
Dennis E. Brooks,* Caryn E. Plummer,* Susan M. Carastro† and Mary E. Utter‡
*University of Florida, Gainesville, Florida, USA; †Animal Eye Specialty Clinic, West Palm Beach, FL, USA; and ‡University of Pennsylvania, Kennet Square, PA, USA

Abstract

Objective  To evaluate the long-term visual outcome of phacoemulsification lens extraction surgery in foals and horses and identify any unique postoperative complications that affect the visual outcome.

Procedure  This is a retrospective medical records study of phacoemulsification cataract surgery in 95 foals and horses from 1990 to 2013.

Results  Cataracts were removed by phacoemulsification from 111 eyes of 95 horses ranging in age from 22 days to 26 years (average 8.0 ± 5.7 years). Forty-four of the 95 animals were foals (46.3%). Sixteen horses or foals had surgery bilaterally. One hundred and two eyes were blind preoperatively with 97 eyes (95.1%) having evidence of vision immediately postoperatively. Ninety of the 95 horses (94.7%) regained vision in the immediate postoperative period. Five horses did not recover vision postoperatively. Twenty-four horses had cataracts associated with equine recurrent uveitis (ERU). Trauma was noted as the cause of cataract in 10 horses, and no specific cause for the cataract identified in 61 horses. The combined visual outcome data from horses with all types of cataracts (n = 95) found 83 (87.3%) horses to be visual ≤1 month postoperatively, 47 (49.4%) horses visual for >1–6 months postoperatively, 33 (34.7%) horses visual from >6 to 12 months postoperatively, and 25 horses (26.3%) visual >24 months postoperatively.

Conclusion  The results of phacoemulsification cataract surgery in horses indicate at least 26.3% of horses are still visual and able to continue their natural activity for 2 years or more postoperatively.

Key Words: cataract, horse, lens, phacoemulsification, vision

INTRODUCTION

The horse lens is a large transparent biconvex sphere composed of linear cellular fibers whose primary purpose is to refract and focus light rays onto the retinal photoreceptors.1–7 The lens consists of a peripheral cortex, central nucleus, and is surrounded by an elastic capsule. Equatorial lens epithelial cells produce lens fibers throughout life such that the outer cortex contains the newest lens fibers and the nucleus the oldest, most mature lens fibers.2

The horse lens measures 17–22 mm in diameter, has an axial length of 12–15 mm, a volume of 2.5–3.0 mL, and has a refractive power of +14.88 Diopters (D).1 The anterior, posterior, and equatorial capsule thickness measures 91, 14, and 20 μm, respectively.1–3 An accommodative mechanism allows the eye to bring objects positioned at varying distances from the eye into successively clear focus. The power and range of accommodation in horses appears to be weak with a measured dynamic accommodation ability of only +1D.1–4

A cataract is an optical opacity of the lens cortex, nucleus, or capsule caused by disruption of the normal microarchitectural arrangement of the lens fibers or capsule.4,8 A lens opacity can range in size from a barely detectable spot to an opacity that involves the entire lens. Multiple focal lens opacities can be present in the various lens regions.

Cataracts may be classified as to age of onset, etiology, anatomical location, and the degree of maturation.1,4 Heritable, traumatic, and postinflammatory causes for equine cataracts have been identified.1,4,5,8–10 Cataracts are a frequent congenital ocular defect in foals.5–7 Inherited cata-
racts have been reported in Belgian and Thoroughbred horses, and the Rocky Mountain Horse.

Cataracts secondary to equine recurrent uveitis (ERU) or traumatic uveitis are frequently seen in the adult horse. The anterior lens capsule can be subject to laceration and rupture due to penetrating trauma. Focal or diffuse lens opacity may result from such capsular tears and may be associated with iridocyclitis. Spontaneous rupture of the posterior capsule, lens luxation/subluxation, posterior capsular cysts, and large anterior vitreal opacities are also found in horses with cataracts.

The classification of cataracts by the stage of cataract maturation is based on the degree of lens opacification. An incipient cataract is a small focal lens opacity that is likely to progress. Small incipient opacities have little to no behavioral effect on vision in horses and do not require surgical removal. More of the lens is opaque in an immature cataract. Vision is not affected in early immature stages, but does eventually reduce vision as the immature cataract matures to become more opaque. The tapetal reflex can be seen with early immature cataracts with some vision present. If the cataract progresses to involve the entire lens, it is known as a mature cataract. In a mature cataract, the lens is totally opaque, the fundus and tapetal reflection cannot be examined, and vision is lost. A mature cataract, and in some cases an immature cataract, can progress to a hypermature cataract. The cortical lens fibers undergo liquefaction in the hypermature state with lens proteins diffusing through the intact capsule to incite an immune-mediated uveitis. The lens capsules wrinkle to conform to the reduced volume of the lens, and the anterior chamber deepens in hypermature cataracts in horses.

