ISSN: 2754-4990

Journal of Ophthalmology Research Reviews & Reports

SCIENTIFIC Research and Community

Research Article

Open Access

Comparison of Intraocular Pressure Measurements After LASIK Using Goldmann Applanation Tonometry and CorVis ST: A Prospective Clinical Study

Essam Ragab A Mohamed[1*], Mokhtar Abushanab[2], Ahmed Hammoud[3], Yasser N Elkholy[4], Ahmed Algihady[3], Mohammad Elfeki[3] and Khaled Ghaith[5]

[1]Ophthalmology Consultant, Saudi Airlines Medical Center, Jeddah, Kingdom of Saudi Arabia

[2]Ophthalmology Consultant, Glaucoma Department, Research Institute of Ophthalmology (RIO), Egypt

[3]Ophthalmology Department, Alnoor Specialist Hospital, Makkah, Kingdom of Saudi Arabia

[4]Ophthalmology Consultant, Vision Specialist Eye Center, Hail Saudi Arabia

[5]Department of Ophthalmology, King Fahad Hospital, Al Baha Health Cluster, Al Baha, Saudi Arabia

ABSTRACT

Background: Accurate measurement of Intraocular Pressure (IOP) is essential for the diagnosis, management, and follow-up of glaucoma. Laser in situ keratomileusis (LASIK) alters corneal thickness and biomechanical properties, which may affect the accuracy of IOP measurements obtained by conventional methods such as Goldmann Applanation Tonometry (GAT). The CorVis ST, a Scheimpflug-based device, has been proposed as a more reliable alternative for assessing IOP after refractive surgery.

Objective: To compare changes in IOP measurements before and after LASIK surgery using Goldmann Applanation Tonometry and CorVis ST, and to evaluate the influence of Central Corneal Thickness (CCT) on these measurements.

Methods: This prospective comparative clinical study included 50 eyes of 50 myopic patients aged 20-40 years who underwent LASIK surgery between February 2024 and June 2025 at Al Baha Health Cluster, Al Baha, Saudi Arabia. IOP was measured preoperatively and two months postoperatively using both GAT and CorVis ST. Central corneal thickness was assessed using Pentacam and CorVis ST. Statistical analysis was performed using SPSS version 16, with significance set at $p < 0.05$.

Results: Mean preoperative IOP measured by CorVis ST and GAT was 16.02 ± 2.01 mmHg and 16.22 ± 2.30 mmHg, respectively, with no significant difference between methods. Postoperatively, IOP significantly decreased with both devices ($p < 0.001$). However, GAT showed a greater reduction (11.44 ± 2.02 mmHg) compared with CorVis ST (14.72 ± 1.87 mmHg). Average IOP underestimation after LASIK was approximately 6.5 mmHg with GAT and 1.6 mmHg with CorVis ST. Significant positive correlations were found between CCT and IOP measurements both preoperatively and postoperatively.

Conclusions: CorVis ST demonstrated strong agreement with GAT before LASIK and provided more reliable postoperative IOP measurements. Compared with GAT, CorVis ST was less affected by LASIK-induced corneal changes and showed substantially lower IOP underestimation, making it a preferable tool for postoperative IOP assessment.

***Corresponding author**

Essam Ragab A Mohamed, Ophthalmology Consultant, Saudi Airlines Medical Center, Jeddah, Kingdom of Saudi Arabia.

Received: November 05, 2025; **Accepted:** November 10, 2025; **Published:** November 15, 2025

Keywords: LASIK, Intraocular Pressure, Goldmann Applanation Tonometry, CorVis ST, Central Corneal Thickness, Corneal Biomechanics, Refractive Surgery, Glaucoma

List of Abbreviations

BCVA: Best Corrected Visual Acuity
BIOP: Biomechanically Corrected Intraocular Pressure
CCT: Central Corneal Thickness
CorVis ST: Corneal Visualization Scheimpflug Technology
GAT: Goldmann Applanation Tonometry
ICC: Intraclass Correlation Coefficient
IOP: Intraocular Pressure
LASIK: Laser-Assisted in Situ Keratomileusis

Introduction

Intraocular Pressure (IOP) measurement is a fundamental component of ophthalmic practice and plays a critical role in the diagnosis, monitoring, and management of glaucoma. Elevated IOP remains the most important modifiable risk factor for the development and progression of glaucomatous optic neuropathy. Goldmann Applanation Tonometry (GAT) has long been considered the gold standard for IOP assessment because of its reliability and widespread clinical acceptance [1]. However, the accuracy of GAT is influenced by several corneal properties, particularly Central Corneal Thickness (CCT), corneal curvature, and corneal biomechanical characteristics. Consequently, any alteration in corneal structure may lead to inaccurate IOP measurements and

potentially affect clinical decision-making [2].

Laser in Situ Keratomileusis (LASIK) is one of the most commonly performed refractive surgical procedures for the correction of myopia and other refractive errors. By reshaping the corneal stroma, LASIK reduces corneal thickness and modifies corneal biomechanics. These postoperative changes may cause significant underestimation of IOP when measured using conventional tonometry methods, particularly GAT [3]. Such underestimation is clinically important because it may delay the diagnosis of glaucoma, mask ocular hypertension, or hinder the detection of steroid-induced ocular hypertension in postoperative patients. Therefore, accurate assessment of IOP following refractive surgery remains a major challenge in contemporary ophthalmology [4].

Recent advances in corneal imaging and biomechanical assessment have introduced the CorVis ST, a non-contact Scheimpflug-based device capable of evaluating corneal deformation responses and providing biomechanically corrected IOP measurements. Unlike GAT, the CorVis ST incorporates corneal biomechanical properties into its calculations and may therefore provide more accurate IOP values in eyes that have undergone refractive surgery. Several studies have demonstrated promising results regarding its performance; however, discrepancies still exist regarding the level of agreement between CorVis ST and GAT measurements after LASIK, and the influence of postoperative corneal thickness on these measurements remains controversial [5-8].

Although numerous studies have investigated the effect of LASIK on IOP measurements, most have focused on conventional tonometry techniques and reported varying degrees of postoperative IOP underestimation. Furthermore, limited data are available regarding the comparative performance of CorVis ST and GAT in the same cohort of LASIK patients, particularly in relation to changes in corneal thickness and biomechanical properties. The extent to which CorVis ST can overcome the limitations of GAT and provide a more reliable estimation of true IOP after LASIK remains insufficiently established [9-11].

The novelty of the present study lies in the direct comparison between Goldmann Applanation Tonometry and CorVis ST measurements before and after LASIK surgery in the same patient population. In addition, the study evaluates the relationship between postoperative changes in central corneal thickness and IOP measurements obtained by both devices. By assessing the degree of IOP underestimation associated with each method, this study provides further evidence regarding the clinical usefulness of biomechanically corrected IOP measurements in post-LASIK eyes [10].

Given the increasing number of patients undergoing LASIK worldwide, accurate postoperative IOP assessment has become increasingly important. Failure to recognize falsely low IOP readings may lead to delayed glaucoma diagnosis and inappropriate patient management. Therefore, identifying a tonometry method that is less affected by LASIK-induced corneal alterations is essential for improving the long-term ophthalmic care of these patients. This study was undertaken to address this clinical challenge and to determine whether CorVis ST offers a more reliable alternative to GAT in measuring IOP after LASIK surgery [12].

Therefore, this study was conducted to compare IOP measurements obtained by Goldmann Applanation Tonometry and CorVis ST before and after LASIK surgery and to evaluate the relationship between central corneal thickness and the accuracy of IOP measurements obtained by both methods.

Patients and Methods

After obtaining informed consent from all participants, this prospective comparative clinical study was conducted on 50 eyes of 50 patients who were candidates for LASIK surgery. The study was carried out at the Ophthalmology Department at Al Baha Health Cluster, Al Baha, Saudi Arabia between February 2024 and June 2025. All procedures were performed in accordance with the ethical principles outlined in the Declaration of Helsinki.

Inclusion and Exclusion Criteria

Patients were included if they were candidates for LASIK surgery, aged between 20 and 40 years, had clear corneas, and had mild to moderate myopia ranging from −2 to −6 diopters. Patients were excluded if they had any ocular pathology that could affect corneal integrity or IOP measurements, including corneal scarring or keratoconus, or if they had a previous history of intraocular surgery.

Study Procedures

All participants were subjected to the following:

- **History Taking and Preoperative Assessment**
  A detailed medical and ophthalmological history was obtained from each participant, with particular emphasis on age, previous ocular surgeries, and any history of ocular disease. Written informed consent was obtained from all participants prior to enrollment in the study. A comprehensive ophthalmological examination was performed, including measurement of best-corrected visual acuity (BCVA), manifest refraction, slit-lamp biomicroscopy, and fundus examination using indirect ophthalmoscopy.
- **Corneal Assessment**
  Corneal evaluation was performed using Pentacam® (Oculus, Germany) and CorVis ST. Central corneal thickness (CCT) was measured using CorVis ST, and corneal topographic and tomographic parameters were assessed to confirm suitability for LASIK surgery and exclude corneal abnormalities.
- **Intraocular Pressure Measurement**
  Intraocular pressure (IOP) was measured preoperatively using both Goldmann Applanation Tonometry (GAT) and CorVis ST.

