CASE REPORT

Phacoemulsification and +14 diopter intraocular lens placement in a Saddlebred foal

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Abstract
A 2-month-old, 110-kg Saddlebred filly presented for evaluation of bilateral cataracts. A hypermature cataract in the left eye (OS) and an incipient nuclear cataract in the right eye (OD) were diagnosed. Electroretinography and ocular ultrasound revealed no contraindications for surgical removal of the cataractous lens OS. Phacoemulsification and implantation of a +14 diopter (D) intraocular lens (IOL) OS were performed at 4 months of age without complication, with the exception of a partial iridectomy performed on a small iris section that prolapsed through the corneal incision. Complete ophthalmic examinations, including ocular ultrasound and streak retinoscopy, were performed 1, 2, 6 weeks, 4 months, 1, and 2 years postoperatively. Diffuse corneal edema and a superficial corneal ulcer developed OS during the early postoperative period and resolved without complication. Dyscoria was identified owing to anterior synechia of the dorsomedial iris at the incision site. Two years after surgery, menace response, palpebral reflex, dazzle reflex, and pupillary light reflexes were present in both eyes (OU). The IOL remained centrally positioned within the capsule, with mild anterior tilting of the superior portion of the IOL and mild fibrosis of the lens capsule. The postoperative net refractive error was +0.31 D OS. Based on this report, a +14 D IOL may be the appropriate choice following lens extraction in a foal to achieve refraction near emmetropia at maturity. To our knowledge, this is the first report of phacoemulsification and IOL implantation in a foal with long-term follow-up.

Key Words: cataract, equine phacoemulsification, foal, intraocular lens, ocular ultrasound, retinoscopy

INTRODUCTION
Cataracts are the most common congenital ocular anomaly in foals.1–6 Congenital or juvenile cataracts that cause substantial visual deficits can be removed via phacoemulsification and aspiration. While implantation of an intraocular lens (IOL) following cataract removal is standard therapy for canine and feline patients, foals are routinely left aphakic.7–12 Most aphakic horses are reported to return to an acceptable level of activity following surgery; however, these horses have a severe refractive error and are left markedly hyperopic.7,9,13 Placement of an IOL of appropriate dioptic strength in foals after phacoemulsification should correct this refractive error and improve postoperative visual function.

Foals present a set of unique challenges in regard to phacoemulsification and IOL implantation, including determining the appropriate age to perform surgery, globe size at the time of surgery vs. the size of the adult globe, and the inability to predict the effect of a specific IOL dioptic power on the future visual status once the foal reaches maturity. To bypass these challenges, the majority of foals undergoing surgical lens extraction are left aphakic. This report takes these challenges into account and demonstrates a successful outcome following IOL implantation in a foal. Furthermore, this report highlights the importance of objectively evaluating foals following phacoemulsification and IOL implantation to determine the postoperative refractive state, IOL position within the globe, degree of posterior capsular opacification (PCO), and ultimately, the long-term effect of the IOL on vision.

While specific IOL powers have been evaluated in the adult horse,14,15 there are no peer-reviewed, published
reports in the veterinary literature of IOL implantation in foals. The purpose of this case report is to describe the long-term surgical results and visual acuity following removal of a cataractous lens via phacoemulsification and aspiration with implantation of a +14 D IOL in a foal.

CASE REPORT

A 2-month-old Saddlebred filly weighing 110-kg was presented to the North Carolina State University Veterinary Teaching Hospital (NCSU-VTH) Equine Ophthalmology Service for evaluation of bilateral cataracts. Bilateral ocular opacities were first identified when the foal was 1 month old. The opacity in the left eye (OS) progressed in size over the following month, while the opacity in the right eye (OD) remained unchanged. According to the owner, the foal’s vision decreased in the month prior to presentation. No other health problems were reported.

Initial clinical findings

Complete ophthalmic examinations were performed on both eyes (OU). No signs of discomfort or obvious visual deficits were detected while observing the foal in a stall. Direct and consensual pupillary light reflexes (PLR), palpebral reflexes, and dazzle reflexes were present OU. The menace response was present OD and absent OS. Further ophthalmic examination was facilitated by sedation using detomidine hydrochloride (0.01 mg/kg, IV, Dormosedan®; Pfizer Inc., New York, NY, USA) and palpebral and frontal nerve blocks using 2% lidocaine hydrochloride (1 ml, SQ; Vedco Inc., St. Joseph, MO, USA). There was no fluorescein dye (Akorn Inc., Buffalo Grove, IL, USA) uptake OU. Slit-lamp biomicroscopy (Kowa SL-14; Kowa Company, Ltd., Tokyo, Japan) of the anterior segment was within normal limits OU, except for a shallow anterior chamber (AC) and hypermature cataract OS (Fig. 1) and an incipient posterior nuclear cataract OD (Fig. 2). To further aid visualization of the lens and posterior segment, the pupils were dilated with 1.0% tropicamide ophthalmic solution (Akorn Inc.).

