**Case Report**

**Bilateral Phacoemulsification in an African Elephant (Loxodonta africana)**

Anthony J. Cerreta,¹ Richard J. McMullen Jr,² Heather E. Scott,³ Jennifer D. Ringenberg,⁴ Julie E. Hempstead,⁵ Ryan S. DeVoe,⁶ Michael R. Loomis,¹,³ and Larry J. Minter¹,³

¹Department of Clinical Sciences, North Carolina State University, College of Veterinary Medicine, 1060 William Moore Drive, Raleigh, NC 27607, USA
²Auburn University College of Veterinary Medicine, JT Vaughan Large Animal Teaching Hospital, 1500 Wire Road, Auburn, AL 36849, USA
³Hanes Veterinary Medical Center, North Carolina Zoo, 4401 Zoo Parkway, Asheboro, NC 27205, USA
⁴Blue Pearl Specialty and Emergency Pet Hospital, 3000 Busch Lake Blvd., Tampa, FL 33614, USA
⁵Gulf Coast Veterinary Specialists, 8042 Katy Freeway, Houston, TX 77024, USA
⁶Department of Animal Health, Disney’s Animal Kingdom, 2901 Osceola Parkway, Lake Buena Vista, FL 32830, USA

Correspondence should be addressed to Larry J. Minter; jb.minter@nczoo.org

Received 8 April 2019; Accepted 19 June 2019; Published 10 July 2019

Academic Editor: Franco Mutinelli

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A 37-year-old bull African elephant (Loxodonta africana) at the North Carolina Zoo (NCZ) was diagnosed with bilateral cataracts leading to behavioral changes and significant weight loss secondary to functional blindness. On initial examination, a weight loss of 234 kg, a mature cataract in the right eye, and a focal cataract in the left eye were diagnosed. Ultrasound and electroretinography (ERG) indicated normal retinal attachment and both eyes were viable candidates for surgery. After careful planning and behavioral training, the left cataract was surgically removed via phacoemulsification and irrigation/aspiration. The right eye subsequently developed a ventral lens subluxation, and phacoemulsification and irrigation/aspiration were performed six months after the first procedure. Four years after surgery, menace response, palpebral reflex, dazzle reflex, and pupillary light reflexes were present in both eyes. Body weight was 5,515 kg, 88 kg more than at the time of the second surgery. This is the first published report of an African bull elephant undergoing bilateral cataract removal using phacoemulsification and irrigation/aspiration. The lack of significant postoperative inflammation and uneventful recovery of the elephant suggests that this surgical procedure along with proper preoperative planning and postoperative medical management can be a safe and effective treatment option for elephants with cataracts.

1. Introduction

Lenticular abnormalities such as cataracts and lens luxation have been described in both Asian and African elephants [1, 2]. However, the extent of ocular disease in these species is equivocal due to limited data from ocular examination and treatment [3]. It has been proposed that excess infrared and visible radiation due to limited shade and reflection of heat from the ground are responsible for lesions of the lens and retina [4]. These risk factors place both wild elephants and those in human care at an increased chance for ocular damage. In field studies of Asian and African elephants, large proportions of the populations had ocular lesions, including cataracts [1, 4–6]. Surgical intervention is not considered necessary until cataract maturation affects sight and quality of life [7, 8]. This is especially relevant in zoological species where the risks of anesthesia and the ability to administer pre- and postoperative treatments must be considered when deciding whether to pursue surgical correction of cataracts.

Several methods used to surgically address cataracts in humans, wildlife, and domestic animals have been reported [9–13]. Phacoemulsification is the preferred method for...
cataract removal in domestic species, even in animals with large eyes, including the horse, because it allows for a smaller corneal incision and thus a faster return to activity [14, 15]. Phacoemulsification requires that a small incision be made in the cornea for insertion of a handpiece to ultrasonically fragment the lens, which is then aspirated for removal [8]. Furthermore, phacoemulsification can be used for all stages of cataract maturity and has a favorable prognosis for restoring vision [16]. Cataract removal via phacoemulsification has been anecdotally reported in one Asian elephant, although details of the procedure were not provided [3].

