Consecutive case series of 244 age-related macular degeneration patients undergoing implantation with an extended macular vision IOL
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Consecutive case series of 244 age-related macular degeneration patients undergoing implantation with an extended macular vision IOL

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ABSTRACT

Purpose: To determine safety and visual outcomes in eyes with age-related macular degeneration (AMD) implanted with a novel intraocular lens (IOL) that delivers an optimized retinal image to all macular areas within 10 degrees of retinal eccentricity.

Methods: This was a consecutive case series of 244 eyes with dry/stable wet AMD and logMAR visual acuity ≥0.3 implanted with iolAMD Eyemax mono™ (London Eye Hospital Pharma), a single-piece, injectable, hydrophobic acrylic IOL sited in the capsular bag. Primary outcome was safety. Secondary outcomes were changes in corrected distance visual acuity (CDVA) and corrected near visual acuity (CNVA) (logMAR).

Results: Mean age at surgery was 80 years. Mean duration of follow-up was 3 months (range 1-16 months). No eyes had worsening of CDVA. Frequency of perioperative complications was equivalent to standard IOL implantation. Postoperative refractive outcomes were within ±1 D of the target refraction in 88% of cases. Mean preoperative CDVA improved from 1.06 to 0.71 postoperatively (mean of differences -0.35; 95% confidence interval [CI] -0.3886 to -0.3223; p<0.0001), equating to an approximate Early Treatment Diabetic Retinopathy Study gain of 18 letters. Mean preoperative CNVA (N-point; logMAR conversion) improved from 1.36 to 0.88 postoperatively (mean of differences -0.48; 95% CI -0.53 to -0.44; p<0.0001).

Conclusions: This novel IOL appears safe in the short to medium term. Improvements in postoperative CDVA and CNVA exceed those observed with standard implants.

Keywords: Age-related macular degeneration, Cataract, Eccentric fixation, Intraocular lens, Macular degeneration, Preferred retinal locus

Introduction

The socioeconomic burden of age-related macular degeneration (AMD) is well-documented, with the numbers of those affected expected to increase dramatically over the coming decade (1). Treatment options are currently limited to the minority of patients with choroidal neovascularization (CNV), with other measures being essentially supportive, as in the case of visual aids, or preventative, as in the case of nutritional supplementation (2).

The practical and optical limitations of hand-held and spectacle-mounted visual aids have prompted the development of intraocular telescopes that may be implanted at the time of cataract or clear lens extraction, or subsequently, to deliver a magnified image at the retina (3, 4). Some devices also generate a prismatic effect to target the image at the patient’s preferred retinal locus (PRL) (5). The role of these implants in rehabilitating vision in patients with AMD or other maculopathies has yet to be clearly established. The variability of geographic atrophy and patients’ preferences for multiple retinal loci in some instances would likely require a sizeable and phenotypically homogeneous investigative study cohort, but uptake of the technology has been limited because the implantation of existing devices is both surgically complex and associated with high rates of perioperative complications. One such device, the implantable miniature telescope (IMT; VisionCare Ophthalmic Technologies), affords a magnification of up to 3-fold and has been demonstrated to improve visual function, albeit with a high rate of complications that include posterior capsule rupture, choroidal haemorrhage, and zonular dehiscence (6). Another device, the IOL-VIP™ (Soleko) generates a high hypermetropic shift and requires a large capsulorhexis and corneal wound for the siting of a high-plus anterior chamber intraocular lens (IOL),...
with the all the attendant risks of such an approach (5). We and others have previously described initial results following implantation with the iolAMD® (London Eye Hospital Phar-
ma), an injectable intraocular telescope that was developed to overcome the limitations associated with other implantable
tables (7-9). This Galilean telescope affords less magnification than the IMT (1.25-1.3x compared with 3x) but, in theory, confers all the benefits associated with a small corneal wound and posterior chamber implantation while permitting the targeting of a patient’s PRL. The device is composed of 2 separate lenses—one sited in the capsular bag and the other in the ciliary sulcus. However, this approach is limited to eyes with a predictable postoperative IOL separation and eyes in which sulcus implantation of an IOL is not contra-
indicated; in permitting the targeting of a solitary PRL, it also overlooks the reliance of many patients on multiple PRLs for activities of daily living (10).

