as controversial by some authors due to the possible complications associated with irregular tears, vitreal prolapse, and/or the presence of excessive vitreal pressure leading to a vitreous "push".[12] Planned PCCC might not be as frequently used in canine patients due to a lack of direct patient demand for the best postoperative visual acuity possible and due to the perceived risks PCCC may pose in the minds of the surgeons. The study in canine patients by Johnstone and Ward[3] concluded that there was no difference in the outcomes regarding vision or incidence of postoperative complications in patients with planned and unplanned posterior capsule disruption compared to those without. There was no significant difference in the median follow-up time in the present study between the routine and LCD groups, similar to that reported by Johnstone and Ward.[3] The median follow-up time for the LCD group was longer in the present study with 283 days compared to Johnstone and Ward (2005) which reported 157 days in the capsular disruption group.

Planned PCCC and accidental intraoperative tears are the most commonly reported posterior LCD in humans.[21,30] This is similar to the current study in which intraoperative tears among non-diabetic dogs accounted for the majority of tears of the LCD group.[12] The

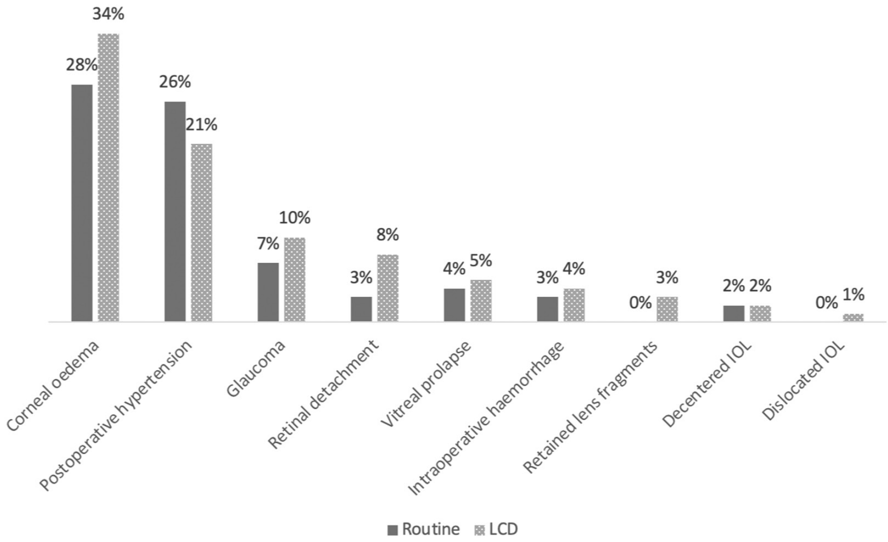

FIGURE 2 Cumulative percentage of eyes from all time points following phacoemulsification with intraoperative or postoperative complications. No significant difference in complications was identified between the routine group without LCD ($n=375$) and the group with lens capsule disruption (LCD) ($n=145$, $p=.2$).

incidence of accidental intraoperative posterior LCD in the present study was very similar to that reported by Johnstone and Ward.[3] This is predominantly attributable to the surgeon's experience according to studies in human patients.[3,31] Surgeon's experience alongside other reported predisposing factors of capsule tears (phacoemulsification machine, intra- and extra-ocular characteristics, rhexis, and fluidics factors), are yet to be investigated in the veterinary field.[4]

Spontaneous LCD was more common in diabetic patients as reported by Wilkie et al.[2] Interestingly, a small number of non-diabetic patients in the present study had bilateral spontaneous LCD. This was associated with patients of different ages, making this the first veterinary report to describe the presence of spontaneous LCD in non-diabetic and non-rapidly progressive cataracts in adult and geriatric dogs. This highlights the importance of preoperative ultrasonography to identify potential spontaneous LCD in all patients undergoing phacoemulsification and not solely those at high risk, e.g., diabetic patients.[1,2] Spontaneous LCD most commonly affected the posterior capsule in the present study, which differed from the study by Wilkie et al.[2] where ruptures were more commonly identified at the lens equator. The cause of this difference remains unknown.[2] In people, an anterior or posterior spontaneous rupture is seen in hypermature senile cataracts whereas an anterior spontaneous rupture has been reported in Alport's syndrome associated with anterior lenticonus.[15,16]