2. Case Presentation

2.1. Initial Ophthalmic Examination. Keepers at the North Carolina Zoo (NCZ) reported that a 37-year-old, bull African elephant (Loxodonta africana) appeared to have cloudiness in both eyes in March 2010 with a concomitant weight loss of 188 kg. Complete ophthalmic examination was performed which indicated that direct and consensual pupillary light reflexes (PLR), palpebral reflexes, and dazzle reflexes were present and there was no fluorescein stain uptake in either eye. Slit lamp biomicroscopy of the anterior chamber (AC) was within normal limits, with the exception of a focal cataract in the right eye and a newly forming incipient cataract in the left eye. Indirect ophthalmoscopy revealed no abnormalities. 0.03% flurbiprofen sodium ophthalmic solution (Bausch and Lomb, Bridgewater, NJ, 08807) was prescribed topically twice daily indefinitely to decrease the inflammation associated with cataract formation.

A complete ophthalmic examination was repeated six months later. The size of the cataracts had increased in both eyes and the elephant had an additional weight loss of 89 kg. A mature cataract was found in the right eye (Figure 1(a)) and a nuclear incipient cataract was found in the left eye (Figure 1(b)). Intraocular pressures (IOP) measured via applanation tonometry (Tono-Pen Vet™, Dan Scott and Associates, Inc., Westerville, OH) were 18 mmHg in the right eye and 21 mmHg in the left eye which are considered to be within normal limits [17, 18]. Based upon examination, it was suspected that there was only limited vision in the right eye and there were only light and shadows visible in the left eye. The elephant began showing signs of significant blindness such as unsure footing, knocking his tusks into doorways, and utilizing his trunk to navigate. Approximately one year after initial diagnosis, he was no longer able to independently traverse the runway from the holding barn to the habitat. In addition to the ophthalmic abnormalities, an additional weight loss of 269 kg was noted. Outdoor paddocks and indoor stalls were available to the elephant during the day, but the majority of the time he was observed leaning against supports or swaying in place. A total weight loss of 546 kg, the bull’s loss of vision, and development of subsequent stereotypical behavior prompted discussion about his quality of life and the feasibility of performing surgery to remove his cataracts.

2.2. Ancillary Diagnostic Tests. Ocular ultrasonography and electroretinography were performed to determine whether the elephant was a candidate for phacoemulsification and intraocular lens (IOL) implantation. Transcorneal B-scan ultrasonography revealed hyperechoic lens in both eyes, consistent with cataractous changes (Figure 2). Preoperative anterior chamber depth (ACD) measured 5.0 mm, axial globe length measured 38.6 mm, and crystalline lens thickness measured 12.2 mm. Electroretinography (ERG), performed in the darkened elephant holding area, confirmed that the retina of the right eye (OD) was functional; however, due to waning cooperation by the patient, ERG was unable to be performed in the left eye (OS). Both the dazzle reflex and PLRs were positive in both eyes (OU). The results of a complete blood count and serum biochemistry panel were within normal limits for an adult elephant [19]. Based on these preoperative findings, the elephant was considered a good candidate for surgery.

2.3. Treatment and Surgical Management. Unilateral phacoemulsification was chosen to remove the mature cataract in

![Figure 1](ophthalmic_reexamination.jpg)
Figure 2: B-mode ocular ultrasonography of the elephant’s right eye revealing a hyperechoic nuclear lens. Despite the clinical diagnosis of a mature cataract, the lens cortex appears to be less significantly affected in the ultrasound image. The crystalline lens thickness (A: 12.2 mm), crystalline lens diameter (B: 17.9 mm), and the vitreal chamber depth (C: 21.4 mm) are visible in this image, as well. Note that D is not a valid measurement and that the caliper measurements were inadvertently saved.

