"GOLDMANN APPLANATION TONOMETER VERSUS NONCONTACT AUTOTONOMETER IN MEASUREMENT OF INTRAOCULAR PRESSURE IN EYES WITH MYOPIA – A DESCRIPTIVE OBSERVATIONAL STUDY"

By

DR. DHAVALIKAR MRUNALI MOHAN

REGISTRATION NO: BK0109003

Dissertation

Submitted to the

KLE University Belgaum, Karnataka

In partial fulfillment

of the requirements for the degree of

MASTER OF SURGERY

IN

OPHTHALMOLOGY

Under the Guidance of

DR. MAHESH .I. MAGDUM M.S.(Ophth),D.O.

PROFESSOR

DEPARTMENT OF OPHTHALMOLOGY,

JAWAHARLAL NEHRU MEDICAL COLLEGE,

BELGAUM, KARNATAKA.

MAY - 2012

KLE UNIVERSITY BELGAUM, KARNATAKA

Declaration By The Candidate

I hereby declare that this dissertation entitled ***"GOLDMANN APPLANATION TONOMETER VERSUS NONCONTACT AUTOTONOMETER IN MEASUREMENT OF INTRAOCULAR PRESSURE IN EYES WITH MYOPIA– A DESCRIPTIVE OBSERVATIONAL STUDY"*** is a bonafide and genuine research work carried out by me under the guidance of **Dr. MAHESH .I. MAGDUM**$_{\text{M.S.(Ophth),D.O,}}$ Professor, Department of Ophthalmology, Jawaharlal Nehru Medical College, Nehru Nagar, Belgaum-590010.

Date:

Place: Belgaum **(DR. DHAVALIKAR MRUNALI MOHAN)**

KLE UNIVERSITY BELGAUM, KARNATAKA

Certificate By The Guide

This is to certify that the dissertation entitled ***"GOLDMANN APPLANATION TONOMETER VERSUS NONCONTACT AUTOTONOMETER IN MEASUREMENT OF INTRAOCULAR PRESSURE IN EYES WITH MYOPIA– A DESCRIPTIVE OBSERVATIONAL STUDY"*** is a bonafide research work done by **Dr. DHAVALIKAR MRUNALI MOHAN** in partial fulfillment of the requirement for the Degree of **M.S. (Ophthalmology)**, examination to be held in May 2012.

Date:

Place:

Guide :

Dr. MAHESH .I. MAGDUM$_{\text{M.S.(Ophth),D.O.}}$
Professor,
Department of Ophthalmology,
J. N. Medical College,
Belgaum.

KLE UNIVERSITY BELGAUM, KARNATAKA

Endorsement By The HOD, Principal/ Head Of The Institution

This is to certify that the dissertation entitled ***"GOLDMANN APPLANATION TONOMETER VERSUS NONCONTACT AUTOTONOMETER IN MEASUREMENT OF INTRAOCULAR PRESSURE IN EYES WITH MYOPIA– A DESCRIPTIVE OBSERVATIONAL STUDY"*** is a bonafide research work done by **Dr. DHAVALIKAR MRUNALI MOHAN** under the guidance of **Dr. MAHESH .I. MAGDUM** M.S.(Ophth),D.O. Professor, Department of Ophthalmology, Jawaharlal Nehru Medical College, Nehru Nagar, Belgaum-590010.

Dr. R. K. DANDURM.S., D.O.M.S.
Professor & Head,
Department of Ophthalmology
J. N. Medical College,
Belgaum-590010
Date:
Place:

Dr. V. D. PATIL M.D., D.C.H.
Principal,
J. N. Medical College,
Belgaum-590010.

Date:
Place:

KLE UNIVERSITY BELGAUM, KARNATAKA

Copyright

Declaration by the candidate

I hereby declare that the **KLE UNIVERSITY, BELGAUM** shall have the rights to preserve, use and disseminate this dissertation in print or electronic format for academic / research purpose.

Date: **(Dr. DHAVALIKAR MRUNALI MOHAN)**

Place:

Acknowledgement

This dissertation work has been a great learning experience and encouragement in all walks of my postgraduate life, which by the grace of The Almighty was carried out with enthusiasm, for which I am always indebted to him.

It has been a great pride, inspiration and privilege to work and carry out this study under the guidance of **Dr. Mahesh .I. Magdum** *M.S.(Ophth),D.O. Professor, Department of Ophthalmology, J. N. Medical College, Belgaum. I express my heartfelt gratitude and sincere thanks for his constant encouragement, motivation, supervision and support in carrying out my study and also in completing this dissertation with deliberation.*

I am very grateful to **Dr. R. K. Dandur,** *Professor and Head, Department of Ophthalmology, J. N. Medical College, Belgaum for his permission to undertake this study and I express my deep sense of gratitude and sincere thanks for his constant motivation and invaluable guidance.*

I am also very grateful to The Principal **Dr. V. D. Patil,** *J. N. Medical College, Belgaum, for his support and permission to undertake this study.*

I owe an immense debt of gratitude to **Dr. U. S. Dandavatimath,** *Professor,* **Dr. S. B. Patil,** *Professor,* **Dr. Rekha B. K,** *Professor and* **Dr. A. L. Tenagi,** *Professor, Department of Ophthalmology for their invaluable suggestions and support throughout the study.*

I am very grateful to ***Dr. Umesh Harakuni,*** *Associate Professor, Department of Ophthalmology, for his support, understanding and invaluable guidance throughout my study.*

I express my gratitude to Associate Professor, ***Dr. Arvind Yakkundi, Dr. Shivanand Bubanale,*** *Department of Ophthalmology, for their immense help and constant encouragement.*

I am thankful to Assistant Professor, ***Dr. Smitha K.S.*** *and* ***Dr. Harshavardhan Patil*** *for their valuable suggestions and support.*

I am also thankful to Professor, ***R. H. Dhareshwar*** $_{MSc,\ MPhil,}$ *Statistician for statistical analysis.*

I am also thankful to ***Mr. Mahesh, Mr. Pundalik Patil, Mr. Mahantesh*** *&* ***Nagarkar*** *sister, Department of Ophthalmology.*

I wish to offer my thanks to Department of Medical Education for their valuable information and support.