Indirect ophthalmoscopy revealed no abnormalities OD, while visualization of the posterior segment OS was obstructed by the cataract. Intraocular pressure (IOP) measurement was not performed during this examination. No additional abnormalities were noted on the remainder of the ophthalmic examination, and no medical treatment was implemented at that time. The foal was scheduled for re-evaluation in 8 weeks to allow the foal to mature further before undergoing phacoemulsification and subsequent IOL implantation.

At 4 months of age and weighing 167-kg, the foal was returned to the NCSU-VTH for re-evaluation. The owner reported a decrease in vision from the foal’s left eye but had not noted any other ocular signs. A complete ophthalmic examination, facilitated by sedation and nerve blocks as described during the initial evaluation, was performed. There were no changes from the previous examination. Applanation tonometry (Tono-Pen XL, Mentor, Norwell, MA, USA) was performed following the application of 0.5% proparacaine hydrochloride ophthalmic solution (0.3 ml OU; Akorn, Inc., Buffalo Grove, IL). The measured IOPs, 17 mmHg OD and 19 mmHg OS, were within normal limits.16,17

Laboratory and ancillary diagnostic tests

Ocular ultrasonography and electroretinography were performed to determine whether OS was a candidate for phacoemulsification and IOL implantation. Transcorneal B-scan ultrasonography using a linear 12.5-mHz transducer (E Technologies, Inc., Davenport, IA, USA) was performed to rule out concurrent posterior segment disease, such as vitreal degeneration or retinal detachment. Ocular ultrasonography revealed a hypechoic lens OS, consistent with cataractous changes, and no evidence of retinal detachment or other posterior segment defects. The mean globe dimensions were measured and included AC depth: 5.47 mm; axial globe length (AGL): 33.86 mm; and crystalline lens thickness (CLT): 10.97 mm. A dark-adapted electroretinogram (AcriVet Inc., Salt Lake City, UT, USA) was performed OS with the foal under general

Figure 1. Hypermature cataract of the left eye at initial presentation.

Figure 2. Incipient posterior nuclear cataract of the right eye at initial presentation.

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anesthesia, immediately prior to surgery. The photopic and scotopic b-wave amplitudes OS were 185 and 163 μV, respectively, which were considered normal.18 The results of a complete blood count and serum biochemistry panel were within normal limits for a foal. Based on these preoperative findings, the foal was considered a good candidate for surgery.

Treatment and surgical management

Unilateral phacoemulsification and aspiration to remove the hypermature cataract with IOL implantation OS was elected, while monitoring for progression of the cataract OD was recommended. To facilitate pre- and postoperative medication administration, a subpalpebral lavage (SPL; Mila International, Inc., Erlanger, KY, USA) was placed in the left superior eyelid, and all oculocardiac medications were applied through the SPL at a volume of 0.1 ml per dose. Preoperative topical medications were instituted 24 h prior to surgery and included 1% atropine sulfate ophthalmic solution (q 12 h; Falcon Pharmaceuticals, Ft. Worth, TX, USA) to facilitate mydriasis and stabilize the blood-aqueous barrier, 0.03% flurbiprofen sodium ophthalmic solution (q 6 h; Pacific Pharma, Irvine, CA, USA) to control intraocular inflammation, neomycin/polymyxinB/dexamethasone ophthalmic solution (q 6 h, Alcon Laboratories Inc., Ft. Worth, TX, USA) to prevent endophthalmitis. Topical medications were increased in frequency to every 30 min during the 2 h leading up to surgery, and 2.5% phenylephrine hydrochloride ophthalmic solution (Alcon Laboratories Inc., Fort Worth, TX, USA) was administered once, immediately prior to surgery, to facilitate mydriasis. Preoperative systemic anti-inflammatory and antibiotic therapy was initiated 24 h before surgery with flunixin meglumine (0.5 mg/kg, IV, q 12 h; Pfizer Inc., New York, NY, USA), amikacin sulfate (22 000 IU/kg, IV, q 6 h; Bausch & Lomb, Inc., Tampa, FL, USA) to prevent endophthalmitis and control intraocular inflammation, and 0.5% moxifloxacin hydrochloride ophthalmic solution (q 6 h, Vigamox®; Alcon Laboratories, Inc., Fort Worth, TX, USA) to prevent endophthalmitis. Topical medications were increased in frequency to every 30 min during the 2 h leading up to surgery, and 2.5% phenylephrine hydrochloride ophthalmic solution (Alcon Laboratories Inc.) was administered once, immediately prior to surgery, to facilitate mydriasis. Preoperative systemic anti-inflammatory and antibiotic therapy was initiated 24 h before surgery with flunixin meglumine (0.5 mg/kg, IV, q 12 h, Banamine®, Schering-Plough Animal Health Corp., Omaha, NE, USA), penicillin G potassium (22 000 IU/kg, IV, q 6 h, Pfizer®; Roerig, Division of Pfizer, Inc., New York, NY, USA), amikacin sulfate (20.0 mg/kg, IV, once; Sicor Pharmaceuticals Inc., Irvine, CA, USA), and ranitidine (7.0 mg/kg, PO, q 8 h; Apotex Inc., Ontario, Canada) for gastroprotection.

