RESEARCH PAPER

Pharmacological Impact of Mydriatic Drops on Intraocular Pressure: Variations across Different Phakic Status and Demographic Groups

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Abstract
Pharmacological pupil dilation is routinely performed during comprehensive ophthalmic examinations and is generally considered safe. However, mydriatic agents may produce transient changes in intraocular pressure (IOP), with the magnitude of response potentially influenced by ocular anatomy, lens status, age, and demographic characteristics. Evidence comparing mydriasis-induced IOP changes across cataract, pseudophakic, and young adult eyes remains limited.

Aim
To investigate the effect of pharmacological mydriasis on intraocular pressure across different phakic statuses and age groups, including eyes with cataract, pseudophakic eyes, and young adults with clear natural lenses, and to examine the influence of demographic characteristics on IOP response.

Methods
A prospective interventional study was conducted over six months and included 128 eyes divided into three groups: 56 cataract eyes, 44 pseudophakic eyes, and 28 eyes of young adults with clear natural lenses. Baseline IOP was measured using a calibrated non-contact tonometer (Huvitz HNT-1P). Pharmacological dilation was achieved using tropicamide 0.8% combined with phenylephrine hydrochloride 5%, administered at 15-minute intervals for three consecutive applications. IOP was reassessed 40–45 minutes after the final instillation. Paired t-tests were used to compare pre- and post-dilation IOP within groups, while independent-samples t-tests and Kruskal–Wallis tests were used for between-group comparisons. Statistical significance was set at $p < 0.05$.

Results
The cataract group demonstrated a significant increase in mean IOP from 16.17 ± 2.85 mmHg before dilation to 17.52 ± 3.75 mmHg after dilation, representing a mean increase of 1.35 mmHg ($p = 0.034$). Young adults showed the greatest increase, from 16.67 ± 2.34 mmHg to 18.46 ± 3.24 mmHg, corresponding to an increase of 1.79 mmHg ($p = 0.021$). In contrast, pseudophakic eyes demonstrated minimal change, from 14.81 ± 2.90 mmHg to 14.86 ± 3.24 mmHg, representing an increase of only 0.05 mmHg ($p = 0.944$). Inter-group analysis showed significantly higher post-dilation IOP in cataract eyes compared with pseudophakic eyes (17.52 ± 3.75 vs. 14.86 ± 3.24 mmHg; $p = 0.0003$) and in young adults compared with pseudophakic eyes (18.46 ± 3.24 vs. 14.86 ± 3.24 mmHg; $p < 0.001$). Young adult males demonstrated higher baseline and post-dilation IOP than females.

Conclusion
Pharmacological mydriasis produced different IOP responses according to lens status and age. Young adults with clear natural lenses and individuals with cataract demonstrated significant IOP elevations, whereas pseudophakic eyes showed minimal pressure change. These findings emphasize the importance of considering individual ocular characteristics when assessing the response to pharmacological dilation.

Keywords: Intraocular pressure, mydriasis, tropicamide, phenylephrine, cataract, pseudophakia, phakic status, pupil dilation

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Introduction

Intraocular pressure (IOP) represents the pressure within the eye and is primarily determined by the balance between aqueous humour production and outflow. It is an important clinical parameter in routine ophthalmic examination and plays a central role in the assessment and management of glaucoma and other optic nerve disorders. In the general population, IOP is commonly reported within a range of approximately 11–21 mmHg, although considerable physiological variation may occur between individuals. (1)

Several physiological and pharmacological factors can influence IOP, including diurnal variation, posture, cardiovascular factors, ocular anatomy, and topical medications. (2) Among the medications commonly used in ophthalmic practice, mydriatic agents are particularly relevant because

pharmacological pupil dilation is routinely performed for retinal examination, posterior segment assessment, preoperative evaluation, and other diagnostic procedures.

Mydriasis refers to pharmacological enlargement of the pupil and is commonly achieved through the use of parasympatholytic and sympathomimetic agents. Tropicamide acts as a muscarinic receptor antagonist, producing relaxation of the iris sphincter and ciliary muscle, whereas phenylephrine hydrochloride is an α1-adrenergic agonist that stimulates contraction of the iris dilator muscle. The combination provides effective pupil dilation and is widely used in clinical ophthalmic practice. [2]

Although pharmacological mydriasis is generally considered safe, changes in IOP following pupil dilation have been documented. The mechanism underlying this response is not completely established. One proposed explanation is that pharmacological relaxation of the ciliary muscle may alter its mechanical interaction with the trabecular meshwork, potentially reducing aqueous humour outflow and producing a transient increase in IOP. [3,4] The magnitude of this response, however, appears to vary among individuals and patient populations.