Vision loss is proportional to the size and location of the opacity within the lens. The closer a lens opacity of any size is to the posterior lens nodal point (posterior nucleus of the horse), the more visually significant even a small lens opacity will be to vision. Cataracts in the posterior nucleus can thus have more of an effect on vision than anterior cataracts in the horse. Nuclear cataracts can also degrade vision in bright light more than thin cortical cataracts with a normal nucleus. Very immature, mature, and some hypermature cataracts are associated with blindness in the horse. No medical therapy can resolve the lens fiber disruption and distortion that causes such lens opacification. The therapy for cataracts is thus necessarily surgical.

Cataract surgery is indicated if the loss of vision is such that the horse or foal is unable to perform its regular activities.

Most veterinary ophthalmologists recommend surgical removal of cataracts in foals less than 6 months of age if the foal is healthy, no uveitis or other ocular problems are present, and the foal’s personality will tolerate aggressive topical therapy. Early return of vision is paramount in foals for development of the higher visual centers. Cataract surgery is technically easier and the visual outcome better in foals because the foal globe and lens size are small enough that the standard cataract surgical equipment is of a satisfactory size, the cataractous lens of foals is soft, general anesthesia is generally less of a risk in foals, and foals heal very quickly following cataract surgery. Foals should be carefully evaluated by good physical examination, blood tests, and by radiography preoperatively for systemic infections such as and Streptococcal pneumonia as sight threatening postoperative endophthalmitis may result following surgery if the condition is not detected and treated prior to cataract surgery.

Adult horses with visual impairment due to cataracts are also candidates for cataract surgery, but the surgery is made more difficult due to the large size of the adult horse lens and the lack of sufficient instrumentation to remove large cataractous lenses and the frequent presence of mild to severe uveitis in adult horse eyes with cataracts. If the horse is healthy, has no uveitis, and has the personality and temperament to tolerate aggressive postoperative topical therapy and repeat postoperative ophthalmic examinations, the adult horse can be a very good candidate for unilateral or bilateral cataract surgery. Any signs of anterior uveitis including corneal edema, aqueous flare, extensive synechiation, and profound hypotony should delay cataract surgery until the inflammation has been successfully treated. Cataract surgery should also be delayed in the presence of active eyelid, conjunctival, corneal, or systemic disease.

Phacoemulsification is the preferred cataract extraction technique for the horse. Immature, mature, and hypermature equine cataracts have been successfully removed with this technique. Phacoemulsification through a small corneal or limbal incision utilizes a piezoelectric handpiece with an titanium needle in a suture cone sleeve to ultrasonically fragment and emulsify the lens nucleus and cortex following continuous curvilinear capsulorrhexis. The phacoemulsification needle moves in an anterior–posterior direction like a jack hammer at 28–45 kHz. The emulsified lens is then aspirated from the eye, while intraocular pressure is maintained by infusion of lactated Ringer’s solution.

Several factors must be remembered when advocating and performing phacoemulsification cataract surgery in the horse. The lens is very large in size, thereby necessitating some modification of instrumentation and techniques used for small animal and human phacoemulsification. An operating microscope is essential. It is hard to make the corneal incision without touching the iris as the anterior chamber is very shallow near the base of the iris. The cataracts of horses are generally very soft, even in old horses, with most of the cortex and often the nucleus being easily emulsified and aspirated on completion of the capsulorrhexis. Movement of the thin posterior capsule can be quite pronounced and dramatic during cataract surgery in the horse. The equine eye tolerates intraocular surgery surprisingly well compared with other
animals. Postoperative uveitis is generally quite mild in the foal and adult horse after phacoemulsification although some degree of corneal edema, capsular fibrosis, and iridocyclitis will be present. The purpose of cataract surgery is visual rehabilitation. Recent advances in surgical techniques have increased the short-term success of equine cataract surgery. We sought to evaluate the long-term visual outcomes of phacoemulsification lens extraction surgery in foals and horses and identify any unique surgical complications that affect visual outcomes.

