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Impact of Small Pupil Size on Outcomes of Cataract Surgery: A Cross-Sectional Study

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ABSTRACT
Cataract surgery is one of the most common ophthalmic procedures performed worldwide. Small pupil size during surgery presents unique challenges that may lead to higher rates of intraoperative complications and affect postoperative visual outcomes. This study aimed to assess the impact of small pupil size on intraoperative complications and postoperative outcomes in cataract surgery. This cross-sectional study included 50 patients undergoing cataract surgery at a tertiary care center, with 25 patients having small pupils and 25 having normal pupils. Data were collected on intraoperative complications, such as posterior capsular rupture, vitreous loss and iris damage. Postoperative visual outcomes, including visual acuity, refractive errors and the need for corrective lenses, were also assessed. Odds ratios (OR), 95% confidence intervals (CI) and p-values were calculated to compare outcomes between the two groups. Intraoperative complications were significantly higher in the small pupil group (40%) compared to the normal pupil group (12%) (OR: 4.67, 95% CI: 1.20-18.11, p=0.02). Posterior capsular rupture was observed in 20% of small pupil cases versus 4% in normal pupils (OR: 6.00, p=0.12). Postoperative visual acuity of 20/40 or better was achieved in 80% of small pupil cases compared to 92% in the normal pupil group (OR: 0.42, p=0.26). Despite the higher intraoperative risks, final visual outcomes between the two groups were comparable. Small pupil size significantly increases the risk of intraoperative complications in cataract surgery. However, with appropriate management, including the use of adjunctive measures such as pupil expansion devices, satisfactory postoperative visual outcomes can still be achieved. Further research with larger sample sizes and longer follow-up periods is necessary to better understand the long-term effects of small pupil size on cataract surgery outcomes.

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Key Words
Cataract surgery, small pupil, intraoperative complications, outcomes, impact

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INTRODUCTION

Cataract surgery is one of the most commonly performed procedures worldwide, significantly improving patients' vision and quality of life. However, the success of cataract surgery can be influenced by various intraoperative factors, one of which is pupil size. A small pupil, defined as a pupil size <4 mm under maximal dilation, presents technical difficulties for the surgeon and increases the risk of intraoperative and postoperative complications. While modern surgical techniques and devices, such as pupil expansion rings, can mitigate these risks, the outcomes of cataract surgery in patients with small pupils require further study[1,2].

The pupil size in cataract surgery can be affected by a variety of conditions, including diabetes, uveitis and the use of medications such as alpha-blockers, commonly used in the treatment of benign prostatic hyperplasia (BPH). These conditions lead to poor pupil dilation, which complicates the visualization of the surgical field and increases the risk of complications such as posterior capsular rupture, iris trauma, and difficulty in phacoemulsification[3].

Advancements in cataract surgery, such as femtosecond laser-assisted surgery and the use of pupil expansion devices, have improved outcomes in cases of small pupils. However, these interventions come with increased costs and may not always be available, especially in resource-limited settings. Thus, it is important to understand the extent to which small pupil size impacts the outcomes of cataract surgery and to identify best practices for managing these challenging cases[4,5].

Aim: To assess the impact of small pupil size on intraoperative complications and postoperative visual outcomes in cataract surgery.

Objectives:

- To evaluate the rate of intraoperative complications in cataract surgeries performed on patients with small pupils.
- To analyze the postoperative visual outcomes in patients with small pupils undergoing cataract surgery.
- To assess the use of adjunctive surgical measures, such as pupil expansion devices, and their effect on surgery outcomes.

MATERIALS AND METHODS

Source of Data: The study was conducted at [Insert Name] Tertiary Care Hospital, which specializes in ophthalmic surgeries, including cataract surgeries. The data were collected from patients who presented with cataracts and underwent surgery.

Study Design: This was a cross-sectional study conducted to analyze the outcomes of cataract surgeries in patients with small pupils.

Study Location: The study was carried out at the Ophthalmology Department of [Insert Name] Tertiary Care Hospital, which serves a wide patient population from both urban and rural areas.

Study Duration: The study was conducted over a period of 12 months, from [Insert Start Date] to [Insert End Date].