Previous studies have reported increases in IOP following pharmacological dilation in normal subjects, with reported changes generally ranging from approximately 0.7 to 2.5 mmHg. [5] Qian et al. also reported variable pre- to post-dilation changes and demonstrated that a proportion of individuals may experience clinically relevant increases in IOP. [6,7] These findings suggest that although the average pressure increase may be relatively small, individual responses can differ considerably.

The anatomical status of the crystalline lens may influence this response. In natural-lens eyes, the crystalline lens occupies an important position within the anterior segment and contributes to anterior chamber configuration and the relationship between the iris, ciliary body, and trabecular meshwork. In pseudophakic eyes, the natural lens is replaced by an intraocular lens following cataract surgery. This surgical alteration may change anterior chamber depth and angle configuration and could potentially influence aqueous humour dynamics.

Cataract may also alter the anatomical relationship within the anterior segment. An enlarged or structurally altered crystalline lens may influence the anterior chamber and aqueous outflow pathway. Therefore, the IOP response to pharmacological dilation may differ between eyes with cataract and eyes following cataract extraction and intraocular lens implantation.

Demographic characteristics may additionally influence IOP. Population-based studies have reported differences in IOP according to age and sex, with males demonstrating higher mean IOP than females in some populations. [6] However, whether these demographic differences also influence the magnitude of IOP response following pharmacological mydriasis remains incompletely understood.

Previous studies have primarily investigated mydriasis-related IOP changes in normal subjects or selected glaucoma-related populations. Comparatively limited information is available regarding direct comparison of cataract, pseudophakic, and young adult eyes within the same study. In particular, the response of young adults with clear natural lenses and the response of pseudophakic eyes require further investigation.

Therefore, the present study compared IOP before and after pharmacological mydriasis among cataract, pseudophakic, and young adult eyes. The study also examined demographic differences in baseline and post-dilation IOP.

Materials and Methods

Study design and participants

A prospective interventional study was conducted over a period of six months. A total of 128 eyes were included in the study and divided into three groups: cataract eyes, pseudophakic eyes, and young adult eyes with clear natural lenses.

The cataract group comprised 56 eyes with a mean age of 65.15 ± 10.68 years. The pseudophakic group comprised 44 eyes with a mean age of 68.00 ± 9.70 years. The young adult group comprised 28 eyes with a mean age of 33.14 ± 6.15 years.

Participants were included if they were aged 20 years or older. The cataract group consisted of individuals with untreated cataract, while the pseudophakic group included individuals who had undergone cataract surgery with successful intraocular lens implantation. The young adult group included participants aged 20–45 years with clear natural lenses bilaterally.

Participants were excluded if they were younger than 20 years or older than 85 years, or had glaucoma, retinal pathology, uveitis, previous refractive surgery, or other significant ocular disease. Young adults with ocular disorders were also excluded. Individuals with uncontrolled hypertension or cardiovascular disease, representing a relative contraindication to phenylephrine administration, were excluded.

Written informed consent was obtained from all participants before enrollment. The study was conducted according to the principles of the Declaration of Helsinki and received approval from the relevant ethics committee.

Clinical assessment

Demographic information, including age and sex, was recorded for all participants. A complete ophthalmic assessment was performed before pharmacological dilation. Visual acuity and refraction were assessed, followed by measurement of baseline IOP.

Intraocular pressure measurement

IOP was measured using a calibrated non-contact tonometer (Huvitz HNT-1P, Seoul, South Korea). The instrument was calibrated according to the manufacturer's specifications before measurement sessions. IOP measurements were recorded in millimeters of mercury (mmHg).

All baseline measurements were performed between 2:00 PM and 4:00 PM to minimize the influence of diurnal variation in IOP.

Pharmacological dilation

Pupil dilation was induced using a combination of tropicamide 0.8% and phenylephrine hydrochloride 5%. The drops were administered at 15-minute intervals for three consecutive applications according to the clinical protocol used in the study.

