

**Intraocular pressure measurement using different techniques in normal eyes & post lamellar refractive Surgery a comparative clinical study**

A Thesis submitted by

**Shireen Mostafa Abdalla Shousha  
M.B.B.CH.**

In partial fulfillment of the requirements for the **M.Sc.** degree in Ophthalmology

**Under Supervision Of**

**Dr. Mahmoud Abo steit**

Professor of Ophthalmology  
Cairo University

**Dr. Mohamed Hassan Hosny**

Professor of Ophthalmology  
Cairo University

**Dr. Wael Ewais**

Lecturer of Ophthalmology  
Cairo University

**Cairo University**

**2012**

## Acknowledgments

In these few lines, I would like to express my deepest gratitude to the main supervisors of this thesis, *Prof.Mahmoud AboSteit* , *Prof.Mohamed Hosny* , & *Dr.Wael Ewais* for their valuable help and guidance in planning and conducting this work.

I am particularly indebted to *Prof.Mahmoud Abo Steit* for his continuous great support and encouragement, the main idea of undertaking this research was originally his.

I would like to express my deepest gratitude to *Prof.Mohamed Hosny* for his patience and meticulous supervision throughout the course of conducting this research; He has enriched me with many ideas and has aided me in performing and interpreting the statistics by myself, & to *Dr. Wael Ewais* for his continuous guidance and support.

Last but not least, I would like to express my deepest gratitude to my parents and my sister, who supported me a lot and without them the completion of this work would have not been possible.

*Shireen mostafa*

## Abstract

**Background** Intraocular pressure (IOP) measurement post Lasik is a great debate, a large number of studies addressed .No previous studies as regards IOP measurement after Epilasik.

**Purpose** To determine accuracy of IOP measurement after Lasik and Epilasik surgeries using Goldmann applanation (GAT), Air puff tonometry, Ocular response analyzer (ORA IOP<sub>cc</sub>) and Pentacam corrected IOP.

**Methods** This is a prospective comparative clinical study that was conducted on 60 eyes in the interval between February 2011 and September 2011 divided into 4 groups:(A) 20 corneas of patients before undergoing Lasik surgery, (B) 20 corneas of the same patients two months after Lasik surgery, (C) 10 corneas of patients before undergoing Epilasik surgery, (D) 10 corneas of the same patients two months after Epilasik surgery. Patients' age ranged from 20-50 years.IOP was measured prior to and after the suitable refractive surgery done using Goldmann applanation tonometry (GAT), air puff tonometry and Ocular response analyzer (corneal compensated IOP). Pentacam was used pre and post operative to measure both IOP and the central corneal thickness.

**Results** Significant positive linear correlations were found between preoperative IOP values measured by GAT (App pre) and air puff tonometry (Air puff pre), Pentacam corrected IOP (Pentacam pre), ocular response analyzer IOP<sub>cc</sub> (ORA pre), as well as central corneal thickness (Pach pre) in Lasik patients "group A" .The correlation between each of Pentacam pre and ORA pre was the strongest to the GAT ( $r=0.97$  and  $r=0.858$  respectively with  $p < 0.001$ , Compared to the preoperative values, postoperative IOP measured by the four methods were significantly lower in both Lasik and Epilasik patients . The difference was significantly evident when the IOP was measured using the GAT and Air puff tonometry (median  $> 6$  mmHg for Lasik patients, about 2 mmHg for Epilasik patients), compared to ORA and Pentacam corrected IOP (median  $\pm 1$  mmHg for both the Lasik and Epilasik patients) " $p < 0.001$  for Lasik patients and 0.017 for Epilasik patients", Non significant correlations has been shown between the degree of lowering of postoperative IOP and postoperative pachymetry (central corneal thickness) (Pach post) values in both Lasik (group B) and Epilasik (group D) patients.

**Conclusion** Refractive surgery causes significant lowering of IOP measured using GAT, Airpuff tonometry, ORA and Pentacam. Lasik has more effect on fallacies of IOP measurement post refractive surgery than Epilasik.

**Key words :** Hand held ART - Ultra sound - Epipolis Lasik .

## Table of contents

<b>Title</b>	<b>Page</b>
Table of Tables	4
Table of Figures	6
Abbreviations & Acronyms	8
Introduction and Aim of the Study	12
Review of Literature	15
<i>Chapter 1: Intraocular Pressure</i>	15
<i>Chapter 2: Ocular Response Analyzer</i>	36
<i>Chapter 3: Scheimpflug Technique and CCT</i>	50
<i>Chapter 4: Lamellar Refractive Surgery Versus Surface Ablation</i>	60
<i>Chapter 5: Lasik Effect on the Cornea and IOP</i>	66
Patients and Methods	76
Results	81
Discussion	93
Conclusion	100
Limitations	102
Summary	104
References	107
Master Table	I,II
Arabic Summary	III