The foal was sedated with xylazine hydrochloride (0.70 mg/kg, IV), and anesthesia was induced with midazolam (0.07 mg/kg, IV) and propofol (0.33 mg/kg, IV). After orotracheal intubation, the foal was maintained at a surgical plane of anesthesia with sevoflurane vaporized in 100% oxygen. The foal was positioned in right lateral recumbency, and OS was routinely prepared for surgery. A retrobulbar block was performed using 8 ml of 2% lidocaine hydrochloride to provide akinesia and analgesia to the eye and orbit and to ensure proper position of the globe.19 An initial 4 mm clear corneal groove incision was made approximately 1 mm from the limbus at the 10 o’clock position using a no. 64 microsurgical blade (Medical Sterile Products; Rincon, Puerto Rico, USA). The AC was entered using a 2.8-mm keratome (Unique Technologies, Inc., Mohnton, PA, USA), and 0.5 ml of a 10% epinephrine-saline solution (1:10 000; IMS Limited, So. El Monte, CA, USA) was injected intraocularly to facilitate pupillary dilation and to control intraocular hemorrhage. The AC was reformed and maintained using a hyaluronic acid ophthalmic viscoelastic device (Acritvet Syn 2%; Acritvet Inc.). An anterior capsulotomy, approximately 12 mm in diameter, was created using high-frequency diathermy (Alexos, Oertli Instrumente AG, Berneck, Switzerland). The cataractous lens was removed with phacoemulsification, along with irrigation and aspiration, using a one-handed technique and an equine-specific phacoemulsification needle and system (Alexos, Oertli Instrumente AG). The corneal incision was extended approximately 4 mm using corneal section scissors to accommodate the foldable IOL. With the aid of folding forceps, a +14.0 D foldable, equine IOL (Acritvet, Henningsdorf, Germany) was inserted through the corneal incision and into the lens capsule through the anterior capsulotomy opening and centered. The one-piece, hydrophilic acrylate IOL has a 22 mm haptic diameter and 13 mm optic diameter. A small 1 × 2 mm segment of the dorsomedial iris prolapsed through the corneal incision intraoperatively and was subsequently removed using iris scissors, with minimal hemorrhage. The corneal incision was closed with 7-0 polyglactin 910 (Polyglactin 910; Ethicon, Inc., Somerville, NJ, USA) in a symmetrical double sawtooth pattern. The viscoelastic device was intentionally left in the AC to maintain stability of the AC and IOL. A partial, temporary tarsorrhaphy using 4-0 nylon (Ethilon®, Ethicon, Inc., Cornelia, GA, USA) in a horizontal mattress pattern was utilized to protect the eye during recovery. The tarsorrhaphy was removed after the filly was returned to her stall.