Goldmann Applanation Tonometry (GAT): Patients were examined in the sitting position. A drop of topical anesthetic (Benoxinate hydrochloride 0.4%) and fluorescein dye were instilled into the lower conjunctival fornix. Through the Goldmann prism, two fluorescein semicircles were visualized, and the applied force was adjusted until the inner margins of the semicircles were aligned, allowing IOP measurement according to standard clinical practice.

CorVis ST: IOP and biomechanically corrected IOP (bIOP) measurements were obtained using the CorVis ST device, which utilizes ultra-high-speed Scheimpflug imaging to evaluate corneal deformation response following a calibrated air puff.

• LASIK Surgical Procedure

LASIK surgery was performed using the Teneo 317 Model 2 excimer laser system. Following topical anesthesia with Benoxinate hydrochloride 0.4%, an eyelid speculum was inserted and corneal marking was performed. A superior hinged corneal flap was created using an automated microkeratome (Moria M2, 90-µm blade). The flap was reflected, and laser ablation of the stromal

bed was carried out according to the patient's refractive error. Following ablation, the flap was repositioned, and the interface was irrigated thoroughly. Proper flap centration, adherence, and coaptation were confirmed before completing the procedure. A postoperative slit-lamp examination was performed to ensure flap integrity and absence of interface debris.

• Postoperative Assessment

All participants were re-evaluated two months after LASIK surgery. Postoperative assessment included repeat measurement of intraocular pressure using Goldmann Applanation Tonometry and CorVis ST, as well as reassessment of central corneal thickness and corneal parameters. The postoperative measurements were compared with the preoperative findings to evaluate the effect of LASIK on IOP measurements obtained by both techniques.

Outcome Measures

Primary Outcome Measure

- Comparison of preoperative and postoperative intraocular pressure measurements obtained using Goldmann Applanation Tonometry and CorVis ST.

Secondary Outcome Measures

- Assessment of the agreement between GAT and CorVis ST measurements before and after LASIK surgery.
- Evaluation of the effect of central corneal thickness on IOP measurements.
- Determination of the degree of IOP underestimation associated with each measurement technique following LASIK surgery.

Sample Size

A total of 50 eyes from 50 patients were included in this prospective comparative clinical study. The sample size was selected to provide adequate statistical power for detecting clinically significant differences between preoperative and postoperative intraocular pressure measurements obtained using Goldmann Applanation Tonometry and CorVis ST. Since each participant underwent both measurements before and after LASIK surgery, paired comparisons increased the efficiency of the study design and reduced inter-subject variability. The final sample size was considered sufficient for evaluating agreement between the two tonometric methods and for assessing correlations between intraocular pressure and central corneal thickness.

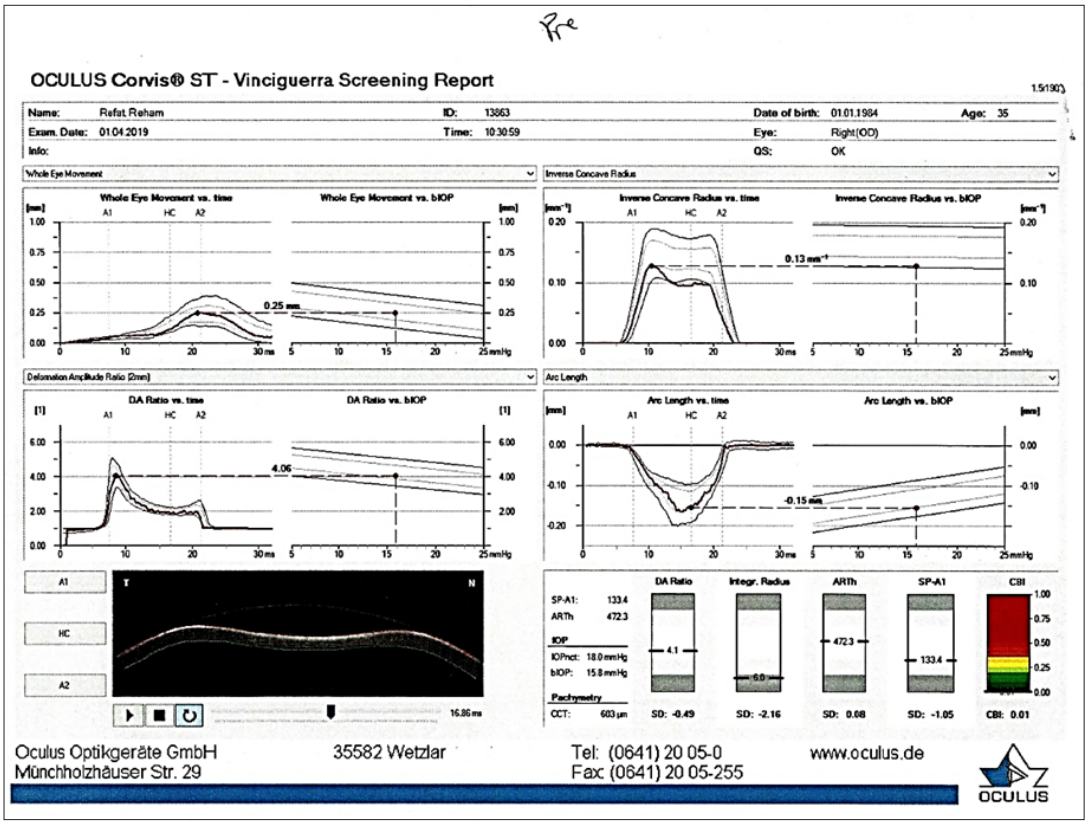
Statistical Analysis

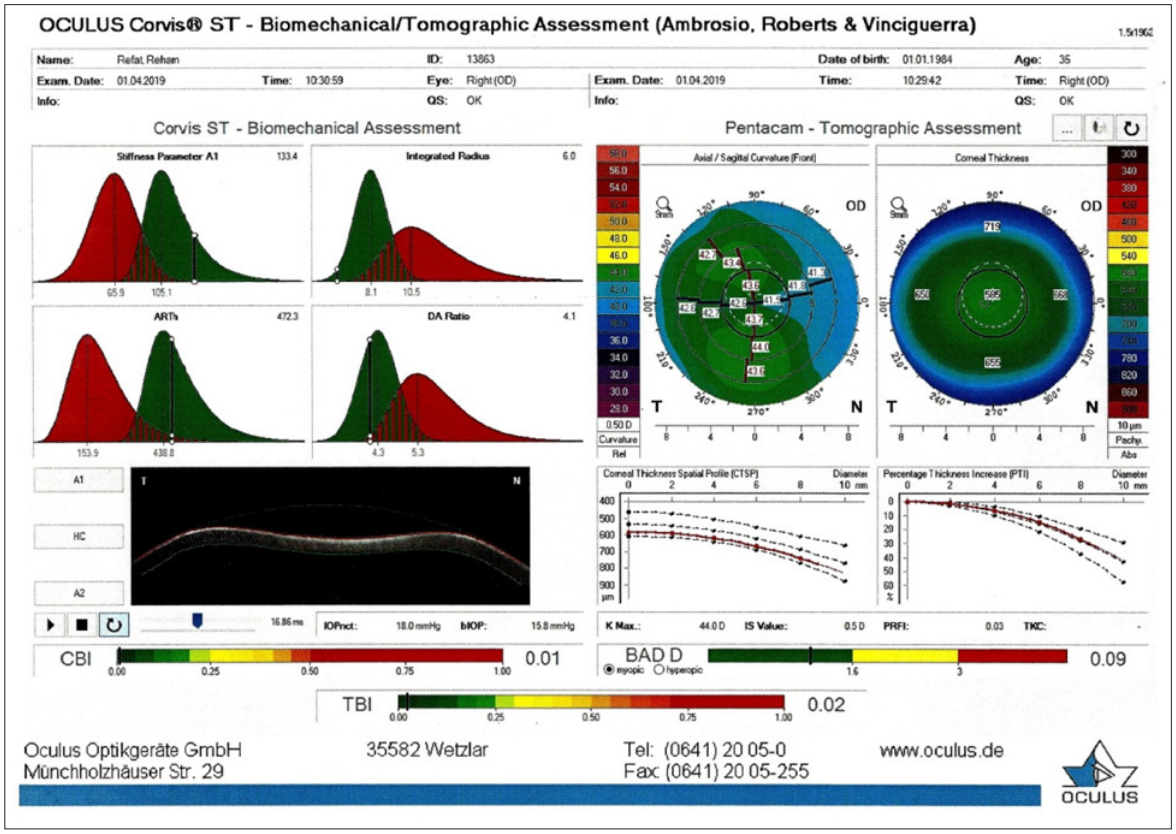
The collected data were coded, entered, and analyzed using the Statistical Package for Social Sciences (SPSS), version 16.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were tested for normality using the Kolmogorov–Smirnov test. Since the test indicated a non-normal distribution of the studied variables, quantitative data were expressed as median and range, while qualitative data were presented as frequencies and percentages.