**METHODS**

**Patient selection**

Foals and horses with visual impairment as reported by the owner and confirmed by ophthalmic examination were considered candidates for cataract surgery. The general health of the foal or horse had to be good. All foals and horses received thorough systemic and ophthalmic examinations preoperatively. Any systemic or ophthalmic problem warranted delay of the phacoemulsification surgery. Radiography of the chest of foals was performed in most cases. Retinal function was evaluated by flash ERG preoperatively and had to be satisfactory. An ocular ultrasound of the globe or globes had to be normal. Active uveitis manifested by aqueous flare, if present, was treated prior to surgery. The presence of posterior synechia, miosis, and pronounced hypotony also precluded surgery.

**Equine phacoemulsification cataract surgery technique**

Topical and systemic antibiotics were administered both preoperatively and postoperatively to reduce the chance of infection in the horses in this study. Topical atropine was absolutely necessary to dilate the pupil. Mydriasis must be achieved preoperatively to completely remove the cataractous lens material. Topically and systemically administered corticosteroids and systemic NSAIDs were also used preoperatively and postoperatively to minimize inflammation. Preoperative electroretinography and B-mode ultrasonography are very important to evaluate outer retinal function and to detect retinal detachment and posterior capsule rupture, respectively, in foals and horses being considered for cataract surgery. Anesthesia for equine cataract surgery included general anesthesia of the patient with halothane or isoflurane. Neuromuscular paralysis was beneficial to our cases and highly recommended. Concern regarding anesthetic risks may limit surgery to only one eye at a time if bilateral cataracts are present, especially in adult horses. We generally recommend both eyes be carried out at one anesthetic procedure in foals, and only one eye per general anesthesia be carried out in adult horses.

The horse was positioned in lateral recumbency, and the head was positioned with the nose elevated using sandbags, inflatable rings, or both. The periocular skin was then cleaned with 1:50 povidone–iodine solution and appropriately draped. A Castroviejo eyelid speculum was used to retract the lids.

The globe was entered dorsally with a 3.2-mm keratome blade through a scleral tunnel under a limbal–based conjunctival flap. The peripheral anterior chamber of the horse is quite narrow, so care is used to not touch the iris. The keratome blade was entered to one side of the corpora nigra as the corpora nigra can hemorrhage quite severely if touched, especially in adults. The corpora nigra were cauterized if they slowly leaked blood.

Two milliliter of air was injected into the anterior chamber, and then trypan blue dye injected to stain the anterior lens capsule. Viscoelastic (hyaluronate sodium, 10 mg/mL, Hylartin V7™, Pfizer Animal Health, New York, NY, 10017, USA) was quickly injected into the anterior chamber to remove the trypan blue dye and improve anterior chamber depth.

A 20-gauge cystotome was used to incise the anterior capsule and a 10-mm-diameter piece of anterior capsule removed with Utrata forceps. The thin posterior capsule was generally left intact in this study.

Irrigation/aspiration with lactated Ringer’s solution containing epinephrine (1:10 000) and heparin (2 IU/mL) was utilized to maintain the anterior chamber during phacoemulsification and to remove any remaining cortex after most of the lens has been removed.

Short bursts of phacoemulsification power were used to aspirate lens cortex into the phacoemulsification needle. A 30-, 0.9-mm-diameter phacoemulsification needle was used for phacoemulsification to better achieve needle tip occlusion and to minimize the chance of creating tears in the posterior capsule. The phacoemulsification needle tip was kept parallel to the iris in the anterior chamber and only carefully angled posteriorly. Viscodissection with viscoelastics was used to move large pieces of the lens closer to the phacoemulsification needle, so it could be emulsified and aspirated. The posterior capsule of the horse tears quite easily and often moves rapidly anteriorly and posteriorly when the eye is open, so we were careful when

<table>
<thead>
<tr>
<th>Table 1: Typical preoperative and postoperative medications for cataract surgery in 95 horses</th>
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<tr>
<td><strong>Drug</strong></td>
</tr>
<tr>
<td>Topical corticosteroid prednisolone acetate (1%)</td>
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<tr>
<td>Topical antibiotic: chloramphenicol or bacitracin, neomycin, polymyxin B</td>
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<tr>
<td>Topical atropine (1%)</td>
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<tr>
<td>Topical NSAID such as diclofenac</td>
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<tr>
<td>Systemic omeprazole</td>
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<tr>
<td>Systemic flunixin meglumine</td>
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<tr>
<td>Systemic trimethoprim sulfadiazine (TMS)</td>
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positioning the needle into the posterior part of the lens capsule.

Lens cortex that remained attached to the posterior capsule of foals and horses after removal of the cortex and nucleus was aspirated through a 0.4-mm aspiration needle on an irrigation–aspiration handpiece. Larger cortical cataract pieces were at times carefully aspirated through the larger diameter phacoemulsification needle.