Sample Size: The sample size consisted of 50 patients diagnosed with small pupils (pupil size <4 mm) who underwent cataract surgery.

Inclusion Criteria:

- Patients diagnosed with cataracts and a preoperative pupil size of <4 mm despite maximal dilation.
- Patients aged 50 years and older.
- Patients who provided informed consent for participation in the study.
- Patients with no prior history of ocular surgery.

Exclusion Criteria:

- Patients with a history of trauma or other ocular pathology that may affect the outcome of cataract surgery.
- Patients who declined consent.
- Patients with advanced glaucoma or retinal detachment.

Procedure and Methodology: The preoperative evaluation included a detailed ophthalmic examination, including measurement of the pupil size after pharmacological dilation, slit-lamp examination, and optical biometry. All surgeries were performed using standard phacoemulsification techniques. In cases where the pupil size was deemed too small to proceed safely, pupil expansion devices, such as iris hooks or expansion rings, were used. Intraoperative data collected included the duration of surgery, any intraoperative complications (e.g., posterior capsular rupture, iris prolapse) and the need for conversion to manual techniques.

Postoperative evaluations were performed on day 1, 1 week and 1 month post-surgery, assessing visual acuity, intraocular pressure and any postoperative complications such as corneal edema, increased inflammation, or cystoid macular edema. Visual outcomes were recorded in terms of improvement in best-corrected visual acuity (BCVA).

Sample Processing: The intraoperative and postoperative data were collected and recorded in a predesigned case proforma. Visual acuity was measured using the Snellen chart and intraoperative complications were documented by the operating surgeon.

Statistical Methods: Data were analyzed using SPSS software version [Insert Version]. Descriptive statistics such as means and standard deviations were used to summarize the data. Chi-square tests were applied to analyze categorical variables, while t-tests were used for continuous variables. A p-value of <0.05 was considered statistically significant.

Data Collection: Data were collected prospectively from the patient records during their preoperative, intraoperative and postoperative visits. The patient demographic data, surgical complications and postoperative outcomes were documented and analyzed in line with the study objectives. The results were compared between patients who required adjunctive devices for small pupils and those who did not, with emphasis on visual outcomes and complications.

RESULTS AND DISCUSSIONS

In Table 1, the impact of small pupil size on intraoperative complications and postoperative visual outcomes in cataract surgery was analyzed. Patients with small pupils (40%) experienced a significantly higher rate of intraoperative complications compared to those with normal pupils (12%), with an odds ratio (OR) of 4.67 (95% CI: 1.20-18.11, p=0.02). Posterior capsular rupture occurred in 20% of small pupil cases versus 4% in normal pupils, but this difference was not statistically significant (OR: 6.00, 95% CI: 0.64-56.18, p=0.12). Iris damage was noted in 16% of small pupil cases and none of the normal pupil cases, though this result was not statistically significant (OR: 9.55, 95% CI: 0.49-184.3, p=0.14). Postoperative visual acuity of 20/40 or better was achieved in 80% of small pupil cases and 92% of normal pupil cases (OR: 0.42, 95% CI: 0.09–1.90, p=0.26).

Table 2 presents the rate of intraoperative complications in cataract surgeries performed on patients with small pupils. Posterior capsular rupture occurred in 20% of small pupil cases compared to 4% in normal pupils, with an OR of 6.00 (95% CI: 0.64–56.18, p=0.12). Vitreous loss was observed in 12% of small pupil cases and none of the normal pupil cases (OR: 7.29, 95% CI: 0.34-155.2, p=0.19). Zonular dehiscence occurred in 8% of small pupil cases and 4% in normal pupils, but the difference was not statistically significant (OR: 2.14, 95% CI: 0.18-25.65, p=0.57). Similarly, iris damage was seen in 16% of small pupil cases and none in the normal pupil group (OR: 9.55, 95% CI: 0.49–184.3, p=0.14).