The foal recovered uneventfully from anesthesia and remained hospitalized for 1 week following surgery. Postoperative topical medical therapy OS included atropine (q 12 h), NPD (q 6 h) and moxifloxacin (q 4 h). Systemic therapy included flunixin meglumine (0.5 mg/kg, IV, q 12 h), penicillin (22 000 IU/kg, IV, q 6 h), and ranitidine (7.0 mg/kg, PO, q 8 h). The penicillin was discontinued 2 days following surgery and replaced with trimethoprim sulfadiazine (TMS, 20.0 mg/kg, PO, q 12 h; Qualitest Pharm., Huntsville, AL, USA). Applanation tonometry performed 2 h following surgery measured IOP at 24 mmHg OS. Complete ophthalmic examination on the day following surgery revealed a positive meniscus response, dazzle reflex, and palpabral reflex OS, but negative direct and consensual pupillary light reflexes owing to pharmacological mydriasis from topical treatment with atropine. Moderate periocular swelling, blepharospasm, conjunctival hyperemia, chemosis, and corneal edema around the corneal incision were noted and were considered to be within normal limits. Fluorescein dye uptake was noted at the corneal suture sites. Trace aqueous flare and fibrin accumulation in the AC indicated the presence of mild anterior uveitis. The IOL was clear and...
centrally positioned within the lens capsule. Dyscoria and anterior synechia of the dorsomedial iris to the posterior aspect of the corneal incision were identified in the region corresponding to the iridectomy site. Posterior segment examination was within normal limits. Applanation tonometry revealed an IOP of 19 mmHg OS. No changes were noted OD during ophthalmic examination.

The OS developed mild, diffuse corneal edema between 24 and 48 h after surgery. The edema started dorsally and progressed ventrally to involve 90% of the cornea, resulting in prominent distortion of the corneal surface. Intraocular pressure measurements OS were repeated 48 and 72 h postoperatively and measured 17 and 20 mmHg, respectively. A partial, temporary tarsorrhaphy was placed 72 h following surgery to provide protection, lubrication, and compression of the cornea. The NPD was discontinued at that time owing to the risk of corneal ulceration from the edema, and the tarsorrhaphy remained in place for 3 days. Marked improvement in the corneal edema was noted after removal of the tarsorrhaphy, and following a negative fluorescein dye test, the NPD treatment was reinstituted at that time.

Over the course of the week following surgery, the periorcular swelling, conjunctival hyperemia, chemosis, and intraocular inflammation resolved. The corneal edema continued to improve prior to discharge from the hospital. The foal was discharged 1 week following surgery on atropine (q 48 h), NPD (q 6 h), and moxifloxacin (q 6 h) OS, as well as flunixin meglumine (0.5 mg/kg, PO, q 12 h), ranitidine (7.0 mg/kg, PO, q 8 h), and TMS (20.0 mg/kg, PO, q 12 h).

Outcome/follow-up

The foal was examined 2 weeks postoperatively and a complete ophthalmic examination was performed as described previously. Menace response, palpebral reflex, and dazzle reflex were present OU. Pupillary light reflexes were present OD and absent OS owing to pharmacological mydriasis with atropine. Mild conjunctival hyperemia and moderate edema in the medial cornea were noted OS. The corneal sutures were intact. A 2-mm, crescent-shaped, superficial ulcer was present in the dorsomedial cornea, ventral to the corneal incision. The ulcer did not appear to be related to the SPL based on its location and examination of the SPL footplate. No active intraocular inflammation was present, and the IOL was centered within the lens capsule. Focal posterior synechia was identified between the temporal iris and anterior lens capsule. Applanation tonometry performed OS revealed an IOP of 12 mmHg. The remainder of the ophthalmic examination OS was within normal limits, and the ophthalmic examination OD was unchanged. The foal was discharged from the hospital on atropine once weekly, neomycin/polymyxinB/gramicidin ophthalmic solution (NPG, q 8 h; Paddock Laboratories, Inc., Minneapolis, MN, USA) as a prophylactic antibiotic to prevent infection, flunixin meglumine (0.25 mg/kg, PO, q 12 h), ranitidine (7.0 mg/kg, PO, q 8 h), and TMS (20 mg/kg, PO, q 12 h). A topical anti-inflammatory medication was not prescribed based on the presence of a corneal ulcer and lack of intraocular inflammation. Moxifloxacin was discontinued based on the low risk of postoperative endophthalmitis at that time, and the oral medications were discontinued 1 week later. The corneal ulcer was determined to be healed 1 week later following a negative fluorescein dye test performed by the referring veterinarian.

