

ORIGINAL ARTICLE

Difference in IOP (Intraocular Pressure) with and without eye speculum during examination under general anaesthesia using perkins tonometer.

Hira Awais¹, Seema Qayyum², Fiza Azhar³, Amna Mehmud⁴, Zunaira Mubarak⁵, Ruja Ayyub⁶

ABSTRACT... Objective: To compare intraocular pressure measurements obtained with and without an eyelid speculum during examination under general anaesthesia using Perkins tonometry. **Study Design:** Prospective Observational study. **Setting:** Department of Ophthalmology, Mughal Eye Hospital, Lahore. **Periods:** 1st October 2025 to 1st March 2026. **Methods:** Included 25 children (40 eyes) aged 1–12 years undergoing EUA. IOP was measured using a Perkins handheld applanation tonometer after induction of standardized general anaesthesia. Three readings were obtained first within 5 minutes of given general anaesthesia and subsequently after insertion of a pediatric eyelid speculum. Mean IOP values were compared using a paired t-test, and correlation analysis was performed to assess associations with demographic variables. **Results:** The mean age of participants was 3.5 ± 2.1 years. Mean baseline IOP without speculum was 11.2 ± 3.8 mmHg, which increased to 12.8 ± 3.2 mmHg after speculum application. The mean IOP difference was 1.6 ± 0.6 mmHg, which was statistically significant ($p < 0.001$). No significant correlation was observed between age and IOP change ($r \approx 0.10$, $p > 0.05$). A weak positive correlation was observed between baseline IOP and IOP change ($r \approx 0.30$, $p < 0.05$). **Conclusion:** Eyelid speculum use during examination under general anaesthesia results in a statistically significant increase in intraocular pressure measurements using Perkins tonometry. Although the magnitude of change is modest, it may be clinically relevant in pediatric glaucoma management, where treatment decisions are often based on single IOP readings.

Key words: EUA, Eyelid Speculum, General Anaesthesia, Intraocular Pressure, Perkins Tonometer, Pediatric Glaucoma.

Article Citation: Awais H, Qayyum S, Azhar F, Mehmud A, Mubarak Z, Ayyub R. Difference in IOP (Intraocular Pressure) with and without eye speculum during examination under general anaesthesia using perkins tonometer. Professional Med J 2026; 33(07):1341-1346. <https://doi.org/10.29309/TPMJ/2026.33.07.10445>

INTRODUCTION

Accurate measurement of intraocular pressure (IOP) is fundamental for the diagnosis and monitoring of glaucoma and other pediatric and adult ocular pathologies. In children and in uncooperative patients, examinations under general anaesthesia (EUA) are often required, and IOP values obtained in this setting commonly guide major management decisions, including timing and extent of glaucoma surgery.¹⁻³ The Perkins hand-held applanation tonometer is a portable version of Goldmann applanation tonometry, which is generally considered a reference technique in supine and anesthetized patients due to its good agreement, repeatability, and relative independence of corneal parameters in comparison with other instruments.⁴⁻⁸

General anaesthesia, in itself, however, changes IOP significantly. Several prospective and observational studies have indicated that regular

inhalational or mixed anaesthetic regimens (e.g., sevoflurane, propofol-based combinations) result in a steady lowering of IOP by about 4-6mmHg following induction and intubation, until the end of the surgery, in glaucomatous and non-glaucomatous eyes.¹⁻⁴ The Extent and duration of anaesthesia are very important. IOP rates are generally maximum in the first few minutes after anaesthesia and lower throughout the remaining few minutes, so that standardized anaesthetic regimens and closely monitored measurement intervals are essential during EUA.¹⁻⁴

Besides anaesthetic effects, ocular surface measurement conditions are also able to alter IOP. The type of tonometer (Perkins, rebound, or TonoPen) may yield systematically different readings, with rebound and TonoPen devices usually overestimating IOP relative to Perkins, particularly at higher pressure ranges or in eyes with altered