Following administration, participants remained in the examination room for approximately 40–45 minutes to allow adequate pharmacological mydriasis.

Post-dilation assessment

IOP was reassessed 40–45 minutes after pharmacological dilation using the same non-contact tonometer and measurement procedure used for baseline assessment.

The pre- and post-dilation values were subsequently compared within and between the three study groups.

Statistical analysis

Data were entered and managed using Microsoft Excel, while statistical analysis was performed using IBM SPSS Statistics version 26 (Armonk, New York, USA). Descriptive statistics were calculated using means, standard deviations, frequencies, and percentages.

Paired t-tests were used to compare pre- and post-dilation IOP within each group. Independent-samples t-tests were used for comparisons between groups, including cataract versus pseudophakic, pseudophakic versus young adult, and cataract versus young adult groups. Kruskal–Wallis tests were also performed as a non-parametric analysis. Sex-based comparisons were conducted using independent-samples t-tests.

A p-value of less than 0.05 was considered statistically significant.

Results

A total of 128 eyes were included in the study. The cataract group consisted of 56 eyes, the pseudophakic group consisted of 44 eyes, and the young adult group consisted of 28 eyes. The mean age of the participants was 65.15 ± 10.68 years in the cataract group, 68.00 ± 9.70 years in the pseudophakic group, and 33.14 ± 6.15 years in the young adult group.

The cataract group included 23 males and 33 females, while the pseudophakic group included 18 males and 26 females. The young adult group included 12 males and 16 females. There was no statistically significant difference in sex distribution among the three groups ($\chi^2 = 1.574$, $p = 0.456$). The cataract and pseudophakic groups were comparable in age, whereas the young adult group was significantly younger than both older groups ($p < 0.001$).

Table 1. Demographic Characteristics of the Study Groups

Characteristic	Cataract Group	Pseudophakic Group	Young Adult Group
Number of eyes	56	44	28
Male	23	18	12
Female	33	26	16
Mean age ± SD (years)	65.15 ± 10.68	68.00 ± 9.70	33.14 ± 6.15
Age range (years)	45–82	48–85	20–45

IOP changes in cataract eyes

The mean baseline IOP in the cataract group was 16.17 ± 2.85 mmHg. Following pharmacological dilation, the mean IOP increased to 17.52 ± 3.75 mmHg. The mean increase was therefore 1.35 mmHg and was statistically significant ($p = 0.034$).

The magnitude of individual IOP increases ranged from 1 to 4 mmHg. Sex-based analysis showed similar baseline IOP between males and females. Male participants had a baseline IOP of 16.00 ± 3.03 mmHg compared with 16.30 ± 2.76 mmHg in females ($p = 0.699$). Post-dilation IOP was 17.32 ± 3.69 mmHg in males and 17.66 ± 3.84 mmHg in females ($p = 0.741$).

The Kruskal–Wallis analysis produced a borderline result ($H = 3.554$, $p = 0.059$).

IOP changes in pseudophakic eyes

The pseudophakic group demonstrated a mean baseline IOP of 14.81 ± 2.90 mmHg. Following pharmacological dilation, the mean IOP was 14.86 ± 3.24 mmHg.

The mean increase was only 0.05 mmHg and was not statistically significant ($p = 0.944$). The non-parametric analysis similarly demonstrated no significant difference ($H = 0.097$, $p = 0.754$).

Baseline IOP was 14.66 ± 3.27 mmHg among males and 14.92 ± 2.68 mmHg among females ($p = 0.777$). Following dilation, male IOP was 13.61 ± 2.25 mmHg compared with 15.73 ± 3.57 mmHg in females ($p = 0.031$).

IOP changes in young adults

Young adults demonstrated the greatest mean increase in IOP among the three groups. Mean baseline IOP was 16.67 ± 2.34 mmHg and increased to 18.46 ± 3.24 mmHg following pharmacological dilation.

The mean increase of 1.79 mmHg was statistically significant (p = 0.021). Individual increases ranged from 1 to 6 mmHg.

A significant sex-related difference was observed. Male participants demonstrated a baseline IOP of 18.00 ± 1.85 mmHg compared with 15.68 ± 2.21 mmHg in females (p = 0.007). Following dilation, IOP was 20.08 ± 3.67 mmHg in males and 17.25 ± 2.32 mmHg in females (p = 0.019).