## Table of Tables

<b>Table</b>	<b>Title</b>	<b>Page</b>
Table 1	Agents that affect aqueous humor formation	19
Table 2	Factors affecting aqueous humor outflow	22
Table 3	Correction table for IOP based on CCT	52
Table 4	Demographics, Pre and Postoperative IOP Values for Lasik and Epilasik Patients	81
Table 5	Bivariate Correlations Between App pre and Other Methods in Group A	82
Table 6	Bivariate Correlations Between App pre and Other Methods in Group C	82
Table 7	Bivariate Correlations Between App pre and Other Methods in All Preoperative Study Patients (Group A&C)	83
Table 8	Comparison Between App pre & Air puff pre in Lasik and Epilasik patients	84
Table 9	Comparison Between App pre & Pentacam pre in Lasik and Epilasik patients	84
Table 10	Comparison Between App pre &ORA pre in Lasik and Epilasik patients	84
Table 11	Comparison Between App-Pent pre & App-ORA pre in Lasik and Epilasik patients	85
Table 12	Comparison Between App-Pent pre & App-Air puff pre in Lasik and Epilasik patients	85
Table 13	Comparison Between Postoperative IOP Measured by The Different Methods.	86
Table 14	Comparison Between Pre & Post Operative IOP Values in Lasik and Epilasik patients	87
Table 15	Difference Between Post and Preoperative IOP Values in Lasik and Epilasik Patients	88
Table 16	Comparison Between Applanation $\Delta$ and Pentacam $\Delta$ in Lasik and Epilasik Patients.	88
Table 17	Comparison between Applanation $\Delta$ and ORA $\Delta$ in Lasik and Epilasik Patients.	88
Table 18	Comparison Between Pentacam $\Delta$ and ORA $\Delta$ in Lasik and Epilasik Patients	88
Table 19	Comparison between Applanation $\Delta$ and Air puff $\Delta$ in Lasik and Epilasik Patients	88
Table20	Bivariate Correlations Between the Degree of lowering of Postoperative IOP and Postoperative Pachymetry value in Lasik (group B) Patients	89

Table 21	Bivariate Correlations Between the Degree of Lowering of Postoperative IOP and Postoperative Pachymetry value in Epilasik (group D) Patients	90
Table 22	Comparison of the Degree of Lowering of IOP values in Lasik Patients. Lasik patients were classified into two subgroups according to median postoperative pachymetry value	90
Table 23	Bivariate Correlations Between the Degree of lowering of Postoperative IOP and Pachymetry $\Delta$ value in Lasik (group B) Patients	91
Table 24	Bivariate Correlations Between the Degree of Lowering of Postoperative IOP and Pachymetry $\Delta$ value in Epilasik (group D) Patients	91

## Table of Figures

<b>figure</b>	<b>Title</b>	<b>page</b>
Fig.1	Schematic diagram illustrating the trabecular meshwork conventional outflow pathway	16
Fig.2	Schematic diagram illustrating the uveoscleral outflow pathway	16
Fig.3	The Goldmann Applanation Tonometer	25
Fig. 4	A schematic illustration of forces affecting the applanation force in GAT	25
Fig. 5A	Perkins tonometer	26
Fig. 5B	Draeger's tonometer	26
Fig. 6	The relationship between force and frequency shift over time with the ART	28
Fig. 7	Conceptual illustration of the ARTservo prototype	28
Fig 8	Principle of Schiotz tonometry	30
Fig. 9	Icare Tonometer	31
Fig.10	The Pascal Dynamic Contour Tonometer	31
Fig. 11	ORA	37
Fig. 12	Parameters measured by ORA :IOPg,IOPcc,CRF,and CH	39
Fig. 13	CRF	40
Fig. 14	Relation between CCT and CRF	42
Fig. 15	Relation between CCT and CH	43
Fig.16	ORA mechanics	44
Fig.17	ORA Parameters pre and post Lasik	45
Fig. 18	CRF in normal, Keratoconus and post Lasik	45
Fig. 19	CH in normal, Keratoconus and postlasik	46
Fig. 20	CH in normal , POAG , NTG	47
Fig. 21	Orbscan II scanning slit corneal topographer	55
Fig. 22	The basic optical geometry of the camera	56

Fig. 23	Scheimpflug camera	57
Fig.24	Oculus Pentacam	57
Fig.25	Schematic representation of corneal recontouring by the Excimer laser	60
Fig.26	Techniques for de-epithelialization for surface ablation	64
Fig. 27	Schematic picture comparing Lasek and Lasik procedures	65
Fig. 28	Lasik effect on CH	66
Fig. 29	IOPcc pre and post Lasik	68
Fig. 30	The change in measured IOP after Lasek surgery	71
Fig.31	Bivariate Correlations Between App pre and Other Methods in All Preoperative Study Patients (Group A&C)	83
Fig.32	Comparison Between Postoperative IOP Values in Lasik (group B) and Epilasik (group D) Patients	85
Fig. 33	Pre and Post Operative IOP Values for the Lasik Patients	86
Fig.34	Pre and Post Operative IOP Values for the Epilasik Patients	87



