Bilateral simultaneous cataract surgery and intraocular lens implantation in an adult female chimpanzee (Pan troglodytes) inducing monovision

Notting, F.; Cheng, Y.; Marinkovic, M.; Bolhuis, H. van; Notting, I.

Received: 5 September 2022 | Revised: 1 April 2023 | Accepted: 6 April 2023

DOI: 10.1111/vop.13100

WILEY

CASE REPORT

Bilateral simultaneous cataract surgery and intraocular lens implantation in an adult female chimpanzee (*Pan troglodytes*) inducing monovision

F. Notting[1] | **Y. Cheng**[2] | **M. Marinkovic**[2] | **H. van Bolhuis**[2,3] | **I. Notting**[2]

[1]Amsterdam University Medical Center, Amsterdam, The Netherlands

[2]Department of Ophthalmology, Leiden University Medical Center, Leiden, The Netherlands

[3]AAP, Animal Advocacy and Protection, Almere, The Netherlands

Correspondence
I. Notting, Department of Ophthalmology, Leiden University Medical Center, Albinusdreef 2, 2333 ZA Leiden, The Netherlands.
Email: i.c.notting@lumc.nl

Abstract

Background: Cataract is the major cause of visual impairment in humans. Phacoemulsification with intraocular lens (IOL) implantation is the standard technique for cataract treatment with a high success rate. In a few cases, the surgical cataract procedure and lens implantation have been applied in non-human primates.

Case Description: A +/− 40-year-old female chimpanzee (*Pan troglodytes*) in captivity was diagnosed with mature cataract optical density (OD) and posterior subcapsular cataract combined with cortical opacities OS after ophthalmic examination. To restore vision and facilitate far- and near sight, phacoemulsification OU with +22.5 diopter (D) IOL implantation OD and + 24 D OS were performed. Despite complicated surgery OD due to posterior capsular rupture, the outcome was successful during 1-year follow-up. The chimpanzee regained adequate vision, normal behavior, and was successfully re-introduced to her group of chimpanzees.

Conclusion: This is the first case report of a simultaneous bilateral cataract surgery with IOL implantations in both eyes, targeting emmetropia OS and near vision OD resulting in monovision, in a chimpanzee. Vision was restored without postoperative complications.

KEYWORDS

cataract surgery bilateral, chimpanzee, IOL implantation, monovision, phaco emulsification

1 | INTRODUCTION

Cataract is a major cause of visual impairments in humans[1,2] and repeatedly reported in animals, for example in dogs,[3] cattle,[4] dogs, and cats.[5] Mature cataract in humans with complete loss of sight may even develop in only the course of several days–months in the case of head trauma[6] or uncontrolled diabetes.[7] Although the etiology of cataract may be variable, such as advancing age,[7,8] trauma,[9] genetic predisposition,[10] or nutritional deficiencies,[11,12] vision can be restored by surgical intervention. Since human and non-human primates live in groups and heavily depend on their vision for social interactions,[13] cataract surgery not only restores basic needs, but also increases the quality of life on a behavioral level.

In humans, preoperative ocular biometry is performed to calculate the intraocular lens (IOL) diopter (D) power, followed by phacoemulsification with IOL implantation. This is the standard procedure.[14] IOL implantation in non-human primates was experimentally studied in rhesus monkeys[15] and cynomolgus monkeys,[16] where phacoemulsification and aspiration with cataract-curing end points were first used in a spider monkey.[17] Since then, phacoemulsification[18] and phacoemulsification in combination with IOL implantation[19–22] have been successfully applied to gorillas and orangutans suffering from vision loss by cataract.

The chimpanzee (*Pan troglodytes*), with which we share roughly 96% of our genome,[23] is the humans closest relative, and both species are expected to have considerable similarities in eye structure. Unilateral phacoemulsification with IOL implantation has been performed in a chimpanzee.[22] To our knowledge, this is the first report of a bilateral cataract surgery and monofocal IOL implantation, aiming at monovision, in an adult, female chimpanzee.