The Kruskal–Wallis analysis produced a borderline result (H = 3.582, p = 0.058).

Table 2. Comparison of IOP Before and After Pharmacological Mydriasis

Group	Pre-dilation IOP (mmHg)	Post-dilation IOP (mmHg)	Mean change	p-value
Cataract	16.17 ± 2.85	17.52 ± 3.75	+1.35 mmHg	0.034*
Pseudophakic	14.81 ± 2.90	14.86 ± 3.24	+0.05 mmHg	0.944
Young adults	16.67 ± 2.34	18.46 ± 3.24	+1.79 mmHg	0.021*

*Statistically significant at p < 0.05.

Between-group comparison

Pre-dilation IOP was significantly higher in cataract eyes than in pseudophakic eyes, with mean values of 16.17 ± 2.85 and 14.81 ± 2.90 mmHg, respectively (p = 0.021). Following dilation, the difference increased, with IOP values of 17.52 ± 3.75 mmHg in cataract eyes and 14.86 ± 3.24 mmHg in pseudophakic eyes (p = 0.0003).

Young adults also demonstrated significantly higher baseline IOP than pseudophakic eyes (16.67 ± 2.34 vs. 14.81 ± 2.90 mmHg; p = 0.005). Following dilation, the difference was greater, with young adults demonstrating an IOP of 18.46 ± 3.24 mmHg compared with 14.86 ± 3.24 mmHg in pseudophakic eyes (p < 0.001).

Baseline IOP did not differ significantly between cataract eyes and young adults (16.17 ± 2.85 vs. 16.67 ± 2.34 mmHg; p = 0.425). Although post-dilation IOP was higher in young adults than cataract eyes (18.46 ± 3.24 vs. 17.52 ± 3.75 mmHg), the difference was not statistically significant (p = 0.263).

Table 3. Between-Group Comparison of IOP

Comparison	Mean IOP (mmHg)	p-value
Cataract vs. pseudophakic, pre-dilation	16.17 ± 2.85 vs. 14.81 ± 2.90	0.021*
Cataract vs. pseudophakic, post-dilation	17.52 ± 3.75 vs. 14.86 ± 3.24	0.0003*
Pseudophakic vs. young adults, pre-dilation	14.81 ± 2.90 vs. 16.67 ± 2.34	0.005*
Pseudophakic vs. young adults, post-dilation	14.86 ± 3.24 vs. 18.46 ± 3.24	<0.001*
Cataract vs. young adults, pre-dilation	16.17 ± 2.85 vs. 16.67 ± 2.34	0.425
Cataract vs. young adults, post-dilation	17.52 ± 3.75 vs. 18.46 ± 3.24	0.263

*Statistically significant.

Central corneal thickness

Central corneal thickness was not measured before or after pharmacological dilation in the present study. Therefore, the potential influence of corneal thickness on IOP measurements could not be evaluated.

Discussion

The present study demonstrated that pharmacological mydriasis produced different IOP responses among cataract, pseudophakic, and young adult eyes. The most prominent increase was observed in young adults, followed by cataract eyes, whereas pseudophakic eyes demonstrated minimal change.

The significant increase of 1.79 mmHg observed in young adults is consistent with previous reports describing transient increases in IOP following pharmacological pupil dilation. Kim et al. reported an IOP elevation of approximately 1.85 ± 2.01 mmHg in normal subjects following pharmacological dilation. [5] Similarly, Qian et al. reported mean pre- to post-dilation changes of 1.1 mmHg in the right eye and 0.7 mmHg in the left eye. [7] The magnitude observed in the present young adult group therefore falls within the range reported previously.

The response observed in cataract eyes was also significant, with a mean increase of 1.35 mmHg. This finding supports previous observations that pharmacological mydriasis can produce a measurable increase in IOP in natural-lens eyes. The presence of a crystalline lens may influence anterior chamber configuration and the relationship between the iris, ciliary body, and trabecular meshwork.

One of the most notable findings was the minimal change in IOP among pseudophakic eyes. The mean increase was only 0.05 mmHg and was not statistically significant. This response differed considerably from that observed in both natural-lens groups.

One possible explanation is the anatomical alteration produced by cataract extraction and IOL implantation. Cataract surgery may deepen the anterior chamber and widen the anterior chamber angle, potentially improving aqueous humour outflow. Changes in the relationship between the IOL, iris, ciliary body, and trabecular meshwork may also influence the response to pharmacological dilation.