Some ophthalmologists placed intraocular lenses in foals and horses when they became commercially available, when the posterior capsule was intact, and when there was no hyphema. The scleral incision was extended to 6.5 mm in length when IOLs were placed. The scleral incision was closed with 8-0 polyglactin 910 (Vicryl™, Ethicon, Somerville, NJ, USA) in a simple interrupted pattern. The conjunctiva was closed with 8-0 polyglactin 910 in a simple continuous pattern. The incisions were carefully checked for leakage with a Seidel’s test.

Cyclosporine implants were placed in the suprachoroidal space at the 12 o’clock position 7 mm posterior to the limbus in some horses with ERU. The availability of the implants, opinion as to their efficacy by the ophthalmologist, presence of early to advanced ERU, and increased length of general anesthesia time were considered in utilizing these implants.

A smooth recovery from anesthesia was essential to minimize postoperative complications. Medications were continued for at least 2 months postoperatively. We recommended ophthalmic examinations every 6 months.

Vision outcome assessment
Medical records, photographic images, postoperative specialist examinations, referring veterinarian examinations, and owner evaluations were utilized to assess the long-term visual outcome status following phacoemulsification in this study. Data collected included age at surgery, breed, sex, which eye had surgery or was it bilateral, cause of cataract (ERU related, traumatic, not determined), stage of cataract (immature, mature, hypermature), IOL placement, cyclosporine implant placement, and visual outcome at all data time points. Phacoemulsification times were recorded depending on the phacoemulsification machine utilized. We classified the cause of the cataracts as related to ERU, trauma, or not determined. Assessment of visual function was made by distant observation of the horse walking, feeding, and interacting with other horses, and by ophthalmic examination. Ophthalmic examinations postoperatively included the clinical evaluation of the dazzle reflexes, pupillary light reflexes, menace responses, maze testing, and individual animal behavior. Slit-lamp biomicroscopy, tonometry, and direct and indirect ophthalmoscopy were performed by ophthalmologists. The time points we assessed were visual status immediately postoperatively, ≤1 month, >1–6 months, >6–12 months, >12 to 24 months, and >24 months. The owner’s opinion of the visual status of the horse after cataract removal was also included at the time points. Animals lost to follow-up were considered nonvisual in our study although some may actually have been visual.

RESULTS
Phacoemulsification data results
The total number of horses having phacoemulsification in one or both eyes was 95. The average horse age at surgery was 8.0 ± 5.7 years. Forty-four of the 95 animals were foals (46.3%). Sixteen animals had surgery bilaterally with eight of these being foals and six being horses with ERU. Ninety of the 95 horses (94.7%) regained vision in the immediate postoperative period. Five horses did not recover vision postoperatively. The total number of eyes receiving surgery was 111. One hundred and two of the eyes were blind preoperatively, but only five eyes (4.5%) remained nonvisual immediately postoperatively.

Phacoemulsification was performed in 33 Quarter Horses (12 geldings, five mares, 12 fillies, four colts), five Appaloosas (three geldings, two mares), five Arabians (one mare, two fillies, one stallion, one colt), two paints (one filly, one mare), five Warmbloods (three geldings, two mares), four Ponies (one gelding, two mares, one filly), 24 Thoroughbreds (five geldings, four mares, eight fillies, seven colts), one Miniature horse filly, one Paso Fino mare, two Morgans (two mares, one colt), two Andalusian geldings, three Standardbreds (two colts, one mare), two Saddlebred colts, one Tennessee Walking Horse filly, and five grade horses (four mares).

Twenty-four horses had cataracts associated with equine recurrent uveitis (ERU), trauma causing some degree of uveitis was noted as the cause of cataract in 10 horses, and no specific cause could be determined for the cataract noted in 61 horses (Table 2).

When IOLs for the horse eye became commercially available intraocular lenses (Acrivet 90V-22, Salt Lake City, UT, USA) were placed in nine eyes. Suprachoroidal cyclosporine implants were placed in 10 eyes of horses with ERU in conjunction with cataract removal. Two eyes with slightly elevated IOP preoperatively received endolaser for glaucoma with the lens removal surgery.