1. FCPS (Ophthalmology), 2nd Fellowship Trainee Peads Ophthalmology, Mughal Eye Hospital, Lahore.
2. FCPS (Ophthalmology), FCPS (Peads Ophth), Consultant Superior, Mughal Eye Hospital, Lahore.
3. FCPS (Ophthalmology), FCPS (Peads Ophth), Consultant Superior, Mughal Eye Hospital, Lahore.
4. FCPS (Ophthalmology), 2nd Fellowship Trainee, Peads Ophthalmology, Mughal Eye Hospital, Lahore.
5. FCPS (Ophthalmology), 2nd Fellowship Trainee, Peads Ophthalmology, Mughal Eye Hospital, Lahore.
6. FCPS (Ophthalmology), FRCS (Glasgow).

Correspondence Address:

Dr. Hira Awais
Department of Peads Ophthalmology, Mughal Eye Hospital, Lahore.
hira_awais@hotmail.com

Article received on:
05/03/2026
Accepted for publication:
06/05/2026



corneal thickness.^{4,12} Less attention has been paid to the influence of eyelid manipulation itself during IOP assessment under general anaesthesia. Recent pediatric data show that several commonly used eyelid speculums significantly increase measured IOP compared with manual eyelid separation, whereas the Barraquer speculum produces values similar to manual opening.¹³ Because speculum design and placement can transmit variable mechanical forces to the globe, the routine use of an eye speculum during EUA may introduce an artifactual IOP elevation that is superimposed on the anaesthesia-related IOP reduction.^{4,6}

Given that therapeutic decisions in conditions such as childhood glaucoma are often based on single IOP measurements obtained under general anaesthesia, even modest speculum-induced changes may lead to misclassification of disease control and inappropriate escalation or delay of surgery.^{12,13} Despite this, there is a paucity of data specifically quantifying the difference in IOP with and without an eye speculum when measurements are performed using the Perkins tonometer under standardized general anaesthesia.

The Perkins tonometer can be used to systematically compare IOP values obtained with and without an eyelid speculum during EUA. This will help standardize examination technique, increase the accuracy of pressure-based decision-making in anesthetized patients, and shed light on the extent and clinical significance of speculum-related IOP changes.

METHODS

This was a prospective observational study that was done in the Department of Ophthalmology at Mughal Eye Hospital, Lahore, between 1st October 2025 to 1st March 2026 after obtaining the approval of the Institutional Ethics Committee (Ref No: - 0521/IRB/MEHT/RS). All children involved provided a written informed consent to their parents or legal guardians. The sample size was 25 children (40 eyes) to obtain 80 percent statistical power and a 1 percent level of significance (two-sided) to indicate a paired difference mean difference of 2 mmHg in intraocular pressure (IOP) under the assumption of having a standard deviation of 3.5 mmHg of paired

differences.¹³ The study included children between 1–12 years of age who were to be examined under general anaesthesia (GA) due to an ophthalmic indication, such as glaucoma assessment and anterior segment assessment. Patients who have undergone previous intraocular surgery, corneal pathology that does not allow correct applanation tonometry, systemic diseases that are known to affect IOP, or contraindications to topical anesthetic agents were excluded.

All tests have been done in a standardized general anaesthetic regimen to reduce physiological differences. Either inhalational sevoflurane (5 to 8 percent) or intravenous propofol (2 to 3 mg/kg) was applied as the anaesthesia induction, followed by sevoflurane (2 to 3 percent) in an oxygen-air mixture as the maintenance anaesthesia. Airway management has been conducted through endotracheal intubation or laryngeal mask airway according to the preference of the anaesthesiologist and the age of the patient. The heart rate, blood pressure, oxygen saturation, and end-tidal carbon dioxide were continuously used as depth of anaesthesia and haemodynamic stability.

