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Population-Based Incidence of Intraocular Lens Exchange in Olmsted County, Minnesota

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Abstract

Purpose—To determine the population-based incidence of pseudophakic intraocular lens exchange in Olmsted County, Minnesota.

Design—Retrospective review of a population-based cohort.

Methods—Patients undergoing pseudophakic intraocular lens exchange in Olmsted County, MN between January 1, 1986 and December 31, 2016, were identified from the Rochester Epidemiology Project medical record linkage system. Indications and outcomes were determined, and the incidence rate was calculated as cases per 1,000,000 person-years. Poisson regression analysis was used to assess changes in incidence over time, and the cumulative probability of needing a lens exchange was estimated by Kaplan-Meier analysis.

Results—Eighty cases of intraocular lens exchange were identified yielding an overall age- and sex-adjusted incidence rate of 28.4 per million (CI, 22.1–34.7), which increased over the study period ($p=0.04$). The 30-year cumulative probability of intraocular lens exchange among patient undergoing cataract surgery was 1.5% (CI, 0.6–2.4%), increasing at a relatively constant rate. Dislocated lenses accounted for 72.5% of lens exchanges. Unplanned refractive outcome of primary cataract surgery, and uveitis-glaucoma-hyphema syndrome from squared-edged haptics emerged as newer indications for intraocular lens exchange.

Conclusions—The population-based incidence of pseudophakic intraocular lens exchange has increased over the last 30 years, and can be explained by the increase in incidence rate of cataract surgery over the same period. Surgeons should be aware of emerging indications of intraocular lens exchange, which reflect changes in lens design and increasing expectations of refractive outcomes.

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Keywords

Intraocular lens exchange; dislocated intraocular lens; pseudoexfoliation syndrome; uveitis-glaucoma-hyphema syndrome

Introduction

Intraocular lens technology has been one major factor that has revolutionized cataract surgery over the last several decades. Cataract surgery is the most common intraocular surgery performed today, and provides dramatic improvement in quality of life and vision.¹ The population-based incidence of cataract surgery has increased gradually and current techniques allow for excellent clinical outcomes.^{1–3} However, while most patients undergoing cataract surgery do so without significant complication, some patients require secondary procedures, including intraocular lens exchange. Intraocular lens exchange may be indicated when complications occur related to the primary cataract surgery or after surgery related to the lens implant or to pre-existing disease or trauma. Most published reports of intraocular lens exchange outcomes originate from tertiary referral centers,^{4–6} potentially preventing a true estimate of the incidence of this procedure in the general population. A recent study suggested that the 5-year incidence proportion risk of a secondary intraocular lens procedure was <1%, but did not report the population-based incidence rate.⁷

In this study we used the Rochester Epidemiology Project (REP) to determine the population-based incidence of intraocular lens exchange in Olmsted County, Minnesota. The REP captures the medical records of nearly all residents of Olmsted County, MN, and therefore affords an excellent opportunity to determine the incidence of various diseases and surgical procedures in a population-based manner in the United States. We also assessed the trend in incidence of intraocular lens exchange over time, and the clinical outcomes of the eyes that underwent this surgery.

Methods

This was a retrospective study using the REP medical records linkage system, which is a database currently consisting of 148,201 unique residents of Olmsted County, MN. Mayo Clinic and Olmsted Medical Center provide the vast majority of medical care in Olmsted County, and while other small independent clinics also participate in the REP to allow for capture of nearly all county residents,^{8,9} ophthalmic surgery is only performed at Mayo Clinic and Olmsted Medical Center. The database is not biased toward patients with health conditions that require more frequent monitoring, and it has excellent agreement for patient status at last contact, date of last contact, and date of death when compared with manual record abstraction.^{10–12} This study complied with the Health Insurance Portability and Accountability Act (HIPAA) and was approved by the Institutional Review Boards of Mayo Clinic and Olmsted Medical Center; data were only included from subjects who had provided authorization to review their medical record for research.

All patients undergoing intraocular lens exchange between January 1, 1986 and December 31, 2016, were identified by searching the REP database. The initial search criteria were broad to include surgical codes for intraocular lens exchange, secondary intraocular lens implantation, and intraocular lens explantation. Intraocular lenses that were exchanged at the primary cataract surgery (for reasons such as damaged optic or haptic segments) were not included. All identified cases were reviewed to include only patients who underwent an intraocular lens exchange procedure as a secondary surgery, whether in isolation or combined with other ocular surgical procedures. Cases of intraocular lens explantation without replacement were reviewed separately, whereas cases of secondary intraocular lens implantation were excluded.