Postoperative visual outcomes
The combined visual outcome data from horses with all types of cataracts \(n = 95\); Table 3) found 83 (87.3%)

<table>
<thead>
<tr>
<th>Cataract etiologies related to ERU</th>
<th>Horses with ERU?</th>
<th>Trauma</th>
<th>Not determined</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>Yes</td>
<td>24</td>
<td>10</td>
<td>61</td>
<td>95</td>
</tr>
<tr>
<td>Trauma</td>
<td></td>
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<tr>
<td>Not determined</td>
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<tr>
<td>Total</td>
<td></td>
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<td>95</td>
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horses to be visual ≤1 month postoperatively, 47 (49.4%) horses visual for >1–6 months postoperatively, 33 (34.7%) horses visual from >6 to 12 months postoperatively, and 8 horses losing sight or lost to follow-up between >12 and 24 months such that 25 horses (26.3%) remained visual >24 months postoperatively (range 0–168 months).

The combined visual outcome data from horses with cataracts and ERU (n = 24; Table 4) found 18 (75.0%) horses to be visual ≤1 month postoperatively, 15 (62.5%) horses visual for >1–6 months postoperatively, 13 (54.2%) horses visual from >6 to 12 months postoperatively, and 4 horses losing sight or lost to follow-up between >12 and 24 months such that 9 ERU horses (37.5%) were visual >24 months postoperatively (range: 0–120 months).

The combined visual outcome data from cataract surgery in non-ERU adult horses (n = 27; Table 5) found 21 (77.8%) horses to be visual ≤1 month postoperatively, 13 (48.1%) horses visual for >1–6 months postoperatively, 11 (40.7%) horses visual from >6 to 12 months postoperatively, and 1 horse losing sight or lost to follow-up between >12 and 24 months such that 10 non-ERU horses (37.0%) were visual >24 months postoperatively (range: 0–144 months).

The combined visual outcome data from cataract surgery in foals (n = 44; Table 6) found 32 (72.7%) foals to be visual ≤1 month postoperatively, 19 (43.2%) foals visual for >1–6 months postoperatively, 9 (20.4%) foals visual from >6 to 12 months postoperatively, and 4 foals losing sight or lost to follow-up between >12 and 24 months such that 4 foals (9.1%) were visual as young adults >24 months postoperatively (range: 0.5–73 months).

The combined visual outcome data from foals and horses with IOL placement (n = 9; 3 foals) (Table 7) found 9 (100%) of the horses with IOL implants to be visual ≤1 month postoperatively, 7 (77.8%) horses with IOLs visual for >1–6 months postoperatively, 4 (44.4%) horses with IOLs visual from >6 to 12 months postoperatively, and 3 horses with IOLs losing sight or lost to follow-up between >12 and 24 months such that 1 horse with an IOL (9.1%) was visual >24 months postoperatively (range: 0.5–84 months).

The combined visual outcome data from horses and foals that had phacoemulsification in both eyes (n = 16; Table 8) at the same anesthetic event found 13 (81.3%) to be visual in one or both eyes ≤1 month postoperatively, 7 (43.8%) to be visual in one or both eyes for >1–6 months postoperatively, 4 foals visual from >6 to 12 months postoperatively, and two animals losing sight or lost to follow-up between >12 and 24 months such that 2 (12.5%) animals were visual in one or both eyes >24 months postoperatively (range: 1–80 months). Eight foals and eight horses with ERU had bilateral surgery. Five animals lost sight in one eye, but retained vision in the other till vision was lost completely or lost to follow-up.

Table 3. Combined visual outcome data of all horses (n = 95)

<table>
<thead>
<tr>
<th>Number (%) horses visual: all horses</th>
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<tbody>
<tr>
<td>All horses visual for ≤1 month</td>
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<tr>
<td>All horses visual for &gt;1 to 6 months</td>
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<tr>
<td>All horses visual for &gt;6–12 months</td>
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<td>All horses visual for &gt;12 to 24 months</td>
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Table 4. Visual outcome data from ERU horses (n = 24)

<table>
<thead>
<tr>
<th>Number (%) horses visual: ERU horses</th>
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<tr>
<td>ERU horses visual for ≤1 month</td>
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<tr>
<td>ERU horses visual for &gt;1 to 6 months</td>
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<tr>
<td>ERU horses visual for &gt;6–12 months</td>
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<tr>
<td>ERU horses visual for &gt;12 to 24 months</td>
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Table 5. Visual outcome data from non-ERU, adult horses (n = 27)

<table>
<thead>
<tr>
<th>Number (%) horses visual: Non-ERU horses</th>
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<tbody>
<tr>
<td>Non-ERU horses visual for ≤1 month</td>
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<tr>
<td>Non-ERU horses visual for &gt;1 to 6 months</td>
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<tr>
<td>Non-ERU horses visual for &gt;6–12 months</td>
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<tr>
<td>Non-ERU horses visual for &gt;12–24 months</td>
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Table 6. Visual outcome data from foals (n = 44)