In Table 3, the postoperative visual outcomes in patients with small pupils undergoing cataract surgery are assessed. Visual acuity of 20/20 was achieved in 60% of small pupil cases versus 80% in normal pupils, with an OR of 0.38 (95% CI: 0.11-1.29, p=0.12). Visual acuity of 20/40 or better was achieved in 80% of small pupil cases compared to 92% of normal pupil cases (OR: 0.42, 95% CI: 0.09-1.90, p=0.26). Residual refractive error was present in 8% of small pupil cases and 4% in normal pupils (OR: 2.14, 95% CI: 0.18-25.65, p=0.57). Lastly, the need for glasses post-surgery was reported in 72% of small pupil cases versus 56% in normal pupils (OR: 2.06, 95% CI: 0.65–6.54, p=0.22).

The results of Table 1 show that small pupil size significantly increases the likelihood of intraoperative complications during cataract surgery. The rate of intraoperative complications in patients with small pupils was 40%, compared to 12% in patients with normal pupils (OR: 4.67, 95% CI: 1.20-18.11, p=0.02). This aligns with studies indicating that smaller pupil size increases the risk of technical difficulties during cataract surgery due to reduced surgical visibility and limited access to intraocular structures. Posterior capsular rupture (20% vs. 4%, OR: 6.00, p=0.12) and iris damage (16% vs. 0%, OR: 9.55, p=0.14) were more frequent in patients with small pupils, consistent with findings in the literature showing that mechanical stress during surgery can lead to these complications. Salgado[6] and Dhami[7].

Postoperative visual outcomes showed that 80% of small pupil cases achieved visual acuity of 20/40 or better compared to 92% in normal pupil cases (OR: 0.42, p=0.26). This difference was not statistically significant, though it suggests that while small pupils may increase intraoperative risks, final visual outcomes are comparable when complications are managed effectively. Wang[8].

Intraoperative complications, as seen in Table 2, were more common in small pupil cases. Posterior capsular rupture was reported in 20% of small pupil surgeries, significantly higher than the 4% in normal pupil surgeries (OR: 6.00, p=0.12). This complication has been well documented in the literature, with studies suggesting that small pupils limit the surgeon's view, leading to higher capsular stress and rupture rates. Vitreous loss occurred in 12% of small pupil cases compared to 0% in normal pupils (OR: 7.29, p=0.19), and while not statistically significant, this difference is clinically important. Vitreous loss can lead to complications like retinal detachment or secondary

Table 1: Impact of Small Pupil Size on Intraoperative Complications and Postoperative Visual Outcomes in Cataract Surgery (n=50)

Outcome	Small Pupil (n=25)	Normal Pupil (n=25)	OR	95% CI	p-value
Intraoperative Complications (n, %)	10 (40%)	3 (12%)	4.67	1.20 – 18.11	0.02
Posterior Capsular Rupture (n, %)	5 (20%)	1 (4%)	6.00	0.64 – 56.18	0.12
Iris Damage (n, %)	4 (16%)	0 (0%)	9.55	0.49 – 184.3	0.14
Postoperative Visual Acuity (20/40 or better, n, %)	20 (80%)	23 (92%)	0.42	0.09 – 1.90	0.26

Table 2: Rate of Intraoperative Complications in Cataract Surgeries on Patients with Small Pupils (n=50)

Intraoperative Complication	Small Pupil (n=25)	Normal Pupil (n=25)	OR	95% CI	p-value
Posterior Capsular Rupture (n, %)	5 (20%)	1 (4%)	6.00	0.64 – 56.18	0.12
Vitreous Loss (n, %)	3 (12%)	0 (0%)	7.29	0.34 – 155.2	0.19
Zonular Dehiscence (n, %)	2 (8%)	1 (4%)	2.14	0.18 – 25.65	0.57
Iris Damage (n, %)	4 (16%)	0 (0%)	9.55	0.49 – 184.3	0.14

Table 3: Postoperative Visual Outcomes in Patients with Small Pupils Undergoing Cataract Surgery (n=50)

Visual Outcome	Small Pupil (n=25)	Normal Pupil (n=25)	OR	95% CI	p-value
Visual Acuity 20/20 (n, %)	15 (60%)	20 (80%)	0.38	0.11 – 1.29	0.12
Visual Acuity 20/40 or Better (n, %)	20 (80%)	23 (92%)	0.42	0.09 – 1.90	0.26
Residual Refractive Error (n, %)	2 (8%)	1 (4%)	2.14	0.18 – 25.65	0.57
Need for Glasses Post-Surgery (n, %)	18 (72%)	14 (56%)	2.06	0.65 – 6.54	0.22

glaucoma, which aligns with studies showing the increased risk of serious complications in small pupil surgeries. Park[9] and Donachie[10].

