The Effect of Gonioscopic Examination Using a Four-Mirror Goniolens on Intraocular Pressure

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ABSTRACT

Purpose: To evaluate whether gonioscopic examination using a four-mirror goniolens affects intraocular pressure (IOP).

Materials and Methods: This cross-sectional study included one randomly selected eye of 30 patients with primary open-angle glaucoma (POAG) under medical treatment and 27 healthy controls. IOP was measured using a noncontact tonometer (NT), then with a Tono-pen, followed by gonioscopic examination using a four-mirror goniolens (without gel), and finally a second IOP measurement by Tono-pen. We compared NT and Tono-pen measurements obtained before gonioscopic examination, and Tono-pen measurements obtained before and after gonioscopic examination. We evaluated the relationship between the difference in Tono-pen measurements before and after gonioscopy and central corneal thickness (CCT) and palpebral fissure height (PFH).

Results: Mean IOPs in the POAG and control groups were 15.7±3.2 and 16±2.7 mmHg with NT before gonioscopy, 15.3±2.6 and 14.81±2.27 mmHg with Tono-pen before gonioscopy, and 14.9±3.1 and 14.37±2.13 mmHg with Tono-pen after gonioscopy, respectively. In pre-gonioscopic measurements, NT and Tono-pen measurements did not differ significantly in the POAG group ($p>0.05$), whereas NT measurements were higher than Tono-pen measurements in controls ($p<0.05$). The mean change in IOP after gonioscopy was −0.32±1.60 and −0.44±1.69 mmHg in the POAG and control groups, respectively ($p>0.05$). There was no difference in CCT between groups ($p>0.05$), whereas PFH was smaller in controls (9.67±0.73 vs. 10.1±0.55 mm; $p<0.05$). Change in IOP was not correlated with CCT or PFH in either group ($p>0.05$).

Conclusions: Our results indicate that gonioscopic examination using a four-mirror goniolens has no significant effect on IOP in open-angle eyes.

Keywords: Gonioscopy, Intraocular pressure, Glaucoma.

INTRODUCTION

Gonioscopy is a technique used to examine the structures of the anterior chamber drainage angle.[1] Examination of the anterior chamber angle is a fundamental component in the clinical examination of patients with glaucoma or suspected glaucoma.[2] Improvements in gonioscopic lenses and techniques have made the gonioscopy procedure accessible to practitioners for primary eye examination.[1] The Zeiss goniolens is a corneal-type lens with four mirrors that does not require rotation to view different quadrants.[3] Because the contact area is smaller (9 mm) and the surface is flatter than the cornea, it can be used for indentation or compression in angle-closure glaucoma.[1]

It is suspected that compression by hand[4] or eyelid speculum[5] and headband tension from goggles[6] can increase orbital tissue pressure and compress the globe, resulting in sustained intraocular pressure elevation.[7] On the other hand, it has been observed that IOP values decrease in repeated measurements made with applanation.[8-11] Various potential reasons for this reduction in IOP have been discussed, including the patient relaxing[8] or aqueous humor being pressed out of the anterior chamber.[12]

Based on this, we supposed that pressure inadvertently applied to the globe by the examiner during gonioscopy could cause IOP to increase or, contrarily, may cause IOP to decrease by pressing aqueous humor from the anterior chamber. Therefore, in this study we aimed to evaluate the effect of gonioscopic examination using a four-mirror goniolens on intraocular pressure in patients with primary open-angle glaucoma receiving medical treatment. In

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this study, intraocular pressure values were measured before and after gonioscopy, the difference between these measurements was determined, and the relationship between this difference and central corneal thickness (CCT) and palpebral fissure height (PFH) was examined.

MATERIALS AND METHODS

We conducted a cross-sectional study including 30 randomly selected eyes of 30 patients with POAG and 27 randomly selected eyes of 27 healthy control patients evaluated in the ophthalmology outpatient clinic between October 2020 and June 2021. The study was approved by the hospital ethics committee and was carried out in accordance with the principles of the Declaration of Helsinki.