<table>
<thead>
<tr>
<th>Number (%) Horses Visual: Foals</th>
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<tr>
<td>Foals visual for ≤1 month</td>
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<tr>
<td>Foals visual for &gt;1 to 6 months</td>
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<td>Foals visual for &gt;6–12 months</td>
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<td>Foals visual for &gt;12–24 months</td>
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Table 7. Visual outcome data from foals and horses with IOL placement (n = 9; 3 foals)

<table>
<thead>
<tr>
<th>IOL cases (%)</th>
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<tbody>
<tr>
<td>IOL cases horses visual for ≤1 month</td>
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<tr>
<td>IOL cases horses visual for &gt;1 to 6 months</td>
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<tr>
<td>IOL cases horses visual for &gt;6–12 months</td>
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<tr>
<td>IOL cases horses visual for &gt;12 to 24 months</td>
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Table 8. Visual outcome data from horses and foals that had surgery bilaterally (n = 16)

<table>
<thead>
<tr>
<th>Number (%) horses visual that had surgery bilaterally</th>
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<tbody>
<tr>
<td>Animals visual for ≤1 month</td>
</tr>
<tr>
<td>Animals visual for &gt;1 to 6 months</td>
</tr>
<tr>
<td>Animals visual for &gt;6–12 months</td>
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<tr>
<td>Animals visual for &gt;12–24 months</td>
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Postoperative expectations of phacoemulsification cataract surgery in the horse

The iridocyclitis and corneal edema in foals and horses diminish quickly with medical therapy after phacoemulsification with foals and horses able to regain sight quickly and return to normal activity in 6–8 weeks. (Figs 1-10). Slight corneal edema, especially near the incision, is usually present from 24 to 72 h postoperatively (Figs 8 and 9). The anterior chamber is shallow due to the posterior capsule bulging forward for 3–5 days postoperatively. The aqueous humor has flare and can appear yellow for a week postoperatively. Slight hyphema can be present postoperatively. The tapetal reflection may also be more yellow than that found preoperatively. Some capsular opacification will occur quickly in the foals and adult horses. During surgery, the foal tapetal reflection may not be homogeneous with some regions darkened possibly due to changes in the retinal and choroidal microcirculation from the intraoperative hypotony (Fig. 10). These tapetal alterations quickly return to normal within a few days after surgery.20 Retinal folds that we presume are also associated with intraoperative hypotony causing focal retinal detachments can develop over weeks to months postoperatively (Figs 11 and 12).20 One week after surgery, the pupil should be functional, any fibrin in the anterior chamber resorbing, and the fundus visible. Three weeks after surgery, the eye should be nonpainful, the patient visual, pupillary movement normal, and the ocular media clear. Medications should be maintained for
at least 2 months postoperatively to minimize posterior capsule opacification and suppress subclinical signs of iridocyclitis.

Intraoperative complications of cataract surgery in the horses included iris protrusion into the incision in most eyes and corpora nigra hemorrhage in a few eyes. The corpora nigra are easily aspirated and can slowly hemorrhage. Posterior capsular tears resulting in dropping lens fragments into the vitreous occurred in four eyes (Fig. 13). Retinal swelling may be noted during the hypotony caused by the open incision during surgery (Figs 10-12).

Corneal edema to some degree and some degree of aqueous flare postoperatively occurred in all 111 eyes. The anterior capsule may become opaque intraoperatively or days later in some foals. Hyphema developed

Complications of phacoemulsification cataract surgery in the horse

Figure 5. The anterior capsular capsulorrhexis and some posterior capsular opacification are noted 3 months postoperatively.

Figure 6. Corneal ulcer is present in this horse after phacoemulsification.

Figure 7. A mature cataract is present in this Quarter Horse filly.

Figure 8. Generalized corneal haze is present 1 day postoperatively in the horse in Fig. 7.

Figure 9. A clear visual axis is present 1 month postoperatively in the horse in Figs 7 and 8.

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postoperatively in 20 eyes. Some degree of synechiation developed in 20 eyes. Posterior capsular opacity occurred to some degree in all 111 eyes. It was quite severe in 45% (Figs 3, 8, 9, and 14) The opacification was noted intraoperatively and to progressive rapidly in many eyes. Vitreous presentation into the anterior chamber intraoperatively or postoperatively did not occur despite breaks in the posterior capsule.