I would like to acknowledge the tireless and timely work done by Miss. Veena & Mr. Deepak of ***Sai Xerox & D.T.P. Centre*** *for their excellent data processing and completion of this manuscript in a short time.*

My deep sense of gratitude to my dear friends, ***Dr. Rishi Bhardwaj, Dr. Prakash Parimal, Dr. Robin Bhandari, Dr. Sneha Dhavalikar, Dr. Manisha Sharma, Dr. Bhagyajyothi Kurbet, Dr. Devesh Sharma*** *and* ***Dr. Saraswathy Shivanandan*** *and all other Postgraduate colleagues and friends for their relentless support in carrying out this dissertation.*

No amount of words can measure up to the deep sense of gratitude and thankfulness that I feel towards my in-laws and my parents and other family members whose cherished blessings and countless sacrifices are behind whatever success I have achieved in my life.

I am immensely thankful for continuous moral support extended with love and co-operation by my husband, ***Dr. Sunay Bhat*** *and my sister,* ***Dr. Mrugaya Purohit****.*

Last but not the least, I wish to express my profound thanks to all the subjects who have whole-heartedly participated and co-operated in the study and have made the study complete.

I bow my head in respect before God Almighty.

Dr. Mrunali Dhavalikar

LIST OF ABBREVIATIONS

ACD	Anterior Chamber Depth
AXL	Axial length
D	Diopter
GAT	Goldmann applanation tonometer
IOP	Intraocular pressure
K	Keratometry reading
NCT	Non-contact autotonometer
NS	Non-Significant
S	Significant
S.D	Standard deviation
WWP	White Without Pressure

ABSTRACT

Purpose of the study:

To find out the specificity and sensitivity of non-contact autotonometer in detecting intraocular pressure in eyes with myopia and also to compare the positive and negative predictive value of non-contact autotonometer and Goldmann applanation tonometer.

Methods:

A total of 236 eyes of 118 patients having myopia of more than 2 D and age between 18 to 40 years were studied. Each eye had undergone subjective refraction testing, IOP measurement with non-contact autotonometer and Goldmann applanation tonometer and then the measurement of corneal curvature, axial length and anterior chamber depth. Funduscopic examination was carried out thoroughly by indirect ophthalmoscopy with +20 D lens.

Results:

The sensitivity of non-contact autotonometer in detecting IOP > 21 mm Hg was found to be 84.21%. The specificity, positive and negative predictive values were 95.96%, 80% and 96.94% respectively. The correlation coefficient between the two instruments was found to be 0.880 ($p < 0.0001$) which was highly significant. Positive correlation was found between degree of myopia and axial length with IOP whereas a negative correlation was found between the corneal curvature and anterior chamber depth with IOP as measured with both non-contact autotonometer and Goldmann applanation tonometer.

Conclusion:

Eventhough the Goldmann applanation tonometer is considered to be the gold standard for measurement of IOP, non-contact autotonometer with its reliable, practical, associated low cross infection risk, with high sensitivity and specificity, comparable performance with Goldmann applanation tonometer and a good patient compliance, can be used to screen the myopes who are likely to be associated with raised IOP and primary open angle glaucoma. Degree of myopia and axial length were seen to have an influence on IOP with a positive correlation, while a negative correlation of corneal curvature and anterior chamber depth with IOP as measured with non-contact autotonometer and Goldmann applanation tonometer was observed. Hence it was concluded from the present study that irrespective of degree of myopia, axial length, corneal curvature and anterior chamber depth, non-contact autotonometer can provide a reliable and an accurate measurement of IOP when compared to the standard Goldmann applanation tonometer.

KEY WORDS: Non-Contact Autotonometer; Goldmann Applanation Tonometer; Sensitivity; Specificity; Positive Predictive Value; Negative Predictive Value; Myopia; Primary open angle glaucoma.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF GRAPHS

LIST OF PHOTOGRAPHS

INTRODUCTION

Glaucoma is the second leading cause of irreversible blindness worldwide. The risk factors for primary open angle glaucoma are demographic factors like race, age, family history in parent or sibling and ocular factors like intraocular pressure, nerve fibre layer thickness and myopia. IOP plays an important role in the development of glaucoma and is one of the strongest known risk factors for the condition.[1]

Intraocular pressure (IOP) refers to the pressure exerted by intraocular contents on the coats of the eyeball. The normal level of IOP is essentially maintained by a dynamic equilibrium between the aqueous humour formation, aqueous humour outflow and episcleral venous pressure. Normal IOP varies between 10.5 and 20.5 mm Hg with a mean pressure of 15.5$\pm$2.57 mm Hg.[2]

The importance of intraocular pressure (IOP) assessment in the evaluation of glaucoma has been understood for over 100 years. Digital estimation of globe firmness yielded to instrumental (Schiotz) tonometry over the first 20 years of the twentieth century. Today, the Goldmann applanation tonometer provides the gold standard for the clinical measurement of IOP.[1]

It is possible to measure intraocular pressure directly in a living eye using a manometric technique. Tonometry is an indirect method of measuring the IOP with the help of specially designed instruments known as tonometers which are divided into two major groups, referred to as applanation and indentation tonometers.[3]

The different types of tonometers in clinical practice are applanation tonometers like Goldmann tonometer, Perkin's tonometer, Draegers tonometer,

Mackay Marg tonometer –Tono-pen, Pneumotonometer, Maklakov tonometer, and non- contact tonometer and indentation tonometer like Schiotz tonometer.

With applanation tonometer the clinician measures the force necessary to flatten a small, standard area of the cornea. With indentation tonometer, the clinician measures the amount of deformation or indentation of the globe in response to a standard weight applied to the cornea.(3)

The non-contact tonometer applanates the cornea by a jet of air , so there is no direct contact between the device and the surface of the eye. This theoretically avoids the need to sterilize the instrument. The force of the air jet increases rapidly and linearly with time.(3)

The non- contact tonometry is useful for screening programs because it can be operated by non- medical personnel , it does not require topical anaesthesia and there is no direct contact between the instrument and the eye.(3)

More recent tonometers work on different principles such as contour matching, transpalpebral phosphine induction, indentation / rebound and intraocular implantation of pressure sensors.(3)

Factors affecting IOP are demographic factors like age, sex, race, heredity, systemic factors like diurnal variation, seasonal variation, blood pressure, obesity, posture, **e**xercise**,** neural**,** hormones and ocular factors like refractive error, eye movements**,** eyelid closure**,** inflammation.(3)

Myopia is a common optical aberration. Physiological myopia, by far the most prevalent, is less than - 6 D in magnitude and is considered a normal biological variation. Eyes that have errors greater than – 6D are said to have high myopia.