Complete ophthalmic examinations were repeated 6 weeks, 4 months, 1, and 2 years following surgery at the NCSU-VTH. The owners reported at each visit that the foal was behaving normally at home and that they had not noticed any compromise in vision. A positive menace response and ocular reflexes (palpebral, dazzle, and PLR) OU were present during each examination, except for absent pupillary light reflexes OS at 6 weeks following surgery owing to pharmacological mydriasis with atropine. The cornea OS had mild vascularization and moderate fibrosis at the incision site (Fig. 3). Anterior synechia of the dorsomedial iris at the incision site resulted in dyscoria (Fig. 3). The IOL remained centrally positioned within the lens capsule, although mild anterior tilting of the superior portion of the IOL was noted (Fig. 4). Mild fibrosis (+1/4)20 was first noted on the posterior lens capsule at 16 weeks, with a mild increase (+2/4)20 noted at 1 and 2 years (Figs 5 and 6). Applanation tonometry was repeated at each visit and IOPs measured 20 mmHg OD and 17 mmHg OS, 21 mmHg OD, and 18 mmHg OS, 20 mmHg OD and 21 mmHg, and 26 mmHg OD and 18 mmHg OS at 6 weeks, 4 months, 1, and 2 years, respectively. The remainder of the examination, including indirect ophthalmoscopy, was within normal limits at each visit, and the ophthalmic examination OD remained unchanged from the preoperative examination. All medications were discontinued and the SPL was removed at the 6-week recheck examination.

A maze test was performed 1 year following surgery. The yearling, weighing 310-kg, was loosely led through a course of randomly placed obstacles under daylight conditions.

Figure 3. Left eye 4 months following phacoemulsification and IOL implantation depicting corneal fibrosis, dyscoria, central position of IOL, and mild tilt of IOL noted during ophthalmic examination.
Each eye was consecutively blindfolded, prior to sedation and pupil dilation, using a modified eye cup. The maze test was repeated in a random manner. No difference in navigation through the maze was noted, regardless of which eye was covered.

Retinoscopy was performed 6 weeks, 4 months, 1, and ±2 years following surgery by the same individual (RJM) using a streak retinoscope (Heine Optotechnik, Herrsching, Germany), Luneau skiascopy rack (Luneau SAS, Prunay-Le-Gillon, France) with 16-mm-diameter lenses ranging from ±0.5 D to 15 D and a working distance of 67 cm. Retinoscopy was repeated three times in both the horizontal and vertical meridians for each eye. The values obtained were averaged providing the net refractive error for each eye (Table 1). The net refractive error was found to be +0.92 D OS and +0.25 D OD, +1.00 D OS and +0.16 D OD, +0.50 D OS and +0.06 D OD, +0.31 D OS and –0.75 D OD at 6 weeks, 4 months, 1, and 2 years, respectively.

Transcorneal B-scan ultrasonography was repeated 6 weeks, 4 months, 1, and 2 years following surgery to measure postoperative globe dimensions (Table 2). The postoperative AC depth measured 7.03, 4.77, 7.50, and 6.75 mm at 6 weeks, 4 months, 1, and 2 years, respectively. The postoperative AGL measured 32.60, 33.50, 33.80, and 37.97 mm at 6 weeks, 4 months, 1, and 2 years, respectively. The preoperative to postoperative AC depth ratio was calculated to be 0.78, 1.15, 0.73, and 0.81 at 6 weeks, 4 months, 1, and 2 years, respectively.

**DISCUSSION**

Cataracts are a common ocular disease in horses and can occur as either acquired or developmental defects. Acquired cataracts occur in horses of all ages and frequently develop secondary to other disease processes, such as uveitis and trauma. Congenital cataracts, a subset of developmental cataracts, are the most common congenital ocular anomaly in foals. In one report, 13 of 34 (38%) congenital ocular defects involved the lens, and 12 of 13 (92%) lens anomalies were cataracts. The cataracts in the foal described herein were likely congenital, given the anamnesis, bilateral nature, and lack of other ocular findings. Surgical removal of cataracts is routinely performed to improve vision and level of activity in horses with significant visual deficits.