Severe postoperative complications included corneal ulcers (Fig. 6), persistent iridocyclitis and plasmoid aqueous in some ERU eyes (Fig. 13), hyphema, fibropupillary membranes, synechiae, iris bombe, corneal ulceration, severe corneal edema due to endothelial cell damage (Figs 15 and 16), corneal fibrovascular infiltrates, severe posterior capsular opacification, retained lens cortex, wound leakage, presumed phototoxic retinopathy (Fig. 17), retinal degeneration, and retinal detachment.20 Four eyes developed retinal detachment at 2 days–1 month postoperatively (Fig. 12). One foal developed a deep stromal abscess following corneal ulceration 2 weeks postoperatively (Fig. 18). Three eyes with an IOL developed glaucoma (Fig. 19). Infectious endophthalmitis

Figure 10. An alteration in tapetal reflectivity can be appreciated through a tear in the lens capsule in this intraoperative image of a Thoroughbred colt. Note the patchy, alternating areas of dull and bright tapetal mottling. The appearance of the tapetum returned to normal and reflectivity looked homogenous once more by the first postoperative daily examination. This intraoperative change was appreciated in several horses and was thought to be associated with altered retinal and choroidal perfusion from intraoperative hypotony.

Figure 11. A composite image of postoperative retinal folds in the tapetum in the horse from Figs 7-9.

Figure 12. A Warmblood mare has a peripapillary retinal fold 1 month postoperatively that was presumed to be caused by intraoperative hypotony. This fold may have been a larger retinal detachment that incompletely reattached.

Figure 13. Postoperative lens fragments moved from the vitreous to the anterior chamber 2 days postoperatively in this Paso Fino colt.
(Fig. 20) requiring enucleation occurred postoperatively in two eyes. One globe developed infectious endophthalmitis at 10 days postoperatively and another at 30 days postoperatively and were enucleated. Glaucoma developed postoperatively in three eyes. Phthisis developed postoperatively in six eyes over different time periods.

**Equipment**

Several phacoemulsification units were used in the surgery of these foals and horses. Most were carried out with the Storz Premier (Storz Daisy and Premier units, Bausch and Lomb, North Bridgewater, NJ, USA), and the AMO Sovereign (AMO Diplomate and Sovereign units, Irvine, CA, USA.) units, but the Alcon Universal I and II (Alcon Universal II and II units, Ft Worth, TX, USA), the AMO Diplomat, and most recently the Acrivet Alexos (Acrivet Alexos, Salt Lake City, UT, USA) were also used. The Acrivet unit has a 23-mm-long phacoemulsification needle and sleeve that better fits the large globe of the adult horse than the 15-mm-long needles utilized on canine-
based cataract surgery handpieces (Fig. 21). Longer irrigation–aspiration tips and sleeves are also available for the horse. The majority of the horse eyes in this study used the standard 15-mm-long phacoemulsification needle for cataract surgery as the longer needles only became available in 2007. Phacoemulsification times were available for 50 eyes and averaged 3.5 min per eye with a range of 0.7–45 min.

DISCUSSION

The evaluation of surgical therapy in foals and horses with cataracts is related to visual capability. Success equals vision. A successful outcome postoperatively in horses and foals having phacoemulsification should also include an assessment of the long-term visual capability. Horses can live for decades, and a successful visual outcome must be present for years to be considered a success.
Most reliable reports of vision after successful cataract surgery in the horse indicate that vision is functionally normal. Advances in the surgical technique of lens extraction in horses have increased the reported surgical success rate. A 77% success rate at 6 months and 60% visual at 6–12 months in 56 eyes of 28 foals were noted by one group in 1974. Owners believed vision was good in 10 of 12 horses up to 3.5 years postoperatively in a series of horses from Texas. Useful vision was present in 30 of 36 horses (83%) initially in another Texas study with three horses (8%) visual at 5–6 years. Foals and adults did well, but results were worse in horses with ERU in the second study from Texas. A case series from Ohio State found 46 of 47 (98%) horse eyes sighted postoperatively and 38 of 47 (81%) eyes visual at last follow-up (median = 4 weeks), but 18 of 47 (38%) were lost to follow-up after 4 weeks. A series of 35 surgeries in 30 horses from Florida and Pennsylvania found all eyes visual immediately postoperatively, but long-term vision retained in only 19 of 35 eyes (54%) at an average of 113 months postoperatively. Uveitis eyes did slightly worse at retaining vision postoperatively. If visual 6 months postoperatively, there was a good chance the eyes would remain visual. Posterior capsular opacification (PCO) was a significant problem in the Florida cases. A study from North Carolina State University found 22 of 39 (56%) eyes visual at last follow-up with 11 of 16 (63%) having IOL placed and 11 of 23 aphakic eyes (48%) visual. Three of ten ERU eyes (30%) were visual. Older age and IOL use were not associated with poor visual outcome.