2 | CASE DETAILS

2.1 | History

An approximately 40-year-old female chimpanzee from a rescue center for exotic animals, specializing in non-human primates, in the Netherlands (AAP, Animal Advocacy and Protection) presented with bilateral opacity of the lenses. The chimpanzee had inhabited the center for 12 years, being obese at the moment of rescue. Caretakers first noticed behavioral changes when she started covering her eyes from light, 3 months before development of cataract was diagnosed. The behavior of the chimpanzee progressively deteriorated, leading to the loss of her dominant position in the group of one male and four females, so she had to be isolated. Her movements were careful, scanning the environment with her hands before stepping from a platform. Other behavioral signs included foraging with her head close to the ground and frequently hiding under a blanket. At AAP, a veterinary treatment room was equipped for ophthalmic examination and the subsequent surgical procedure.

2.2 | Ophthalmic examination

For anesthetic and immobilization purposes, a combination of tiletamide and zolazepam (2.5 mg/kg; Zoletil 100, 100 mg/mL, Virbac) and detomidine (0.04 mg/kg; domidine 10 mg/mL, Eurovet Animal Health), IM was administered by hand injection. Before lifting the animal from her enclosure, ketamine IM was given (1.6 mg/kg, ketamine 10%, 100 mg/mL, Alfasan Nederland B.V.). Anesthesia was maintained with isoflurane (Isoflutek 1000 mg/g, Laboratorios Karizoo) and O_2 1.5 mL/min by a 7 mm endotracheal tube.

FIGURE 1 Mature cataract of the right eye.

Ophthalmic examination revealed mature cataract optical density (OD) (Figure 1), and posterior subcapsular cataract combined with cortical opacities OS. Pupillary light reflex was absent on OD, but positive on OS. To dilate the pupils, 0.28 mg tropicamide and 5.4 mg phenylephrine hydrochloride (Mydriasert®, Théa Pharma) were installed in the fornix for 20 min, and it was removed at the end of the examination. During ophthalmic examination using a slit lamp biomicroscope (Zeiss Style Optel Portable Slit Lamp, Model Name/Number: Z), the conjunctiva, cornea, anterior chamber, and iris appearances were normal. Fundus examination could not be carried out due to cloudiness of the lens OD. In OS, there was a red fundus reflex, and centrally, the optic nerve head was visible with a normal aspect, but further details could not be observed.

For the IOL power calculation, keratometry and A-scan biometry were executed. Keratometry only succeeded in OS and was performed with the retinomax (Righton laser vision). Keratometry values from OS were used in OD. An immersion ultrasound A-scan biometry (Rockmed) was carried out to determine the axial length (AL). The average ALs were 21.86 mm OD and 21.27 mm. Table 1 summarizes the ophthalmic measurements with A-scan details. The refraction power of the IOLs was calculated based on the SRK/T-II formula.[23,24] To enable increased near sight in one eye, a target of minus 1.0 D was chosen in OD to achieve slight myopia (Hoya PC-60AD IOL with +22.5 D). Emmetropia was chosen for OS (Hoya VivinexC MultiSert IOL with +24.0 D) (Figure 2).

Physical examination, hematology, and blood chemistry results were within normal limits (Table 2 Blood chemistry results). The total procedure, including induction,

TABLE 1 Ophthalmologic measurements.

	OD	OS
Cornea diameter[a]	~13 mm	~13 mm
Hand slit lamp		
Cornea	Clear	Clear
Anterior eye chamber	Moderate deep	Moderate deep
Lens	Mature cataract	Opacity anterior + posterior capsule
Conjunctiva	Brown	Brown
Eye lids	Normal	Normal
Mydriasis[b]	Wide	Wide
Papil	n.s.	Sharp/vital, cup-disk ratio 0.3–0.4
Macula	n.s.	n.s.
Retina	n.s.	Red reflex
A-scan		
Axial length	21.86 mm	21.27 mm
Anterior eye chamber	3.23 mm	3.69 mm
Lens thickness	2.98 mm	4.01 mm
Vitreous	15.65 mm	13.56 mm
k1	n.s.	7.06 mm at 178°
k2	n.s.	6.72 mm at 88°
Anterior segment OCT	n.s.	n.s.
Posterior segment OCT	n.s.	n.s.
Diopter	20.5	24
Lens type	Sulcus	Monofocal
Emmetropia	0.07	−0.15
Chosen IOL	22.5	24

Abbreviations: n.s., not succeeded; OCT, optical coherence tomography.

[a]By measuring tape.

[b]Mydriasert: tropicamide 0.5% eyedrops and phenylephrine 5% eyedrops.