Participants

Thirty eyes of 30 patients under medical treatment in our clinic for primary open-angle glaucoma (POAG) and 27 healthy control subjects were included in the study. Both eyes of each patient were examined and IOPs were measured, but one eye was randomly selected and included in the statistical analysis. For both groups, patients with spherical or cylindrical refractive errors greater than 3 diopters, and patients who did not cooperate with gonioscopy or intraocular pressure measurement by non-contact tonometer or Tono-pen were excluded from the study. Patients with a history of ocular trauma or surgery were also excluded. Patients in the POAG group with known ocular comorbidities other than glaucoma and controls with any ocular disease were excluded.

All patients underwent a detailed eye examination including autorefraction, PFH measurement, visual acuity assessment, slit-lamp anterior segment examination, and undilated fundus examination. The same experienced clinician examined the anterior chamber angle using the Van Herick method during slit-lamp examination and confirmed that the angle was grade 3 or 4.[13]

IOP measurements and gonioscopic examination were performed by the same experienced operator with the patients in sitting position. All measurements were obtained between 9:00 and 12:00 in the morning to minimize the effects of diurnal variation in IOP. In all patients, IOP measurements were first performed using a noncontact tonometer (NT). Four minutes later, a local anesthetic drop (proparacaine hydrochloride 0.5%; Alcaine®, Alcon Laboratories Inc, Fort Worth, TX, USA) was instilled and IOP measurements were repeated with a Tono-pen. Four minutes after the Tono-pen measurement, angle examination in all four quadrants was performed with a Zeiss goniolens. After another 4-minute interval, IOP measurement was repeated with the Tono-pen. Local anesthetic was instilled once and both Tono-pen measurements and gonioscopy were performed under this anesthesia. We compared the NT and Tono-pen measurements obtained before gonioscopy and the Tono-pen measurements obtained before and after gonioscopy. In addition, we evaluated the relationship between the difference in Tono-pen measurements before and after gonioscopy (Δ IOP) and the patients' CCT and PFH values.

CCT was determined using a Sirius topography device (CSO, Firenze, Italy). The average of three consecutive measurements was used in data analyses.

PFH (the distance between the upper eyelid and the lower eyelid) was measured using a caliper with the patient sitting comfortably, eyes open naturally and fixating on a distant point. The average of two consecutive measurements was used in data analyses.

Noncontact tonometer

The NT used in this study was a Canon TX-20P (Canon Corp, Japan). All measurements were performed by the same experienced operator after calibration and in accordance with the manufacturer's instructions. The operator centered the tonometer and obtained measurements using automatic mode. Three consecutive NT measurements were taken for each eye and the average value was used in statistical analysis.

Tono-pen

The Tono-pen Avia (Reichert, NY, USA) was used in this study. This battery-powered device utilizes micro strain gauge technology and has a 1.5 mm transducer tip. Its measurement range is 5 to 55 mmHg according to the user manual. The Tono-pen is calibrated daily and all measurements were performed by the same experienced operator in accordance with the manufacturer's instructions. After instilling local anesthetic, measurements were obtained from the central cornea by gently touching the tip of the Tono-pen to the corneal surface without applying pressure. For each measurement, the device averages 10 readings. Three consecutive measurements were made for each eye and the average of these measurements was used in the statistical analysis.

Gonioscopic examination

Before gonioscopy, the patients were informed about the examination procedure. The clean goniolens was placed on the cornea under topical anesthesia and the lens was held lightly on the eye while examining all four quadrants. We did not use a coupling agent during gonioscopy. Particular attention was paid not to apply pressure to the eye during the examination, and patients who were found to have

Descemet's folds during the examination were excluded from the study.

We used a Zeiss 4-mirror lens, which has a 9-mm diameter corneal surface (radius of curvature 7.72 mm) and requires no coupling agent before placing it on the cornea, making it easy to use for gonioscopic examination. However, the Zeiss lens may have lower reproducibility because it requires a higher skill level.[14]

Statistical analysis

Descriptive statistics were given for continuous variables (mean, standard deviation, median, minimum, maximum). Spearman's correlation analysis was used to analyze the relationship between two nonnormally distributed continuous variables, while Pearson correlation analysis was used for normally distributed continuous variables. Wilcoxon Signed Rank test was used for comparisons of two dependent, nonnormally distributed continuous variables and Mann-Whitney U test was used for comparisons of two independent, nonnormally distributed variables. The level of statistical significance was set at $p < 0.05$. Analyses were performed using SPSS version 24 (IBM Corp, Armonk, NY).