The majority of patients with macular pathology, specifi-
cally AMD, undergo implantation with a standard monofocal IOL at the time of cataract surgery. Evidence suggests that cataract surgery in subjects with AMD is safe in the short-to medium-term and can result in improved vision; however, standard IOLs (and the natural crystalline lens) serve mainly to provide a tightly focused image at the center of the fovea and the quality of this image deteriorates rapidly beyond the fovea, despite significant levels of cone photoreceptor density in these areas (11-14). Consequently, visual outcomes in subjects with center-involving maculopathy undergoing cata-
ract surgery are compromised by deficiencies in the optics of the standard IOLs implanted. We have recently described initial results with a novel IOL, the iolAMD Eyemax mono™, a single-piece, hydrophobic acrylic lens that is designed to im-
prove on the quality of the retinal image supplied by standard IOLs, thereby permitting subjects with single or multiple PRLs to extract maximum benefit from the healthiest parts of their macula (manuscript submitted). The optics of this device are uniquely optimized to provide an enhanced quality of image across an area extending 10 degrees from the foveal center without the need for any prismatic effect, while providing up to 1.2x magnification, if required. Laboratory simulations indi-
cate that the lens delivers superior image quality compared with standard monofocal IOLs at 4 and 7.5 degrees of retinal eccentricity and the device therefore constitutes a new class of IOL delivering ‘extended macular vision’.

This study examines safety and visual outcomes in 244 eyes with moderate to severe visual loss secondary to AMD who underwent femtophacoemulsification and implantation of the iolAMD Eyemax mono™ between 2015 and 2017.

Methods

Patients

Local ethics approval was obtained and anonymized data were collected retrospectively from hospital records for a consecutive sample of 244 eyes with dry, or stable wet, AMD and logMAR visual acuity ≥0.3 (≥20/40 Snellen) that under-
went clear lens or cataract extraction and implantation with the iolAMD Eyemax mono™ between December 2015 and February 2017 under the care of 3 surgeons. Subjects’ eyes were defined as having stable, wet AMD if free of active CNV for ≥3 months without the need for intravitreal injection of an anti-vascular endothelial growth factor medication. Patients with a minimum of 1 month postoperative follow-up were included in the analysis. Perioperative complications were recorded in line with rates cited for key complications in the American Academy of Ophthalmology Preferred Practice Pat-
tern for Adult Cataract (2011).

Patient assessment

Data were obtained on the following investigations per-
formed at baseline, 1 week, 1 month, and at each subsequent postoperative assessment (if undertaken): full subjective re-
fraction, best-corrected distance acuity (logMAR), near acuity (N-point at 40 cm; logMAR conversion), intraocular pressure (IOP) (Goldmann applanation tonometry), macular optical coherence tomography (Stratus OCT™, Carl Zeiss Meditec), specular microscopy (Nidek CEM-530, Nidek Co. Ltd.; 3 ac-
ceptable images derived from the central cornea), and clinical examination. Preoperative biometry was obtained using the IOLMaster® (Carl Zeiss Meditec). The position of the implant was recorded postoperatively using anterior segment OCT without pupillary mydriasis (Visante® OCT, Carl Zeiss).

Intervention

The iolAMD Eyemax mono™ (London Eye Hospital Phar-
ma) is a single-piece, injectable, soft, hydrophobic acrylic IOL designed for siting in the capsular bag. The lens optics are wavefront-optimized to provide an enhanced quality of image across an area extending 10 degrees from the foveal center and the device therefore constitutes a new class of IOL delivering extended macular vision. Laboratory simulations indi-
cate that the lens delivers superior image quality compared with standard monofocal IOLs at 4 and 7.5 degrees of retinal eccentricity with potential benefits for patients with macu-
lar pathology (manuscript submitted). The implant requires a modest postoperative refractive target of +2 D to +3.5 D for up to 1.2 D magnification, though this may be increased or reduced at the surgeon’s discretion depending on the severity of the maculopathy. Intraocular lens powers were available in 11, 13, 15, 17, 19, 21, 23, and 25 D. Intraocular lens power was estimated using the SKT formula, using an A-constant of 119.2 and targeting a postoperative refraction of 0 to +3.00 D.