The right eye. Preoperative treatment with topical ophthalmic medications was implemented 24 hours prior to surgery. Medications were applied with a 1.0 ml syringe with the needless hub at a volume of 0.1 ml. These included 1.0% prednisolone acetate ophthalmic suspension (Omnipred, Alcon Laboratories, Inc., Fort Worth, Texas 76134) (q 30 minutes) to prevent endophthalmitis and reduce intraocular inflammation, 0.5% moxifloxacin hydrochloride ophthalmic solution (Vigamox, Alcon Laboratories, Inc., Fort Worth, Texas 76134) (q 30 minutes) to prevent endophthalmitis, and 1.0% nepafenac ophthalmic suspension (Nevanac, Alcon Laboratories, Inc., Fort Worth, Texas 76134) (q 12 hours) to control intraocular inflammation prior to surgery.

The elephant was induced with etorphine (1.5 µg/kg, IV) and became semisternally recumbent within 2 minutes. The elephant could not be manually manipulated into left lateral recumbency. However, right lateral recumbency was achieved (Figure 3) and the decision to continue with phacoemulsification of the left eye, rather than the right eye, was made. Six mg of etorphine was added to a 250 ml bag of 0.9% sodium chloride and a constant rate infusion was instituted at 3 ml/hour for the first 30 minutes of the procedure, increased to 6 ml/hour for one hour, and then reduced to 4 ml/hour for the remainder of the procedure. A size 30 endotracheal tube (ET) was used for intubation (Figure 4). Intermittent positive pressure ventilation (IPPV) and supplemental oxygen were provided with a modified Y-piece apparatus and electric leaf blower (Figure 5) [20]. This apparatus was capable of maintaining blood oxygen saturation (SPO2) levels of 93-99% throughout the procedure.

A modified retrobulbar block was performed following aseptic preparation of the periocular region and bulbar conjunctiva. Using a 19-gauge, 2.5-inch spinal needle with a slight bend, approximately 25 ml of 2% mepivacaine (Pharmacia & Upjohn Company, Pfizer Inc. NY, NY, USA) was deposited behind the globe from both dorsal and temporal conjunctival access points (Figure 6) [21]. Access to these regions was facilitated by slight manual depression of the upper and lower eyelids (Figure 7).
Due to the unconventional head position and limited access to the globe, a head-mounted microscope (Varioscope M5®, Acrivet, Veterinary Division of S&V Technologies AG, Hennigsdorf, Germany) was utilized (Figure 8). A trilaminar, clear corneal incision (CCI) was created [22–24]. Briefly, a 4 mm groove incision was created approximately 1 mm from the limbus at the 7 o’clock position using a 2.8 mm sapphire crescent blade (Acrivet, Veterinary Division of S&V Technologies AG, Hennigsdorf, Germany) and was followed by a 2 mm tunnel incision extending axially from a depth of approximately 50 percent of the initial groove incision. Finally, using a 2.8 mm sapphire slit/phaco blade (Acrivet, Veterinary Division of S&V Technologies AG, Hennigsdorf, Germany) entering through the tunnel incision, the deep corneal layers were penetrated, providing access to the anterior chamber through a hinged, self-sealing incision. 0.2-0.3 mL epinephrine hydrochloride was infused into the
The elephant was examined two weeks postoperatively and a complete ophthalmic examination was performed. Menace response, palpebral reflex, dazzle reflex, and pupillary light reflexes were present in both eyes. IOP in both eyes were within normal limits and the incision sites appeared to be healing well. The elephant was cleared to be let out into his habitat but was started on atropine ophthalmic solution (Akorn Animal Health, Lake Forest, IL 60045) 1 drop q 12 hours for 3 days.

Complete ophthalmic examinations were repeated at 3 weeks, 8 weeks, 12 weeks, 6 months, and 12 months. At the 8-week recheck, a small lens remnant was discovered in the vitreous in the right eye that could only be visualized when the pupil was fully dilated (Figure 12). As there were no signs of inflammation associated with the lens remnant, no action was taken at this time. Six months postoperatively, a corrective contact lens (Acrivet, Veterinary Division of
Figure 10: A series of images illustrating the use of an overhead hoist attached to a sling that was placed under his thorax prior to induction (see Figure 3).

