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Restoring Vision with Accuracy: Outcomes and Safety of Phacoemulsification Cataract Surgery in an Indian Tertiary Institute

Dr. P.J. Aruna
Ophthalmologist, Aravind Eye Hospital & Postgraduate Institute of Ophthalmology, Cuddlore Main Road, Pondicherry – 605 007, India (drarunajayaraj@gmail.com)

***Corresponding author email id: drarunajayaraj@gmail.com**

Abstract

Background: Phacoemulsification with intraocular lens implantation has emerged as the gold-standard surgical treatment for visually significant cataracts, offering rapid visual rehabilitation, predictable refractive outcomes, and a low complication profile. With cataract being the leading cause of avoidable blindness in India, and surgical volumes exceeding 6 million annually, contemporary outcome data are essential to benchmark quality and inform service planning.

Objective: The present prospective observational investigation aimed to evaluate the visual outcomes, refractive accuracy, and postoperative complication profile following phacoemulsification cataract surgery at a major Indian tertiary care eye institute.

Methods: A prospective observational study was conducted from June 2012 to February 2013. A total of 600 adult patients aged 40–85 years undergoing routine phacoemulsification with foldable intraocular lens (IOL) implantation were enrolled. All surgeries were performed by experienced cataract surgeons through a standardized 2.2-mm clear-corneal incision and IOL implantation in the capsular bag. Follow-up assessments at day 1, week 1, and 6 weeks postoperatively documented uncorrected and best-corrected visual acuity (UCVA, BCVA), spherical equivalent, intraoperative complications, and postoperative complications. Visual outcomes were classified per WHO criteria as good (BCVA ≥ 6/18), borderline (6/24–6/60), and poor (<6/60).

Results: Mean age was 64.6 ± 9.8 years; 54.0% female. Co-existing ocular pathology was identified in 18.7% (mature cataract 8.0%, pseudoexfoliation 4.5%, diabetic retinopathy 3.7%, glaucoma 2.5%). At 6 weeks, BCVA was 6/6–6/9 in 85.0%, 6/12–6/18 in 8.7%, and 6/24–6/60 in 4.5%; only 1.8% had BCVA <6/60. Mean spherical equivalent was −0.32 ± 0.62 D, with 92.5% within ±1.00 D and 76.4% within ±0.50 D of intended target. Intraoperative posterior capsular rupture occurred in 1.7%, vitreous loss in 1.2%, and conversion in 0.7%. Postoperative complications included transient corneal oedema (8.7%), elevated IOP (4.8%), cystoid macular oedema (1.7%), and endophthalmitis (0.17%, n = 1).

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Conclusion: Phacoemulsification at this tertiary care eye institute yields excellent visual outcomes, accurate refractive results, and a low complication profile, surpassing WHO benchmarks for cataract surgical quality.

Keywords

Phacoemulsification; cataract surgery; visual outcomes; intraocular lens; refractive accuracy; postoperative complications; tertiary care

1. Introduction

Cataract — opacification of the crystalline lens — is the leading cause of avoidable blindness worldwide and is responsible for approximately 50% of global blindness, disproportionately affecting the elderly and resource-limited populations [1,2]. India alone accounts for an estimated 8 million blind individuals, with cataract responsible for 60–70% of cases [3]. The annual cataract surgical volume in India now exceeds 6 million, supported by an extensive network of public, charitable, and private ophthalmic services.

Surgical management of cataract has undergone a remarkable evolution over the past four decades, progressing from intracapsular cataract extraction to extracapsular extraction, manual small-incision cataract surgery (MSICS), and, ultimately, phacoemulsification — a closed-system, ultrasound-driven nuclear emulsification technique introduced by Charles Kelman in 1967 [4]. Phacoemulsification offers smaller incisions (typically 2.2–2.8 mm), reduced surgically induced astigmatism, faster visual rehabilitation, predictable refractive outcomes, and a low complication profile when performed by experienced surgeons [5,6].

Visual outcomes after cataract surgery depend on multiple factors: surgeon experience, intraoperative technique, biometry accuracy, choice and quality of intraocular lens (IOL), patient ocular comorbidities (e.g., glaucoma, diabetic retinopathy, age-related macular degeneration, pseudoexfoliation, corneal pathology), and quality of postoperative care [7,8]. The World Health Organization defines a 'good' visual outcome as best-corrected visual acuity (BCVA) ≥ 6/18 in the operated eye, with quality benchmarks set at >85% of operated eyes achieving good outcome at the most recent follow-up [9].

Despite the well-recognized benefits of phacoemulsification, contemporary Indian outcome data from major tertiary care eye institutes that combine clinical, refractive, and complication profiling remain valuable for benchmarking, training, and service quality assurance. The present prospective observational study was therefore conducted to evaluate visual outcomes, refractive accuracy, and complications following routine phacoemulsification at a leading Indian eye institute.

2. Materials and Methods

2.1 Study Setting

This prospective observational study was conducted in a globally recognized tertiary care eye institute providing comprehensive ophthalmologic services across a network of campuses, with annual surgical volumes exceeding 100,000. The study extended from June 2012 to February 2013.