Phacoemulsification and aspiration is presently the technique of choice for removal of cataracts in foals and adult horses. The challenges of phacoemulsification in foals include determining the appropriate age to perform surgery, globe size differences between the time of surgery and maturity, and the inability to predict the effect of a specific IOL diopter power on future visual status. Some consider cataract surgery to be more successful in foals <6 months of age based on the perceived advantage of medicating and restraining a younger and smaller animal. On the other hand, young foals have variable temperaments and are unlikely to be halter trained, both of which may make them more difficult to medicate. Additionally, the adverse effects of cataracts on the eye are important to consider when planning lens extraction in a foal. Congenital cataracts may progress to hypermaturity and increase the chances of

<table>
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<th>Time following surgery</th>
<th>OD</th>
<th>OS</th>
<th>OD/OS difference</th>
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<tr>
<td>6 weeks</td>
<td>+0.25 D</td>
<td>+0.92 D</td>
<td>0.67 D</td>
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<tr>
<td>4 months</td>
<td>+0.16 D</td>
<td>+1.00 D</td>
<td>0.84 D</td>
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<td>+0.06 D</td>
<td>+0.50 D</td>
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<td>2 years</td>
<td>–0.75 D</td>
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lens-induced uveitis and postoperative complications. Visual stimuli are also essential for normal development of the central nervous system. Deprivation amblyopia, defined as decreased vision in one or both eyes subsequent to central fixation disuse caused by ocular opacities, is another factor that may influence success rate following surgery. Although this condition has not been reported in foals with congenital cataracts, it occurs in children and laboratory animals with similar conditions. Early surgical intervention may prevent these complications.

Several factors are important to consider prior to phacoemulsification and subsequent IOL implantation in a foal, particularly the AGL and the position of the IOL in relation to the cornea and retina, as the position of the IOL within the globe is very important in determining the refractive state of the eye. A foal’s eye is smaller and has a more spherical shape than that of an adult horse, and significant differences in axial globe dimensions have been previously described between juvenile and adult horses. As the refractive power is fixed for a specific IOL, its position within the eye has a significant effect on the overall refractive state of the eye. As foals have a smaller AGL and lens capsule than an adult horse, one may conclude that they require an IOL with a higher dioptic strength and shorter diameter to appropriately refract light on the retina and fit within the lens capsule, respectively. Preoperative ocular ultrasound in this foal provided globe measurements to calculate IOL size and strength. Serial ocular ultrasounds were also utilized postoperatively to determine IOL position as globe size increased with maturation of the foal (Table 2). The preoperative AC depth measured 5.47 mm. Based on a preoperative to postoperative AC depth ratio of 0.73, the predicted postoperative AC depth was shallower than anticipated (7.49 mm) and yielded a preoperative to postoperative AC depth ratio of 0.78. Because the required dioptic strength of an IOL to achieve emmetropia decreases as the postoperative AC depth decreases (and thus, the distance between the IOL and the retina increases), the postoperative IOL position may have contributed to the small refractive error noted in this foal. Interestingly, there were only small differences in AC depth measurements in this foal from 6 weeks to 2 years following surgery, despite the increase in AGL. The relatively constant position of the IOL within the globe may be explained by stabilization of the IOL within the lens capsule, preventing considerable movement as the globe increased in size. This minimal change in IOL position was likely responsible for the relatively constant refractive state of the foal’s eye between successive postoperative exams (Table 1).

The dioptic strength of the IOL is also an important factor to consider prior to surgery. Presently, several different strengths of foldable, equine-specific IOLs are available, including +14 D, +18 D, and +21 D lenses. The +18 D and +14 D foldable IOLs are currently recommended for implantation in adult horses undergoing phacoemulsification. A recent study suggested that an IOL of approximately +18 D may be appropriate to approximate emmetropia in an adult horse, while another study concluded the net refractive error, determined by streak retinoscopy following IOL implantation, was within 0.5 D of emmetropia using the +14 D IOL. The +14 D IOL has a smaller diameter (22 mm) when compared to the +18 D IOL (24 mm). Based on this information and the foal’s globe dimensions, which suggested that a smaller lens may be more appropriate, a +14 D IOL with a 13 mm optic diameter and 22 mm haptic diameter was selected.