RESULTS

The patients' mean age was 55.7 ± 6.3 (43-66) years in the POAG group and 55.6 ± 6.6 (43-67) years in the control group. The POAG group included 19 women (63.3%) and 11 men (36.7%); the control group included 17 women (63%) and 10 men (37%).

The mean CCT was 530.2 ± 24.9 (460-568) µm in the POAG group and 539.19 ± 29.87 µm in the control group, and the mean PFH was 10.1 ± 0.55 (9-11) mm in the POAG group and 9.67 ± 0.73 mm in the control group. In the POAG group, mean IOP was 15.7 ± 3.2 mmHg with NT before gonioscopy, 15.3 ± 2.6 mmHg with Tono-pen before gonioscopy, and 14.9 ± 3.1 mmHg with Tono-pen after gonioscopy. In the control group, mean IOP was 16 ± 2.7 mmHg with NT before gonioscopy, 14.81 ± 2.27 mmHg with Tono-pen before gonioscopy, and 14.37 ± 2.13 mmHg with Tono-pen after gonioscopy (Figure 1; Table 1). The mean change in IOP was −0.32 ± 1.60 mmHg in the POAG group and −0.44 ± 1.69 mmHg in the control group (Table 1).

There was no significant difference between IOP measurements taken with NT and Tono-pen before gonioscopy ($p = 0.942$) in the POAG group, whereas in the control group, IOP measurements taken with NT before gonioscopy were significantly higher than IOP measurements taken with Tono-pen before gonioscopy ($p = 0.032$; Figure 2). There was no significant difference between Tono-pen measurements obtained before and after gonioscopy in either group ($p = 0.216$ in the POAG group and $p = 0.094$ in the control group; Table 2). Change in IOP after gonioscopy was not significantly correlated with CCT or PFH in either group ($p > 0.05$; Table 3).

DISCUSSION

The results of our study indicate that gonioscopic examination using four-mirror goniolens without use of coupling agent did not cause a significant change in