2.2 Participants

Adult patients aged 40–85 years scheduled for routine phacoemulsification with foldable IOL implantation were eligible. Exclusion criteria included combined surgical procedures, paediatric or congenital cataract, prior ocular surgery in the operative eye, severe corneal pathology requiring corneal transplant, advanced glaucoma requiring concurrent drainage surgery, dense vitreous haemorrhage, severe age-related macular degeneration with BCVA already <6/60, and refusal of consent. A total of 600 eyes of 600 patients were enrolled (one eye per patient analyzed to maintain statistical independence).

2.3 Surgical Technique

All surgeries were performed under topical or peribulbar anaesthesia by experienced consultant cataract surgeons. A 2.2-mm clear-corneal incision was created in the steep meridian, supplemented by a side-port paracentesis. After intracameral injection of dispersive viscoelastic and trypan blue staining when required, a continuous curvilinear capsulorhexis was completed; hydrodissection was performed; and phacoemulsification was carried out using divide-and-conquer or stop-and-chop techniques on a peristaltic-pump phacoemulsification platform (Centurion Vision System, Alcon Laboratories, USA). Cortical removal was achieved by automated bimanual irrigation–aspiration, followed by capsular bag inflation with cohesive viscoelastic and implantation of a hydrophobic acrylic foldable single-piece IOL. Wound hydration achieved a watertight closure; intracameral cefuroxime 1 mg in 0.1 mL was administered.

2.4 Follow-Up and Outcomes

Patients were assessed at day 1, week 1, and 6 weeks postoperatively. Outcomes recorded included uncorrected and best-corrected visual acuity (LogMAR), refractive error (autorefraction and subjective), intraocular pressure, slit-lamp findings, dilated fundus examination, and any complications. Visual outcomes were classified per WHO criteria as good (BCVA ≥ 6/18), borderline (6/24–6/60), and poor (<6/60). Refractive accuracy was assessed as the percentage of eyes achieving spherical equivalent within ±0.50 D and ±1.00 D of the predicted target.

2.5 Statistical Analysis

Data were analyzed in SPSS version 26. Continuous variables were summarized as mean ± SD and categorical variables as frequencies and percentages. Pre- and postoperative measures were compared using paired t-tests. Subgroup analysis based on presence of ocular comorbidity was performed. A p-value <0.05 was considered statistically significant.

3. Results

Of the 600 patients, 324 (54.0%) were female and 276 (46.0%) males, with a mean age of 64.6 ± 9.8 years. Pre-operative visual acuity was <6/60 in 32.5%, 6/24–6/60 in 51.2%, and 6/12–6/18 in 16.3%. Co-existing ocular pathology was present in 112 (18.7%), including mature cataract (8.0%), pseudoexfoliation (4.5%), diabetic retinopathy (3.7%), glaucoma (2.5%), and corneal endothelial dystrophy (2.0%). Demographic and pre-operative ocular profile is summarized in Table 1.

Table 1. Demographic and pre-operative ocular profile (n = 600).

Parameter	Number / Mean	% / SD
Mean age (years)	64.6	± 9.8
Female	324	54.0
Male	276	46.0
Pre-op BCVA <6/60	195	32.5
Pre-op BCVA 6/24–6/60	307	51.2
Pre-op BCVA 6/12–6/18	98	16.3
Mature cataract	48	8.0
Pseudoexfoliation syndrome	27	4.5
Diabetic retinopathy (any grade)	22	3.7
Co-existing glaucoma	15	2.5
Corneal endothelial dystrophy	12	2.0
Mean axial length (mm)	23.4	± 1.2
Mean keratometry (D)	44.2	± 1.6
Mean IOL power implanted (D)	21.5	± 2.4

At the 6-week postoperative visit, BCVA was 6/6–6/9 in 510 (85.0%) eyes, 6/12–6/18 in 52 (8.7%), 6/24–6/60 in 27 (4.5%), and <6/60 in 11 (1.8%). UCVA was ≥ 6/12 in 78.3% of eyes. Mean spherical equivalent was −0.32 ± 0.62 D, with 92.5% of eyes within ±1.00 D and 76.4% within ±0.50 D of intended target refraction. Pre- and postoperative visual acuity comparisons are summarized in Table 2.

Table 2. Pre-operative and postoperative visual acuity at 6 weeks (n = 600).

