Original Article

Refractive Results and Complications of Lensectomy in Simple Extreme Microphthalmos Cases

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Abstract

Objectives: To evaluate the refractive outcomes, changes in intraocular pressure (IOP) and anterior chamber depth (ACD), and postoperative complications following lensectomy for angle-closure in cases of simple extreme microphthalmos.

Materials and Methods: This retrospective study analyzed eyes with simple extreme microphthalmos (axial length <18 mm) that underwent lensectomy between January 2015 and July 2024. Data collection included demographic details, preoperative and postoperative best corrected visual acuity (BCVA), IOP, number of antiglaucoma medications, ACD, the diopter (D) of the implanted intraocular lens (IOL) according to the Hoffer-Q formula, postoperative refractive error, and surgical complications.

Results: A total of 20 eyes from 12 patients were analyzed, with a mean patient age of 55.4±8.7 years and an average axial length of 16.48±0.8 mm. The average power of the implanted IOL was 53.32±6.2 D, ranging from 44 to 64 D. The mean preoperative spherical refractive equivalent (SE) was +12.4±2.8 D, while the mean postoperative SE was -6.67±5.2 D (p<0.05). Postoperative spherical refractive error exceeding -1.00 D was detected in 15 eyes (75%). Postoperatively, significant decreases were observed in IOP and the need for antiglaucoma medication (p=0.02 for both). The mean ACD increased significantly after surgery compared to the preoperative ACD (p=0.01). The difference between the intended refractive outcome and the postoperative spherical refractive error was statistically significant (p<0.05). Postoperatively, 8 eyes (40%) had a BCVA of ≤0.7 logarithm of the minimum angle of resolution (logMAR), 10 (50%) had a BCVA between >0.7 and <1.4 logMAR and 2 eyes (10%) had a BCVA of ≥1.4 logMAR.

Conclusion: Lensectomy in cases of extreme microphthalmos effectively reduces IOP and reliance on antiglaucoma medications and increases the ACD. However, a notable incidence of postoperative myopic refractive error remains a concern.

Keywords: Axial length, lensectomy, nanophthalmos

Introduction

Microphthalmos is defined as an eye with an axial length (AL) that is at least 2 standard deviations (SDs) below the average for individuals in the same age group. This condition may involve developmental abnormalities in both the anterior and posterior segments.[1,2] Simple microphthalmos is described as an anterior chamber depth (ACD) of ≤2.2 mm and AL of ≤20.0 mm without other congenital ocular anomalies.[3,4] Nanophthalmos is a type of simple microphthalmos marked by a thickened sclera and the absence of notable systemic or ocular abnormalities.[2] Eyes with an AL shorter than 18.0 mm are described as extreme microphthalmos.[5]

With age, the lens thickens and tends to protrude into the anterior chamber, increasing the risk of angle-closure glaucoma, especially in eyes with a short AL.[6] In such cases, a lensectomy should be performed to prevent damage to the optic nerve. Eyes with microphthalmos usually require very high dioptric intraocular lenses (IOLs).[1] Performing lensectomy in these cases presents a significant challenge in ophthalmic surgery. The restricted operating area, shallow anterior chamber, and small corneal diameter can result in more complex surgical procedures and an increased risk of complications.[4,7]

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Precise preoperative IOL calculations before lensectomy are crucial for achieving good visual outcomes. Advancements have been made in IOL calculation formulas, with Hoffer Q, Haigis, and Holladay II commonly used for eyes with moderately short AL, including those with nanophthalmos.[7,8] Despite advancements in IOL calculations, the effective lens position (ELP) can influence refractive outcomes, and patients with short AL often experience significant refractive deviations from emmetropia.[7] Therefore, this study aimed to assess the refractive outcomes, intraocular pressure (IOP) and ACD changes, and complications associated with lensectomy in eyes with simple extreme microphthalmos.

Materials and Methods

This retrospective study included eyes with simple extreme microphthalmos that underwent lensectomy for angle-closure at our clinic between January 1, 2015, and July 1, 2024 and had at least 6 months of follow-up. Written informed consent to use their data was obtained from all patients in accordance with the tenets of the Declaration of Helsinki. Ethical approval was received from a Hamidiye Scientific Research Ethics Committee of the University of Health Sciences, Türkiye (meeting number: 2024/8, decision number: 8/9, dated: 01.08.2024).

Inclusion criteria were lens surgery due to angle closure, age over 18 years, no history of previous intraocular surgery, and AL <18 mm. Patients with AL >18 mm, those under the age of 18, and those who had undergone previous intraocular surgery were excluded.