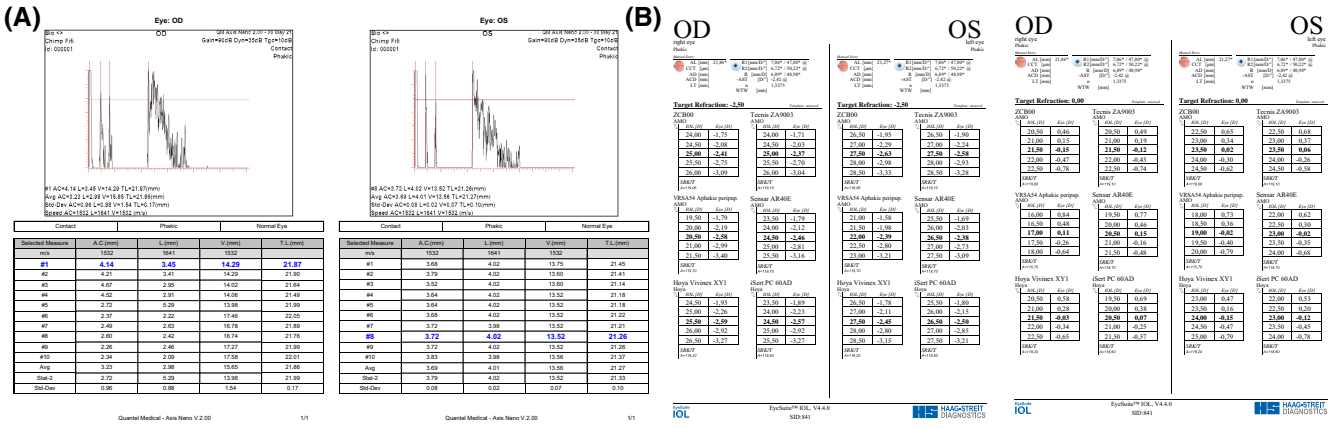

FIGURE 2 (A) Immersion ultrasound A-scan biometry of both eyes (OD and OS); (B) biometry calculation for the IOL of both eyes (OD and OS) for emmetropia and near vision (−2.5 D).

TABLE 2 Blood chemistry results.

Leukocytes	**6.2/nL**
Erythrocytes	4.4/pL
Hemoglobin	7.9 mmol/L
Hematocrit	0.40 L/L
Thrombocytes	140/nL
Neutrophilic granulocytes	58.9%
Lymphocytes	33%
Monocytes	5.5%
Sodium	144 mmol/L
Potassium	6.7 mmol/L
Magnesium	1 mmol/L
Calcium	2.4 mmol/L
Phosphate	0.97 mmol/L
Cholesterol	3.73 mmol/L
Triglycerides	1.11 mmol/L
Glucose	7.39 mmol/L
Protein total	75 g/L
Bilirubin	1.7 µmol/L
ASAT	66 U/L
Gamma-GT	40 U/L
GLDH	1 U/L
Alkaline phosphate	31 U/L
LDH	494 U/L
CK	2108 U/L
Urea	3.17/mmol
Creatinine	92/µmol
Albumin	37.6 g/L

had taken 65 min. in which the chimpanzee had developed slight hypothermia (35.0–35.7°C). Back in the animal enclosure, detomidine was reversed with atipamezole (0.1 mg/kg, Sedastop 5 mg/mL, AST Farma B.V.) i.m. Cataract surgery and IOL implantation were planned within 2 weeks to reduce the risk that a mature cataract would develop in the left eye as well.

2.3 | Pre- and postoperative management and anesthesia

The same procedure for anesthesia, sedation, and transport to the operation room, as described for the ophthalmic examination, was carried out in preparation for the cataract surgery. After fastening to the surgical chair (ACE Ophtha, Rockmed), the chimpanzee was covered with blankets to prevent hypothermia. Pain treatment during the procedure consisted of meloxicam (0.2 mg/kg, metacam 5 mg/mL, Boehringer Ingelheim B.V.) with continuous monitoring of temperature (38.6–37.4°C), heart rate (62–78 bpm), respiration rate (17–22/min), SpO_2 (93%–100%) and CO_2 (6.6–8.7 mmHg). Prior to extubating and transport back to the enclosure, an extra dose of combined tiletamide and zolazepam (1.2 mg/kg) and detomidine (0.04 mg/kg) IM was administered. Back in the enclosure, detomidine was reversed with atipamezole (0.1 mg/kg) IM.