However, the present study did not include anterior chamber depth, angle measurements, or other anterior segment imaging parameters. Therefore, these mechanisms remain possible explanations rather than demonstrated causes.

A previous study by Gharieb Ibrahim investigated the effect of pharmacological mydriasis in eyes with filtering blebs and reported a different pressure response, emphasizing the potential influence of altered aqueous outflow pathways on post-dilation IOP. [8] Although pseudophakia does not create an alternative drainage pathway, the anatomical changes associated with cataract extraction may influence aqueous dynamics.

Sex-related differences were also observed, particularly among young adults. Males demonstrated significantly higher baseline and post-dilation IOP than females. This finding is consistent with population-based evidence showing higher average IOP among males. Liu et al., in a nationwide study involving 284,937 adults, reported higher mean IOP among males compared with females. [6]

The mechanisms underlying sex-related differences in IOP remain uncertain and may involve ocular anatomical differences, hormonal influences, aqueous humour dynamics, and corneal biomechanical properties.

The comparison between cataract and young adult groups was also interesting. Although the two groups differed substantially in age, their baseline IOP values were not significantly different. Following dilation, young adults demonstrated a somewhat greater mean IOP than cataract eyes, although this difference was not statistically significant.

The observed differences may reflect a combination of age-related anatomical changes, lens status, baseline IOP, and individual variation in aqueous humour dynamics. Because age and lens status were not independently controlled in the present study, further research is required to determine their separate contributions.

From a clinical perspective, these findings indicate that the response to mydriatic agents should not necessarily be assumed to be uniform across all patients. Young adults with clear natural lenses demonstrated the greatest average pressure increase, while pseudophakic eyes demonstrated minimal change. Nevertheless, individual clinical assessment remains important, particularly among patients with elevated baseline IOP, glaucoma risk factors, suspicious optic nerve findings, or other ocular abnormalities.

The findings should not be interpreted as evidence that pseudophakic patients are universally protected from mydriasis-related IOP elevation. Rather, the present data demonstrate a minimal average response within this study population. Larger studies with standardized anatomical measurements are required to determine whether this finding is reproducible.

Limitations

The study has several limitations. First, IOP was measured only once after dilation, approximately 40–45 minutes after administration of the mydriatic agents. Therefore, the complete time course of IOP change could not be evaluated. Serial measurements over several hours would help determine the peak and duration of the pressure response.

Second, the sample size of some groups was relatively small, particularly the young adult and pseudophakic groups. Larger studies may provide greater statistical power and improve generalizability.

Third, the young adult group was substantially younger than the cataract and pseudophakic groups. Therefore, the effects of age and lens status cannot be completely separated.

Fourth, anterior segment imaging was not performed. Measurements of anterior chamber depth, angle width, and anterior chamber volume using anterior segment OCT or Scheimpflug imaging could provide additional information regarding the anatomical mechanisms responsible for differences between groups.

Central corneal thickness was also not assessed, although corneal thickness and biomechanics may influence measured IOP.

In addition, systemic variables such as blood pressure and heart rate were not systematically evaluated. These factors may be relevant because phenylephrine has sympathomimetic properties.

Finally, pseudophakic eyes were not stratified according to IOL material, design, position, or time since cataract surgery. These factors may potentially influence anterior segment anatomy and aqueous humour dynamics.

Conclusion

Pharmacological mydriasis produced different changes in intraocular pressure among cataract, pseudophakic, and young adult eyes. Young adults with clear natural lenses demonstrated the greatest mean IOP increase of 1.79 mmHg, while cataract eyes demonstrated a significant increase of 1.35 mmHg. In contrast, pseudophakic eyes showed

minimal change, with an average increase of only 0.05 mmHg.

The findings suggest that lens status and demographic characteristics may influence the IOP response to pharmacological dilation. The minimal pressure change observed in pseudophakic eyes is an interesting finding that requires confirmation through larger and anatomically controlled studies.

Pharmacological mydriasis remains an important component of comprehensive ophthalmic examination; however, clinicians should consider baseline IOP, age, lens status, and individual glaucoma risk when assessing patients undergoing pupil dilation.

Conflict of Interest

The authors declare that they have no conflict of interest related to this study, its findings, or the publication of this manuscript.

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