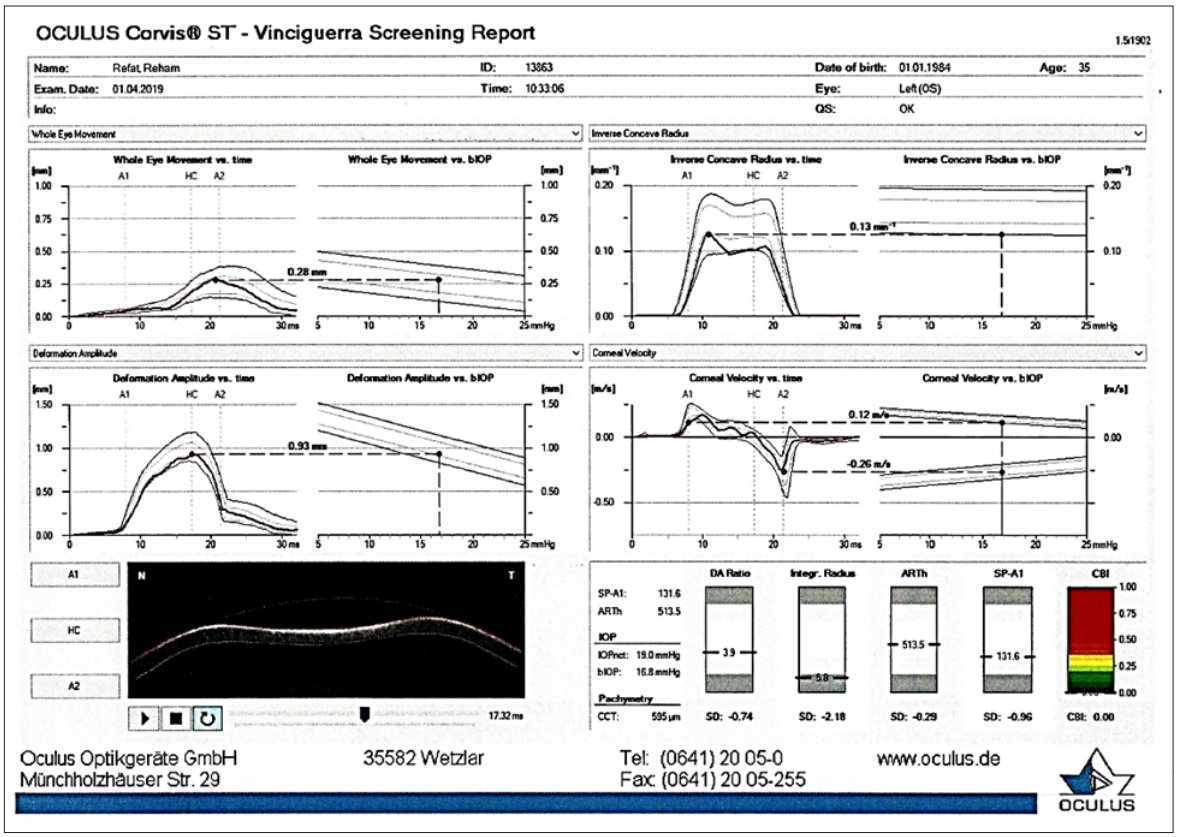
Comparisons between preoperative and postoperative measurements within the same patients were performed using the Wilcoxon signed-rank test. Comparisons between independent groups were carried out using the Mann–Whitney U test. Correlations between intraocular pressure measurements and central corneal thickness were assessed using Spearman's rank correlation coefficient (r). Agreement between Goldmann Applanation Tonometry (GAT) and CorVis ST measurements was evaluated using the Intraclass Correlation Coefficient (ICC) and Bland–Altman analysis. Continuous variables were presented as mean ± Standard Deviation (SD) where appropriate. A p-value < 0.05 was considered statistically significant.