2.4 | Pre-surgical preparation and phacoemulsification technique

Standard surgical preparation was performed by eyelash, eyelids, and conjunctival flushing with 1:50 povidone-iodine solution. Two different ophthalmologists performed the surgeries. The surgery was started in the left eye. A clear corneal incision of 2.75 mm was made at 11 o'clock, and two additional side ports at 2 o'clock and 10 o'clock of 1.2 mm were made. Intracameral administration of 0.1 mL of 0.1% trypan blue (Vision blue®, DORC) for anterior lens capsule staining was carried out. The anterior chamber was filled with sodium hyaluronate 2% (HEALON®, Johnson&Johnson) and sodium hyaluronate 1.4% (ArtiVisc Plus 1.4%, Ophtec). The anterior lens capsule was incised with a Utrata capsulorhexis forceps and continuous capsulorhexis of 5 mm was conducted. The anterior lens capsule was stiff and thin. The hydrodissection was performed using balanced salt solution. The lens was very soft and removed with an irrigation/aspiration (I/A) probe. Only 1% phaco power for 0.44 min was used to remove the lens. All cortical lens material was completely removed using an I/A probe. An IOL was place in the bag OS. Intracameral injection with cefuroxime 0.1 mL/mg and stromal hydration of all clear corneal incisions were performed (Figure 3). Two milliliters dexamethasone chronodose 4 mg/mL was injected subconjunctivally. Tobradex® (tobramycin 3 mg/mL and dexamethasone 1 mg/mL) ointment was applied on the surface of the cornea.

The right eye surgical preparation was the same as the left eye. A clear corneal incision of 2.75 mm was made at 11 o'clock, and two additional side ports at 2 o'clock and 10 o'clock of 1.2 mm were made. The lens capsule was also stained with Vision Blue (Vision blue®, DORC). The capsule was wrinkled and adhered to the lens preventing hydrodissection. The anterior lens capsule was opened with the surgical instrument. Given the capsular fibrosis and wrinkling, completion of the capsulorhexis with a Utrata capsulorhexis forceps resulted in a small anterior capsule tear at 1 o'clock. A posterior segment scissor (DORC disposable micro scissors curved [23 gauge/0.6 mm] the side

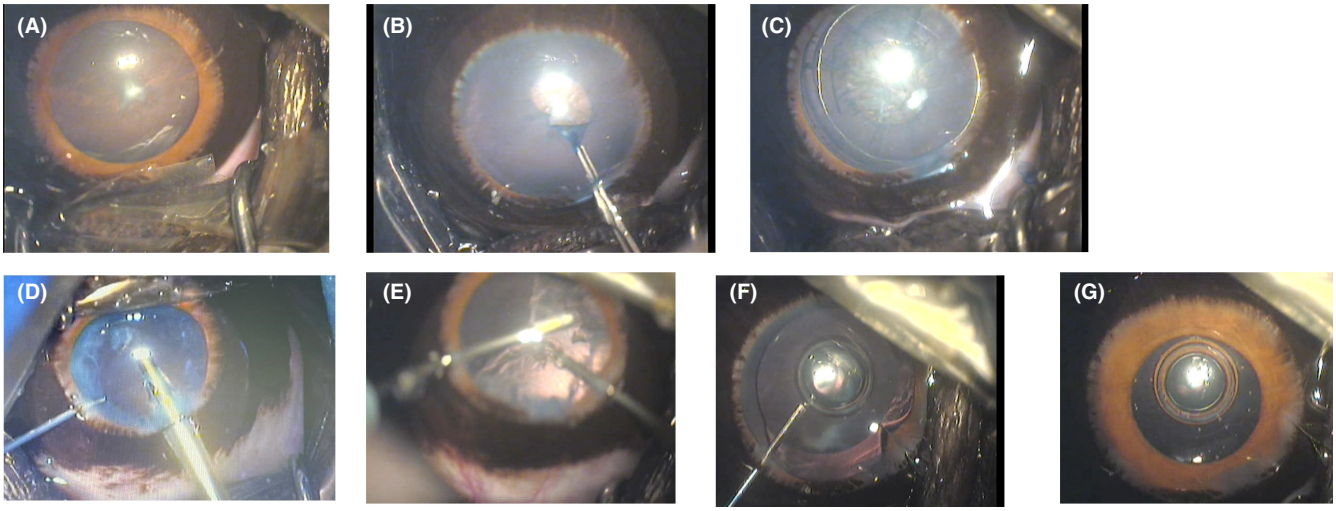

FIGURE 3 Overview cataract operation of the left eye (OS). (A) Overview before operation, (B) vision blue stained anterior capsule which is opened by capsulorhexis forceps, (C) hydrodissection of the lens, (D) phacoemulsification of the lens, (E) cortex extraction of lens particles, (F) filling of the anterior chamber, and (G) result after the operation.