Not all the eyes that have myopia greater than – 6 D progress, nor does every eye that has progressive myopia develop degenerative complications. A number of

studies have reported higher IOPs in myopic individuals. IOP also correlates with the axial length.[1]

In view of the various advantages of non-contact tonometer over Goldmann applanation tonometer like patient preference, less operator dependence, and low risk of transmission of infection as well as considering the role of myopia in causation of primary open angle glaucoma the present study was undertaken to find out the accuracy of noncontact autotonometer in detecting raised intraocular pressure in our group of patients.

AIMS AND OBJECTIVES:

1. To find out the specificity and sensitivity of noncontact autotonometer in detecting intraocular pressure in myopes.
2. To compare the positive and negative predictive value of noncontact autotonometer and Goldmann applanation tonometer.

REVIEW OF LITERATURE

Historical review:

Digital estimation of the ocular tension was formally introduced by William Bowman in 1862. The first efforts toward instrumental tonometry were apparently made by Von Graefe in the same year. But none of these instruments, however , reached the drawing board stage.

The first impression tonometers actually produced and tested on human eyes were developed by Donder between 1863 and 1868. They were the instruments for use on the sclera. The scleral curvature at the site of tonometer application was determined first; it then served as a reference plane for the measurement of the depth of the indentation.

The principal flaw of impression tonometry is that the indentation, by displacing a significant amount of intraocular fluid, changes the pressure it is intended to measure ; this was clearly expressed for the first time by Adolf Weber in 1867. He also invented the first applanation tonometer, which was intended to give a tension reading with only minimal fluid displacement. But the instrument did not gain wide acceptance.

The principal of applanation tonometry was explored again in 1885 by Maklakoff and a few years later by Imbert and Fick. It was again recognized as a sounder basis of tonometry, and several new applanation tonometers resulted. Only one of them, Maklakoff ‘s model of 1892, has stood the test of time and has remained in use.

Schiotz first reported on his impression tonometer in 1905; comprehensive major reports on the clinical value of tonometric results began to appear in 1910. The

core of today‘s knowledge of the intraocular pressure in the normal and in the diseased human eye was acquired between 1910 and 1920 through the use of Schiotz tonometers.

Most of the pioneers in digital or instrumental tonometry realized that properties of the eyeball wall, viz, distensibility and elasticity, affected their estimates of the intraocular pressure. Early experimental attempts to measure these properties revealed multiple variables which defied all efforts to eliminate them.

Thirty years later, the electronic form of his instrument came closest to yielding reasonable estimates of “ocular rigidity”, the term introduced by Friedenwald for the resistance that the in vivo eyeball offers to a change in intraocular volume.

As a means of correcting readings taken with the Schiotz tonometer for deviation of the particular eye from average ocular rigidity, the coefficient of ocular rigidity lost some of its clinical importance through the tremendous progress in applanation tonometry that occurred in the early 1950s through the work of Goldmann, Perkins and Maurice.

The term myopia was introduced from the habit which short – sighted people frequently have of half closing the lids when looking at the distant objects so that they may gain the advantages of a stenopaeic opening.

The first satisfactory definition of the condition was stated by Kepler in1611, and Plempius, 1632, first examined the myopic eye anatomically and attributed the condition to a lengthening of its posterior part. Donders in 1866 established its pathological basis, and detailed its clinical manifestations. [4,5]

Instruments for measuring intraocular pressure:

It is possible to measure IOP directly in a living eye using a manometric technique. For this technique a needle is inserted into the anterior chamber through a self-sealing, beveled corneal puncture. The needle is connected to a fluid filled tubing, and the height of fluid in the tube corresponds to the IOP. This is the only direct measure of IOP. The tubing can also be connected to a fluid filled reservoir that has a pressure sensitive membrane. The movement of the membrane recorded optically or electronically, is a measure of IOP. Although the direct method is perhaps the most accurate, its obvious clinical limitations necessitate alternative means for measuring pressure in patients .[3]

Most techniques for measuring IOP in clinical use are indirect in that they are based on the eye's response to an applied force. An example of this process is palpation, during which an examiner estimates IOP by the response of the eye to the digital pressure – that is , he or she determines whether the globe indents easily or whether it feels firm to the touch. Palpation should be used only in the most extraordinary circumstances because it is capable of detecting only gross alterations of IOP. It may be especially useful in patients with irregular corneas where applanation tonometry may not be possible.[3]

Traditionally, tonometers could be divided into two major groups, referred to as applanation and indentation instruments.

Applanation instruments:

Goldmann applanation tonometer

Perkins tonometer

Draeger tonometer

MacKay – Marg tonometer

Tonopen

Pneumatic tonometer

Non - contact tonometer

Ocuton tonometer

Maklakow tonometer.

Goldmann applanation tonometer :

It is considered to be the international gold standard instrument for measuring the IOP.[3]

Goldmann based his concept of tonometry on a modification of the Maklakov –Fick law (also referred to as the Imbert –Fick law). This law states that an external force (W) against a sphere equals the pressure in the sphere (Pt) times the area flattened (applanated) by the external force (A)

$$W = Pt \times A$$

The validity of the law requires that the sphere be a perfectly spherical, dry, perfectly flexible and infinitely thin. The cornea fails to satisfy any of these requirements, in that it is aspherical and wet, and neither perfectly flexible nor infinitely thin. The moisture creates a surface tension(S), and the lack of the flexibility requires a force to bend the cornea (B) , which is independent of the internal pressure . In addition, because the cornea has a central thickness of approximately 550 microns , the outer area of the flattening (A) is not the same as the inner area (A1) . Therefore the Imbert-Fick law was modified in the following manner to account for these characteristic of the cornea.

$$W + S = Pt\ A1 + B$$

When A1 = 7.35mm square, S balances B and W = Pt. This internal area of applanation is obtained when the diameter of the external area of corneal applanation is 3.06mm, which is used in the standard instrument. The volume of the displacement produced by applanating an area with a diameter of 3.06mm is approximately 0.50 cu.mm, so that Pt is very close to P0 and ocular rigidity does not significantly influence the measurement. [(6)]

It determines the force necessary to flatten or applanate an area of the cornea 3.06 mm in diameter. This technique is referred to as constant–area applanation. When the cornea is flattened the force of the tonometer supplied by a coiled spring or a weight, counter balances and provides a measure of IOP. For this area of applanation the IOP in millimeters of mercury is equal to the force of the tonometer in grams multiplied by 10.[(3)]

Applanation tonometer displaces only about 0.5ml aqueous humour which raises IOP by 3%, because the volume displaced is so small, ocular rigidity has little effect on the pressure readings. The degree of applanation is judged while viewing the cornea through a split prism device in the applanation head.[(3)]

To better distinguish the tear film and the cornea, which have similar refractive indices, fluorescein is instilled in the anaesthesized conjunctival cul- de – sac. When the front surface of the eye is illuminated with a cobalt blue filter, the fluorescein- stained tear film appears bright yellow green. When the clinician looks through the split prism in contact with the eye, he or she sees a central blue circle, the flattened cornea, surrounded by two yellow green semicircles. When the inner margins of the two semicircles are aligned in a smooth S curve at the midpoint of their pulsations, the proper degree of applanation has been achieved.[(3)]

Figure No. 1: Goldmann applanation tonometer

Technique of applanation tonometry:

The cornea is anaesthesized with a topical preparation and the tear film is stained with sodium fluorescein.