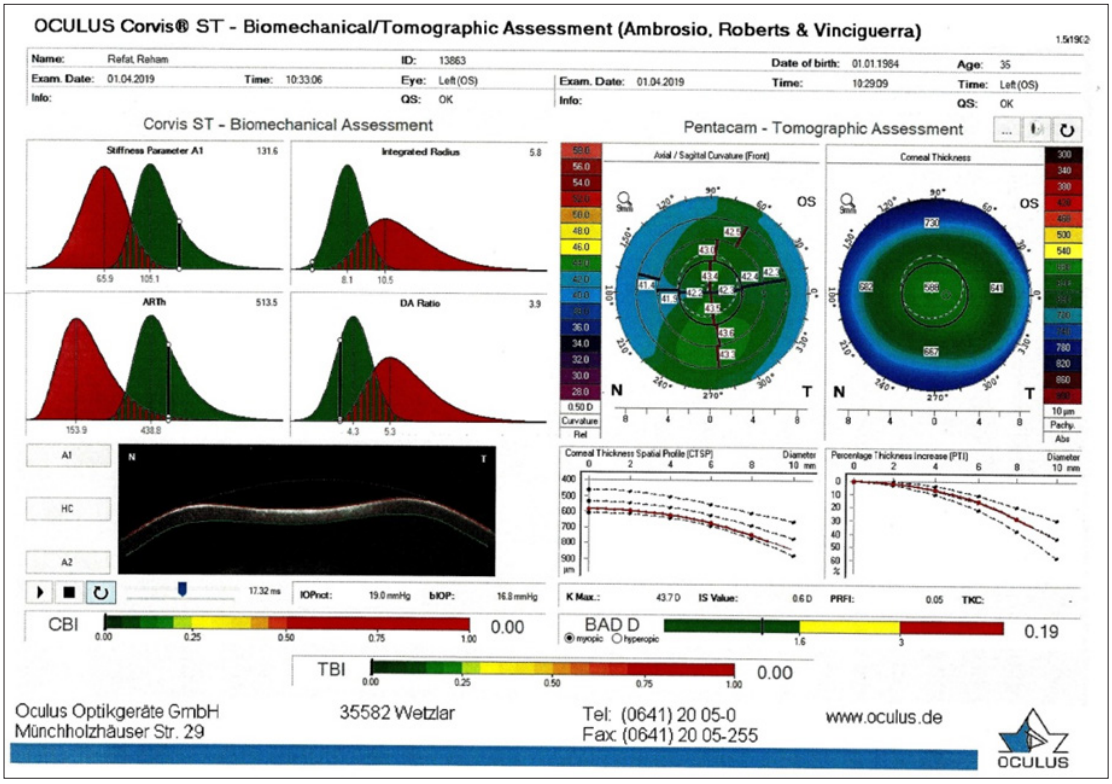
Case Presentation

Case 1: Pre Lasik

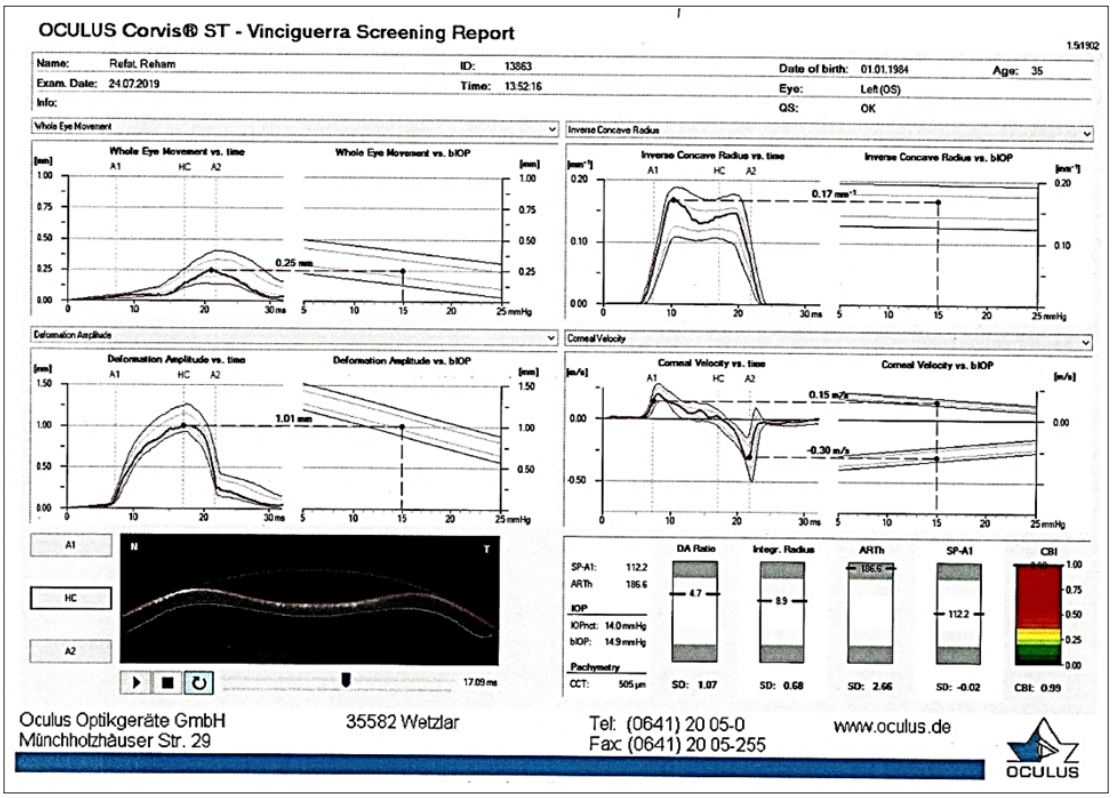


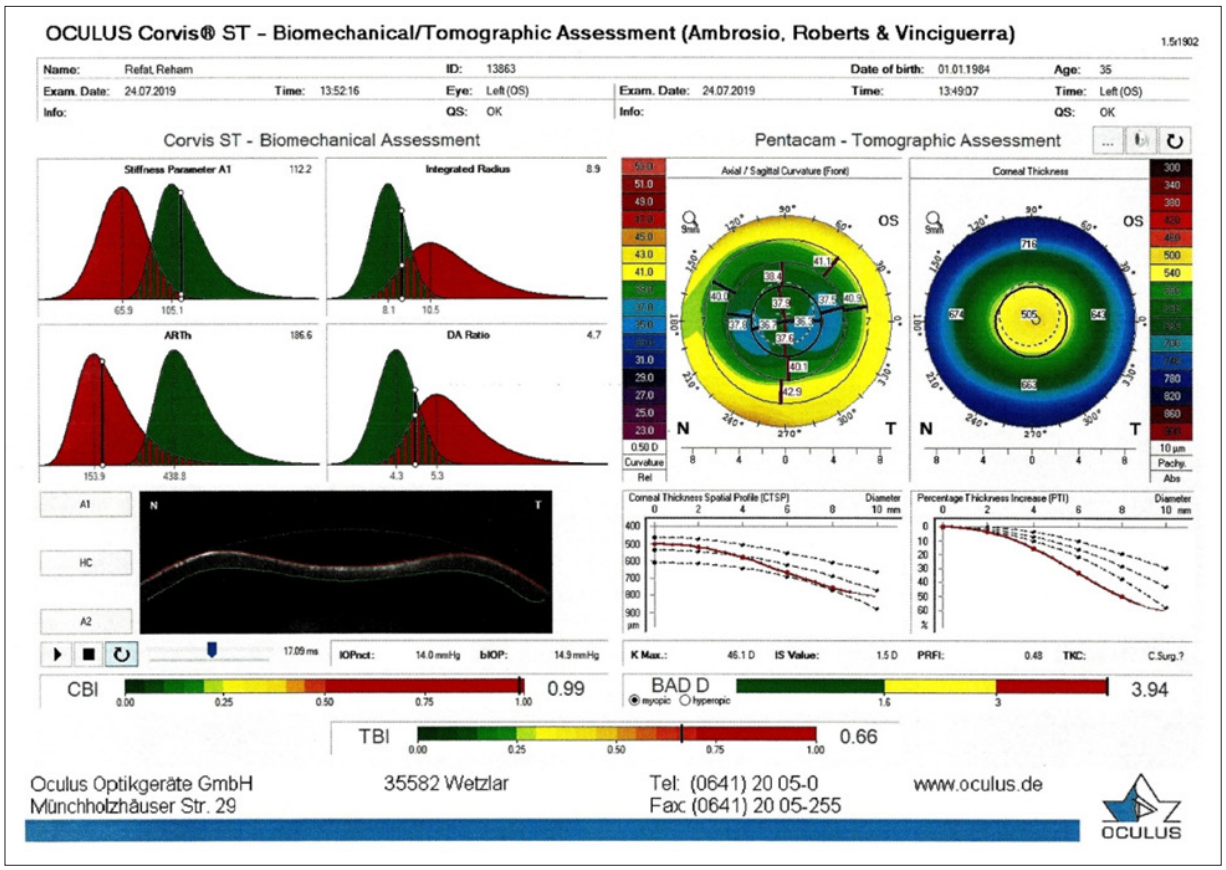

OCULUS Corvis® ST - Biomechanical/Tomographic Assessment (Ambrosio, Roberts & Vinciguerra)
Name: Refat, Reham
ID: 13863
Date of birth: 01.01.1984
Age: 35
Exam. Date: 01.04.2019
Time: 10:30:59
Eye: Right (OD)
QS: OK
Exam. Date: 01.04.2019
Time: 10:29:42
Time: Right (OD)
QS: OK
Corvis ST - Biomechanical Assessment
Pentacam - Tomographic Assessment
Stiffness Parameter A1
Integrated Radius
ARTh
DA Ratio
Axial / Sagittal Curvature (Front)
Corneal Thickness
Corneal Thickness Spatial Profile (CTSP)
Percentage Thickness Increase (PTI)
CBI
BAD D
TBI
Oculus Optikgeräte GmbH
Münchholzhäuser Str. 29
35582 Wetzlar
Tel: (0641) 20 05-0
Fax: (0641) 20 05-255
www.oculus.de
OCULUS

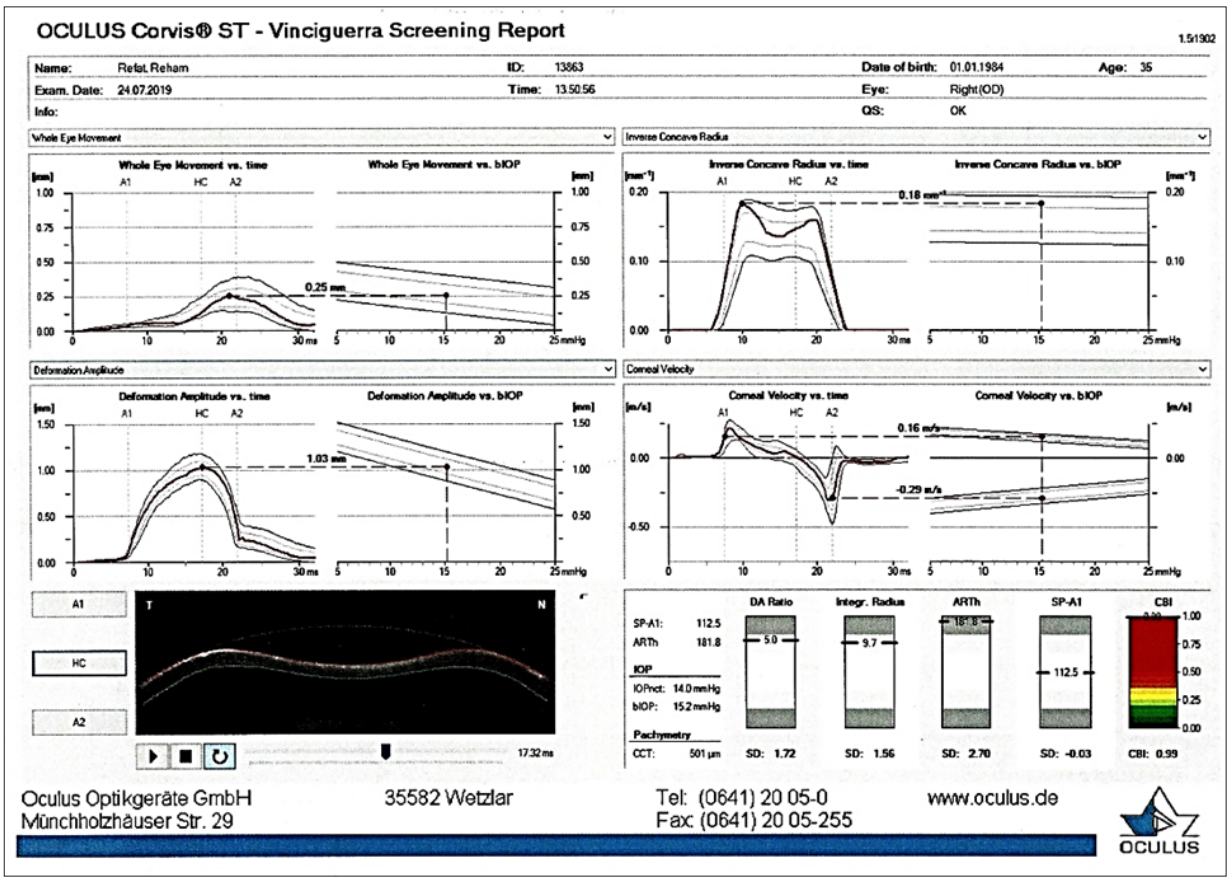

OCULUS Corvis® ST - Vinciguerra Screening Report
Name: Refat, Reham
ID: 13863
Date of birth: 01.01.1984
Age: 35
Exam. Date: 01.04.2019
Time: 10:33:06
Eye: Left (OS)
QS: OK
Whole Eye Movement vs. time
Whole Eye Movement vs. bIOP
Inverse Concave Radius vs. time
Inverse Concave Radius vs. bIOP
Deformation Amplitude vs. time
Deformation Amplitude vs. bIOP
Corneal Velocity vs. time
Corneal Velocity vs. bIOP
DA Ratio
Integr. Radius
ARTh
SP-A1
CBI
Oculus Optikgeräte GmbH
Münchholzhäuser Str. 29
35582 Wetzlar
Tel: (0641) 20 05-0
Fax: (0641) 20 05-255
www.oculus.de
OCULUS