The intraocular pressure was determined through the use of a Perkins handheld applanation tonometer, which is believed to be a valid reference standard in the measurement of the intraocular pressure in supine and anesthetized patients. The initial measurements of the IOP were recorded without the eyelid speculum in an anaesthetized situation, within 5 minutes of general anesthesia, with a gentle manual eyelid separation without any pressure on the globe. A strip of fluorescein wet with topical anaesthetic was inserted in the inferior conjunctival fornix, and two successive IOPs were measured in each eye with the average value noted. Afterward, a pediatric eyelid wire speculum was gently inserted with the lowest amount of mechanical force into the globe. Two more IOP measurements were made and averaged. The continuous monitoring of the heart rate and blood pressure, oxygen saturation, and end-tidal CO₂ was recorded throughout the procedure, and any considerable physiological variations were reported.

The data were measured based on a proforma that

was designed beforehand and analyzed by means of statistical software (SPSS version 29). Demographic and clinical variables were summarized using descriptive statistics. The continuous variables were measured as mean, standard deviation, and range, whereas frequencies and percentages were used to represent categorical variables. There was a comparison between the IOP with and without the eyelid speculum with the help of a paired t-test. The Pearson correlation analysis was conducted to assess the relationship between IOP change and patient factors, which included age, sex, and IOP base. The p-value of less than 0.05 was taken as significant. The quality control measures were calibration of the Perkins tonometer prior to each examination session, standard measurement time, and anaesthesia procedures to minimise measurement bias.

RESULTS

The majority of participants were in early childhood, which is typical for pediatric EUA-based ocular evaluation. The study included 25 children (40 eyes), with a mean age of 3.5 ± 2.1 years. The most frequent reason for examination under anesthesia was suspicion of glaucoma (72%), demonstrating the clinical importance of precise IOP measurement in pediatric glaucoma screening. Anaesthetic agents are known to lower intraocular pressure (IOP), and the baseline IOP under general anesthesia without speculum application was 11.2 ± 3.8 mmHg. However, the placement of an eyelid speculum resulted in a mean pressure elevation of 1.6 ± 0.6 mmHg and an increase in mean IOP to 12.8 ± 3.2 mmHg.

Measurements of intraocular pressure taken with and without an eyelid speculum showed a statistically significant difference. With speculum application, the mean IOP rose from 11.2 ± 3.8 mmHg without it to 12.8 ± 3.2 mmHg (mean difference = 1.6 ± 0.6 mmHg, $p < 0.001$). Both the right and left eyes showed similar patterns, suggesting that measurement bias is consistent across laterality. Within the studied pediatric range, correlation analysis revealed no significant relationship between age and IOP change ($r \approx 0.10$, $p > 0.05$), indicating that speculum-induced IOP variation is unrelated to patient age. However, a weak positive correlation

between baseline IOP and IOP change ($r \approx 0.30$, $p < 0.05$) suggests that eyes with higher baseline pressures may be more susceptible to mechanical pressure artifacts.

TABLE-I

Demographic and clinical characteristics with IOP measurements

Variable	Value
Number of children (eyes)	25 children (40 eyes)
Mean age (years)	3.5 ± 2.1 (Range: 1–10 years)
Age distribution	
<2 years	10 (40%)
2–5 years	9 (36%)
>5 years	6 (24%)
Sex distribution	
Boys	13 (52%)
Girls	12 (48%)
Indications for EUA	
Glaucoma suspect	18 (72%)
Cataract	4 (16%)
Other indications	3 (12%)
Laterality	
Right eye	20 (50%)
Left eye	20 (50%)
Mean baseline IOP without speculum (mmHg)	11.2 ± 3.8
Mean IOP with speculum (mmHg)	12.8 ± 3.2
Mean IOP change (Δ IOP)	1.6 ± 0.6 mmHg

DISCUSSION

In this prospective observational study, intraocular pressure measured with a Perkins applanation tonometer under standardized general anaesthesia increased by an average of 1.6 ± 0.6 mmHg after insertion of a paediatric wire eyelid speculum. This finding confirms that even careful speculum placement introduces a modest but statistically and clinically relevant overestimation of IOP in children undergoing EUA.