ports were 1.2 mm each) was used to finish the capsulorhexis with a size of about 5 mm. The divide-and-conquer phacoemulsification technique was performed with 17% phaco power for 1.08 min. At the end of the phacoemulsification, a small round posterior lens capsule rupture with vitreous incarceration occurred. Subsequent vitrectomy was carried out, and cortical lens material was completely removed using an IA probe. An IOL was placed in the sulcus with optic capture, and Miostat® (approximately 0.3 mL) was used to constrict the pupil immediately. Sodium hyaluronate was then aspirated from the anterior chamber with IA probe. Intracameral injection with 0.1 mL cefuroxime (0.1 mL/mg) and stromal hydration of all clear corneal incisions were performed. Two milliliters dexamethasone chronodose 4 mg/mL was injected subconjunctivally. Tobradex® ointment was applied on the surface of the cornea. Both eyes were not bandaged at the end of the surgery. The surgical procedure took 32 min in OS and 60 min in OD, resulting in a total anesthetic period close to 2.5 h (137 min). The chimpanzee recovered from anesthesia uneventfully.

2.5 | Surgical outcome and rehabilitation

One day postoperatively, the vision of the chimpanzee appeared to be restored. She studied her feet and hands, looked at her caretakers straight in the eye, and could precisely catch small fruit, such as raisins, that was thrown to her. Overall, she was more assertive, vocal and her movements were quicker. She showed no adverse behavior to disturb the surgical wounds, and consequently, eye protection was unnecessary. First 3 weeks postoperatively, no inflammation was found and ocular media remained clear (Figure 4). Postoperative management with topical Tobradex® eyedrops four times a day was administered in the medial canthus by cotton swab for 3 weeks and tapered down weekly. Prednisone 20 mg was given once a day for 5 days po, after which she was successfully re-introduced to the alpha-male. Upon completion of the Tobradex® treatment, she rejoined the full group of chimpanzees (five members) where she quickly regained her dominant position among the females. After a month, even a second male was added to the group without relegation on her social status.

3 | DISCUSSION

Visual impairment in chimpanzees decreases the quality of life by conflicting with foraging, social contact, and safekeeping. Additionally, behavior and social interaction rely heavily on visual cues within the troop. Chimpanzees live in families with a hierarchical structure[25] and therefore depend on social eye contact to respond to intraspecies cues and aggression.[25,26] Cataract surgery and lens implantation are thus advisable if an animal with cataract loses sight and normal social behavior, as demonstrated by this case report, where the chimpanzee had been expelled by her group members during her progressive vision loss. She had developed a mature cataract in one eye during the course of several months, a clinical presentation often seen in cataracts associated with diabetes[27] or trauma.[28] In humans, diabetes mellitus Type 2 (DMII) is associated with higher risk of cataract development,[29,30] while the prevalence of DMII increases with the increasing rate