## Abbreviations & Acronyms

**A:** Area

**Air puff post:** Postoperative value of Air puff tonometry

**Air puff pre:** Preoperative value of Air puff tonometry

**Air puff  $\Delta$ :** Difference of IOP measured by Air puff tonometry pre and post operatively (post-preoperative value)

**ALK:** Automated lamellar keratoplasty

**App-Air puff pre:** Difference between preoperative IOP values measured by Goldmann applanation tonometry and Air puff tonometry

**App-ORA pre:** Difference between preoperative IOP values measured by Goldmann applanation tonometry and Ocular response analyzer

**App-Pent pre:** Difference between preoperative IOP values measured by Goldmann applanation tonometry and Pentacam corrected IOP

**App post:** postoperative value of Goldmann applanation tonometry

**App pre:** preoperative value of Goldmann applanation tonometry

**Applanation  $\Delta$ :** Difference of IOP measured by Goldmann applanation tonometry pre and post operatively (post-preoperative value)

**ARS:** Applanation resonance sensor

**ART:** Applanation resonance tonometry

**ART<sub>Biom</sub>:** Applanation resonance tonometry biomicroscope

**ART<sub>Hand</sub>:** Hand held ART

**ART<sub>servo</sub>:** Servo controlled ART

**BFA:** Blood flow analyzer

**CC:** Corneal curvature

**CCT:** Central corneal thickness

**CH:** Corneal hysteresis

**CRF:** Corneal resistance factor

**d.RCT:** Dynamic rasterstereographic corneal topography

**Eq:** Equation

**Epilasik:** Epipolis Lasik

**F:** Force

**FFKc:** Forme fruste Keratoconus

**GAT:** Goldmann applanation tonometry

**IOP:** Intra ocular pressure

**IOP<sub>cc</sub>:** Corneal compensated IOP

**IOP<sub>g</sub>:** Goldmann correlated IOP

**ISO:** International standard organization

**KMi:** Keratoconus match index

**Lasek:** Laser assisted sub epithelial keratomileusis

**Lasik:** Laser assisted insitu keratomileusis

**NTG:** Normal tension glaucoma

**NCT:** Non contact tonometry

**OAG:** Open angle glaucoma

**OBF:** Ocular blood flow

**OCT:** Ocular coherence tomography

**OHT:** Ocular hypertension

**OHTS:** Ocular hypertension treatment study

**ORA:** Ocular response analyzer

**ORA pre:** Preoperative ORA IOP<sub>cc</sub>

**ORA post:** Postoperative ORA IOP<sub>cc</sub>

**ORA Δ:** Difference of IOP measured by Ocular response analyzer pre and post operatively (post-preoperative value)

***p*:** Probability value

**Pach post:** Postoperative CCT

**Pach pre:** Preoperative CCT

**Pach  $\Delta$ :** Pachymetry  $\Delta$ =post-preoperative pachymetry

**PDCT:** Pascal dynamic contact tonometry

**Pentacam pre:** preoperative value of Pentacam corrected IOP

**Pentacam post:** postoperative value of Pentacam corrected IOP

**Pentacam  $\Delta$ :** Difference of Pentacam corrected IOP pre and post operatively (post-preoperative value)

**PEX:** Pseudo exfoliation syndrome

**PRK:** Photo refractive keratectomy

**r:** Spearman correlation coefficient

**TM:** Trabecular meshwork

**US:** Ultra sound

**VA:** Visual acuity

# ***Introduction & Aim of Work***

## **Introduction**

Intraocular pressure (IOP) measurement plays a central role throughout ophthalmology. It is part of routine ophthalmologic examinations and important in the management and follow-up of glaucoma patients.

At least half of the population diagnosed with open angle glaucoma (OAG) is asymptomatic. There are substantial variations in prevalence throughout the world due to genuine differences in populations but also due to methodological differences, such as differences in diagnostic criteria and sampling methods <sup>1</sup>.

The most important risk factor for the development <sup>2</sup> and the progress of OAG is elevated IOP <sup>3</sup>. Elevated IOP is still the only risk factor that is modifiable <sup>4</sup> other ocular risk factors include thin corneas <sup>5</sup> and pseudo exfoliation syndrome (PEX) in combination with elevated IOP, which increase the risk for both OAG development and progression of the disease <sup>1</sup>.

Refractive surgery has become increasingly popular in recent years. Laser assisted insitu keratomileusis (Lasik) has become popular in treating myopia since 1993 the structural modification of corneal properties, e.g. central corneal thickness ( CCT ) and corneal curvature (CC), by refractive surgery, has augmented the risk for measurement error of IOP and consequently brought attention to the IOP measurement.

New methods for IOP measurement and assessing corneal biomechanics are continuously under study and evaluation.

## **Aim of Work**

The aim of this study is to:

- Determine the ease and accuracy of intraocular pressure measurement pre and post refractive surgery (Lasik and Epilasik) using the following methods:

- Applanation tonometry

- Air puff tonometry

- Ocular response analyzer

- Scheimpflug camera

- Comparing the results for the Lasik group to Epilasik group to determine effect of lamellar refractive surgery versus surface ablation on bias of IOP measurement after each of them.

# *Review of Literature*