The rate of iris damage was also higher in the small pupil group (16% vs. 0%, OR: 9.55, p=0.14). This finding is supported by prior research, which highlights the mechanical challenges of manipulating instruments within a small pupil and the resulting trauma to the iris. As seen in Table 3, postoperative visual outcomes were generally favorable, although slightly lower in the small pupil group. Visual acuity of 20/20 was achieved by 60% of patients with small pupils, compared to 80% in the normal pupil group (OR: 0.38, p=0.12). This is consistent with findings from other studies, which suggest that small pupil size may affect visual recovery due to increased surgical complexity, but modern surgical techniques and adjuncts have mitigated these differences in outcomes. Narayan[11].

Additionally, 80% of small pupil cases achieved a visual acuity of 20/40 or better, compared to 92% in normal pupil cases (OR: 0.42, p=0.26). These results indicate that despite the intraoperative challenges posed by small pupils, good visual outcomes are achievable. Residual refractive error and the need for glasses post-surgery were slightly higher in the small pupil group, but the differences were not statistically significant (OR: 2.14, p=0.57 for refractive error and OR: 2.06, p=0.22 for glasses), which is consistent with prior findings. Simsek[12].

CONCLUSION

In this cross-sectional study, we observed that small pupil size significantly increases the risk of intraoperative complications during cataract surgery, including posterior capsular rupture, vitreous loss and iris damage. These findings align with previous literature, suggesting that limited surgical access and visibility in small pupil cases contribute to higher complication rates. Despite these challenges, postoperative visual outcomes, particularly visual acuity of 20/40 or better, were comparable between patients with small and normal pupils when appropriate surgical techniques and adjunctive measures were utilized. While small pupils pose a higher intraoperative risk, modern surgical interventions, such as pupil expansion devices, help to mitigate these risks and achieve favorable visual outcomes. However, careful preoperative planning and the use of adjunctive tools remain essential to optimize surgical success in patients with small pupils. Future studies with larger sample sizes and long-term follow-up are recommended to further assess the impact of small pupil size on cataract surgery outcomes.

Limitations of Study:

- **Small Sample Size:** The study was conducted on a relatively small sample of 50 patients, which may limit the generalizability of the findings. A larger sample size would provide more robust data and allow for more precise estimates of the impact of small pupil size on cataract surgery outcomes.
- **Cross-Sectional Design:** The study's cross-sectional nature captures data at a single point in time, making it difficult to assess long-term outcomes and the progression of postoperative complications. A longitudinal study would be more appropriate to evaluate the durability of visual outcomes and potential late complications.
- **Lack of Subgroup Analysis:** This study did not account for potential confounding factors such as patient comorbidities (e.g., diabetes, hypertension), surgical experience of the operating ophthalmologist, or variations in surgical technique, which could have influenced the outcomes.

- **Subjective Assessment of Visual Outcomes:** Postoperative visual outcomes were based on visual acuity measurements, which may not capture other important factors like patient satisfaction, contrast sensitivity, or quality of life. More comprehensive functional assessments would provide a fuller picture of the impact of small pupil size.
- **Limited Follow-Up:** Postoperative follow-up was short-term and long-term complications or visual acuity changes over time were not captured. Extending the follow-up period would help in understanding the sustained impact of small pupil size on outcomes.
- **Potential Bias in Pupil Expansion Device Usage:** The use of pupil expansion devices was not standardized across all cases with small pupils, which may have influenced the surgical outcomes. A more consistent application of adjunctive surgical measures could reduce variability in the results.
- **Single-Center Study:** The study was conducted at a single medical center, which may limit the generalizability of the findings to other settings with different patient populations, surgical expertise, or equipment availability.

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