Surgical technique

Surgery was performed by 3 surgeons using standard tech-
niques. Topical mydriatic agents were used for pupil dilation and anesthesia was induced by sub-Tenon delivery. A 5-mm capsulotomy and crystalline lens fragmentation were undertak-
en using a femtosecond laser surgery platform (LenSx®, Alcon) and lens extraction completed using the WHITESTAR Signature® phacoemulsification system (Abbott Medical Optics, Abbott Lab-
oratories Inc.) with a standard 2.2 mm corneal incision sited at 100°. The capsular bag was filled with a cohesive ophthalmic viscoelastic device (OVD) and the lens then loaded into the injector cartridge, followed by injection into the capsular bag via the main wound, centration of the lens, and OVD/balanced
salt solution exchange. Subjects were managed on a standard postoperative regimen of guttae dexamethasone 0.1% 4 times daily for a month, guttae bromfenac 0.9 mg/mL twice daily for 1 month, and topical antibiotic therapy for 2 weeks.

Statistics

Data were analyzed using Prism 7 (GraphPad Software Inc.). Paired, 2-tailed, parametric t tests were undertaken for p values, where described.

Results

Mean age at surgery was 80 years (range 43-94; 146 F, 98 M; n = 244). Mean duration of follow-up was 3 months (range 1-16 months). No patients had worsening of corrected distance visual acuity (CDVA). Three patients had preexisting glaucoma controlled on topical ocular hypotensive treatment and one had preexisting mild, nonproliferative diabetic retinopathy. One patient experienced an anterior capsular tear during surgery with implantation of the IOL in the capsular bag and no sequelae; 4 patients had intraoperative floppy iris syndrome managed successfully with intracameral phenylephrine; 3 patients required iris hooks for management of small pupils. One patient developed postoperative subretinal fluid at 1 month that resolved spontaneously; another patient required a YAG laser posterior capsulotomy at 10 months.

Mean of differences between preoperative and postoperative endothelial cell counts was -143 (95% confidence interval -219.1 to -66.24; p<0.001; error bars represent SEM), in line with levels of endothelial cell loss expected with standard phacoemulsification cataract surgery and intraocular lens implantation.

Postoperative refractive outcomes were within ±1 D of the target refraction in 88% of cases (mean targeted refraction 3.04 D, 95% confidence interval 2.97-3.11; mean postoperative refraction 2.70 D, 95% CI 2.62-2.79; error bars represent SEM).

Two subjects experienced steroid-induced ocular hypertension, with IOP of 30 mm Hg and 34 mm Hg, respectively, at 4 weeks postoperatively, that was controlled on topical ocular hypotensive treatment and resolved on cessation of topical steroid therapy. Mean preoperative IOP was 16.2 mm Hg (95% CI 15.9-16.6 mm Hg); mean postoperative IOP was 14.8 mm Hg (95% CI 14.5-15.0 mm Hg) (Fig. 3). Mean preoperative CDVA (logMAR) improved from 1.06 to 0.71 (Snellen 20/230 to 20/103) postoperatively (mean of differences -0.35; 95% CI -0.39 to -0.32; p<0.0001), equating to an approximate Early Treatment Diabetic Retinopathy Study (ETDRS) gain of 18 letters (Fig. 4). Mean preoperative corrected near visual acuity (N-point; logMAR conversion) improved from 1.36 to 0.88 postoperatively (mean of differences -0.48; 95% CI -0.53 to -0.44; p<0.0001) (Fig. 5).

Discussion

This is the first study to examine safety and visual outcomes in a cohort of eyes with AMD consecutively implanted with a novel, extended macular vision IOL, the iolAMD Eyemax mono™.