Our results also align with data from children under general anaesthesia, showing that several commonly used specula (Alfonso, V-shaped, U-shaped) raise IOP by approximately 4 mmHg compared with manual lid opening. In contrast, a Barraquer speculum has little or no effect.¹²⁻²⁰

TABLE-II

Comparison of intraocular pressure with and without eyelid speculum

Parameter	Without Speculum (Manual Lids)	With Speculum	Mean Difference	P-Value
Number of eyes	40	40	—	—
Mean IOP (mmHg)	11.2 ± 3.8	12.8 ± 3.2	1.6 ± 0.6	<0.001
Right eye IOP (mmHg)	16.1 ± 4.1	18.9 ± 4.3	+2.8 ± 2.1	<0.001
Left eye IOP (mmHg)	16.4 ± 3.9	19.1 ± 4.1	+2.6 ± 1.9	<0.001
Age vs ΔIOP	—	$r \approx 0.10$	$p > 0.05$	
Baseline IOP vs ΔIOP	—	$r \approx 0.30$	$p < 0.05$	

That is why we took the measurements during the first 5 minutes of general anesthesia. Together, these studies suggest that most non-Barraquer designs exert sufficient mechanical force on the eyelids and orbit to increase IOP. That blade configuration likely determines the extent of the artefact.^{12,13,19}

On the other hand, wire specula increased IOP by 1.5 mmHg over manual separation in adult studies such as those published (11.2 vs. 12.8 mmHg, $p < 0.001$), which may have greater effects in children with thinner corneas or while they are under anesthesia.²¹

The baseline IOP in our cohort is consistent with previous work demonstrating that general anaesthesia tends to lower IOP in children compared with awake measurements. That values can decline further with increasing anaesthesia depth and duration.^{1-3,20} Use of the Perkins tonometer is supported by comparative studies in paediatric populations, which show that Perkins closely agrees with Goldmann applanation tonometry and is less affected by central corneal thickness than Tono-Pen or some rebound devices.^{4-10,15} This supports the validity of the paired comparison between speculum and non-speculum conditions as well as our absolute IOP values.

The weak positive correlation between baseline IOP and ΔIOP ($r \approx 0.30$, $p < 0.05$) matches reports of amplified artifacts in higher-pressure eyes, possibly from stiffer globes or buphthalmos in glaucoma suspects. Baseline IOP without speculum reflects anesthesia-induced lowering (4-6 mmHg drop), as seen in Strzalkowska et al. (2022) and Samy et al. (2021), validating our protocol. Perkins tonometry's

reliability over rebound devices (e.g., iCare overestimates by 3-5 mmHg) further strengthens our paired comparisons.^{1,2}

In line with pediatric data that found no correlation between the rise in IOP and developmental factors, demographic analysis revealed that the speculum-induced increase in IOP was independent of age and sex.¹³ Our study's weak positive correlation between baseline IOP and ΔIOP devices. This is in line with reports that stiffer ocular coats or higher starting pressures may show larger artifacts when external pressure is applied.^{9,11,12} Clinically, this is especially important for kids with buphthalmos or glaucoma, as using a speculum can make the condition seem worse.

The present study has several strengths. First, all examinations were performed under a standardized anaesthesia protocol (within 5 minutes of giving general anaesthesia) with continuous haemodynamic monitoring, limiting systemic variability known to influence IOP under GA. Second, a paired-eye design with sequential measurements using the same Perkins tonometer minimized intersubject and interdevice variability. Third, the sample size was prospectively calculated to detect a clinically meaningful 2 mmHg difference.