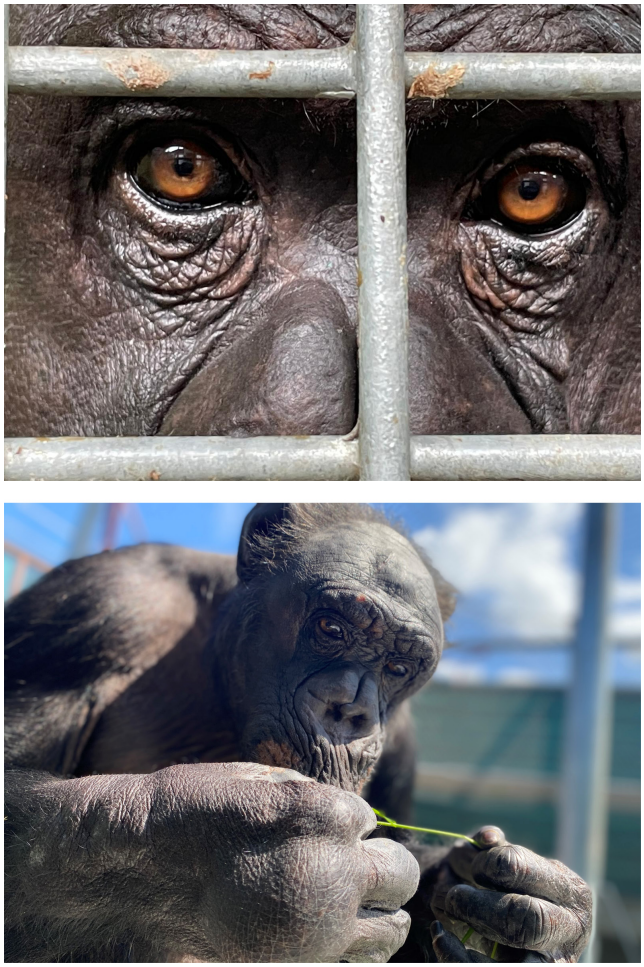

FIGURE 4 Female chimpanzee 12 weeks after the cataract operation of both eyes.

of obesity worldwide.[31] Under her former owner, the reported chimpanzee was immobilized in a cage, lived on a diet of high-sugar-containing foods, and therefore developed obesity. The hyperglycemia and obesity may have played a role in the etiology of the cataract. Moreover, she suffered from nutritional deficiencies, which is an additional factor in cataract development.[32] However, with her 45 years of age and progressive age as leading cause of cataract,[32] this may not be excluded as an important factor.

It is recommended to perform surgery before a mature cataract has developed to optimize the results, since there is a higher risk of complicated surgery. Additionally, ophthalmic measurements (keratometry and AL) become impracticable. Indeed, ophthalmologic examination was limited on the eye with mature cataract because of cloudiness of the lens and the dioptric power for the IOL had to be estimated from the contralateral eye. Moreover, the surgical procedure on the eye with mature cataract was complicated due to hardening of the lens material which had fastened itself to the lens capsule and the sulcus ridges. Optimally, a foldable IOL is placed in the capsule bag, but on this side, the lens had to be inserted in the sulcus with optic capture. Phacoemulsification with IOL implantation turned out to be successful in OU, but the complicated surgery in OD resulted in an extended procedure and long anesthetic period. To prevent hypothermia during extended surgical procedures, using blankets or a heat mat is recommended. Also, the use of mobile surgical chair for eye surgery (ACE Ophtha, Rockmed) made it possible to operate from superior inducing less risk for endophthalmitis. Thus, early diagnosis of cataract and quick follow-up by surgical intervention is important to optimize prognosis in future cases.

With the chimpanzee being our closest relative, it is expected that ocular biometry techniques and ophthalmic surgical procedures, as practiced in human clinics, can be useful in members of this species as well. In humans, optical biometry for AL determination and keratometry is the gold standard and provides the highest accuracy for IOL determination. However, such a procedure is not feasible in a chimpanzee. Instead, ultrasound A-scan biometry has to be used, which is less accurate. Corneal curvature and AL were comparable to the human eye, and the SKR/T-II formula could be applied to calculate the dioptric power. Accordingly, standard IOLs could be inserted in the chimpanzee. During examination, dark adaptation was not performed to reduce the anesthetic time. Despite the apparent difference in resistance of the anterior lens capsule compared with the human eye, the team of specialized ophthalmologists regarded the surgical cataract procedure on the chimpanzee as comparable to human phacoemulsification. Previously, Leiva and colleagues[22] described the need to approach the eye from the temporal side, unhampered by the orbital rim. However, our surgeons disposed of an ophthalmological chair with flexible headrest enabling a superior approach. Leiva et al.[22] reported unilateral phacoemulsification and IOL implantation in a chimpanzee, but here, we present the first case of a successful bilateral cataract surgery and IOL implantation in an adult, female chimpanzee.

Vision was quickly restored after surgery without signs of ocular inflammation or the animal showing intent to disturb the eye area, corresponding to similar reports.[18,19,21,22] With her sight, the chimpanzee regained her assertive behavior and was successfully introduced to the group members. Moreover, she successfully reclaimed her position as the alpha-female. Ocular media remained clear during 1-month follow-up, but an after cataract (posterior lens capsule becomes cloudy) might present in OS in a later stage. Periodical check-ups are therefore recommended to timely start intervention to treat cloudiness of the posterior lens capsule.