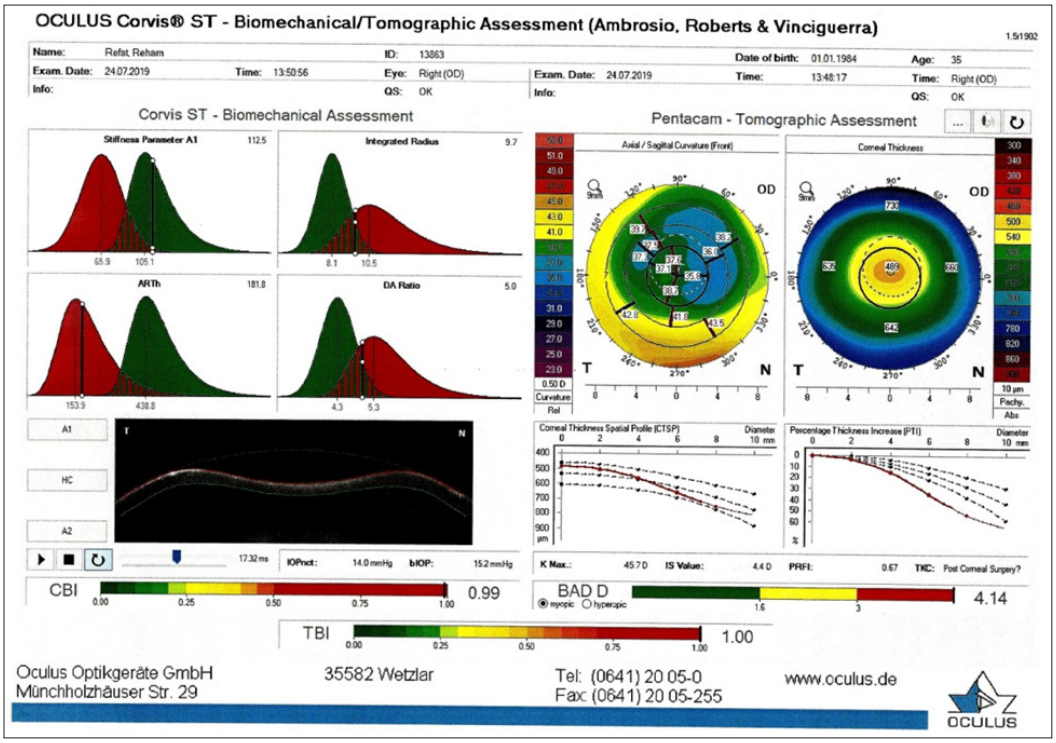

OCULUS Corvis® ST - Biomechanical/Tomographic Assessment (Ambrosio, Roberts & Vinciguerra)
Name: Refat, Reham
ID: 13863
Date of birth: 01.01.1984
Age: 35
Exam. Date: 01.04.2019
Time: 10:33:06
Eye: Left (OS)
QS: OK
Exam. Date: 01.04.2019
Time: 10:29:09
Time: Left (OS)
QS: OK
Corvis ST - Biomechanical Assessment
Pentacam - Tomographic Assessment
Stiffness Parameter A1
Integrated Radius
ARTh
DA Ratio
Axial / Sagittal Curvature (Front)
Corneal Thickness
OS
N
T
CBI
0.00
BAD D
0.19
TBI
0.00
Oculus Optikgeräte GmbH
Münchholzhäuser Str. 29
35582 Wetzlar
Tel: (0641) 20 05-0
Fax: (0641) 20 05-255
www.oculus.de
OCULUS

Post Lasik


OCULUS Corvis® ST - Vinciguerra Screening Report
Name: Refat, Reham
ID: 13863
Date of birth: 01.01.1984
Age: 35
Exam. Date: 24.07.2019
Time: 13:52:16
Eye: Left (OS)
QS: OK
Whole Eye Movement
Whole Eye Movement vs. time
Whole Eye Movement vs. bIOP
0.25 mm
Inverse Concave Radius
Inverse Concave Radius vs. time
Inverse Concave Radius vs. bIOP
0.17 mm⁻¹
Deformation Amplitude
Deformation Amplitude vs. time
Deformation Amplitude vs. bIOP
1.01 mm
Corneal Velocity
Corneal Velocity vs. time
Corneal Velocity vs. bIOP
0.15 m/s
-0.30 m/s
DA Ratio
Integr. Radius
ARTh
SP-A1
CBI
SD: 1.07
SD: 0.68
SD: 2.66
SD: -0.02
CBI: 0.99
Oculus Optikgeräte GmbH
Münchholzhäuser Str. 29
35582 Wetzlar
Tel: (0641) 20 05-0
Fax: (0641) 20 05-255
www.oculus.de
OCULUS


OCULUS Corvis® ST – Biomechanical/Tomographic Assessment (Ambrosio, Roberts & Vinciguerra)
1.5r1902
Name: Refat, Reham
ID: 13863
Date of birth: 01.01.1984
Age: 35
Exam. Date: 24.07.2019
Time: 13:52:16
Eye: Left (OS)
QS: OK
Exam. Date: 24.07.2019
Time: 13:49:07
Eye: Left (OS)
QS: OK
Info:
Corvis ST - Biomechanical Assessment
Pentacam - Tomographic Assessment
Stiffness Parameter A1
Integrated Radius
ARTh
DA Ratio
Axial / Sagittal Curvature (Front)
Corneal Thickness
Corneal Thickness Spatial Profile (CTSP)
Percentage Thickness Increase (PTI)
CBI 0.99
BAD D 3.94
TBI 0.66
Oculus Optikgeräte GmbH
Münchholzhäuser Str. 29
35582 Wetzlar
Tel: (0641) 20 05-0
Fax (0641) 20 05-255
www.oculus.de
OCULUS


OCULUS Corvis® ST - Vinciguerra Screening Report
1.5r1902
Name: Refat, Reham
ID: 13863
Date of birth: 01.01.1984
Age: 35
Exam. Date: 24.07.2019
Time: 13:50:56
Eye: Right (OD)
QS: OK
Info:
Whole Eye Movement vs. time
Whole Eye Movement vs. bIOP
Inverse Concave Radius vs. time
Inverse Concave Radius vs. bIOP
Deformation Amplitude vs. time
Deformation Amplitude vs. bIOP
Corneal Velocity vs. time
Corneal Velocity vs. bIOP
DA Ratio
Integr. Radius
ARTh
SP-A1
CBI
Oculus Optikgeräte GmbH
Münchholzhäuser Str. 29
35582 Wetzlar
Tel: (0641) 20 05-0
Fax (0641) 20 05-255
www.oculus.de
OCULUS



Results

The Results of the Present Study are Demonstrated in the Following Tables

Table 1: Basic Characteristics of Participants

	Descriptive data (=50)
Sex Male female	 8 (16%) 42 (84%)
Age (year) Mean±SD (Range)	 27.3± 5.3 (21-40)
Preoperative CCT (µm) Mean±SD (Range)	 549.08±24.65 (507-603)

Table (1) demonstrates the baseline demographic and clinical characteristics of the study population. A total of 50 participants were enrolled, including 42 females (84%) and 8 males (16%). The mean age of the participants was 27.3 ± 5.3 years, ranging from 21 to 40 years. The mean preoperative central corneal thickness (CCT) was 549.08 ± 24.65 µm, with values ranging from 507 to 603 µm.

Table 2: Pre- and Postoperative IOP Values

Method	Pre (n=50)	Post (n=50)	p value (pre vs post)
Corvis ST Mean±SD (Range)	 16.02±2.01 (12.8-21.8)	 14.72±1.87 (10.2-19)	<0.001*
GAT Mean±SD (Range)	 16.22±2.3 (12-22)	 11.44±2.02 (8-16)	<0.001*
P value	0.651	<0.001*	

Independent sample t-test for comparison between both methods
Paired t-test for comparison between pre- and postoperative IOP
*P-value is considered significant at <0.05

Table (2) shows the comparison of intraocular pressure measurements obtained using CorVis ST and Goldmann Applanation Tonometry (GAT) before and after LASIK surgery. There was no statistically significant difference between the two methods preoperatively (p = 0.651), indicating good agreement before surgery. Following LASIK, both methods demonstrated a significant reduction in IOP measurements compared with preoperative values (p < 0.001 for both). However, postoperative IOP measured by GAT (11.44 ± 2.02 mmHg) was significantly lower than that measured by CorVis ST (14.72 ± 1.87 mmHg) (p < 0.001).

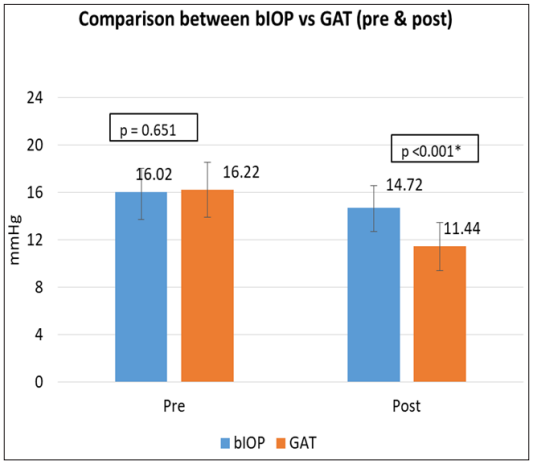


Figure 1: Comparison between bIOP vs GAT Pre and Post-Operatively

Table 3: Agreement Between CorVis ST and GAT

Measurements of the Mean Differences ± SDs and 95% limits of agreement between the Two Instruments (n= 50 Eyes).

	Mean difference ± SD (Range)	95% limits of agreement (1.96× SD of difference)	ICC	Pearson correlation (r)
Preoperative	-0.14±1.55 (-3.3 to 4)	-3.18 to 2.9 (±3.04)	0.855 **P<0.001***	0.754 **P <0.001***
Postoperative	3.28±1.9 (0.1-7.7)	-0.44 to 7 (±3.72)	0.689 **P <0.001***	0.527 **P <0.001***

The results indicated acceptable agreement between measurements ofpreoperative IOP by the Corvis and applanation, as shown by the semisymmetrical distribution of the Bland-Altman plot (Fig 2.) and an ICC in the high agreement range (ICC=0.855). The postoperative of measurement did not yield sufficient agreement, as shown by the widely distributed Bland-Altman plot (Fig 3.) and ICCs below the critical value of 0.80 (ICC=0.689).