All medical records were reviewed to determine patient demographics, the indication for intraocular lens exchange including pre-existing risk factors, the types and locations of the lenses removed and replaced, and the clinical outcomes with length of follow-up. When the primary cataract surgery with lens implantation was performed at either Mayo Clinic or Olmsted Medical Center, those records were also reviewed to clearly characterize factors that might have contributed to needing an intraocular lens exchange. The indications for intraocular lens exchange were categorized according to pre-defined criteria. Dislocated lenses were those that had sufficiently moved to impair vision (reduced visual acuity, monocular diplopia, or glare) or to create complications within the eye. This was further categorized as dislocations occurring from capsular tears (tears that occurred at the primary cataract surgery), zonular weakness (from pseudoexfoliation syndrome and other causes), external head or facial trauma, and haptic disinsertion. Subcategories included dislocated lenses causing corneal edema or a uveitis-glaucoma-hyphema syndrome. Other major categories for intraocular lens exchange were corneal edema without lens dislocation, unplanned refractive outcome, optic failure (impaired integrity of the optic unrelated to lens insertion at primary cataract surgery), and dysphotopsia.

The age- and sex-adjusted incidence rate of intraocular lens exchange was calculated for the overall time period and each decade by dividing the number of cases by the number of patients at risk per unit time. Populations were determined from the US census data and population figures for Olmsted County. The population for inter-census years was determined by using linear interpolation and methods outlined for typical Rochester Epidemiology Project studies. Incidence rates were reported as cases per 1,000,000 person-years, and were age- and sex-adjusted to the 2010 United States white population rates; 95% confidence intervals (CI) were estimated for the rates of interest. Poisson regression test was used to analyze the change in incidence rates over time. The 30-year cumulative probability of needing an intraocular lens exchange in patients receiving cataract surgery in Olmsted County was determined by Kaplan-Meier survival analysis; the overall population for this calculation was derived from the Rochester Epidemiology Project too.^{2,3} All statistical analyses were performed with Statistical Analysis System 9.4 (SAS, Cary, NC, USA).

Results

Incidence

Eighty cases of intraocular lens exchange in 78 eyes of 76 patients were identified between January 1, 1986 and December 31, 2016. Age at intraocular lens exchange was 72 ± 14 years (mean $\pm$ standard deviation; range, 27–97 years); 39 patients were female. The overall annual age- and sex-adjusted incidence rate was 28.4 per million (CI, 22.1–34.7), and this increased over the course of the study period from 17.0 per million (CI, 6.8–27.2) between 1986 and 1995, to 26.7 per million (CI, 16.2–37.2) between 1996 and 2005, to 35.9 per million (CI, 25.1–46.7) between 2006 and 2016 ($p=0.04$). The 30-year cumulative probability of needing an intraocular lens exchange among patients receiving primary cataract surgery in Olmsted County was 1.5% (CI, 0.6–2.4%); this probability increased linearly with time (Figure 1). These results did not include an additional 4 cases of intraocular lens explantation over the study period.

Indications

The majority (72.5%) of intraocular lens exchanges were performed for dislocated lenses (Table 1). More than half of these were associated with capsular tears that occurred at the primary cataract surgery, zonular weakness, or corneal edema. Both eyes of one patient underwent intraocular lens exchange for dislocated lenses after sustaining capsular tears associated with bilateral intumescent cataracts. All intraocular lens exchanges associated with capsular tears occurred after 1995. All 10 of the dislocated lenses associated with pseudoexfoliation syndrome were capsular bag/lens complex dislocations, and 8 occurred after 2009. Of the four other cases of zonular weakness, 2 were capsular bag/lens complex dislocations in fellow eyes of the same patient with congenital nystagmus and poor vision (of undetermined etiology), 1 occurred in the setting of retinitis pigmentosa, and 1 had a previous history of pars plana vitrectomy. Lens haptic disinsertion occurred in 2 eyes, one spontaneously several years after YAG-capsulotomy (Figure 2), and the other after a lens repositioning procedure for dislocation.