As demonstrated by the chimpanzee in this case report, diopter calculation, phacoemulsification, and IOL

implantation can be performed in this species following human-clinical procedures and leads to successful outcome. Chimpanzees in captivity can live to approximately 60 years of age,[33] providing the presented chimpanzee with up to 20 years of restored vision. With our case, we show the feasibility of cataract surgery in chimpanzees, provided that the medical team is well experienced and prepared to solve potential complications during surgery.

CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interest. Materials and instruments were sponsored by Rockmed.

ORCID

I. Notting https://orcid.org/0000-0002-3625-0752

REFERENCES

1. Khairallah M, Kahloun R, Bourne R, et al. Number of people blind or visually impaired by cataract worldwide and in world regions, 1990 to 2010. *Invest Ophthalmol Vis Sci*. 2015;56(11):6762-6769. doi:10.1167/iovs.15-17201
2. Flaxman SR, Bourne RRA, Resnikoff S, et al. Global causes of blindness and distance vision impairment 1990-2020: a systematic review and meta-analysis. *Lancet Glob Health*. 2017;5(12):e1221-e1234. doi:10.1016/s2214-109x(17)30393-5
3. Glover TD, Constantinescu GM. Surgery for cataracts. *Vet Clin North Am Small Anim Pract*. 1997;27(5):1143-1173. doi:10.1016/S0195-5616(97)50107-0
4. Krump L, O'Grady L, Lorenz I, Grimes T. Congenital cataracts in an Ayrshire herd: a herd case report. *Ir Vet J*. 2014;67(1):2. doi:10.1186/2046-0481-67-2
5. Wilhie DA, Mh Colitz C. Update on veterinary cataract surgery. *Curr Opin Ophthalmol*. 2009;20(1):61-68. doi:10.1097/ICU.0b013e32831a98aa
6. Mansour A, Jaroudi MO, Hamam RN, Maalouf FC. Isolated posterior capsule rupture following blunt head trauma. *Clin Ophthalmol*. 2014;8:2403-2407. doi:10.2147/OPTH.S73990
7. Orts Vila P, Devesa Torregrosa P, Belmonte Martínez J. Juvenile diabetic cataract. A rare finding which lead us to the diagnosis of this illness. *Arch Soc Esp Oftalmol*. 2003;78(7):389-391.
8. Klein BE, Klein R, Lee KE. Incidence of age-related cataract: the beaver dam eye study. *Arch Ophthalmol*. 1998;116(2):219-225. doi:10.1001/archopht.116.2.219
9. Pieramici DJ, Sternberg P Jr, Aaberg TM Sr, et al. A system for classifying mechanical injuries of the eye (globe). The Ocular Trauma Classification Group. *Am J Ophthalmol*. 1997;123(6):820-831. doi:10.1016/s0002-9394(14)71132-8
10. Haargaard B, Wohlfahrt J, Fledelius HC, Rosenberg T, Melbye M. Incidence and cumulative risk of childhood cataract in a cohort of 2.6 million Danish children. *Invest Ophthalmol Vis Sci*. 2004;45(5):1316-1320. doi:10.1167/iovs.03-0635
11. Weikel KA, Garber C, Baburins A, Taylor A. Nutritional modulation of cataract. *Nutr Rev*. 2014;72(1):30-47. doi:10.1111/nure.12077
12. Braakhuis AJ, Donaldson CI, Lim JC, Donaldson PJ. Nutritional strategies to prevent lens cataract: current status and future strategies. *Nutrients*. 2019;11(5):1186. doi:10.3390/nu11051186
13. Koski JE, Xie H, Olson IR. Understanding social hierarchies: the neural and psychological foundations of status perception. *Soc Neurosci*. 2015;10(5):527-550. doi:10.1080/17470919.2015.1013223
14. Davis G. The evolution of cataract surgery. *Mo Med*. 2016;113(1):58-62.
15. Irvine AR. Extracapsular cataract extraction and pseudophakos implantation in primates: a clinico-pathologic study. *Trans Am Ophthalmol Soc*. 1980;78:780-807.
16. Hashizoe M, Hara T, Ogura Y, Sakanishi K, Honda T, Hara T. Equator ring efficacy in maintaining capsular bag integrity and transparency after cataract removal in monkey eyes. *Graefes Arch Clin Exp Ophthalmol*. 1998;236(5):375-379. doi:10.1007/s004170050093
17. Whitley R et al. Bilateral ultrasonic phacofragmentation and aspiration cataract extraction in a spider monkey (*Ateles geoffroyi*). *J Zoo Anim Med*. 1980;11:58-60. doi:10.2307/20094468
18. Montiani-Ferreira F, Lima L, Bacellar M, D'Otaviano Vilani RG, Fedullo JD, Lange RR. Bilateral phacoemulsification in an orangutan (*Pongo pygmaeus*). *Vet Ophthalmol*. 2010;13(s1):91-99. doi:10.1111/j.1463-5224.2009.00733.x
19. Warwick A, Redrobe S, Lotery A, Watts J. Bilateral cataract surgery with intraocular lens implant in a captive western lowland gorilla. *J Med Primatol*. 2017;46(5):252-255. doi:10.1111/jmp.12268
20. de Faber JT, Pameijer JH, Schaftenaar W. Cataract surgery with foldable intraocular lens implants in captive lowland gorillas (*Gorilla gorilla gorilla*). *J Zoo Wildl Med*. 2004;35(4):520-524. doi:10.1638/03-010
21. Sritrakoon N, Karntip W, Niyom S, et al. A-scan biometry, phacoemulsification, and foldable intraocular lens implantation in a young orangutan (*Pongo pygmaeus*). *Open Vet J*. 2021;11(1):121-127. doi:10.4314/ovj.v11i1.18
22. Leiva M, Peña T, Bayón A, de León M, Morales I. Phacoemulsification considerations in nonhuman primates. *J Med Primatol*. 2012;41(5):317-324. doi:10.1111/j.1600-0684.2012.00562.x
23. Initial sequence of the chimpanzee genome and comparison with the human genome. *Nature*. 2005;437(7055):69-87. doi:10.1038/nature04072
24. Sanders D, Retzlaff J, Kraff M, Gimbel HV, Raanan MG. Comparison of the SRK/T formula and other theoretical and regression formulas. *J Cataract Refract Surg*. 1990;16(3):341-346.
25. Pusey A, Williams J, Goodall J. The influence of dominance rank on the reproductive success of female chimpanzees. *Science*. 1997;277(5327):828-831. doi:10.1126/science.277.5327.828
26. Harrod EG, Coe CL, Niedenthal PM. Social structure predicts eye contact tolerance in nonhuman primates: evidence from a crowd-sourcing approach. *Sci Rep*. 2020;10(1):6971. doi:10.1038/s41598-020-63884-x
27. Pollreisz A, Schmidt-Erfurth U. Diabetic cataract—pathogenesis, epidemiology and treatment. *J Ophthalmol*. 2010;2010:608751. doi:10.1155/2010/608751
28. Cobbs L, Murchison A, Cai L. Traumatic cataract surgery. 2021. EyeWiki American Academy of Ophthalmology. Accessed February 12, 2022. https://eyewiki.aao.org/Traumatic_Cataract_Surgery