Table (3) presents the agreement analysis between CorVis ST and GAT measurements. Preoperatively, there was excellent agreement between both methods, with a small mean difference (-0.14 ± 1.55 mmHg), a high intraclass correlation coefficient (ICC = 0.855), and a strong positive correlation (r = 0.754, p < 0.001). Postoperatively, the mean difference increased to 3.28 ± 1.90 mmHg, while the ICC decreased to 0.689 and the correlation coefficient declined to 0.527.

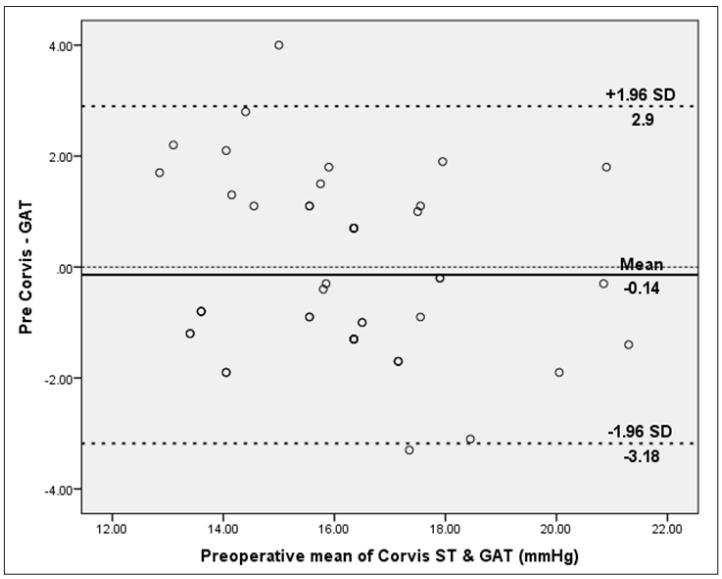


Figure 2: Bland-Altman Plots of agreement Showing the Mean Differences and Limits of Agreement of Preoperative IOP measurements (bIOP vs applaGATnation)

Figure (2) presents the Bland–Altman analysis evaluating the agreement between preoperative IOP measurements obtained using CorVis ST and GAT. The majority of measurements were distributed symmetrically around the mean difference line and remained within the 95% limits of agreement. This pattern indicates a high level of agreement and consistency between the two methods before LASIK surgery, supporting the reliability of CorVis ST measurements in untreated corneas.

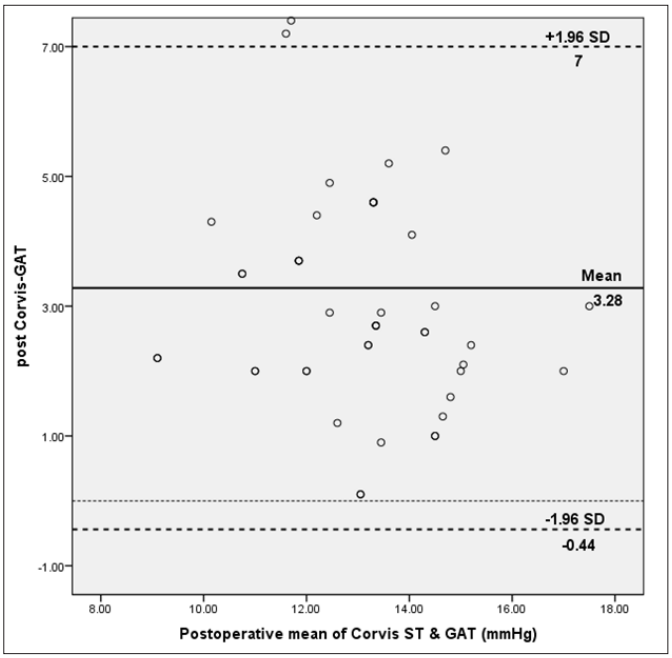


Figure 3: Bland-Altman plots of agreement showing the mean differences and limits of agreement of postoperative IOP measurements (bIOP vs GAT)

Figure (3) demonstrates the Bland–Altman analysis of postoperative IOP measurements obtained using CorVis ST and GAT. Compared with the preoperative plot, a wider distribution of data points and broader limits of agreement were observed. The increased mean difference and reduced agreement indicate that the two methods no longer provide interchangeable measurements after LASIK surgery. This finding reflects the greater influence of postoperative corneal thinning and biomechanical changes on GAT measurements.

Table 4: Pre- and Postoperative Central Corneal Thickness

	Pre (n=50)	Post (n=50)	p value (pre vs post)
CCT (µm) Mean±SD (Range)	549.08±24.65 (507-603)	489.1±29.52 (421-549	<0.001*

Table (4) Demonstrates a significant Reduction in Central Corneal Thickness Following LASIK Surgery. The Mean CCT Decreased from 549.08 ± 24.65 µm Preoperatively to 489.10 ± 29.52 µm Postoperatively ($p < 0.001$).

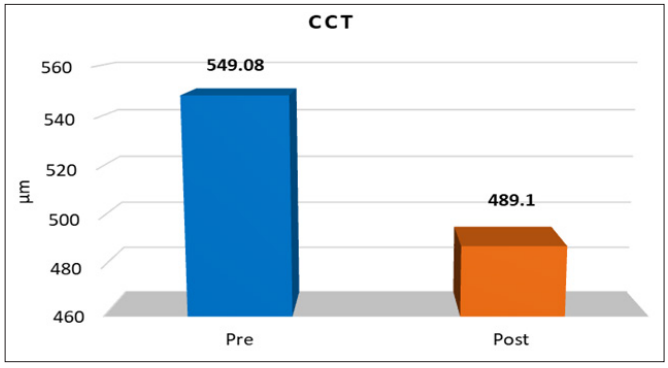


Figure 4: Central Corneal Thickness Pre and Postoperative

Table 5: Correlation between CCT and Preoperative IOP Measured By Both Methods

	r	p
Corvis ST	0.443	0.001*
GAT	0.418	0.002*

Fair positive correlation was found between preoperative CCTand the preoperative IOP measured by Corvis ST (r=0.443, p=0.001) and GAT (r=0.418, p=0.002).

Table (5) illustrates the relationship between preoperative central corneal thickness and preoperative IOP measurements. A statistically significant fair positive correlation was observed between CCT and IOP measured by CorVis ST (r = 0.443, p = 0.001) as well as GAT (r = 0.418, p = 0.002).

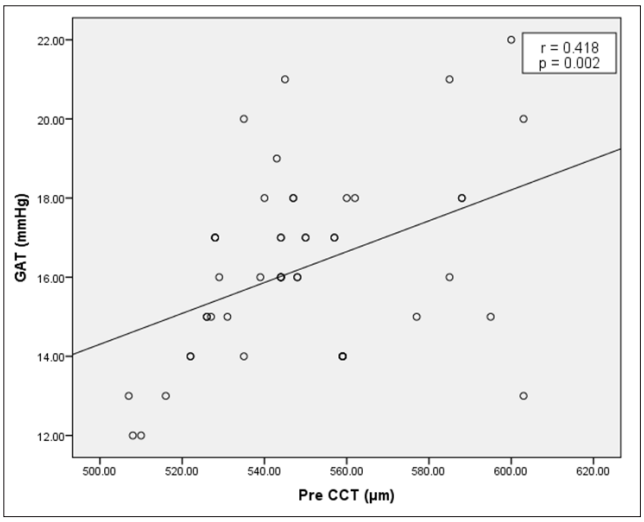


Figure 5: Correlation between GAT and CCT Pre-Operatively

Figure (5) illustrates the relationship between preoperative central corneal thickness and preoperative IOP measured by Goldmann Applanation Tonometry. The scatter plot demonstrates a positive correlation, indicating that eyes with thicker corneas tended to have higher measured IOP values. This finding supports the recognized influence of corneal thickness on GAT measurements and highlights the importance of considering CCT when interpreting IOP values

Table 6: Correlation between CCT and Postoperative IOP Measured by Both Methods

	r	p
Corvis ST	0.459	0.001*
GAT	0.396	0.004*

Pearson correlation coefficient shows significant positive correlation between the postoperative bIOP and the postoperative CCT (r=0.459, *P*=0.001). Also, there was significant positive correlation between the postoperative IOP measured by GAT and the postoperative CCT (r=0.396, *P*=0.004).

Table (9) shows the correlation between postoperative central corneal thickness and postoperative IOP measurements. Significant positive correlations were identified between postoperative CCT and postoperative IOP measured by CorVis ST (r = 0.459, p = 0.001) and GAT (r = 0.396, p = 0.004).