With the cornea and the biprism illuminated by a cobalt blue light from the slit lamp, the bi prism is brought into gentle contact with the apex of the cornea.

The fluorescence of the stained tears facilitates visualization of the tear meniscus at the margin of the contact between cornea and the biprism.

The florescent semicircles are viewed through the biprism and the force against the cornea is adjusted until the inner edges overlap.

The influence of the ocular pulsations is seen when the instrument is properly positioned, and the excursions must be averaged to give the desired endpoint.

The IOP is then read directly from a scale on the tonometer housing. [(6)]

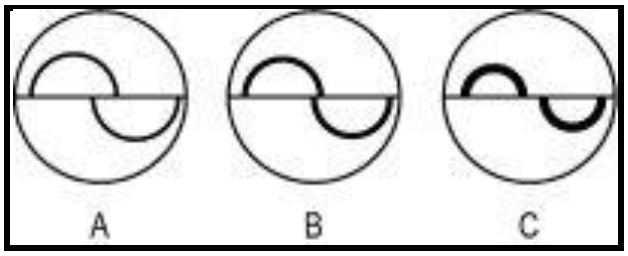


Figure No. 2: Fluorescein pattern on Goldmann applanation tonometer.

Above diagram shows fluorescein pattern seen when the head of the Goldmann applanation tonometer rests against the anterior corneal surface. (A) the dial reading is greater than the IOP; (B) the dial reading is equal to the IOP and the applanated corneal area has a diameter of 3.06 mm; (C) the dial reading is less than the IOP.

Sources of error with Applanation tonometer:

Although the Goldmann tonometer is reliable and accurate through wide range of IOPs errors in measurement can arise from a number of factors as follows:

1. The width of the meniscus may influence the reading slightly , with wider menisci causing falsely higher pressure estimates.[7] Improper vertical alignment (one semicircle larger than the other) will also lead to a falsely high IOP estimate.[8]
2. Inadequate fluorescein staining of the tear film causes an underestimation of IOP.[3]
3. Widening the palpebral fissure excessively causes an overestimation of IOP.
4. Repeated tonometry reduces the IOP, causing an underestimation of the true level.[9,10]This effect is greatest between the first and the second readings , but the trend continues through a number of repetitions.[11]

5. A scarred, irregular cornea distorts the fluorescein rings and makes it difficult to estimate IOP.
6. The thickness of the cornea affects IOP readings. If the cornea is thick because of edema, IOP is underestimated[12]

   In thin corneas, Goldmann tonometer will underestimate the IOP.[13,14,15]

   Central corneal pressures have shown to be lower than peripheral corneal readings following photorefractive keratectomy and LASIK.[16]
7. If the corneal astigmatism is greater than 3D, IOP is underestimated for with the rule astigmatism and over estimated for against the rule astigmatism.[17]

It is possible to transfer bacteria, viruses, and other infectious agents with the tonometer head, including serious infections as epidemic keratoconjunctivitis, hepatitis B, Jacob-Kreutzfeld and, theoretically, acquired immunodeficiency syndrome. The biprism should be rinsed and dried immediately after use. Between uses, the prism head should be soaked in a solution such as diluted bleach or 3% hydrogen peroxide.[3]

Other applanation tonometers with variable force:

Perkins tonometer:

The Perkins tonometer is similar to the Goldmann tonometer except that it is portable and counterbalanced, so it can be used in any position.

This instrument is useful in a number of situations, including in the operating room, at the bedside, and with patients who are obese or for other reasons cannot be examined at the slit lamp. It is also useful in community screening programmes.

The light comes from batteries, and the force comes from a spring, varied manually by the operator.

This tonometer does seem to underestimate the IOP. [3]

Draeger tonometer:

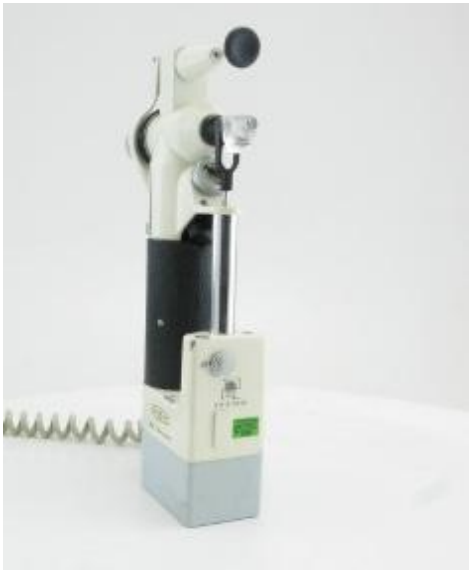


Figure No. 3: Draeger tonometer

This is similar to the Goldmann applanation tonometer and Perkins tonometer, except that it uses a different biprism. The force for the applanation is supplied by an electric motor .

Like the Perkins instrument, the Draeger tonometer is portable and counterbalanced, so it can be used in a variety of positions and locations. [3]

MacKay-Marg and Tono- Pen tonometers:

The MacKay – Marg tonometer consists of a movable plunger, 1.5 mm in diameter, that protrudes slightly from a surrounding footplate or sleeve. The movements of the plunger are measured by a transducer and recorded on a paper strip.[3]

Principle: The force measured is that which is required to keep the flat plate of a plunger flush with a surrounding sleeve against the pressure of corneal deformation. The effect of corneal rigidity is transferred to the sleeve , so the plate reads only the IOP. [6]

Although the original instrument is no longer available , the newer models have been developed that use the same basic principle.