4.2 | Identification of LCDs

Preoperative identification of LCD is essential to optimize surgical planning for the management of it intraoperatively.[2] However, clinical signs that should raise the suspicion of preexisting LCD were raised in just over a quarter of the eyes in the present study compared to the majority of the eyes (93%, 28/30 eyes) reported in the study by Wilkie et al.[2] This might be explained by the fact that the majority of LCDs in the present study were posteriorly located and not equatorial. Direct observation of a capsular tear using slit lamp biomicroscopy may be limited due to the presence of a lens opacity that reduces the ability of the examiner to visually identify a preoperative LCD during the ophthalmic exam.[32] In addition, clinical signs suggestive of a LCD may vary dependent on the location tear. Ultrasonography is thus essential to assess the equatorial and posterior segment when lenticular opacification obscures examination of intraocular structures.[33] Ocular ultrasound was found to be helpful in the preoperative identification of a large percentage of the eyes with LCD in the present study. The reasons why several spontaneous LCDs were not identified preoperatively remain unclear; however, a higher resolution probe than the 16-MHz probe used in the present study might have resulted in a higher number of eyes being correctly identified preoperatively.[34] Small ruptures of the lens capsule might have been missed using a 16-MHz probe and might have enlarged in size during surgical manipulation.[35,36] False positive results could be explained by irregularities of the lens capsule associated with hypermature cataracts and the presence of hyperechogenic degenerative changes in the vitreous.[37]

4.3 | Intraocular lens placement

It is well recognized that aphakia should be avoided and the surgeon should strive for refractive correction to optimize visual acuity for dogs.[38] Placement of an IOL in the LCD group in the present study was significantly less frequent than in the non-LCD group and this was comparable to the results of the Johnstone and Ward study (2005).[3] The higher implantation rate of IOL in LCDs in the present study is likely attributable to the overall advancement of the foldable and injectable IOL, allowing a smaller surgical incision and increased ability to successfully implant a stable IOL in instances of capsular tears.[1,39] However, IOL placement following diabetes-associated spontaneous LCD was lower in the present study compared to what was previously reported by Wilkie et al.[2] The surgeon's ability to place an IOL is associated with the status of surgical training and experience, but it also largely depends on the location and size of the capsular tear, which may have varied between both studies.[4] In this study, IOL decentration did not occur more often with LCD (Figure 2).

Intraocular lens placement rates could be increased via the stabilization of an IOL within the ciliary sulcus or via rhexis fixation.[1,11,39,40] In human patients, aphakia is considered less acceptable; therefore, alternative methods are frequently sought.[40] Further surgical approaches described in people include anterior chamber, iris, sulcus, or scleral fixation of the IOL.[4,21,41] In rare cases, temporary aphakia may be employed, followed by secondary surgical intervention for IOL placement at a later point.[4] In some cases, a technique called 'buttonholing' is used in human patients to reduce posterior capsular opacification.[42,43] This technique was not used in any of the cases in the present study, but it has been described for use in veterinary patients to address posterior LCD.[11] Alternatively, conversion to a PCCC following an accidental intraoperative posterior capsular tear may facilitate the placement of an IOL, as reported previously.[1,3] Despite the finding that placement of an IOL in the LCD group in the present study was significantly lower than in the non-LCD group, it should also be noted that PCCC did not interfere with IOL placement, as nearly all eyes with a PCCC in the present study were fitted with an IOL.