Three were 6 cases of dislocated lens associated with a uveitis-glaucoma-hyphema syndrome requiring intraocular lens exchange. One of these cases caused recurrent vitreous hemorrhage from the lens haptic, placed 29 years previously, abrading the ciliary body. In the other 5 cases, the intraocular lens was a single-piece square-edged foldable acrylic lens that was partially placed within the endocapsular space and partially placed within the ciliary sulcus at primary cataract surgery; these lenses were exchanged between 2012 and 2015, 6 to 15 years after the primary cataract surgery.

Dislocated or malpositioned lenses were associated with corneal edema in 9 cases, of which 2 also had a uveitis-glaucoma-hyphema syndrome, and 1 had pseudoexfoliation syndrome with significant zonular weakness. Intraocular lens exchange was combined with penetrating keratoplasty in 7 of these cases. Combined keratoplasty and intraocular lens exchange was performed in another 9 cases of pseudophakic corneal edema in which the intraocular lens was not obviously malpositioned. Eight of these cases underwent penetrating keratoplasty (all before 2004) with exchange of 5 closed loop and 2 open loop anterior chamber lenses,

and 1 iris-fixated lens. The other eye underwent Descemet stripping endothelial keratoplasty in 2013 with replacement of an open loop anterior chamber lens for a capsule-supported posterior chamber lens. Two cases were in the same eye 3 years apart after graft failure, first exchanging a closed loop for an open loop anterior chamber lens, and subsequently placing a scleral-sutured posterior chamber lens. Of the 18 eyes that had corneal edema, 7 intraocular lens exchanges occurred in the first decade of the study, 6 in the second decade, and 5 in the third decade.

All intraocular lens exchanges associated with unplanned refractive outcomes occurred after 2003; 6 were associated with the patient desiring better uncorrected visual acuity, and 2 were associated with insertion of an incorrect lens power. Optic failure occurred in 1 eye after YAG-capsulotomy resulted in a fragmented surface and in 1 eye with an opacified hydrophilic acrylic lens in the setting of intraocular gas (Figure 3).

Of the 4 cases of intraocular lens explantation, 3 were lens removal associated with complex retinal detachment repair in the setting of proliferative vitreoretinopathy. All 3 cases required pars plana vitrectomy, retinectomy, and silicone oil placement, and scleral buckles had been placed previously; one case was in a 33-year old patient with Stickler syndrome. The fourth case was that of a primary retinal detachment repair associated with dislocated posterior chamber lens.

Lens Placement

Most of the lenses that were explanted were originally fixated within the endocapsular space (52 eyes, Table 2); 13 of these were capsular bag/lens complex dislocations from zonular weakness and 16 were related to capsular tears. Another 12 cases included all cases of unplanned refractive outcome, both cases of dysphotopsia, and both cases of optic failure.

Half of the lenses implanted at lens exchange were open loop anterior chamber lenses; another 16 were scleral-sutured sulcus lenses with a gradual trend away from using 10-0 polypropylene suture towards 9-0 polypropylene suture and then to 7-0 expanded polytetrafluoroethylene (ePTFE) suture. Endocapsular and capsule-supported sulcus placement was possible in 18 cases.

Two eyes of 2 patients underwent 2 intraocular lens exchanges each. One was associated with penetrating keratoplasty, as described above. The other was a case of a uveitis-glaucoma-hyphema syndrome caused by a single-piece square-edged acrylic lens that partially placed in the sulcus and which was replaced by a capsule-supported 3-piece foldable acrylic lens. This lens subsequently also dislocated and repositioning was attempted, but was later found to have haptic disinsertion requiring a second lens exchange with scleral-suture sulcus fixation.

Complications

During the available follow-up period, 6 eyes were noted to have of movement of the new intraocular lens. One eye had a clinically significant dislocation of a capsule-supported sulcus lens that initially required repositioning and then repeat lens exchange. Two capsule-supported sulcus lenses partially subluxed inferiorly without compromise to vision or ocular

health; one was a 3-piece foldable acrylic lens and the other was a single piece polymethylmethacrylate lens. Two eyes had anterior chamber lens rotation from the lens being undersized in one eye and from external trauma in the other eye. Pseudophacodonesis of one scleral-sutured lens was noted 12 years after fixation with 10-0 polypropylene suture.