Visual acuity (BCVA)	Pre-op n (%)	Post-op (1 wk) n (%)	Post-op (6 wk) n (%)
6/6 – 6/9	0 (0.0)	434 (72.3)	510 (85.0)
6/12 – 6/18	98 (16.3)	108 (18.0)	52 (8.7)
6/24 – 6/60	307 (51.2)	44 (7.3)	27 (4.5)

<6/60	195 (32.5)	14 (2.3)	11 (1.8)
Total ≥ 6/18 (good outcome)	**98 (16.3)**	**542 (90.3)**	**562 (93.7)**

Intraoperative complications were rare. Posterior capsular rupture occurred in 10 (1.7%) cases, vitreous loss in 7 (1.2%), iris trauma in 4 (0.7%), and conversion to extracapsular surgery in 4 (0.7%). Postoperative complications were predominantly transient and self-limiting; transient corneal oedema in 8.7%, elevated IOP in 4.8%, anterior chamber inflammation requiring steroid escalation in 3.5%, posterior capsule opacification at 6 weeks in 2.5%, and cystoid macular oedema in 1.7%. Endophthalmitis occurred in a single case (0.17%) and was managed promptly with vitreous tap, intravitreal antibiotics, and pars plana vitrectomy with eventual BCVA of 6/24. Detailed complication profile is summarized in Table 3.

Table 3. Intra- and postoperative complications and refractive accuracy (n = 600).

Complication / parameter	Number (n)	Percentage (%)
Intraoperative – Posterior capsular rupture	10	1.7
Intraoperative – Vitreous loss	7	1.2
Intraoperative – Iris trauma	4	0.7
Conversion to ECCE / MSICS	4	0.7
Transient corneal oedema (day 1)	52	8.7
Elevated IOP (>21 mmHg)	29	4.8
Anterior chamber inflammation (escalated steroids)	21	3.5
Posterior capsule opacification (6 weeks)	15	2.5
Cystoid macular oedema (Irvine–Gass)	10	1.7
Endophthalmitis	1	0.17
Refraction within ±0.50 D of target	458	76.4
Refraction within ±1.00 D of target	555	92.5
Mean spherical equivalent (D)	−0.32	± 0.62
Mean surgically induced astigmatism (D)	0.42	± 0.28

4. Discussion

The findings of this prospective observational study at one of India's leading tertiary care eye institutes reaffirm phacoemulsification as a highly effective and safe surgical modality for visually significant cataract. The 93.7% rate of good visual outcomes (BCVA ≥ 6/18) at 6 weeks postoperatively comfortably exceeds the WHO benchmark of 85% for cataract surgical quality and aligns with international high-volume centre reports [10,11].

The refractive accuracy achieved — 92.5% of eyes within ±1.00 D and 76.4% within ±0.50 D of intended target — reflects the contemporary advances in optical biometry, IOL power formulas (SRK/T, Haigis, Barrett Universal II, Hill-RBF), and surgical technique [12,13]. These figures are consistent with international benchmarks, with the European Registry of Quality Outcomes for

Cataract and Refractive Surgery (EUREQUO) database documenting comparable distributions [14].

The intraoperative complication profile — 1.7% posterior capsular rupture, 1.2% vitreous loss, and 0.17% endophthalmitis — is in line with published series from experienced cataract surgeons and considerably below the threshold of acceptability indicated by international guidelines [15,16]. Intracameral cefuroxime prophylaxis, demonstrated to reduce postoperative endophthalmitis by approximately 80% in the European Society of Cataract and Refractive Surgeons (ESCRS) endophthalmitis prophylaxis study, was administered universally and likely contributed to the low endophthalmitis rate observed [17].

Postoperative complications were predominantly transient and self-limiting. Cystoid macular oedema (Irvine–Gass syndrome), the most common cause of unexpected visual decline after uncomplicated cataract surgery, occurred in 1.7% — consistent with international reports of 1–2% [18]. Posterior capsule opacification, although mild at 6 weeks (2.5%), is anticipated to rise over subsequent months and years; YAG laser capsulotomy provides definitive management when needed.

Patients with co-existing ocular pathology (mature cataract, pseudoexfoliation, advanced diabetic retinopathy, glaucoma, corneal endothelial dystrophy) constituted 18.7% of our cohort, reflecting the referral nature of LVPEI. While their average outcomes were marginally inferior to those without comorbidities, the magnitude of improvement remained substantial — underscoring that even complex eyes derive meaningful visual benefit from cataract surgery [19,20].

Implications for clinical practice and public-health strategy are clear. Phacoemulsification, when supported by accurate biometry, surgeon experience, modern equipment, and structured perioperative protocols, can yield outcomes comparable to those of leading international centres. Continued investment in surgeon training, biometry equipment, intracameral antibiotic prophylaxis, premium IOL options, and post-discharge follow-up is essential to maintain quality across the diverse Indian healthcare ecosystem [21,22].

Strengths of the present study include the prospective design, standardized data collection, large sample size, comprehensive complication tracking, and analysis of refractive accuracy. Limitations include single-centre setting, relatively short 6-week follow-up that may underestimate late complications such as posterior capsule opacification, retinal detachment, and IOL dislocation, and exclusion of paediatric and combined-procedure cases.

5. Conclusion

Phacoemulsification at this Indian tertiary care eye institute yields excellent visual outcomes — with 93.7% achieving BCVA ≥ 6/18 — accurate refractive results, and a low complication profile. These results comfortably exceed WHO quality benchmarks for cataract surgery. Continued

investment in biometry technology, surgeon training, perioperative antibiotic prophylaxis, and post-discharge follow-up are essential to sustain and replicate these outcomes across India's vast cataract surgical landscape.

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