4.4 | Postoperative outcomes and complications

The study by Johnstone and Ward[3] reported no significant decrease in retention of vision in the presence of a posterior LCD at the last follow-up examination. The findings of the present study were largely in agreement with that. However, the present study also found a significant difference in vision between the groups in the 1-year postoperative period, which was associated with the occurrence of retinal detachment in the LCD group (Table 2). This difference was not identified at the two-year time point in the present study. Although posterior LCD with vitreous loss has been associated with retinal detachment in people,[44] the reason for vision loss due to retinal detachment at that specific time point after surgery in the present study remains unexplained. Some studies in human patients conclude that phacoemulsification without capsular rupture could result in significantly better visual outcomes and that an optimal level of vision may not be achievable following LCD.[28,45] Visual acuity was not assessed in the present study, which is a limitation. However, it is difficult to obtain accurate information on the degree of vision impairment in veterinary patients. More reliable measures can be used in the human medical field to quantitatively assess vision.[46,47]

Despite a slightly higher percentage of glaucoma and retinal detachment in the LCD group in the present study compared to the non-LCD group, there was no significant difference in postoperative complications or enucleation. Although this supported the findings by Johnstone and Ward (2005), it contradicted findings in studies on human subjects.[4,45] The number of postoperative complications in the presence of LCD in the present study was different than in some studies of human patients that reported glaucoma in a lesser number of patients and retinal detachment in a similar number of patients.[4,45] Despite these differences, the overall postoperative outcomes of patients with LCD were promising both in veterinary and human patients which agrees with the findings of the present study.[3,48,49] Lastly, just as intraocular pressure monitoring is recommended postoperatively and long-term to help in the management of IOP elevations associated with LCD in human patients, it seems reasonable to recommend the same for veterinary patients.[50]

Some of the limitations of the current study were associated with its retrospective nature. Clinical signs noted on the preoperative examination that raised suspicion of LCD may not have been complete in the medical records. This could have explained the difference in preoperative identification between the present study and the study by Wilkie et al.[2] A limitation of the present study is the missing information of the surgical reasoning to perform a PCCC, therefore, further analysis of whether PCCC facilitated IOL placement is lacking. A standardized approach to managing accidental LCD intraoperatively and explanations for the inability to place an IOL were also lacking. Although a limiting factor, the loss of cases to follow-up is unavoidable. In people, it is well documented that the surgeon's experience level significantly affects the occurrence of accidental intraoperative posterior LCD.[45] The surgeon's level of experience could not be identified from the current retrospective data. Ascertaining this surgeon-specific information would enable future studies to recognize and analyze experience-associated risk factors.

In conclusion, increased surgeon awareness of possible intraoperative, accidental LCDs is important, as LCDs were relatively common and associated with an increased odds for vision loss after 1 year in the present study as well as a significantly reduced lens implantation rate. A prospective study investigating the causes of intraoperative, accidental LCD is warranted.