Four eyes developed subsequent corneal edema. Two cases occurred in penetrating grafts (graft failure) and both had had closed loop anterior chamber lenses replaced for an iris-sutured lens (1 case) and an open loop anterior chamber lens (1 case). In the other 2 cases, 1 eye had an iris-sutured lens that was replaced with a scleral-sutured lens, and 1 eye had a dislocated posterior chamber after a scleral buckle that was replaced with an open loop anterior chamber lens.

Two eyes sustained a retinal detachment. One had undergone anterior vitrectomy with scleral-sutured lens placement for a dislocated lens after complicated cataract surgery, and developed a macula-off retinal detachment within 6 months of lens exchange resulting in hand motion vision. The other had a macula-on retinal detachment 10 months after endocapsular lens exchange to correct the lens power, and maintained best-corrected visual acuity of 20/20 with 8 years of follow-up; the fellow eye had previously undergone a retinal detachment repair several years before primary cataract surgery.

Glaucoma developed in 2 cases. One eye had pseudoexfoliation syndrome and a dislocated posterior chamber lens that was replaced with an anterior chamber lens. The other eye had undergone combined penetrating keratoplasty with lens exchange, and subsequently required trabeculectomy that was complicated by bleb-associated endophthalmitis and complete loss of vision. Additional complications included one case of optic capture, one inadvertent bleb, and one case of recurrent iritis.

Discussion

The population-based incidence of intraocular lens exchange has increased over the last 3 decades, but remains at a low and acceptable rate. Although the incidence rate appears three times higher between the first and last decades of the study period, the small number of cases resulted in wide confidence intervals, and thus the exact change in incidence could be less than 3-fold. Nevertheless, the overall increase in incidence was statistically significant and could have several explanations, including increasing complications of primary cataract surgery or increasing surgeon comfort with exchanging lenses (i.e. a lower threshold for intervention). However, the major contributing factor is likely to be the increase in the population at risk, i.e. subjects who have undergone cataract surgery. The population-based incidence of cataract surgery has doubled over the same period in Olmsted County,^{2,3} suggesting that the risk of intraocular lens exchange has remained relatively stable. Indeed, the 30-year cumulative probability of an intraocular lens exchange was 1.5%, increasing at a relatively constant of approximately 0.3% per 5-year period. Similarly, Szigiato et al. estimated the 5-year risk of a secondary intraocular lens procedure to be <1%,⁷ which included intraocular lens repositioning procedures in addition to intraocular lens exchange.

The indications for intraocular lens exchange changed over the study period, reflecting changing patterns of cataract surgery, technology, and expectations. All dislocated lenses associated with capsular tears occurred after 1995, after conversion to using phacoemulsification and foldable lenses. Similarly, the majority of capsular bag/lens complex dislocations in the setting of pseudoexfoliation syndrome occurred after 2010. Two new indications emerged in the final decade of this study: unplanned refractive error and uveitis-glaucoma-hyphema syndrome. Intraocular lens exchange for unplanned refractive error typically took place within days of the primary surgery, and is associated with the changing nature of cataract surgery with patient and surgeons expecting specific refractive outcomes. Jones et al. noted the same trend.¹³ A uveitis-glaucoma-hyphema syndrome related to the increasing use of single-piece intraocular lenses with squared-edged haptics was responsible for 5 intraocular lens exchanges in this study, all occurring after 2011. All 5 of these lenses were found to have been partially placed in the ciliary sulcus and were not exchanged until 6–15 years after primary cataract surgery. Surgeons should therefore recognize the late presentation of this condition and the need to verify haptic placement during primary cataract surgery. There was only 1 case of opacified intraocular lens in this study occurring in a hydrophilic acrylic lens exposed to intraocular gas; the majority of intraocular lenses implanted in Olmsted County are hydrophobic acrylic, which potentially reduced the risk of lens opacity associated with intraocular gas associated with retina and cornea surgery.¹⁴

Complications of intraocular lens exchange were not infrequent in this study, although only 2 eyes suffered profound loss of vision. Additional surgery was required in several cases, for repeat lens dislocation, corneal edema, retinal detachment, and glaucoma. The overall number of complications was too small to determine changing trends over the course of the study.