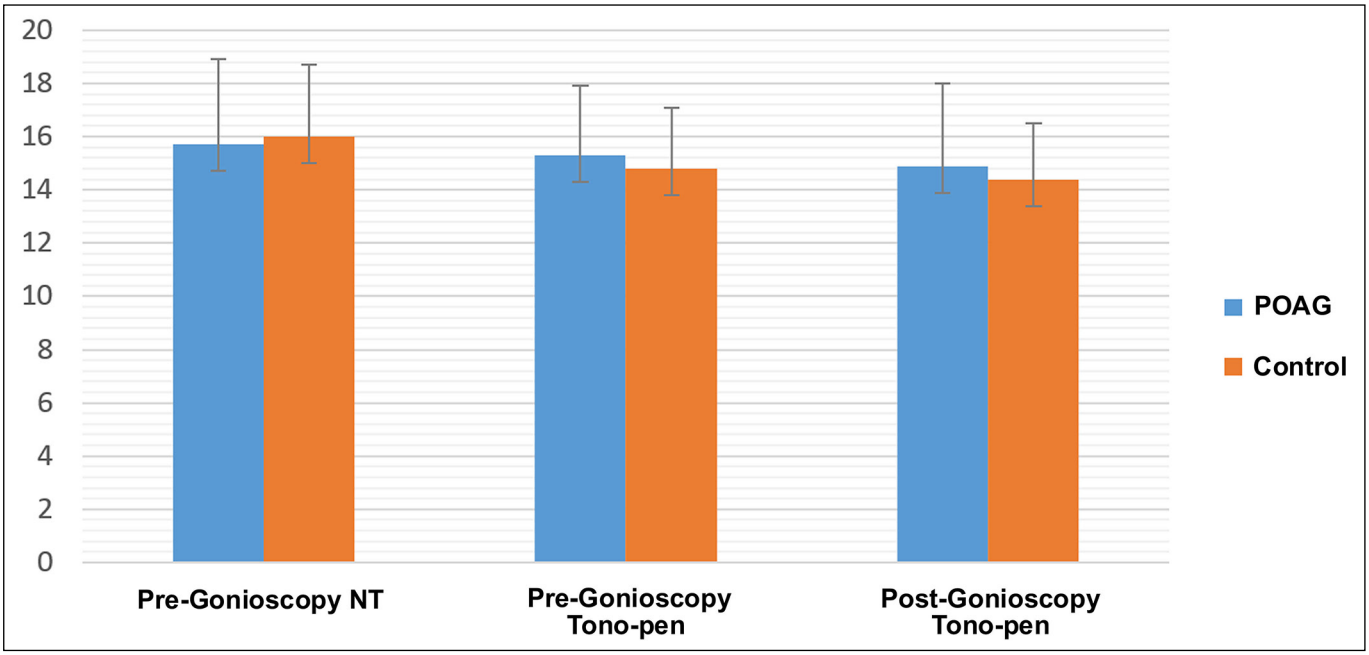

Figure 1: *IOP levels in different measurements.*

Table 1: *Summary of the measurements obtained in the eyes.*

	POAG (n=30)		Control (n=27)		
	Min-Max (Median)	**Mean±SD**	**Min-Max (Median)**	**Mean±SD**	**p**
CCT (µm)	480-568 (540)	530,2±24,9	480-600(543)	539,19±29,87	0,299
PFH (mm)	9-11 (10)	10,1±0,55	9-11(10)	9,67±0,73	**0,011**
Mean IOP (pre-gonioscopy NT)	10-24 (15,5)	15,7±3,2	12-20(16)	16±2,7	0,747
Mean IOP (pre-gonioscopy Tono-pen)	10,3-19 (15,8)	15,3±2,6	11-20(14,33)	14,81±2,27	0,229
Mean IOP (post-gonioscopy Tono-pen)	10-20 (15,3)	14,9±3,1	11,67-19(14,33)	14,37±2,13	0,287
Δ IOP	-3,67-4,00 (0)	-0,32±1,60	-4-4,33(-0,67)	-0,44±1,69	0,791

Mann-Whitney U test, POAG: Primary open angle glaucoma, Min: Minimum, Max: Maximum, SD: Standard deviation, CCT: Central corneal thickness, PFH: Palpebral fissure height, IOP: Intraocular pressure