Data collected for each patient included sex, age, presence of glaucoma before lensectomy, preoperative best corrected visual acuity (BCVA), IOP, number of preoperative antiglaucoma medications, preoperative cup/disc ratio, preoperative keratometry values, preoperative corneal thickness, preoperative ACD and white-to-white (WTW) distance, follow-up time, implanted lens diopter (D), target refractive error according to the chosen IOL, resulting spherical refractive error, intraoperative and postoperative complications, and need for further surgery after lensectomy. Lens power was calculated preoperatively via the Hoffer Q formula, with the goal of achieving emmetropia. IOP was measured with a Goldmann applanation tonometer (AT 900, Haag Streit, Bern, Switzerland). Spherical equivalent (SE) was calculated as half of the cylindrical value added to the spherical value.

ACD was assessed using the Visante OCT, an anterior segment optical coherence tomography device (Carl Zeiss Meditec, Dublin, CA, USA). Keratometric values (K1 and K2), corneal thickness, and WTW corneal diameter were evaluated using the Sirius corneal topography and aberrometry system (Costruzioni Strumenti Oftalmici, Florence, Italy). Optical biometry was performed using a Nidek AL-Scan instrument (Nidek, Aichi, Japan).

Surgical Technique

One hour before surgery, all patients received an intravenous administration of 20% mannitol at a dose of 1 mg/kg to reduce vitreous pressure. All surgeries were performed under general anesthesia. After conducting an anterior chamber paracentesis, viscoelastic was injected, followed by a 2.6-mm clear corneal temporal incision. A pars plana core vitrectomy was performed to deepen the anterior chamber before lens removal in some cases in which the anterior chamber was too shallow. Phacoemulsification was performed using a Centurion system (Alcon Laboratories Inc, USA). IOL implantation was performed after the main incision was enlarged to allow IOL implantation. Anterior vitrectomy, synechiolysis, and capsular tension ring implantation were performed intraoperatively as indicated based on the surgical findings.

Postoperative Follow-up

Postoperative medications included topical prednisolone acetate 1% eye drops (Pred Forte; Allergan, Irvine, CA, USA) and moxifloxacin 0.5% eye drops (Moxai; Abdi İbrahim İlaç Sanayi ve Ticaret A.Ş., İstanbul, Türkiye) administered four times a day, as well as nepafenac 0.1% ophthalmic suspension (Apfecto; World Medicine İlaç Sanayi ve Ticaret A.Ş., İstanbul, Türkiye) three times a day. Antiglaucoma eye drops or oral medication were administered as needed.

Statistical Analysis

SPSS software (version 20.0®, IBM Corp., Armonk, NY) for Windows was used for all statistical computations. The distribution of variables was measured using the Shapiro-Wilk test. Descriptive statistics included the mean ± standard deviation (SD) and range or frequency and percentage values for each variable. Postoperative changes were analyzed using the dependent-samples t-test or Wilcoxon signed-rank test, depending on the distribution. $p<0.05$ was considered statistically significant.

Results

The study included 20 eyes of 12 patients (7 women [58.3%]; 5 men [41.7%]). Lensectomy was performed in 16 eyes (80%), whereas 4 eyes (20%) underwent a combined procedure consisting of lensectomy and a 23-gauge pars plana core vitrectomy to deepen the anterior chamber before lens removal. The mean age of the patients was 55.4±8.7 (35-69) years, and the mean follow-up duration was 47.25±30.71 (6-96) months. The mean AL was 16.48±0.8 (15.26-17.87) mm (Table 1).

Table 1. Baseline characteristics of the eyes

	Mean ± SD (range)
Patient age (years)	55.4±8.7 (35-69)
AL (mm)	16.48±0.8 (15.26-17.87)
CCT (µ)	567.6±30.8 (509-633)
K1 (D)	48.62±1.69 (45.85-51.66)
K2 (D)	50.08±1.98 (46.36-54.43)
WTW (mm)	10.73±0.53 (9.42-11.5)

SD: Standard deviation, K: Keratometry, AL: Axial length, CCT: Central corneal thickness, D: Diopter, WTW: White-to-white distance

Preoperative glaucoma was present in 19 out of 20 eyes (95%), the mean IOP was 19.2±6.6 mmHg, and the mean number of antiglaucoma medications used was 2.5±1.4. Postoperatively, the mean IOP was 14.2±7.7 mmHg and the mean number of medications fell to 1.4±1.4 ($p<0.02$ for both). The mean preoperative SE was +12.4±2.8 (+8.25 to +20.50) D. The mean power of the implanted IOL was 53.32±6.2 (44-64) D, and the mean target refractive error according to biometry was -0.42±0.3 (-0.87 to +0.12) D in all eyes. The mean postoperative SE was -6.67±5.2 (-15.00 to +0.75) D ($p<0.05$). A postoperative refractive error greater than -1.00 D was observed in 15 eyes (75%). Postoperative refractive error was within ±1 D in 3 eyes (15%), within ±2 D in 3 eyes (15%), within ±3 D in 2 eyes (10%), and exceeded ±4 D in 12 eyes (60%). The postoperative differences in spherical refractive error and SE were also significant ($p<0.05$ for both) (Table 2).