ORCID

Amy L. M. M. Andrews https://orcid.org/0000-0001-5536-7692

REFERENCES

1. Miller Michau T. Surgery of the lens. *Gelatt Veterinary Ophthalmology*. Vol 2. 6th ed. Wiley; 2021:1371-1458.
2. Wilkie DA, Gemensky-Metzler AJ, Colitz CMH, et al. Canine cataracts, diabetes mellitus and spontaneous lens capsule rupture: a retrospective study of 18 dogs. *Vet Ophthalmol*. 2006;9(5):328-334. doi:10.1111/j.1463-5224.2006.00490.x
3. Johnstone N, Ward DA. The incidence of posterior capsule disruption during phacoemulsification and associated postoperative complication rates in dogs: 244 eyes (1995–2002). *Vet Ophthalmol*. 2005;8(1):47-50. doi:10.1111/j.1463-5224.2005.00344.x
4. Chakrabarti A, Nazm N. Posterior capsular rent: prevention and management. *Indian J Ophthalmol*. 2017;65(12):1359-1369. doi:10.4103/ijo.IJO_1057_17
5. Davidson MG, Murphy CJ, Nasisse MP, et al. Refractive state of aphakic and pseudophakic eyes of dogs. *Am J Vet Res*. 1993;54(1):174-177.
6. Astbury N, Wood M, Gajiwala U, et al. Management of capsular rupture and vitreous loss in cataract surgery. *Community Eye Health*. 2008;21(65):6-8.
7. Nasisse MP, Davidson MG. Surgery of the lens. *Veterinary Ophthalmology*. 3rd ed. Lippincott Williams and Wilkins; 1999.
8. Biros DJ, Gelatt KN, Brooks DE, et al. Development of glaucoma after cataract surgery in dogs: 220 cases (1987–1998). *J Am Vet Med Assoc*. 2000;216(11):1780-1786. doi:10.2460/javma.2000.216.1780
9. Aaronson A, Viljanen A, Kanclerz P, Grzybowski A, Tuuminen R. Cataract complications study: an analysis of adverse effects among 14 520 eyes in relation to surgical experience. *Ann Transl Med*. 2020;8(22):1541. doi:10.21037/atm-20-845
10. Paulsen ME, Kass PH. Traumatic corneal laceration with associated lens capsule disruption: a retrospective study of 77 clinical cases from 1999 to 2009. *Vet Ophthalmol*. 2012;15(6):355-368. doi:10.1111/j.1463-5224.2011.00990.x
11. Lewin GA, Dixon CJ. Post-operative outcomes in canine eyes receiving a rhexis-fixated prosthetic intra-ocular lens: 30 cases (2014–2020). *J Small Anim Pract*. 2022;63(3):211-219. doi:10.1111/jsap.13443
12. Vajpayee RB, Sharma N, Dada T, Gupta V, Kumar A, Dada VK. Management of posterior capsule tears. *Surv Ophthalmol*. 2001;45(6):473-488. doi:10.1016/s0039-6257(01)00195-3
13. Jackson TL, ed. Chapter 6 – Cataract surgery. *Moorfields Manual of Ophthalmology*. Mosby; 2008:222-273. doi:10.1016/B978-1-4160-2572-6.50011-3
14. Browning DJ, Cobo LM. Early experience in extracapsular cataract surgery by residents. *Ophthalmology*. 1985;92(12):1647-1653. doi:10.1016/s0161-6420(85)33976-3
15. Goel N, Nagar M. Spontaneous rupture of the lens capsule in hypermature cataract: presentations and outcomes. *Br J Ophthalmol*. 2016;100(8):1081-1086. doi:10.1136/bjophthalmol-2015-307184