Our study reports population-based incidence for intraocular lens exchange, giving a true representation of the frequency and indications for this surgery in contrast to reports from tertiary referral series. For example, Fernández-Buenaga et al. reported that intraocular lens opacification accounted for 29% of pseudophakic intraocular lens exchanges in their referral-based series⁶; in contrast, we found that intraocular lens opacification only accounted for 1.3% of exchanges in our population-based series. However, our study is not without limitations. The relatively small number of cases resulted in somewhat broad confidence intervals, which prevented an accurate estimate of the change in rate of intraocular lens exchange and its indications over the course of the study. Although we estimated the cumulative risk of needing an intraocular lens exchange from within the population having cataract surgery in Olmsted County, we could not account for subjects who may have left the county and had an intraocular lens exchange elsewhere; the cumulative probability may therefore be slightly underestimated. In addition, our results can only be extrapolated to the semi-urban United States white population because the population of Olmsted County is predominantly white; nevertheless, the results are applicable to large proportion of the United States population. Ophthalmologists should also be aware that phakic intraocular lenses sometimes require explantation¹⁵; our series only reported on pseudophakic intraocular lens exchange.

This study provides epidemiologic data from a population in the United States without being affected by referral bias and yielding valuable information despite the study limitations. Although the overall incidence of intraocular lens exchange has increased over the last 3 decades, the probability of needing a lens exchange within the population having cataract surgery has remained relatively constant. Surgeons should be aware of newer indications for lens exchange, including unplanned refractive error and uveitis-glaucoma-hyphema syndrome from squared-edged haptics in the ciliary sulcus.

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Figure 1.

Cumulative probability of requiring an intraocular lens exchange in patients undergoing cataract surgery in Olmsted County.

The cumulative probability of intraocular lens exchange in patients undergoing primary cataract surgery in Olmsted County, MN, was 1.5% (CI, 0.6–2.4%) after 30 years, with a relatively linear increase over time.

Figure 2.

Case of spontaneous lens haptic disinsertion leading to lens dislocation.

A 73-year old male presented with spontaneous haptic disinsertion of an endocapsular lens placed 16 years previously, and 11 years after a neodymium-doped yttrium-aluminium-garnet laser posterior capsulotomy resulting in dislocation of the lens. The dislocated lens was exchanged for a capsule supported sulcus lens.

Figure 3.

Opacified hydrophilic acrylic intraocular lens from intracameral gas bubble.

A 56-year old female presented with lens opacification 16 months after macular hole surgery in which intraocular gas had been noted in the anterior chamber in the post-operative period. The hydrophilic acrylic endocapsular lens was exchanged for a capsule-supported polymethylmethacrylate lens placed in the ciliary sulcus. Hydrophilic acrylic lenses have a higher risk of opacification with intraocular gas compared to other lens materials.¹⁶