The mean preoperative BCVA was 1.16±0.50 logarithm of the minimum angle of resolution (logMAR), while the mean postoperative BCVA was 0.94±0.68 logMAR ($p=0.26$). Following surgery, BCVA improved in 13 eyes (65%), remained unchanged in 1 eye (5%), and declined in 6 eyes (30%). Eight eyes (40%) achieved a BCVA of ≤0.7 logMAR, 10 eyes (50%) had a BCVA between >0.7 and <1.4 logMAR, and 2 eyes (10%) demonstrated a BCVA of ≥1.4 logMAR.

IOL implantation was successfully performed in all eyes, and no posterior capsular ruptures occurred in any case. In 1 eye (5 %), iris retractors were used to maintain pupil dilation before phacoemulsification. A capsular tension ring was inserted in 3 eyes (15%) to reinforce inadequate capsular support, and posterior synechiolysis was performed in 1 eye (5%). Three eyes (15%) had postoperative choroidal effusion, 1 eye (5%) had malignant glaucoma postoperatively, and 4 eyes (20%) received diode laser cyclophotocoagulation due to IOP elevation unresponsive to medical treatment.

Discussion

Microphthalmos is a congenital ocular abnormality defined by a markedly smaller globe size and is frequently linked to early-onset cataract and angle-closure glaucoma.[4] Cataract surgery in microphthalmic eyes presents significant challenges due to the heightened risk of complications during and after the surgery. Moreover, the condition is associated with a poor visual prognosis and decreased accuracy in IOL calculations.[4]

There is no universally accepted formula for accurately calculating IOL in microphthalmos cases. The Royal School of Ophthalmologists recommends the Hoffer Q formula as the preferred method for eyes with AL shorter than 22 mm.[9] Different clinical studies have shown that the Haigis and Holladay II formulas are also acceptable for eyes with short AL.[7,1011,12,13] Newer IOL formulas such as the Kane and Olsen formulas have been developed, with some studies showing that the Kane formula is particularly suitable for microphthalmic eyes.[4,12,14] However, a meta-analysis of 15 studies comprising 2,395 eyes with short AL (≤22 mm) found no significant differences in accuracy between the Barrett Universal II, Olsen, and conventional IOL formulas such as Haigis, Hoffer Q, and SRK/T.[15] A large-scale study also showed that the Hoffer Q formula yielded the highest accuracy in eyes with an AL ≤21.50 mm, outperforming both the Holladay I and SRK/T formulas.[16] Another study evaluating the accuracy of various IOL calculation formulas—including Haigis, Hoffer Q, Holladay I, SRK/T, Barrett Universal II, and Hoffer QST—in eyes with nanophthalmos (AL <20 mm) found that the overall prediction errors tended to shift toward myopia.[17]

When the Hoffer Q formula was applied to eyes with AL shorter than 22 mm, a mean of 0.22 D myopic refractive error was observed.[18] Zheng et al.[5] evaluated the outcomes of lensectomy in both simple (n=11) and complex (n=6) extreme microphthalmos cases (AL <18 mm) and used the Hoffer-Q formula for IOL power calculation. They observed postoperative refractive errors of 5.6 D and 4.2 D in simple microphthalmos and complex microphthalmos, respectively. However, they did not mention how many of the cases had a myopic refractive error after surgery.[5] We also used the Hoffer-Q formula in our cases and observed a postoperative myopic refractive error greater than -1.00 D in 75% of cases. The mean postoperative SE was -6.67±5.2 D, with a range of -15.00 to +0.75 D.