The newer models differ from the MacKay – Marg tonometer in having an internal logic program that automatically selects the acceptable measurements and rejects the inappropriate ones .the most commonly used tonometer in this category is the Tono – Pen.[6]

Tono-PenTM :

Figure No. 4: Tono-PenTM

This hand held MacKay – Marg type tonometer has a strain gauge that creats an electrical signal as the foot plate flattens the cornea. A built in single chip microprocessor senses the proper force curves and averages 4 to 10 readings to give a final digital readout.

It also provides the percentage of variability between the lowest and highest acceptable readings from 5% to 20%.[6]

Pneumatic tonometer:

It has a sensing device that consists of a gas chamber covered by a polymeric silicone diaphragm. A transducer converts the gas pressure in the chamber into an electrical signal that is recorded on a paper strip. The gas in the chamber escapes through an exhaust vent between the diaphragm and the tip of the support nozzle. As the diaphragm touches the cornea , the gas vent is reduced in size , and the pressure in the chamber rises.

It is useful for measuring IOP in eyes with scared, irregular, or oedematous corneas. (3)

Non – contact Tonometer:

Figure No. 5: Non-contact Tomometer

The non –contact tonometer was introduced by Grolman and it has the unique advantage over other tonometers of not touching the eye, other than with a puff of air.(6)

Principle: The Noncontact tonometer applanates the cornea by a jet of air , so there is no direct contact between the device and the surface of the eye. This theoretically avoids the need to sterilize the instrument.(6)

A recent study found the air puff produces a tear film aerosol that could potentially contain infectious material.(18)

The force of the air jet increases rapidly and linearly with time.

The instrument also emits a collimated beam of light that is reflected from the central cornea and then received by the photocell.

When an area of the cornea 3.6mm in diameter is flattened, light reflected to the photocell is at maximum . The time required to produce the peak reflection is directly related to the force of the air jet and thus to the counterbalancing IOP.[(3)]

Description of the instrument:

The non-contact tonometer is mounted on a table and it consists of three subsystems. :

a) An alignment system allows the operator to optically align the patient's cornea in three dimensions(axial , vertical, and lateral).
b) An optoelectronic applanation monitoring system consists of a transmitter, which directs a collimated beam of the light at the corneal vertex , and a receiver and detector, which accepts only parallel , coaxial rays reflected from the cornea.
c) A pneumatic system generates a puff of room air which is directed against the cornea.

At the moment that the central cornea is flattened, the greatest number of the reflected light rays are received, which is recorded as the peak intensity of light detected.

The time from an internal reference point to the moment of maximum light detection is converted to IOP.

In a subsequent version of the table mounted non-contact tonometer, the X-Pert non- contact tonometer, the air puff is automatically triggered when alignment criteria are satisfied and the force of air to achieve peak light detection is the measured variable.

Another hand held non-contact tonometer, the Pulsair tonometer, has also been described. **(6)**

Technique:

The patient observes an internal target while the operator aligns the cornea by superimposing a reflection of the target from the patient's cornea on a stationary ring. During this time, light from the transmitter is reflected from the undisturbed cornea, which allows only a small number of rays to enter the receiver .When the cornea is properly aligned , the operator depresses a trigger , which causes a puff of air to be directed against the cornea , and the IOP is displayed on a digital readout. (6)

The non – contact tonometer measures the IOP over very short intervals, so it is important to average a series of readings.(19)

The instrument has an internal calibration system.(3)

In general, at least three but preferably four readings should be obtained on each eye.(20)

The non- contact tonometry is useful for screening programs because it can be operated by non- medical personnel, it does not require topical anaesthesia and there is no direct contact between the instrument and the eye. (3)

The IOP readings taken by the non - contact tonometer correlate fairly well with readings taken by Goldmann tonometer but the difference of several millimeters of mercury are not unusual, particularly pressures higher than the low 20s .(3)

In a study, the Keeler Pulsair 2000 and the American Optical (AO) MK2 non –contact tonometers (NCT) were compared to reference Goldmann applanation tonometer. Forty-five patients (89 eyes) receiving medical treatment for primary open angle glaucoma had their IOP measured with each instrument in a random order using five experienced observers. The Pulsair 2000 read slightly higher than Goldmann

tonometer, whereas the AO MK2 read slightly lower. However, all the differences were statistically significant. In conclusion, the study showed that both NCTs should be useful for measuring IOP as a part of a screening protocol for glaucoma.[21]

Another study compared the performance of non- contact tonometer, Nidek NT-2000, with the Keeler Pulsair 2000 and the Goldmann applanation tonometer. Twenty two subjects with IOP ranging from 10 to 21 mmHg were recruited and their IOP measured. It showed that NT-2000 was comparable to the Goldmann applanation tonometer.[22]

In a study, the Keeler Pulsair 3000 non-contact tonometer was compared to Goldmann tonometer to assess the validity and reliability of the Pulsair 3000 data. In the range of 10 to 24 mm Hg, the Pulsair 3000 tonometer produced the IOP readings that corresponded well with Goldmann values for most eyes and was preferred by majority of the subjects. This study also stated that the non-contact tonometer is relatively easy to use by technicians and has numerous special applications in optometric practice (e.g. measuring IOPs for paediatric patients and those with compromised corneas).[23]

In another study, IOP measurements with XPERT non – contact tonometer and Goldmann applanation tonometer were compared. This study found that the XPERT tonometer provided reliable IOP measurements, especially within the normal range.[24]

OcutonTM tonometer:

It is a hand held tonometer that works on the applanation principle using a probe that is so light that it is barely felt and, therefore, needs no anaesthetic in most patients. It has been marketed for home tonometry in Europe. It is particularly useful

to get some idea of the relative diurnal variation in IOP if the patient can learn to use it. (3)

Maklakov tonometer:

It differs from the other applanation instruments in that a known force is applied to the eye, and the area of applanation is measured – a technique known as constant – force rather than constant –area applanation.

Maklakov tonometer is used widely in Russia and China but has never achieved great popularity in other countries. It displaces a greater volume of aqueous humour than the other applanation devices. (3)

Indentation instruments:

In indentation tonometry, a known weight is placed on the cornea, and the IOP is estimated by measuring the deformation or indentation of the globe.

The Schiotz tonometer is the prototype for this instrument.(3)

Schiotz tonometer:

The Schiotz tonometer determines the IOP by applying a carefully standardized instrument to the cornea and measuring the depth of indentation of the cornea by the plunger while it is loaded with a given weight. The scale of Schiotz tonometer is calibrated in such a fashion that each scale unit represent 0.05 mm protusion of the plunger.