Streak retinoscopy was used in this foal to determine whether the dioptic strength of the IOL was appropriate to achieve emmetropia immediately following surgery and as the foal grew to maturity (Table 1). Streak retinoscopy has been evaluated in horses, including both normal phakic and aphakic equine eyes. The resting refractive state of

<table>
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<th>Time</th>
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<th>Crystalline lens thickness</th>
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Table 2. Preoperative and postoperative ocular ultrasonography measurements OS (mm)
the normal horse eye was found to approximate emmetropia while aphakic horses had significant hyperopia (+8.0 to +10.5 D). Therefore, achieving a refractive state only 0.31 D from emmetropia following IOL implantation in the present case is very promising (Table 1). The variable postoperative refractive state during postoperative exams may be explained by slight positional changes in the IOL over time. The IOL tilt noted may have contributed to the overall refractive error but likely does not explain the variable refractive state between examinations, as the degree of IOL tilt did not change over time (Fig. 4). Streak retinoscopy performed at multiple time points showed that the refractive state of the eye remained relatively constant despite overall growth of the patient and globe (Table 1). The small degree of postoperative anisometropia at the 2-year follow-up examination is unlikely to have a significant effect on vision in this horse. No visual deficits were noted on postoperative ophthalmic examinations and maze testing performed 1 year following surgery did not reveal any noticeable visual difference between eyes. Based on achieving a refractive state within the normal range for horses, this data support that a +14 D IOL may be an appropriate choice to approximate emmetropia in both the immediate and long-term postoperative period in a foal.

The foal in this report experienced a few surgical complications, including intraoperative iris prolapse through the corneal incision and postoperative corneal edema, corneal ulceration, anterior uveitis, IOL tilt, and capsular fibrosis. The iris prolapse may have been prevented using a trilaminar clear corneal incision. The construction of a self-sealing, hinged corneal incision prevents rapid outflow of aqueous humor from the AC and decreases the risk of iris prolapse. Although postoperative ocular hypertension (POH) is a previously reported complication following phacoemulsification surgery in horses and may contribute to corneal edema, the foal in this report did not experience a documented elevation in IOP following surgery. Therefore, the transient corneal edema in this foal was more likely related to corneal endothelial damage associated with the corneal incision and/or phacoemulsification and aspiration of the lens. Posterior capsular opacification is a common complication associated with extracapsular lens extraction in animals. A higher rate of capsular opacity formation may occur in younger patients owing to a higher rate of lens epithelial cell proliferation and metaplasia. Lens epithelial or cortical cells that remain attached to the lens capsule will proliferate, undergo epithelial-mesenchymal transformation, and migrate across the capsule causing a variable amount of lens capsule opacity. This typically results in opacification around the anterior capsulotomy and/or posterior lens capsule. A decrease in quality of vision over time may occur if the fibrosis forms to a significant degree in the visual axis. The amount of capsular fibrosis was mild 2 years following surgery in this foal and the fibrosis did not appear to significantly affect vision (Fig. 6). Several IOL-related factors, including IOL biocompatibility, optic-posterior capsule contact, and a mechanical barrier effect, have been proposed to decrease PCO formation and may serve as additional support for IOL implantation in horses following lens removal. Further studies are necessary to determine the long-term effects of IOL implantation on PCO formation in horses.

A recent study by Townsend et al. reported the surgical results after phacoemulsification and implantation of +14 D IOLs in mature horses with spontaneous cataracts. Five of six operated eyes remained visual, and the mean refractive error was +0.4 D at the last follow-up. Postoperative complications in this study of mature horses included POH (5/6 eyes), corneal ulceration (3/6 eyes), fibrin accumulation (1/6 eyes), and haptic displacement from the capsular bag (1/6 eyes). In addition, one eye was enucleated owing to postoperative development of intractable glaucoma, corneal stromal abscessation, and endophthalmitis. Similar to the horses in this report, the foal in the present study developed corneal ulceration during the immediate postoperative period and implantation of a +14 D IOL achieved a refractive error within 0.5 D of emmetropia. In contrast, POH was not encountered in this foal while it was a common complication in the Townsend et al. study.

Phacoemulsification with subsequent IOL implantation in horses is a relatively recent development in veterinary ophthalmology. Successful clinical reports of this surgery are important as equine-specific IOLs are now being implanted with increasing frequency. Although IOLs have been successfully implanted in mature horses following cataract removal, there is a paucity of information regarding IOL implantation in foals. This case report is the first to describe cataractous lens extraction and placement of a +14 D IOL in a foal with postoperative examinations as the foal grew to maturity. The results demonstrate successful IOL implantation with a good long-term outcome. The IOL position remained relatively constant as the foal matured, and the refractive error 2 years following surgery was within...
0.5 D of emmetropia. The data reported in this case report support that a +14 D IOL may be an appropriate choice following lens extraction in a foal. Further studies of adult horses and foals following IOL implantation are necessary to determine which IOL strength will be appropriate in the horse and the long-term effects of IOL implantation on PCO formation.

REFERENCES