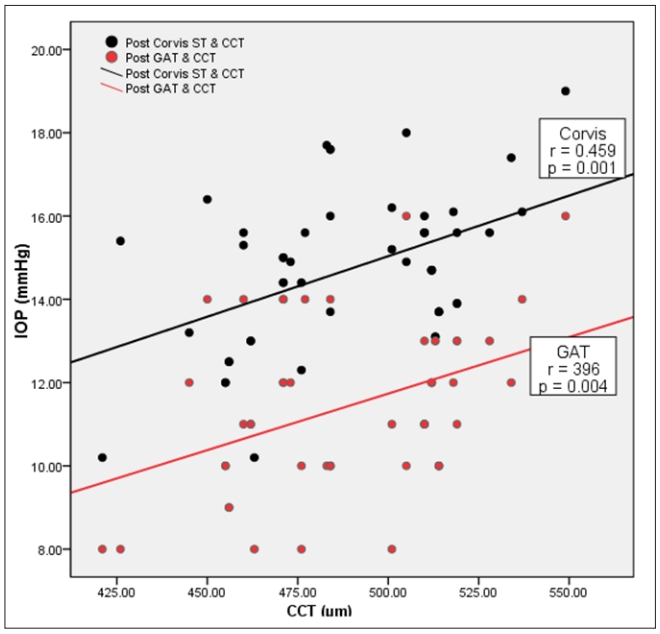


Figure 6: Correlation between CCT and Postoperative IOP Measured by Corvis ST and GAT

Figure (6) demonstrates the relationship between postoperative central corneal thickness and postoperative IOP measurements obtained using CorVis ST and GAT. A significant positive correlation was observed with both methods, indicating that higher postoperative CCT values were associated with higher measured IOP. The figure further emphasizes the influence of corneal thickness on postoperative tonometric readings and supports the concept that corneal structural changes following LASIK affect IOP assessment

Discussion

Intraocular Pressure (IOP) measurement represents a fundamental component of ophthalmic evaluation and is essential for the diagnosis, management, and follow-up of glaucoma. Goldmann Applanation Tonometry (GAT) has traditionally been regarded as the gold standard for IOP assessment because of its long-established accuracy and widespread clinical use. However, the reliability of GAT is highly dependent on corneal characteristics, particularly Central Corneal Thickness (CCT) and corneal biomechanical properties. Any alteration in these parameters may lead to inaccurate IOP measurements and potentially affect clinical decision-making [7].

Laser in situ keratomileusis (LASIK) is one of the most frequently performed refractive surgical procedures worldwide for the correction of myopia. Although LASIK effectively improves visual acuity, it induces significant structural and biomechanical changes in the cornea by reducing corneal thickness and altering corneal rigidity. These changes have been shown to affect the accuracy of conventional tonometric methods, often resulting in underestimation of postoperative IOP. Such inaccuracies are clinically important because they may delay the diagnosis of glaucoma, mask ocular hypertension, and complicate postoperative monitoring of patients who have undergone refractive surgery [8].

Therefore, the present study was conducted to evaluate and compare intraocular pressure measurements obtained using Goldmann Applanation Tonometry and CorVis ST before and after LASIK surgery. In addition, the study aimed to assess the influence of central corneal thickness on IOP measurements and to determine which method provides more reliable postoperative IOP assessment in eyes that have undergone LASIK.

In the current study, preoperative IOP measurements obtained by CorVis ST showed strong agreement with those obtained by GAT. In addition, significant positive correlations were observed between central corneal thickness (CCT) and preoperative IOP measurements obtained by both instruments [13]. These findings are consistent with the observations of who demonstrated that corneal thickness significantly affects GAT measurements, with thicker corneas producing falsely elevated readings and thinner corneas producing lower readings [14]. Similarly, reported a significant correlation between CCT and GAT-derived IOP values [15]. Furthermore, demonstrated parallel fluctuations in CCT and IOP throughout the day, supporting the influence of corneal characteristics on tonometric measurements. The importance of incorporating CCT into glaucoma assessment was also emphasized by who concluded that CCT measurement improves the accuracy of IOP interpretation and clinical decision-making [16,17].

Conversely, the relationship between CCT and IOP remains controversial [18]. argued that correction nomograms based solely on corneal thickness may be unreliable because different correction tables often provide inconsistent results [19]. Likewise, demonstrated that the relationship between CCT and IOP is not linear, suggesting that a single CCT-based correction formula cannot accurately estimate true IOP in all patients [20]. Moreover, highlighted that factors other than corneal thickness, particularly corneal biomechanics, contribute significantly to variations in IOP measurements. These observations support the growing view that corneal biomechanical properties may have a greater influence on tonometric accuracy than pachymetry alone.

A major finding of the present study was the significant reduction in postoperative IOP measurements following LASIK when assessed by both GAT and CorVis ST. However, the degree of reduction was substantially greater with GAT. The average underestimation of IOP was approximately 6.5 mmHg with GAT compared with only 1.6 mmHg with CorVis ST [21-26]. These findings are in agreement with those reported by all of whom documented significant decreases in GAT-measured IOP after LASIK [25]. Furthermore, specifically demonstrated that postoperative GAT measurements were consistently lower than preoperative values in LASIK-treated eyes.

The marked postoperative underestimation observed with GAT can be explained by LASIK-induced alterations in corneal structure [27,28,21]. attributed the reduction in measured IOP primarily to decreases in central corneal thickness and modifications of corneal biomechanical behavior. These changes reduce corneal resistance to applanation, leading to falsely low-pressure readings [29]. Clinically, this phenomenon is important because, as noted by underestimation of IOP may delay glaucoma diagnosis, mask ocular hypertension, and hinder the identification of steroid-induced ocular hypertension following refractive surgery.

The CorVis ST was developed to minimize the influence of corneal properties on IOP assessment by incorporating dynamic Scheimpflug imaging and biomechanical analysis of corneal deformation. In the present study, postoperative IOP values measured by CorVis ST remained significantly higher than those obtained by GAT, suggesting greater resistance to the effects of LASIK-induced corneal changes [30]. Similar findings were reported by, who observed a tendency for CorVis ST to yield higher IOP measurements than GAT in both healthy and glaucomatous eyes [19]. Moreover, suggested that corneal biomechanical properties may exert a greater influence on tonometric accuracy than corneal thickness alone, which may explain the improved

performance of CorVis ST in postoperative eyes.

Despite the strong preoperative agreement between GAT and CorVis ST, the current study demonstrated reduced postoperative agreement between the two devices. The intraclass correlation coefficient declined after LASIK, indicating that the methods should not be considered interchangeable in surgically altered corneas [31]. Although considered calibration errors of 2–3 mmHg acceptable for GAT, the postoperative differences observed in the present study exceeded this range. Therefore, CorVis ST may provide a more clinically meaningful assessment of IOP in post-LASIK patients.

The present study also demonstrated significant positive correlations between postoperative CCT and postoperative IOP measurements obtained by both GAT and CorVis ST. However, the effect appeared less pronounced with CorVis ST, suggesting that biomechanically corrected IOP measurements are less susceptible to postoperative pachymetric changes [30,19]. This observation is consistent with the findings of who emphasized the importance of incorporating corneal biomechanical characteristics into IOP assessment.

Interestingly, no significant correlation was identified between the magnitude of postoperative IOP reduction and postoperative pachymetry in the present study [22]. This finding differs from those reported by who found that changes in residual stromal bed thickness significantly influenced postoperative GAT measurements [32]. Similarly, reported a direct relationship between the amount of corneal tissue ablated during LASIK and the degree of postoperative IOP reduction. The discrepancy between these studies and the current findings may be explained by the relatively small sample size and the limited range of myopia included in the present study, which may have reduced variability in postoperative corneal thickness.

Clinical Implications

The findings of the present study have important clinical implications for ophthalmologists involved in the care of patients undergoing refractive surgery. Accurate assessment of Intraocular Pressure (IOP) after LASIK remains a challenge because corneal thinning and biomechanical alterations may lead to falsely low measurements, particularly when using Goldmann Applanation Tonometry (GAT). The current study demonstrated that CorVis ST showed substantially less postoperative IOP underestimation than GAT, suggesting that it may provide a more reliable estimation of true IOP in post-LASIK eyes. This is particularly relevant for the early detection and monitoring of glaucoma, ocular hypertension, and steroid-induced ocular hypertension, where underestimation of IOP may result in delayed diagnosis and treatment. Therefore, clinicians should interpret GAT readings cautiously in patients with a history of LASIK and consider incorporating biomechanically corrected tonometry methods such as CorVis ST into postoperative follow-up protocols.

Strengths of the Study

Several strengths enhance the validity of the present study. First, the prospective design allowed standardized preoperative and postoperative assessment of the same patients, minimizing inter-individual variability. Second, both GAT and CorVis ST measurements were performed in all participants, enabling direct comparison between the conventional gold-standard technique and a newer biomechanically based method. Third, the study assessed not only IOP measurements but also central corneal thickness (CCT), allowing evaluation of the influence of corneal structural changes on tonometric accuracy. Finally, the use of agreement analysis, including correlation coefficients and intraclass correlation coefficients, provided a comprehensive evaluation of the relationship between both measurement techniques before and after LASIK surgery.

Limitations of the Study

Despite its strengths, the present study has several limitations. The relatively small sample size of 50 eyes may limit the generalizability of the findings and reduce the ability to detect weaker associations. In addition, the study included only patients with mild to moderate myopia (-2 to -6 diopters), which may not reflect the full spectrum of refractive errors encountered in clinical practice. The follow-up period was limited to the early postoperative phase, and longer follow-up could provide additional information regarding the long-term stability of IOP measurements after LASIK. Furthermore, the study was conducted at a single center, which may limit external validity. Finally, other corneal biomechanical parameters that could influence IOP measurements were not comprehensively evaluated.

Conclusion

The present study demonstrated that CorVis ST and Goldmann Applanation Tonometry showed strong agreement in measuring intraocular pressure before LASIK surgery. However, significant differences emerged postoperatively, with GAT showing considerably greater underestimation of IOP compared with CorVis ST. LASIK-induced reductions in central corneal thickness and alterations in corneal biomechanics significantly affected postoperative tonometric measurements. CorVis ST was less influenced by these changes and provided more reliable postoperative IOP values, with an average underestimation of approximately 1.6 mmHg compared with approximately 6.5 mmHg for GAT. These findings support the clinical utility of CorVis ST as a more accurate method for postoperative IOP assessment in patients who have undergone LASIK surgery.