As a third-generation formula, the Hoffer Q formula relies on the relationship between AL and corneal curvature, estimating postoperative ELP using AL and K values, based on a dataset

Table 2. Preoperative and postoperative measurements

	Preoperative Mean ± SD (range)	Postoperative Mean ± SD (range)	p value
BCVA (logMAR)	1.15±0.49 (0.3-2.3)	0.95±0.68 (0.16-3.10)	0.1
IOP (mmHg)	19.2±6.6 (11-34)	14.15±7.7 (7-41)	**0.02**
Antiglaucoma medications (n)	2.5±1.4 (0-4)	1.4±1.4 (0-4)	**0.02**
Spherical refractive error (D)	+12.63±2.9 (+8.25 to +20.50)	-5.55±5.05 (-13.00 to +1.25)	**<0.05**
Spherical equivalent (D)	+12.39±2.8 (+8.25 to +20.50)	-6.67±5.3 (-15.00 to +0.75)	**<0.05**
ACD (mm)	1.59±0.21 (1.24-1.86)	2.72±0.55 (1.68-3.62)	**0.01**

SD: Standard deviation, BCVA: Best corrected visual acuity, logMAR: Logarithm of the minimum angle of resolution, IOP: Intraocular pressure, D: Diopter, ACD: Anterior chamber depth from cases with posterior chamber lenses.[19] Fourth-generation formulas like Haigis and Holladay II incorporate additional biometric variables such as ACD, lens thickness, and WTW distance to refine the estimation of postoperative ELP and improve IOL power calculations.[20] As preoperative expectations regarding ELP often do not align with postoperative ELP, significant refractive deviations are frequently observed in microphthalmos cases.

In eyes with microphthalmos, the lens tends to be relatively larger and thicker, and angle closure may occur earlier compared to eyes with normal AL.[7,9] Lensectomy can alleviate lens-induced anterior chamber narrowing and help deepen the anterior chamber to avoid angle closure glaucoma.[4,7] ACD, AL, and the degree of angle closure before surgery are reported to be closely associated with the likelihood of postoperative glaucoma.[5] In our study, we observed a significant reduction in IOP and number of antiglaucoma medications after surgery. However, no significant difference was observed in postoperative BCVA. Zheng et al.[4] reported that 75% of eyes exhibited persistent low vision postoperatively, with visual acuity of 20/60 or worse, while 25% remained legally blind. The authors attributed these suboptimal visual outcomes predominantly to the high incidence of postoperative complications (16.7%) associated with cataract surgery. In our study, 60% of eyes had a BCVA greater than 0.7 logMAR. There was an improvement in BCVA, but it was not statistically significant. Postoperative complications included choroidal effusion in 15% of eyes, malignant glaucoma in 5% of eyes, and various other complications in 20% of eyes. Additionally, preoperative glaucoma was present in 95% of cases, which may account for the relatively low postoperative BCVA values.

Intra- and postoperative complications during lensectomy include damage to the corneal endothelium, temporary severe swelling of the cornea, cystoid macular edema, inflammation of the anterior uvea, uveal effusion, and malignant glaucoma.[1,7,21] Uveal effusions may develop either before or after surgery due to impaired venous outflow.[1,6] Zheng et al.[5] reported rates of 18% for choroidal effusion, 13% for malignant glaucoma, and 33% for postoperative IOP elevation. In our study, we observed choroidal effusion in 3 eyes (15%), malignant glaucoma in 1 eye (5%), and postoperative IOP elevation in 5 eyes (25%), which is consistent with previous studies.

Study Limitations

Limitations of this study include a limited sample size, the lack of a control group, and the unavailability of ultrasound biomicroscopy for postoperative assessment of effusion and lens position.

Conclusion

Our findings demonstrated that lensectomy was associated with a significant reduction in IOP and the number of antiglaucoma medications, along with a notable increase in ACD. However, postoperative myopic refractive error may occur, and improvement in BCVA may be limited due to intraoperative and postoperative complications. The Hoffer Q formula shows variability in eyes with nanophthalmos, where inaccurate prediction of the ELP can result in considerable postoperative refractive error. Patients should be informed that a myopic refractive outcome may occur following surgery.

Ethics

Ethics Committee Approval: Ethical approval was received from a Hamidiye Scientific Research Ethics Committee of the University of Health Sciences, Türkiye (meeting number: 2024/8, decision number: 8/9, dated: 01.08.2024).

Informed Consent: Written informed consent to use their data was obtained from all patients in accordance with the tenets of the Declaration of Helsinki.

Declarations

Authorship Contributions

Surgical and Medical Practices: G.G.A., N.A., N.K.B., A.K., İ.Ç., Ç.A., Concept: G.G.A., N.A., T.Y., Design: G.G.A., N.A., T.Y., Data Collection or Processing: E.D., N.K.B., A.K., E.E., Analysis or Interpretation: G.G.A., E.E., İ.Ç., Ç.A., T.Y., Literature Search: G.G.A., E.D., E.E., Writing: G.G.A., N.A.

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