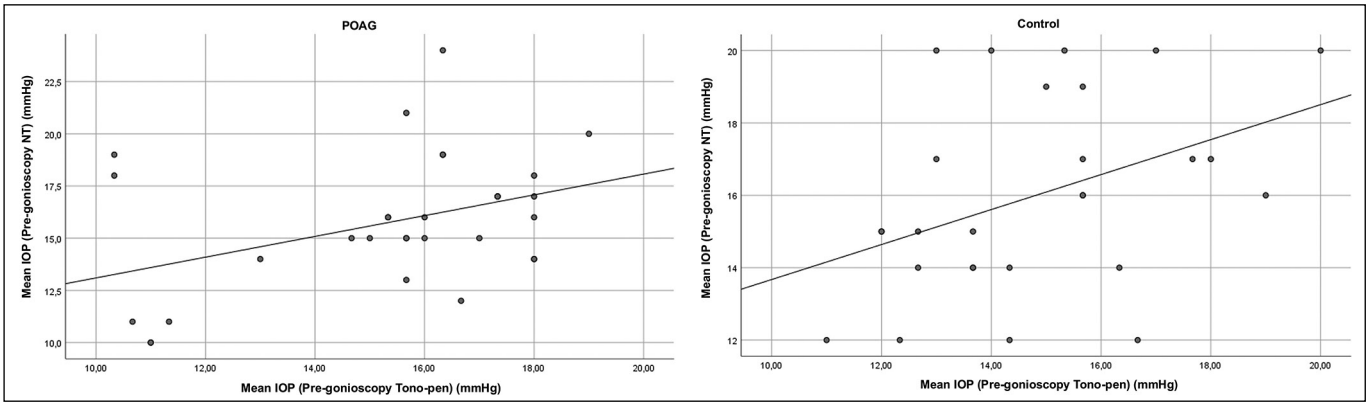

Figure 2: *Mean IOPs taken with different tonometers before gonioscopy.*

Table 2: *Comparison of mean IOP values in different measurements.*

Min-Max (Median) Mean±SD	**Mean IOP** (pre-gonioscopy Tono-pen)	**Mean IOP** (pre-gonioscopy NT)	**Mean IOP** (post-gonioscopy Tono-pen)	**p[1]**	**p[2]**
POAG	10.3-19 (15.8)	10-24 (15.5)	10-20 (15.3)	0.942	0.216
	15.3±2.6	15.7±3.2	14.9±3.1		
Control	11-20(14.33) 14.81±2.27	12-20(16) 16±2.7	11.67-19(14.33) 14.37±2.13	**0.032**	0.094

Wilcoxon test, [1] Pre-gonioscopy Tono-pen vs. Pre-gonioscopy NT, [2] Pre-gonioscopy Tono-pen vs. Post-gonioscopy Tono-pen
POAG: Primary Open Angle Glaucoma , Min: Minimum, Max: Maximum, SD: Standard deviation, IOP: Intraocular pressure, NT: Noncontact tonometer

Table 3: *Relationship between Δ IOP and CCT and PFH.*

Δ IOP (mmHg)	**CCT (µm)**		**PFH (mm)**	
	r	***P***	**r**	***p***
POAG	-0.065	0.732	-0.339	0.067
Control	-0.007	0.973	-0.022	0.914

r: Spearman's rho correlation coefficient, IOP: Intraocular pressure, CCT: Central corneal thickness, PFH: Palpebral fissure height, POAG: Primary Open Angle Glaucoma

IOP in open-angle eyes. In addition, we did not find any association between the difference in IOP measurements by using Tono-pen between before and after gonioscopy and CCT or PFH. We observed that healthy control subjects had higher IOP measurements with NT compared to Tono-pen before gonioscopy.

In a study evaluating the effect of upper eyelid manipulation on IOP, Baek et al. reported mean IOP values of 15.21 ± 2.91 and 13.75 ± 2.44 mmHg when measured by rebound tonometer with and without manual upper eyelid elevation

and determined that IOP was significantly higher in the eyes with manual lid manipulation.[4] They suggested that two mechanisms may be responsible for this rise in IOP: the first was that digital pressure applied to the orbit results in compression of the soft tissues surrounding the globe, thus increasing ocular venous pressure,[5,15,16] and the second was that lid manipulation may compress the globe directly and thereby increase IOP directly.[4] On the other hand, Pagenstecher[17] observed in 1878 that ocular massage reduced IOP, and Polak-van Gelder[18] later determined that the post-massage IOP reduction was more pronounced in glaucomatous eyes than in normal individuals. However, Stocker[12] evaluated IOP changes in eyes after measurement with a Schiötz tonometer and found that IOP decreased by 0.97 when measured again after 30 seconds and by 1.90 mmHg after 4 minutes. Although we observed a decrease in IOP of 0.32 ± 1.60 mmHg in POAG group and 0.44 ± 1.69 mmHg in control group between measurements obtained 4 minutes before and after gonioscopy, it was not statistically significant. We expected that gonioscopic examination might cause inadvertent pressure on the globe, if only slight, and this may either cause an increase in IOP, or cause the aqueous humor to be pressed out of the anterior chamber due to the massage effect and result in a decrease in IOP. On the other hand, in POAG patients, the decrease in IOP might not be evident due to outflow resistance in the trabecular meshwork outflow pathways.[19] However, our results showed no significant change in IOP with gonioscopic examination in both groups. This may be because we were careful not to apply pressure to the cornea when performing gonioscopy and excluded eyes in which Descemet's membrane folds were detected during the gonioscopic examination.