Based on the findings of this study, CorVis ST should be considered as a preferred method for postoperative IOP assessment in patients who have undergone LASIK surgery, particularly in those at risk for glaucoma or ocular hypertension. Clinicians should exercise caution when interpreting GAT measurements after refractive surgery because of the potential for significant underestimation of true IOP. Future studies involving larger sample sizes, broader ranges of refractive errors, and longer follow-up periods are recommended to further validate these findings.

Ethical Considerations

All participants were informed about the purpose, nature, benefits, and potential risks of the study, and written informed consent was obtained from each participant before enrollment. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki for research involving human subjects. Participation was entirely voluntary, and participants had the right to withdraw from the study at any stage without affecting their medical care.

Acknowledgment

None.

Author Contributions

Essam Ragab A Mohamed: Conceptualization, study design, patient recruitment, data collection, manuscript drafting, and final manuscript revision.

Mokhtar Abushanab: Study supervision, methodology development, critical revision of the manuscript, and interpretation of data.
Ahmed Hammoud: Clinical assessment, surgical procedures, data acquisition, and manuscript review.
Yasser N Elkholy: Statistical analysis, interpretation of results, and manuscript editing.
Ahmed Algihady: Patient evaluation, data collection, literature review, and manuscript preparation.
Mohammad Elfeki: Data management, manuscript revision, and final approval of the submitted version.
Khaled Ghaith: Study supervision, surgical procedures, interpretation of results, manuscript revision, and final approval of the submitted version.
All authors read, approved, and agreed to be accountable for all aspects of the final manuscript.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this study.

Confidentiality of Data

All collected data were treated with strict confidentiality throughout the study period. Participants were assigned unique identification codes, and no personal identifiers were included in the study database or manuscript. Access to study data was restricted to the research team only. Data were stored securely and used exclusively for scientific research purposes in accordance with institutional ethical regulations and applicable data protection standards.

Financing Support

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The study was self-funded by the investigators, and all costs related to patient assessment, data collection, analysis, and manuscript preparation were covered by the authors. No external financial support was received for the conduct of this study.

References

1. Chow SC, Yeung BY (2020) A review on different tonometers for intraocular pressure measurement after photorefractive keratectomy or small incision lenticule extraction. Clin Ophthalmol 14: 3305-3323.
2. Bao F, Huang W, Zhu R, Lu N, Wang Y, et al. (2020) Effectiveness of the Goldmann applanation tonometer, the dynamic contour tonometer, the ocular response analyzer and the Corvis ST in measuring intraocular pressure following FS-LASIK. Curr Eye Res 45: 144-152.
3. Hong J, Yu Z, Jiang C, Zhou X, Liu Z, et al. (2015) Corvis ST tonometer for measuring postoperative IOP in LASIK patients. Optom Vis Sci 92: 589-595.
4. Zhang H, Sun Z, Li L, Sun R, Zhang H (2020) Comparison of intraocular pressure measured by ocular response analyzer and Goldmann applanation tonometer after corneal refractive surgery: a systematic review and meta-analysis. BMC Ophthalmol 20: 23.
5. Shen Y, Su X, Liu X, Miao H, Fang X, et al. (2016) Changes in intraocular pressure values measured with Noncontact Tonometer (NCT), ocular response analyzer (ORA) and corvis scheimpflug technology tonometer (CST) in the early phase after small incision lenticule extraction (SMILE). BMC ophthalmology 18: 205.
6. Brusini P, Salvetat ML, Zeppieri M (2021) How to measure intraocular pressure: an updated review of various tonometers. J Clin Med 10: 3860.
7. De Bernardo M, Cembalo G, Rosa N (2020) Reliability of intraocular pressure measurement by Goldmann applanation tonometry after refractive surgery: a review of different correction formulas. Clin Ophthalmol 14: 2783-2788.
8. Garcia-Feijoo J, Martinez-de-la-Casa JM, Morales-Fernandez L, Frances FS, Santos-Bueso E, et al. (2015) new technologies for measuring intraocular pressure. Prog Brain Res 221: 67-79.
9. Bao F, Huang Z, Huang J, Wang J, Deng M, et al. (2016) Clinical evaluation of methods to correct intraocular pressure measurements by the Goldmann applanation tonometer, ocular response analyzer, and Corvis ST tonometer for the effects of corneal stiffness parameters. J Glaucoma 25: 510-519.
10. Karmiris E, Tsiripidis K, Gartaganis PS, Totou S, Vasilopoulou MG, et al. (2022) Comparison of intraocular pressure obtained by Goldmann applanation tonometer, Corvis ST and an airpuff tonometer in healthy adults. Eur J Ophthalmol 32: 951-959.
11. Tejwani S, Dinakaran S, Joshi A, Shetty R, Roy AS (2015) A cross-sectional study to compare intraocular pressure measurement by sequential use of Goldman applanation tonometry, dynamic contour tonometry, ocular response analyzer, and Corvis ST. Indian J Ophthalmol 63: 815-820.
12. Ye Y, Yang Y, Fan Y, Lan M, Yu K, et al. (2019) Comparison of biomechanically corrected intraocular pressure obtained by Corvis ST and Goldmann applanation tonometry in patients with open-angle glaucoma and ocular hypertension. J Glaucoma 28: 922-928.
13. Whitacre MM, Stein R (1993) Sources of error with use of Goldmann-type tonometers. Surv Ophthalmol 38: 1-30.
14. Medeiros FA, Weinreb RN (2006) Evaluation of the influence of corneal biomechanical properties on intraocular pressure measurements using the ocular response analyzer. J Glaucoma 15: 364-370.
15. Kida T, Liu JHK, Weinreb RN (2006) Effect of 24-hour corneal biomechanical changes on intraocular pressure measurement. Invest Ophthalmol Vis Sci 47: 4422-4426.
16. Patwardhan A, Khan M, Mollan SP, Haigh P (2008) The importance of central corneal thickness measurements and decision making in general ophthalmology clinics: a masked observational study. BMC Ophthalmol 8: 1.
17. Uva MG, Reibaldi M, Longo A (2011) Intraocular pressure and central corneal thickness in premature and full-term newborns. J AAPOS 15: 367-369.
18. Myers JK RG (2005) Take the next step in tonometry. Optom Manag 40: 1-8.
19. Liu J, Roberts CJ (2005) Influence of corneal biomechanical properties on intraocular pressure measurement: quantitative analysis. J Cataract Refract Surg 31: 146-155.
20. Kotecha A (2007) What biomechanical properties of the cornea are relevant for the clinician? Surv Ophthalmol 2: S109-S114.
21. Kaufmann C, Bachmann LM, Thiel MA (2003) Intraocular pressure measurements using dynamic contour tonometry after laser in situ keratomileusis. Invest Ophthalmol Vis Sci 44: 3790-3794.
22. Muller L, Kohnen T (2009) Influence of residual corneal bed thickness after myopic LASIK on intraocular pressure measurements: Goldmann applanation tonometry and dynamic contour tonometry. Ophthalmologe 106: 21-28.
23. Ho T, Cheng ACK, Rao SK (2007) Central corneal thickness measurements using Orbscan II, Visante, ultrasound, and Pentacam pachymetry after laser in situ keratomileusis for myopia. J Cataract Refract Surg 33: 1177-1182.

24. Siganos DS, Papastergiou GI, Moedas C (2004) Assessment of the Pascal dynamic contour tonometer in monitoring intraocular pressure in unoperated eyes and eyes after LASIK. J Cataract Refract Surg 30: 746-751.
25. Svedberg H, Chen E, Hamberg-Nyström H (2005) Changes in corneal thickness and curvature after different excimer laser photorefractive procedures and their impact on intraocular pressure measurements. Graefes Arch Clin Exp Ophthalmol 243: 1218-1220.
26. Kirwan C, O'Keefe M (2008) Measurement of intraocular pressure in LASIK and LASEK patients using the Reichert Ocular Response Analyzer and Goldmann applanation tonometry. J Refract Surg 24: 366-370.
27. Pepose JS, Feigenbaum SK, Qazi MA, Sanderson JP, Roberts CJ (2007) Changes in corneal biomechanics and intraocular pressure following LASIK using static, dynamic, and noncontact tonometry. Am J Ophthalmol 143: 39-47.
28. Rashad KM, Bahnassy AA (2001) Changes in intraocular pressure after laser in situ keratomileusis. J Refract Surg 17: 420-427.
29. Bashford KP, Shafranov G, Tauber S, Shields MB (2005) Considerations of glaucoma in patients undergoing corneal refractive surgery. Surv Ophthalmol 50: 245-251.
30. Reznicek L, Muth D, Kampik A, Neubauer AS, Hirneiss C (2013) Evaluation of a novel Scheimpflug-based non-contact tonometer in healthy subjects and patients with ocular hypertension and glaucoma. Br J Ophthalmol 97: 1410-1414.
31. Sandhu SS, Chattopadhyay S, Birch MK, Ray-Chaudhuri N (2005) Frequency of Goldmann applanation tonometer calibration error checks. J Glaucoma 14: 215-218.
32. 32. Sánchez-Navés J, Furfaro L, Piro O, Balle S (2008) Impact and permanence of LASIK-induced structural changes in the cornea on pneumotonometric measurements: contributions of flap cutting and stromal ablation. J Glaucoma 17: 611-618.

Copyright: ©2025 Essam Ragab A Mohamed, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.