Description of Schiotz tonometer:

The body of the tonometer has a footplate , which rests on the cornea. The plunger moves freely and the amount of indentation is indicated by the movement of a needle on a scale.5.5 gm weight is permanently fixed to the plunger which can be raised to 7.5 gm ,10gm , or 15gm by placing additional weight. [6]

Figure No. 6: Schiotz tonometer

Technique of Schiotz Tonometer:

With the patient in supine position and fixing on a target just overhead , the examiner separates the eyelids and gently rests the tonometer footplate on the anaesthesized cornea in a position that allows free vertical movement of plunger, when the tonometer is properly positioned the examiner will observe a fine movement of needle in response to ocular pulsation. The scale reading is taken as the average between the extremes of these exurcations.

If the scale reading is 4 or less, additional weight should be added to the plunger.

A conversion table is then used to derive the IOP in millimeters of mercury from the scale reading and plunger weight. [6]

Sources of error with indentation tonometer:

An important concern is that placing the heavy tonometer (total weight at least 16.5 g) on the eye raises the IOP. The rise in the pressure reflects the distensibility of the ocular coats, a property termed ocular rigidity.[3]

All of the tables that relate the change in the volume to the IOP assume a normal ocular rigidity, and this introduces a substantial error for some measurements.[3]

Eyes with high ocular rigidity e.g. high hyperopia give falsely high Schiotz.IOP reading.[25] Eyes with low ocular rigidity e.g. myopia, strong miotic therapy[25] and retinal detachment surgery[26] or compressible gas [27] give falsely low Schiotz IOP readings.

Either a steeper or thicker cornea causes a greater displacement of the fluid during indentation tonometry, which leads to falsely high IOP reading.[6]

Impact rebound tonometer:

A new and an updated version of tonometer has been developed in which a very light, disposable, sterile probe is propelled forward into the cornea by a solenoid ; the time taken for the probe to return to its resting position and the characteristics of the rebound motion are indicative of the IOP.

As the probe is extremely light and its contact with the cornea is very short like the air puff tonometer, this type can be used without first anaesthetizing the eye.

This tonometer can be used in screening or when patients are unable to sit on the slit lamp. [3]

Dynamic Contour Tonomery:

This tonometer is based on the principle that by surrounding and matching the contour of a sphere, the pressure on the outside equals the pressure on the inside.

In the dynamic contour tonometer (DCT) (Pascal TM), the tip of the probe matches the contour of the cornea. A pressure transducer built into the centre of the probe measures the outside pressure, which should equal the inside pressure, and the IOP is recorded digitally on the liquid crystal display (LCD).

It is independent of corneal thickness and contour and may give more accurate readings than the Goldmann tonometer in those eyes with very thin corneas. [(3)]

FACTORS AFFECTING INTRAOCULAR PRESSURE:

The following factors are thought to exert, to variable degrees, a sustained influence on IOP:

Age :

Most studies found a positive correlation between IOP and age.[(28-31)] The effect of increasing age on IOP is the result, at least in part of increased blood pressure , increased pulse rate , and obesity.[(32-33)]

Sex :

It has been reported that women have higher IOPs than men, especially after age 40.[(28)] The Barbados Eye Study showed that women were more likely to have high IOP without glaucoma damage and men were more likely to have open angle glaucoma[(34)]

Race:

In united states, blacks have higher IOPs than whites.[(30)] In part , this difference appears to be racial or genetic.

Heredity:

There appears to be a hereditary influence on IOP[28]which is polygenic in nature[35]. A number of studies have shown that first degree relatives of patients with open angle glaucoma have higher IOPs than the general population.[28]

***Diurnal** variation:*

Over the course of the day IOP varies an average of 3- 6 mm Hg in normal individuals.[36]

In many people diurnal variation of IOP follows a reproducible pattern , with the maximum pressure in the mid morning hours and the minimum pressure late at night or early in the morning. However some individuals peak in the afternoon or evening , and others follow no consistent pattern.[37][38]

Most of the diurnal pressure variation is caused by fluctuations in the rate of aqueous humour production. The rate of aqueous humour formation falls to low levels during sleep and increases during the day, most likely in response to circulating catecholamines.[39]

The diurnal variation in IOP has extremely important clinical implications for glaucoma patients. Studies have shown that large diurnal variation in IOP is a risk factor for the progression of glaucoma. [40]

Seasonal variation:

Higher IOPs have been noted in winter season. This phenomenon has been attributed to changes in the number of hours of light and to alterations of atmospheric pressure.[41]

Cardiovascular factors:

A number of studies have shown a correlation between IOP and systemic blood pressure. The relationship is such that large changes in blood pressure are accompanied by small changes in IOP.[42][33]

Normally, IOP fluctuates 1-3 mmHg as arterial pressure varies with each cardiac cycle. The magnitude of this IOP fluctuation is related to the height of the ocular pressure and to the variation of arterial pressure. [43]

Lifestyle :

Increased IOP was associated with increasing body mass index, increasing alcohol consumption and increasing cigarette consumption in a Japanese study.[44].

***Posture*:**

When normal individuals go from the sitting to the supine position, IOP rises by as much as 6 mmHg. An even greater response is seen in patients with open angle glaucoma or normal tension glaucoma. [45]

The increase in the IOP occurs very rapidly and probably reflects changes in arterial and venous pressure.[45]

The episcleral venous pressure does increase in the supine position, at least partly accounting for the increase in IOP when lying down.[46]

Exercise:

Strenuous exercise lowers IOP transiently. This phenomenon is at least in part caused by acidosis and alterations in serum osmolality.[47]

Refractive error:

IOP of the myopic eye has usually been considered to be normal or low. But it has interested many observers because of the possible relationship between myopia and glaucoma. Lacroix (1922) found that 30% of high myopes had raised tension and

considered a low tension to be an unfavourable prognostic sign . Because the ocular rigidity of highly myopic eyes is low, false low values for the tension are given by Schiotz tonometry, and hence in these cases applanation tonometry gives more reliable values. [48]

The relationship between refractive error and glaucoma has been investigated in several clinical trials and population based studies.[49-52]

Most studies have suggested that moderate to high myopia is associated with increased risk of primary open angle glaucoma(POAG)[53-54], low tension glaucoma[55,56], and ocular hypertension.[57-60]

In the Blue Mountains Eye Study in Australia, after adjusting for age, sex, and other risk factors, eyes with moderate myopia were 2 times more likely to have POAG.[61]

In the Barbados eye study, a myopic refraction was one of the several risk factors for POAG in adult black people.[63]