Table 1

Indications for Intraocular lens exchange

Indication	n (%)	Age at IOL exchange (years)	Time to IOL exchange (years)	BCVA after IOL exchange (log MAR)	Follow-up (years)
Dislocated IOL	58 (72.5)	75 ± 12 (40–97)	8.8 ± 7.5 (0–29)	0.27 ± 0.32 (0–1.7)	4.2 ± 4.0 (0.1–16.3)
Capsule tear	16 (20)	69 ± 13 (40–85)	6.4 ± 7.4 (0–20)	0.17 ± 0.19 (0–0.7)	3.3 ± 4.0 (0.1–13)
Zonular weakness (PEX)	10 ^a (12.5)	84 ± 7 (76–97)	6.8 ± 3.1 (1–12)	0.15 ± 0.12 (0–0.4)	3.1 ± 3.4 (0.1–11.8)
Zonular weakness (other)	4 ^b (5)	63, 52, 76, 76	7, 7, 18, 0.5	1.0, 1.0, 0.4, 0.4	5.2, 16.3, 6.2, 6.7
Causing corneal edema	9 ^c (11)	83 ± 5 (77–90)	9.8 ± 7.7 (0.8–22)	0.52 ± 0.48 (0.1–1.7)	5.4 ± 4.4 (2.7–9.3)
Causing UGH syndrome	6 (7.5)	68 ± 12 (58–85)	12.3 ± 8.8 (6–29)	0.11 ± 0.13 (0–0.3)	1.4 ± 1.0 (0.4–3.1)
Unknown	4 ^d (5)	77, 81, 83, 72	18, 24, 1.3, 2	0.0, 0.1, 0.1, 0.7	1.7, 7.2, 2.4, 11.2
External trauma	3 (4)	75, 53, 73	20, 15, 0.2	0, 0.3, 0.3	14, 2, 0.1
Haptic disinsertion	2 (2.5)	73, 62	15, 1.3	0, 0.4	9.1, 0.1
Other	4 ^e (5)	59, 84, 97, 70	25, 12, 6, 5	0.1, 0.18, 0.1, 1.0	6.6, 7.8, 2.6, 1.7
Corneal edema (without IOL dislocation)	9 (11)	73 ± 9 (55–85)	9.6 ± 6.1 (2–20)	0.27 ± 0.41 (2–1.3)	5.6 ± 4.4 (1.2–14)
Refractive outcome	8 (10)				
Unplanned myopia (previous myopic LASIK)	4 (5)	60, 64, 51, 64	9, 14, 12, 14 days	0, 0.18, 0, 0	1.4, 0.8, 6.7, 0.7
Unplanned myopia (no previous refractive surgery)	3 ^f (4)	27, 62, 75	44, 9, 1 days	0, 0, 0	4.4, 4.6, 4.8
Unplanned hyperopia (highly myopic eye)	1 (1)	62	9 days	0	4.6
Optic failure	2 ^g (2.5)	41, 56	0.7, 2	0, 0.48	25, 0.2
Dysphotopsia	2 (2.5)	50, 61	1.8, 0.1	0, 0	17.7, 1.7
Chronic endophthalmitis	1 (1)	86	1.5	1.3	4.7
All	80	72 ± 14 (27–97)	7.5 ± 7.4 (0–29)	0.25 ± 0.34 (0–1.7)	4.7 ± 4.7 (0.1–25)

IOL, intraocular lens; log MAR, logarithm of the minimum angle of resolution; PEX, pseudoexfoliation; UGH, uveitis glaucoma hyphema; LASIK, laser assisted in situ keratomileusis

^a 1 case of a partially dislocated IOL completely dislocated after trauma.

^b 2 cases were fellow eyes of the same patient with long-standing congenital nystagmus and poor vision of undefined cause; 1 case had retinitis pigmentosa (Usher syndrome); 1 case was status-post pars plana vitrectomy for retinal detachment.

^c 2 cases were associated with UGH, and 1 case with pseudoexfoliation syndrome.

^d The underlying etiology of IOL dislocation could not be determined based on review of the medical records.

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1 case occurred in the setting of a previous scleral buckle; 1 case was a dislocated Medallion iris clip lens; 1 case was an IOL that dislocated during penetrating keratoplasty for a failed graft; 1 case was a 3 piece foldable IOL placed in the ciliary sulcus that sunset without lens or support failure.

1 case was in a previous contact lens wearer; 2 cases were associated with the wrong lens power being implanted.

1 IOL developed micro-fragments after YAG-laser capsulotomy; 1 hydrophilic acrylic IOL opacified from a gas bubble that migrated into the anterior chamber after macular hole surgery.

Table 2

Types of lenses removed and inserted

Implanted $\rightarrow$ Explanted $\rightarrow$	AC Open Loop	Iris	PC Sulcus, Capsule supported	PC Sulcus, Sutured	PC Endocapsular	TOTAL
AC Closed Loop	3	1 ^a	-	3	-	7
AC Open Loop	3	-	1	3	-	7
Iris ^b	2	-	-	1	-	3
PC Sulcus, capsule supported	3	-	1	-	-	4
PC Sulcus, sutured	-	-	-	1	-	1
PC Partial Capsule/ Partial Sulcus ^c	3	-	2	1	-	6
PC Endocapsular	27	-	9	7	9	52
TOTAL	41	1	13	16 ^d	9	80

AC, anterior chamber; PC, posterior chamber

^a Sutured to iris with 10-0 polypropylene^b All were iris-clip lenses^c Lens was partially within intact capsular bag and partially external to the capsular bag^d Sutured to sclera with 10-0 polypropylene (10 cases), 9-0 polypropylene (4 cases), or 7-0 expanded polytetrafluoroethylene (ePTFE, CV-8 Gore-Tex®, 2 cases).