Age-related macular degeneration accounts for 8.7% of blindness cases worldwide, with the numbers of people affected increasing from an estimated 196 million worldwide in 2020 to a projected 288 million in 2040 (15). Many of these patients will undergo cataract surgery during the course of their macular disease, with age-related cataract affecting >22 million in the United States, the majority of whom are >60 years of age (16). At present, surgical options for these patients are limited to standard IOLs, which are designed to supply a tightly focused image at the foveal center, and tele-}

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that include higher rates of intraoperative and postoperative complications and can result in a reduction of the peripheral visual field that in some instances limits their use to one eye only (17). Neither approach supports a patient’s natural tendency to develop an evolving preferred retinal locus, or loci, in areas of the macula left relatively undamaged by geographic atrophy or macular scarring (10). Evidence suggests that standard IOls, and even the natural crystalline lens, may in fact compromise visual function in patients with center-involving AMD or maculopathy since the quality of the retinal image afforded declines significantly beyond the fovea, even though cone density is still relatively high, at approximately 20,000/mm² in these areas (13, 14, 18).

A recent pilot study of 8 eyes with minimal or no cataract implanted with the Eyemax suggested safety outcomes comparable with standard IOls and CDVA results that are in keeping with image optimization extending 10 degrees out to the peripheral macula (mean preoperative logMAR 0.93 improving to 0.59 at 2 months postoperatively). These results were supported by observed increases in reading speed and fixation stability, and microperimetric evidence for the uptake of preferred retinal loci where, previously, fixation was located in the center of areas of geographic atrophy (manuscript submitted). The latter was observed to occur progressively over a 4-month period, indicating a possible neuroadaptive component to visual rehabilitation with this device.

In the present study, safety outcomes were comparable with those obtained following standard IOL implantation with rates of endothelial loss, IOP differences, and refractive outcomes all in line with those expected following implantation of a standard monofocal IOL (19-21). Cataract surgery appears safe in the short to medium term in subjects with AMD but the indications for surgery, particularly in patients with active CNV, remain poorly defined and further work is needed to determine its role in rehabilitating vision in this population and the long-term impact on visual function (11, 22). However, extended macular vision technology may offer significant advantages over standard IOls in facilitating patients’ natural coping strategies and may serve to maintain visual function for longer in cases of progressive disease without the need for eccentric vision training, further surgery, or supportive interventions. We observed a mean improvement in CDVA
equating to 18 ETDRS letters and improvements in near vision that exceeded this. These results compare favorably with the results of cataract surgery in subjects with AMD implanted with standard IOLs, with the results of a recent meta-analysis indicating that CDVA improves by 6.5-7.5 ETDRS letters after 6-12 months of follow-up (a more extended follow-up period than was undertaken for this study) (11). Visual gains of this magnitude are also likely to have a favorable cost-benefit and risk-benefit profile compared with existing AMD therapies such as ranibizumab, which deliver fewer lines of CDVA in a comparable time period and ultimately result in no visual gain from baseline over a 5-year period (23-25). The improvements in CDVA that we observed appear to be largely due to the refined optics of the iolAMD Eyemax monom™ since we estimate the degree of magnification afforded by a mean postoperative refractive spherical equivalent of +2.7 D to be 1.09x with a standard spectacle correction. The merits of this approach are further supported by our experience with implantation of a version of the device designed for pseudophakic patients (manuscript in preparation).

We did not attempt to correlate visual outcomes with the severity of AMD, the severity of cataract, or the extent of scarring or geographic atrophy; however, results are likely to vary significantly between individuals, if only because, as well as varying with retinal eccentricity, cone photoreceptor densities vary markedly between individuals and with aging (18). More detailed investigation of clinicopathologic correlates in patients with AMD is required to help direct care in this area and inform choice. Similarly, the role of extended macular vision technology in the treatment of other disorders ranging from diabetic maculopathy to glaucomatous visual field loss and macular holes has yet to be explored. It is also likely that bilateral implantation with the Eyemax has a summative effect, as observed with standard IOLs, and this may drive further improvements in reading ability as well as other activities of daily living (26). The results from this study indicate that this extended macular vision IOL has a safety profile comparable with standard IOLs in the short to medium term and may become the lens of choice for optimizing and maintaining visual function in patients with AMD and other macular disorders undergoing cataract surgery.

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