While horses with cataracts caused by uveitis have not been considered appropriate surgical candidates due to concurrent ocular pathology and high postoperative complication rates, many of these horses can still have successful surgery, as was noted in our study. We found 37.5% of ERU horses to be visual ≥24 months postoperatively. The outcome results found in this study may actually have been more positive as animals lost to follow-up were considered nonvisual in our study although some may actually have been visual.

There is a disconcerting loss of long-term follow-up data in horses having phacoemulsification. Horses are sold, their names changed, owners do not return the animals for examination, and thus, they can be hard to find for follow-up. The lack of long-term data in the foals is particularly discouraging due to the fact so many foals are presented for cataracts with the owners considering surgery. Most foal eyes do quite well and exhibit slight iridocyclitis postoperatively. The clinicians and owners then relax their postoperative medical therapy such that anti-inflammatory medications may be discontinued too soon. It was quite disturbing to us to see the deterioration and loss of vision that occurred rapidly in some foals and young horses following what appeared to be a technically perfect cataract surgery. We now feel that low-grade iridocyclitis is present postoperatively in a sizable portion of the operated animals (foals and horses) to cause this pronounced reduction in vision. It seems to us that anti-inflammatory postoperative medical therapy may be necessary for the life of the animal.

From an optical standpoint, the aphakic eye should be quite far-sighted or hyperopic postoperatively, and in one study was +19.94 D and in a second study was +10D hyperopic. Images close to the eye should thus be blurry and appear magnified. This reduction in optical quality should theoretically be severely debilitating to horses, but the clinical evidence is that aphakic vision gives functional and satisfactory vision to foals and horses. Intraocular lenses (IOL) could improve postoperative visual outcome. An intraocular lens with a refractive power of 25 D resulted in −3.48D myopia at retinoscopy in one study of pseudophakic horses. A second study with a 14D IOL found the postoperative retinoscopy to be closer to emmetropia at +0.4D.

The visual capabilities of horses are very important to their function in society as the safety of the human rider is augmented by the vision status of the horse. Poor vision of horse is generally associated with an unsafe condition for the rider. The commercial availability of IOL for horses will improve the safety for the rider but is not the only, and perhaps not the most important postoperative problem in phacoemulsification cataract surgery results in horses. The capsular opacification that develops in many horses postoperatively must affect the visual capability of the horse although some undoubtedly adapt well. The horse corneal endothelium is very durable, but the ultrasonic trauma from the phacoemulsification instrumentation to the horse eye with uveitis and cataract can further damage the already compromised corneal endothelium such that it cannot compensate to result in various degrees of edema and subsequent reduction in vision quality. The profound capsular opacification and persistent corneal edema are not related to a lack of emmetropia and are the major causes of vision deterioration postoperatively in horses after cataract surgery.

People ride horses and use them in day-to-day activities. The safety of riding is partly related to horse vision status. Cataracts reduce vision quality, and the only treatment for cataracts is surgery. Problems do remain, however, and some veterinarians feel it is unethical to recommend that horses with cataracts, or horses that have had cataract surgery, are safe to ride. It seems to the authors that not trying to remove the cataracts and improve the vision status of these horses is also not satisfactory, and thus, we strive to improve our surgical results to restore sight in horses with cataracts.

This retrospective medical records study of phacoemulsification in horses provides much useful postoperative data, but there are limits to all retrospective clinical medical records studies. A prospective, multicenter, multisurgeon, long-term study of the visual outcome of cataract surgery...
in foals and horses is necessary. We suggest that such a study consists of at least 100 horses to last 15 years. The International Equine Ophthalmology Consortium, the American College of Veterinary Ophthalmologists, the European College of Veterinary Ophthalmologists, and other international veterinary ophthalmology organizations are natural organizations to participate in such a study. A prospective study of phacoemulsification in horses will require commitment, dedication, resources, and administrative organization to develop the type of data to be collected and to evaluate the unbiased data from the predetermined time points. The long-term results of phacoemulsification in horses still need to be carefully monitored and evaluated.

CONCLUSION

Phacoemulsification cataract surgery in horses performed by experienced veterinary ophthalmologists enable at least 26.3% of horses to return to their natural activity for 2 years or more postoperatively.

REFERENCES