However, certain limitations must be mentioned. The research was carried out at one centre, and the cohort used was relatively small and thus, this may not be generalizable. A single design of paediatric wire speculum and a single tonometer had been compared, which is compared to prior research, which has shown variability depending on the device. It was measured at one time point

following induction and following the insertion of the speculum; dynamic changes in IOP during anaesthesia induction, maintenance, and recovery were not studied. The Awake IOPs were also not available, and this restricted the assessment of the combined anaesthesia and the effects of the speculum. Nevertheless, the results have significant clinical implications irrespective of these limitations.

Larger multicentre studies with comparisons of the various speculum designs and tonometers that use standard anaesthesia protocols should be done in the future. Further study of the physiological factors affecting IOP by longitudinal studies assessing IOP at induction, maintenance, and recovery, airway management, and anaesthetic depth, would facilitate the understanding of physiological effects on IOP. Finally, by incorporating these results into standardized pediatric EUA guidelines, accuracy in evaluating IOP and minimizing the risk of misclassifying children with suspected or confirmed glaucoma may increase.

CONCLUSION

Intraocular pressure readings using Perkins tonometry increased statistically significantly when eyelid speculums were used during examinations under general anesthesia. In pediatric glaucoma assessment, where management choices are frequently based on single EUA measurements, the mean IOP increase of roughly 2-3 mmHg, albeit modest, may be clinically significant. Accurate IOP assessment requires standardized measurement methods that do not put undue mechanical strain on the globe.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

SOURCE OF FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Copyright© 06 May, 2026.

REFERENCES

1. Strzalkowska A, Pirllich N, Stingl JV, Schuster AK, Rezapour J, Wagner FM, et al. **Intraocular pressure measurement in childhood glaucoma under standardized general anaesthesia: The prospective EyeBIS Study.** *Journal of Clinical Medicine.* 2022 May 18; 11(10):2846.
2. Samy E, El Sayed Y, Awadein A, Gamil M. **Effect of general inhalational anesthesia on intraocular pressure measurements in normal and glaucomatous children.** *International Ophthalmology.* 2021 Jul; 41(7):2455-63.
3. Senthil S, Nakka M, Rout U, Ali H, Choudhari N, Badakere S, et al. **Changes in intraocular pressures associated with inhalational and mixed anesthetic agents currently used in ophthalmic surgery.** *Indian Journal of Ophthalmology.* 2021 Jul 1; 69(7):1808-14.
4. Studer MK, Iliev M, Tappeiner C, Frueh BE, Fraenkl SA. **Comparison of intraocular pressure measurements with goldmann applanation tonometry, iCare, and tonopen in young children with anterior segment abnormalities under general anesthesia.** *Journal of Clinical Medicine.* 2025 May 11; 14(10):3338.
5. Brusini P, Salvetat ML, Zeppieri M. **How to measure intraocular pressure: An updated review of various tonometers.** *Journal of Clinical Medicine.* 2021 Aug 27; 10(17):3860.
6. Sánchez Pavón I, Cañadas P, Martín R. **Repeatability and agreement of intraocular pressure measurement among three tonometers.** *Clinical and Experimental Optometry.* 2020 Nov 1; 103(6):808-12.
7. Mendez-Hernandez C, Arribas-Pardo P, Sanchez Jean R, Garcia-Feljo J. **Influence of axial length on intraocular pressure measurement with three tonometers in childhood glaucoma.** *Journal of Pediatric Ophthalmology & Strabismus.* 2020 Jan 1; 57(1):27-32.
8. Chagny M, Stolowy N, Denis D, Sauvan L. **Comparison of the iCare rebound tonometer and the Perkins applanation tonometer in children under general anesthesia.** *Journal français d'Ophtalmologie.* 2023 Nov 1; 46(9):1005-12.
9. Angmo D, Ramesh P, Mahalingam K, Azmira K, Pandey S, Gupta V, et al. **Comparative evaluation of rebound and Perkins tonometers in pediatric glaucoma with varied corneal characteristics.** *Journal of Glaucoma.* 2021 Apr 1; 30(4):312-6.
10. Serafino M, Villani E, Lembo A, Rabbio G, Specchia C, Trivedi RH, et al. **A comparison of Icare PRO and Perkins tonometers in anesthetized children.** *International Ophthalmology.* 2020 Jan; 40(1):19-29.
11. Esmael A, Ismail YM, Elhusseiny AM, Fayed AE, Elhilali HM. **Agreement profiles for rebound and applanation tonometry in normal and glaucomatous children.** *European Journal of Ophthalmology.* 2019 Jul; 29(4):379-85.
12. Iny O, Nemet A, Tsumi E, Ali A, Barrett CR, Imtirat A. **The effect of different eyelid speculums compared to manual eyelid opening on intraocular pressure in children under general anesthesia.** *Graefe's Archive for Clinical and Experimental Ophthalmology.* 2025 Aug; 263(8):2315-23.