S&V Technologies AG, Hennigsdorf, Germany) was placed in the right eye (Figure 13). Due to waning cooperation of the elephant, a corrective lens was not placed in the left eye. Twenty four hours later it was discovered that the corrective lens was no longer in place and was not replaced. The NCZ keepers reported that the elephant was behaving normally in his habitat and noted a marked improvement in his vision and body condition score, with a weight gain of 107 kg. Mild corneal edema in the right eye was discovered at the 12-month recheck and the left eye showed no active problems.
Both aphakic globes were significantly hyperopic following surgery. Despite this, the elephant bull appeared to navigate his surroundings and was reintegrated into the herd. Four years postoperatively, his keepers noted only mild visual impairment and a normal body condition score for a bull elephant of his age. His weight was increasing at 5,515 kg, 88 kg more than at the time of the second surgery, and closer to his historical weight of 6,095 kg. He no longer displayed any evidence of stereotypical behavior and had successfully been integrated back into the herd, thus appearing to have a vastly improved quality of life following surgery.

3. Discussion

Cataracts are a common finding in many domestic species and are occasionally seen in African elephants (Loxodonta africana) [4, 9]. Cataracts form when there is a disruption to the normal anatomy of the lens and are often caused by trauma, disease, or age-related changes [28]. Cataract development in this elephant was suspected to be most likely due to age, with subsequent progression being relatively fast following diagnosis. There was no inflammation observed at the time of diagnosis or during the months (OS) or years (OD) prior to surgery. As a result, it was suspected that postoperative inflammation would be minimal following surgical removal of the lens(es). Preoperative functional retinal evaluation via ERG and ocular biometry via ultrasound were performed to determine if and which power intraocular lens implant could be used following removal of the cataractous lens via phacoemulsification and irrigation/aspiration. However, the significant lens instability (first noted following the initial stages of surgery, i.e., during creation of the anterior capsulorhexis) prevented implantation of an intraocular lens (IOL) implant.

Previously published methods for cataract removal in domestic and nondomestic species include lensectomy and phacoemulsification. A lensectomy, where the entire lens is removed, often requires multiple or larger incisions, which increases the potential damage to the anterior and posterior capsules and therefore exacerbates postsurgical complications in healing and recuperation [29]. Phacoemulsification employs ultrasound waves to break down, or emulsify, the lens with a high frequency ultrasound probe and then aspiration of the cortex and nucleus through a single needle [30]. Small-incision phacoemulsification with aspiration utilizing instrumentation specifically modified for the equine eye is the current standard of care for cataract surgery in the horse, the species which this surgery was modeled after [16, 31–36]. Phacoemulsification and aspiration are most commonly performed through a single incision, utilizing a single needle.
to infuse irrigating solution, aspirate, and deliver ultrasonic phacoemulsification [15].

Utilizing a trilaminar (three-step) corneal incision, whereby a proximal hinge is created at the base of the incision, helps to prevent the incision from leaking. This technique is advantageous in the horse, since it prevents the iris/corpora nigra from migrating to the corneal incision during phacoemulsification of the lens and aspiration of the cortex [36]. The trilaminar corneal incision also enables the anterior chamber to remain formed throughout the surgical procedure, thus reducing the amount of viscoelastic utilized throughout the surgery. This procedure also requires a small surgical incision, which minimizes the risk of intraoperative iris prolapse and results in fewer postoperative complications and quicker recovery [30, 36].

Following bilateral phacoemulsification and irrigation/aspiration, the elephant bull was able to navigate his surroundings, forage normally, and be reintegrated into the herd, thereby improving his quality of life. Four years postoperatively, the elephant had mild visual impairment, but a normal attitude and mentation for an adult bull elephant. He weighed 5,515 kg, 88 kg more than at the time of the second surgery, and attained a normal body condition score for a bull elephant of his age. The rapid postoperative recovery of the elephant following phacoemulsification and his quick acclimation to navigating and foraging after recovery indicated that this surgical procedure, with proper planning and execution, can be a safe and effective treatment for cataracts in adult elephants. Regular ophthalmic examination in elephants should be included in their annual health check program. Early detection and treatment of any ocular abnormality may avoid the development of subsequent irreversible ocular pathology.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

The authors would like to thank everyone involved in making both of these surgeries a success.

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