16. Lohchab M, Arora R. Bilateral spontaneous lens capsule rupture in Alport's syndrome. *Indian J Ophthalmol*. 2019;67(3):406. doi:10.4103/ijo.IJO_1089_18
17. Olitsky SE, Waz WR, Wilson ME. Rupture of the anterior lens capsule in Alport syndrome. *J AAPOS*. 1999;3(6):381-382. doi:10.1016/s1091-8531(99)70051-0
18. Gibran SK, Jungkim S, Patil B, Cleary PE. Primary posterior continuous capsulorhexis; a new technique. *Br J Ophthalmol*. 2006;90(5):655-656. doi:10.1136/bjo.2005.074872
19. Davidson MG, Nasisse MP, Jamieson VE, English RV, Olivero DK. Phacoemulsification and intraocular lens implantation: a study of surgical results in 182 dogs. *Prog Vet Comp Ophthalmol*. 1991;1(4):233-238.
20. Gimbel HV. Posterior continuous curvilinear capsulorhexis and optic capture of the intraocular lens to prevent secondary opacification in pediatric cataract surgery. *J Cataract Refract Surg*. 1997;23(Suppl 1):652-656. doi:10.1016/s0886-3350(97)80049-1
21. Gimbel HV, Sun R, Ferensowicz M, Anderson Penno E, Kamal A. Intraoperative management of posterior capsule tears in phacoemulsification and intraocular lens implantation. *Ophthalmology*. 2001;108(12):2186-2189. doi:10.1016/s0161-6420(01)00716-3
22. Penninck D, d'Anjou MA, eds. *Atlas of Small Animal Ultrasonography*. 2nd ed. John Wiley & Sons Inc; 2015.
23. MacKay CS, Mattoon JS. Chapter 5–eye. In: Mattoon JS, Nyland TG, eds. *Small Animal Diagnostic Ultrasound*. 3rd ed. W.B. Saunders; 2015:128-154. doi:10.1016/B978-1-4160-4867-1.00005-2
24. Pingree MF, Crandall AS, Olson RJ. Cataract surgery complications in 1 year at an academic institution. *J Cataract Refract Surg*. 1999;25(5):705-708. doi:10.1016/s0886-3350(99)00017-6
25. Ng DT, Rowe NA, Francis IC, et al. Intraoperative complications of 1000 phacoemulsification procedures: a prospective study. *J Cataract Refract Surg*. 1998;24(10):1390-1395. doi:10.1016/s0886-3350(98)80235-6
26. Chen M, LaMattina KC, Patrianakos T, Dwarakanathan S. Complication rate of posterior capsule rupture with vitreous loss during phacoemulsification at a Hawaiian cataract surgical center: a clinical audit. *Clin Ophthalmol Auckl NZ*. 2014;8:375-378. doi:10.2147/OPTH.S57736
27. Thanigasalam T, Sahoo S, Ali MM. Posterior capsule rupture with/without vitreous loss during phacoemulsification in a Hospital in Malaysia. *Asia-Pac J Ophthalmol Phila Pa*. 2015;4(3):166-170. doi:10.1097/APO.0000000000000056
28. Al-Nashar HY, Khalil AS. Primary posterior capsulotomy in adults with posterior capsule opacification. *J Cataract Refract Surg*. 2016;42(11):1615-1619. doi:10.1016/j.jcrs.2016.08.026
29. Lam DS, Law RW, Wong AK. Phacoemulsification, primary posterior capsulorhexis, and capsular intraocular lens implantation for uveitic cataract. *J Cataract Refract Surg*. 1998;24(8):1111-1118. doi:10.1016/s0886-3350(98)80106-5