29. Li L, Wan X-h, Zhao G-h. Meta-analysis of the risk of cataract in type 2 diabetes. *BMC Ophthalmol*. 2014;14(1):94. doi:10.1186/1471-2415-14-94
30. Drinkwater JJ, Davis WA, Davis TME. A systematic review of risk factors for cataract in type 2 diabetes. *Diabetes Metab Res Rev*. 2019;35(1):e3073. doi:10.1002/dmrr.3073
31. Mokdad AH, Ford ES, Bowman BA, et al. Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *JAMA*. 2003;289(1):76-79. doi:10.1001/jama.289.1.76
32. Öktem Ç, Aslan F. Vitamin D levels in young adult cataract patients: a case-control study. *Ophthalmic Res*. 2021;64:116-120. doi:10.1159/000509602
33. Havercamp K, Watanuki K, Tomonaga M, Matsuzawa T, Hirata S. Longevity and mortality of captive chimpanzees in Japan from 1921 to 2018. *Primates*. 2019;60(6):525-535. doi:10.1007/s10329-019-00755-8

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Notting F, Cheng Y, Marinkovic M, van Bolhuis H, Notting I. Bilateral simultaneous cataract surgery and intraocular lens implantation in an adult female chimpanzee (*Pan troglodytes*) inducing monovision. *Vet Ophthalmol*. 2023;00:1-8. doi:10.1111/vop.13100