The Beaver dam eye study showed that, after taking into account the effects of age, sex, and other risk factors, persons with myopia were 60% more likely to have glaucoma than those with emmetropia.[63]

In Asian populations, the relationship of myopia and POAG was reported in the Beijing Eye Study in China which showed significant relationship with high myopia of less than -6D .[64]

Intraocular pressure also correlates with axial length.[59]

Eye movements:

IOP increases if eye moves against mechanical resistance.[56]

Eyelid closure:

Forcible eyelid closure raises IOP by 10-90 mm Hg[56]. Repeated eyelid squeezing reduces IOP.[57] Widening of the lid fissure increases the IOP by 2 mmHg.[59]

Inflammation:

Intraocular pressure is usually reduced when the eye is inflamed because aqueous humour formation is reduced. However, if the outflow channels are more affected than the ciliary body, IOP can be elevated.[3]

Myopia or short sightedness, is that form of refractive error wherein the parallel rays of light coming from infinity are focused in front of the retina when the accommodation is at rest.

There are relatively few studies on myopia prevalence in India, which was estimated to be 7% in an urban cohort in 5- to15-year-olds[65] and 4.1% of 7- to 15-year-olds in a rural cohort.[66] In South India, it was 27% for those above 39-years of age.[67]

Aetiologically myopia may be of the following types:[68]

1) Axial myopia results from the increase in the anteroposterior length of the eyeball. It is the commonest form.
2) Curvatural myopia occurs due to increased curvature of the cornea, lens or both.
3) Positional myopia is produced by anterior placement of crystalline lens in the eye.
4) Index myopia results from increase in the refractive index of crystalline lens associated with nuclear sclerosis.

5) Myopia due to excessive accommodation occurs in the patients with the spasm of accommodation.

Simple myopia:

Simple or developmental myopia, also known as physiological or school myopia, is the commonest variety. It is considered as a physiological error not associated with any disease of the eye. About 29% of general population have low myopia (</= 2D) and about 7% have moderate myopia (2-6D). [(68)]

Aetiology:

Simple myopia results from normal biological variation in the development of eye, which may or may not be genetically determined. Inheritance is considered to be autosomal dominant .However, there are number of reports which claim that recessive mode of inheritance is more common. [(68)]

Some factors associated with simple myopia are as follows: :

Axial type of simple myopia may signify just a physiological variation in the length of the eyeball or it may be associated with precocious neurological growth during childhood.

Curvatural type of simple myopia is considered to be due to underdevelopment of the eyeball.

Theory of excessive near work in childhood was also put forward, but did not gain much importance. [(68)]

Clinical course :

Simple myopia is rarely present at birth. Most of such patients are rather born hypermetropic, but during development the normal mark is over shooted and the child becomes myopic. Simple myopia usually begins between 7 and 10 years of age and may increase during the years of growth until stabilizing around the mid teens usually at about -5D or less and it never exceeds -8D. There is no effective method of halting the progress of this so- called school myopia once it has started. (68)

Symptoms:

Poor vision for the distance is the main complaint. Asthenopic symptoms may occur in the patients with small degree of myopia. Symptoms of eye strain develop due to dissociation between convergence and accommodation.

Change in psychological outlook of the uncorrected myopic children is very common.

These children take the poor far vision for granted and concentrate their energy into indoor activities. They usually become introvert, studious, and develop little interest in outdoor activities. (68)

Signs:

Myopic eyes are typically large and somewhat prominent.

Anterior chamber is slightly deeper than the normal.

Pupils are some what large and a bit sluggishly reacting.

Fundus is normal, rarely temporal myopic crescent may be seen.

In simple myopia, usually the error does not exceed 6 to 8 D. (68)

Pathological myopia/degenerative myopia:

Pathologic myopia has been assigned varying definitions in the ophthalmic literature. Duke-Elder defined pathologic myopia as myopia accompanied by degenerative posterior segment changes.[48]

The American Academy of Ophthalmology Basic Clinical Science Course defines pathologic myopia as refractive error greater than -6D, with axial length in excess of 26.5mm.[69]

Pathologic myopia occurs when a progressive increase in the axial length causes excessive thinning of the sclera, retina, retinal pigment epithelium and choroid, resulting in varying degrees of visual disability.[70]

Pathogenesis:

It is well accepted that pathological myopia is characterized by progressive scleral thinning with localized ectasias.

It is postulated that myopic sclera is biomechanically weak and has been demonstrated to alter its composition and rigidity in response to environmental and visual stimuli. Remodeling of extracellular matrix by matrix metalloproteinases and their tissue inhibitors leads to the abnormalities in collagen fibre bundle and reduction in the size of individual collagen fibres in myopic eyes.[70]

Heredity also has shown to play a role. The mode of inheritance may be autosomal dominant, recessive, or X- linked, but it can also appear sporadically.[1]

Clinical picture:

Symptoms:

Defective vision: There is considerable failure in visual function as the error is usually high. Further, an uncorrected loss of vision may occur due to progressive degenerative changes.

Muscae volitantes and floating black opacities in front of the eyes are also complained of by many patients. These occur due to degenerated liquefied vitreous.

Night blindness may be complained by very high myopes having marked chorioretinal degenerative changes.

Signs:

The eyes are often prominent, appearing elongated and even simulating an exophthalmos, especially in unilateral cases. The elongation of the eyeball mainly affects the posterior pole and surrounding area; the part of the eye anterior to the equator may be normal.

Cornea is large and anterior chamber is deep.

Pupils are slightly large and react sluggishly to light. [68]

Fundus examination reveals following characteristic signs:

The abnormality seen in the myope that justifies use of the term degenerative is the posterior staphyloma (ectasia).The progressively myopic eye expands in all its posterior dimensions, and the formation of an equatorial staphyloma with scleral dehiscence is not uncommon, especially in the superotemporal quadrant. as the scleral shell expands , the neural retina, pigment epithelium, and choroid stretch , and thin to accommodate the area they cover.

Tissue attenuation causes the fundus to have a pale, tessellated appearance. The pigment epithelial cells are flattened, and a reduction occurs in the thickness of the choriocapillaries and in the larger vessel layers and pigment of the choroid.

With time and progression, traction and tension phenomena are observed. The first is a pale, temporal crescent at the disc as the pigment epithelium and choriocapillaries are retracted from the disc's margin toward the deepest area of the staphyloma.

Bruch's membrane is non-cellular and elastic but has a limited capacity to stretch. If its elastic limit is exceeded, the internal tension is relieved by formation of microdehiscences – focal, linear breaks called lacquer cracks.