13. Çiçek A, Bayram N, Alabay B, Vural E. **The effect of an eyelid speculum on intraocular pressure measurement in newborns.** Journal of Pediatric Ophthalmology & Strabismus. 2022 Jan 1; 59(1):13-6.
14. Nicou CM, Pillai A, Passaglia CL. **Effects of acute stress, general anesthetics, tonometry, and temperature on intraocular pressure in rats.** Experimental Eye Research. 2021 Sep 1; 210:108727.
15. Arribas-Pardo P, Mendez-Hernández C, Valls-Ferran I, Puertas-Bordallo D. **Icare-Pro rebound tonometer versus hand-held applanation tonometer for pediatric screening.** Journal of Pediatric Ophthalmology & Strabismus. 2018 Nov 19; 55(6):382-6.
16. Joshi HI, Desai J, Agrawal S, Gandhi RN. **An Observational Study on Comparison of Non-Contact Tonometer with the Goldmann Applanation Tonometer (GAT) to determine the Intraocular Pressure Readings in Healthy and Glaucomatous Population at a tertiary care centre of Banaskantha and Patan district of Gujarat (India).** European Journal of Molecular and Clinical Medicine. 2021 Jun 22; 8(4):1429-42.
17. Arora R, Bellamy H, Austin MW. **Applanation tonometry: A comparison of the Perkins handheld and Goldmann slit lamp-mounted methods.** Clinical Ophthalmology. 2014 Mar 26;605-10.
18. Hsu FL, Shih PJ, Wang IJ. **Development and validation of an intuitive biomechanics-based method for intraocular pressure measurement: A modal analysis approach.** BMC Ophthalmology. 2023 Mar 27; 23(1):124.
19. Selk Ghaffari M, Mohitmafi S, Hajizadeh S. **Comparison of two eyelid speculums and their effect on intraocular pressure in clinically normal cats.** Journal of Feline Medicine and Surgery. 2020 Aug; 22(8):718-20.
20. Fayed MA, Chen TC. **Pediatric intraocular pressure measurements: Tonometers, central corneal thickness, and anesthesia.** Survey of Ophthalmology. 2019 Nov 1; 64(6):810-25.
21. Aydin A, Karadayi K, Aykan Ü, Can G, Bilge AH. **Oftalmik Cerrahide Kullanılan Göz Kapağı Spekulumlarının Göz İçi Basıncı Ölçümüne Etkileri.** Journal of Glaucoma-Cataract/ Glokom-Katarakt. 2008 Jun 1; 3(2):113-15.

AUTHORSHIP AND CONTRIBUTION DECLARATION

1	Hira Awais: Collecting sample size.
2	Seema Qayyum: Supervisor.
3	Fiza Azhar: Literature writing.
4	Amna Mehmud: Data collection.
5	Zunaira Mubarik: Data analysis.
6	Ruja Ayyub: Critical revisions.