30. Galand A, van Cauwenberge F, Moosavi J. Posterior capsulorhexis in adult eyes with intact and clear capsules. *J Cataract Refract Surg*. 1996;22(4):458-461. doi:10.1016/S0886-3350(96)80042-3
31. Ergun ŞB, Kocamış Sİ, Çakmak HB, Çağıl N. The evaluation of the risk factors for capsular complications in phacoemulsification. *Int Ophthalmol*. 2018;38(5):1851-1861. doi:10.1007/s10792-017-0667-3
32. Kucukevcilioglu M, Hurmeric V, Ceylan OM. Preoperative detection of posterior capsule tear with ultrasound biomicroscopy in traumatic cataract. *J Cataract Refract Surg*. 2013;39(2):289-291. doi:10.1016/j.jcrs.2012.11.017
33. van der Woerdt A, Wilkie DA, Myer CW. Ultrasonographic abnormalities in the eyes of dogs with cataracts: 147 cases (1986–1992). *J Am Vet Med Assoc*. 1993;203(6):838-841.
34. Silverman RH. High-resolution ultrasound imaging of the eye – a review. *Clin Experiment Ophthalmol*. 2009;37(1):54-67. doi:10.1111/j.1442-9071.2008.01892.x
35. Nguyen TN, Mansour M, Deschenes J, Lindley S. Visualization of posterior lens capsule integrity by 20-MHz ultrasound probe in ocular trauma. *Am J Ophthalmol*. 2003;136(4):754-755. doi:10.1016/s0002-9394(03)00386-6
36. Sonarkhan S, Ramappa M, Chaurasia S, Mulay K. Bilateral anterior lenticonus in a case of Alport syndrome: a clinical and histopathological correlation after successful clear lens extraction. *BMJ Case Rep*. 2014;2014:bcr2013202036. doi:10.1136/bcr-2013-202036
37. Tabatabaei A, Kiarudi MY, Ghassemi F, et al. Evaluation of posterior lens capsule by 20-MHz ultrasound probe in traumatic cataract. *Am J Ophthalmol*. 2012;153(1):51-54. doi:10.1016/j.ajo.2011.05.038
38. Murphy CJ, Mutti DO, Zadnik K, Ver HJ. Effect of optical defocus on visual acuity in dogs. *Am J Vet Res*. 1997;58(4):414-418.
39. Zeng L, Fang F. Advances and challenges of intraocular lens design [invited]. *Appl Optics*. 2018;57(25):7363-7376. doi:10.1364/AO.57.007363
40. Chen J, Chen Y, Zhong Y, Li J. Comparison of visual acuity and complications between primary IOL implantation and aphakia in patients with congenital cataract younger than 2 years: a meta-analysis. *J Cataract Refract Surg*. 2020;46(3):465-473. doi:10.1097/j.jcrs.0000000000000015
41. Bastawrous A, Parkes C, Prasad S. Choices in correction of aphakia during vitrectomy. *Ophthalmologica*. 2011;226(Suppl 1):46-52. doi:10.1159/000328210
42. Raina UK, Gupta V, Arora R, Mehta DK. Posterior continuous curvilinear capsulorhexis with and without optic capture of the posterior chamber intraocular lens in the absence of vitrectomy. *J Pediatr Ophthalmol Strabismus*. 2002;39(5):278-287. doi:10.3928/0191-3913-20020901-08
43. Menapace R. Posterior capsulorhexis combined with optic buttonholing: an alternative to standard in-the-bag implantation of sharp-edged intraocular lenses? A critical analysis of 1000 consecutive cases. *Graefes Arch Clin Exp Ophthalmol*. 2008;246(6):787-801. doi:10.1007/s00417-008-0779-6
44. Petousis V, Sallam AA, Haynes RJ, et al. Risk factors for retinal detachment following cataract surgery: the impact of posterior capsular rupture. *Br J Ophthalmol*. 2016;100(11):1461-1465. doi:10.1136/bjophthalmol-2015-307729
45. Ti SE, Yang YN, Lang SS, Chee SP. A 5-year audit of cataract surgery outcomes after posterior capsule rupture and risk factors affecting visual acuity. *Am J Ophthalmol*. 2014;157(1):180-185.e1. doi:10.1016/j.ajo.2013.08.022
46. Brazitikos PD, Balidis MO, Tranos P, et al. Sulcus implantation of a 3-piece, 6.0 mm optic, hydrophobic foldable acrylic intraocular lens in phacoemulsification complicated by posterior capsule rupture. *J Cataract Refract Surg*. 2002;28(9):1618-1622. doi:10.1016/s0886-3350(02)01211-7
47. Yap EY, Heng WJ. Visual outcome and complications after posterior capsule rupture during phacoemulsification surgery. *Int Ophthalmol*. 1999;23(1):57-60. doi:10.1023/a:1006462928542
48. Chan FM, Mathur R, Ku JJK, et al. Short-term outcomes in eyes with posterior capsule rupture during cataract surgery. *J Cataract Refract Surg*. 2003;29(3):537-541. doi:10.1016/s0886-3350(02)01622-x
49. Hong AR, Sheybani A, Huang AJW. Intraoperative management of posterior capsular rupture. *Curr Opin Ophthalmol*. 2015;26(1):16-21. doi:10.1097/ICU.0000000000000113
50. Kang S, Park S, Park E, Lim J, Seo K. Influence of an intentionally induced posterior lens capsule rupture on the real-time intraocular pressure during phacoemulsification in canine ex vivo eyes. *Vet Ophthalmol*. 2018;21(1):35-41. doi:10.1111/vop.12475

How to cite this article: Andrews ALMM, Kafarnik C, Fischer M-C. Prevalence and outcome of lens capsule disruption in routine canine cataract surgery: A retrospective study of 520 eyes (2012–2019). *Vet Ophthalmol*. 2023;00:1-9. doi:10.1111/vop.13090