In the first of two different studies on IOP measurement with upper eyelid manipulation, Baek et al. determined that in eyes with small PFH (<7 mm), IOP measurements taken with Goldmann applanation tonometer and measurements obtained with rebound tonometer while applying lid manipulation were higher than those obtained with rebound tonometer without lid manipulation. However, they observed no differences between Goldmann applanation tonometer and rebound tonometer measurements taken without eyelid manipulation in the medium (7-8 mm) and wide (>8 mm) PFH subgroups.[4] In another study, Nakakura et al.[7] reported that PFH being small (8 mm), moderate (≤ 8 to 10 mm), or large (10 mm) had no significant effect on IOP measurements taken by rebound tonometer with or without upper eyelid manipulation. The mean PFH of the eyes included in our study was 10.1 ± 0.55 (9-11) mm in the POAG group and 9.67 ± 0.73 (9-11) mm in the control group and we detected no significant correlation between PFH and change in IOP in either group. Considering that the smallest PFH among the eyes in our study was 9 mm, our results are consistent with both of the aforementioned studies.

In our study, IOP measurements before gonioscopy were found to be higher with NT compared to Tono-pen in the control group. Asking the patient to open their eye as wide as possible for IOP measurement results in anterior movement of the globe, which may also increase IOP.[20] The smaller PFH of participants in the control group may have caused them to open their eyes wider during IOP measurement with NT, thereby intensifying this effect. As the patients in the control group had less experience with IOP measurement compared to the glaucoma patients, they required more instruction to open their eyelids wide while measuring with NT. The fact that measurements taken with the Tono-pen were performed under topical anesthesia may have made the participants more comfortable and allowed measurements to be obtained without the need to open their eyelids wider. These factors may explain why NT measurements were higher than Tono-pen measurements in the control group.

Stocker[12] stated that the pressure applied to the cornea during applanation caused the fluid to be increasingly forced towards the anterior chamber angle, resulting in a decrease in IOP. In their study measuring IOP with and without manual upper eyelid elevation, Nakakura et al.[7] speculated that corneal biomechanical properties such as CCT or corneal curvature may directly influence the difference in IOP between these two measurement methods. They attributed this to the possibility that the upper eyelid touching the cornea could change IOP.[7] In their study, they found that CCT was correlated with the difference between measurements taken by Goldmann applanation tonometry with and without applying upper eyelid elevation.[7] We also thought that during gonioscopy, slight pressure on the central cornea may be applied inadvertently with the goniolens and this may be associated with change in IOP, but we found that there was no significant relationship between CCT and change in IOP in either group. This may be due to the fact that the angle examination was performed with the goniolens held lightly on the corneal surface during gonioscopy, thus minimizing the pressure on the cornea, and the eyes with Descemet's folds were excluded from the study.

This study has several limitations. We conducted the study in eyes with primary open-angle glaucoma under medical treatment, but gonioscopic examination may have different effects on IOP in different types of glaucoma. Due to its rapid measurement capability, we used the Tono-pen to evaluate IOP before and after gonioscopy. The comparison of Tono-pen and NT measurements before

gonioscopy is a strength of our study, but similar studies could be conducted using different IOP measurement tools. Moreover, a different lens could have been selected for gonioscopy, but we preferred the four-mirror goniolens in order to perform the gonioscopic examination quickly and practically and to avoid the use of a coupling agent.[14] In addition, lens rotation during angle examination is not required, thus avoiding the potential effect of rotation on IOP.[3] Measurements taken after gonioscopic examination could be repeated at different intervals. More detailed information could be obtained in future studies using different IOP measurement scales and goniolenses in larger patient samples with different glaucoma types. Finally, it is not possible to standardize the amount of pressure inadvertently applied to eyes during the gonioscopy procedure, but we think that having the same experienced examiner perform gonioscopy in our study contributed to minimizing this variable.

In conclusion, gonioscopic examination using a four-mirror goniolens without coupling agent and taking care not to put pressure on the cornea did not cause a significant change in IOP. In patients believed to have an open angle based on slit-lamp examination, clinicians can feel more confident about the accuracy of IOP measurements obtained after gonioscopy.

Statement of Ethics

The patient signed an informed consent granting the use of data for scientific purposes.

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Conflict of Interest

The authors declare no conflict of interest.

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