If a choroidal neovascular membrane invades a crack, an abrupt macular haemorrhage may be produced. Although usually self-limited, the hyperpigmented fibrovascular scar that evolves(Forster-Fuch's spot) causes a central or paracentral scotoma.

An area of choroidal and pigment epithelial atrophy develops and surrounds the scar. This extends and coalesces with areas of atrophy that advance from other lacquer cracks, eventually to produce large geographical areas in which sclera can be seen through the transparent neural retina. The process is usually bilateral and insidious.

Macular hole formation in extreme myopes may occur, but the exact mechanism is not known. Vitreous syneresis and posterior vitreous detachment are more common and occur at an earlier age among high myopes than among others. [(1)]

Complications:

- Retinal tears and retinal detachment can occur.
- Complicated cataract occurs probably due to an aberration of lenticular metabolism.
- Nuclear sclerosis is the common occurrence in myopics. It may lead to an aggravation of the myopic refraction.
- Vitreous haemorrhage usually accompanies a retinal tear. A choroidal haemorrhage may also leak into the vitreous and fill it with blood.
- Choroidal hemorrhage and thrombosis are quite common and may lead to severe visual loss when involving foveal region.[68]
- Primary open angle glaucoma is a further complication of considerable importance in high myopia. A significant percentage of cases(14%) of glaucoma usually of the slow, insidious and chronic type occurs in high myopes. The relation between the two conditions is not clear. Some writers suggest that the raised IOP determines or accentuates the myopia. Others maintain that high myopia and glaucoma are of the same degenerative nature while a third view is that the glaucoma is a sequel to a generalized atrophy of the choroid. [48]

Several studies have demonstrated increased prevalence of peripheral retinal degenerations in association with high myopia and increased axial length. [71]

Some of the peripheral retinal degeneration are as follows:

Lattice degeneration:

Lattice degeneration is present in about 8% of the population. It probably develops early in life, with a peak incidence during the second and third decades .It is found more commonly in moderate myopes and is the most important degeneration directly related to retinal detachment. It is usually bilateral and most frequently located in the temporal rather than the nasal fundus. It is an important cause of retinal detachment in young myopes.

A characteristic feature is an arborizing network of white lines within the islands.

Some lattice may be associated with snowflakes. Small holes within the lattice are common and are usually innocuous.

Lattice may be complicated by a tear developing along the posterior edge of an island of lattice.

Tears typically occur in myopes over the age of 50 years. Atrophic holes may rarely lead to retinal detachment in young myopes. [(72)]

Snailtrack degeneration:

It is characterized by sharply demarcated bands of tightly packed 'snowflakes' which give the peripheral retina a white frost-like appearance .They are usually longer than the islands of lattice and may be associated with overlying vitreous liquefaction.[(72)]

White- with-pressure :

It is a translucent grey appearance of the retina, induced by indenting the sclera. Each area has a fixed configuration which does not change when the scleral indenter is moved to an adjacent area. It is observed along the posterior border of islands of lattice degeneration snailtrack degeneration. [72]

White- without- pressure:

Pale, discrete areas of the retinal periphery without the application of any external pressure are thought to be the result of vitreous traction which could result in the formation of retinal break. [73]

Considering the role of myopia in causation of primary open angle glaucoma, the present study was undertaken to find out the accuracy of noncontact autotonometer in detecting raised intraocular pressure in eyes with myopia.

MATERIALS AND METHODS

The present study is a one year descriptive observational study to find out the accuracy of the non- contact autotonometer in detecting the intraocular pressure in eyes with myopia.

Source of data:

Participants attending the Ophthalmology Out-Patient Department in KLE's DR.PRABHAKAR KORE HOSPITAL AND MRC, BELGAUM.

Study design:

A descriptive observational study.

Sample size: 118

Sample Size: Assuming the specificity of the Noncontact autotonometer as 88% and error as 10% sample size for specificity will be

$$n = \frac{2 (z^2_{\alpha} + z^2 \beta) p\, q}{d^2}$$

Where p = specificity=88%

q = 100- p%

d = error=10%

α =confidence level

zα = 95% confidence level = 1.96

Zβ=0.84 for power of test to be 80%

n= 118

Inclusion criteria:

- Participants who on initial examination in the Out- Patient Department were found to be having myopia of -2D or more and those between 18 - 40 years of age.
- Participants already wearing an optical correction for myopia and attended the OPD for change of glasses.

Exclusion criteria:

- Participants not willing to give consent.
- Participants with corneal diseases and previous corneal surgery.
- Elderly participants with nuclear sclerotic changes in lens.
- Young children in whom tonometry was difficult to perform.
- Those having undergone any intraocular surgeries.

METHODOLOGY:

After signing of informed consent data was collected in a prescribed data collection form. General data (age, gender) was obtained. Any history of using glasses and duration of using them and any other significant history was noted down.

Visual acuity both corrected and uncorrected were recorded on Snellen's chart. Near vision was recorded on standard Jagger's near type chart.

Anterior segment examination was carried out on each patient.

Refractive error was estimated by Priestly Smith retinoscope , either by dry refraction or under full mydriasis and cycloplegia with cyclopentolate hydrochloride 1% .Spherical equivalent (defined as spherical error plus half of the cylindrical error) was taken for the analysis.

Funduscopic examination was done on patients who had undergone cycloplegic refraction on the same visit. Thorough indirect ophthalmoscopic examination with a 20D lens was done and any peripheral degenerative changes in the retina were noted down.

Corneal curvature was measured using a Keratometer (Bausch and Laumb). Average keratometric reading was used for the analysis.

Axial length and central anterior chamber depth were measured using an A scan (Echorule2, Biomedix).

IOP was measured for the patients in whom dry refraction was carried out during the same visit and the patients in whom cycloplegic was used were given appointment for post mydriatic test after three days of initial examination and during this visit, tonometry was performed. In all the patients, IOP was measured first by non-contact tonometer (Canon TX F Autotonometer) and then with Goldmann applanation tonometer, using a Haag Streit slit lamp to avoid the known mild reduction of IOP by anterior chamber compression with Goldmann applanation tonometer.

Measurement with second instrument was taken 15 – 20 minutes after the first. Non-contact tonometer and Goldmann applanation tonometer measurements were done by two examiners separately. They were masked from each other. Averages of three readings were taken for both Goldmann applanation tonometer and non-contact tonometers respectively. Both the instruments were checked and calibrated according to the instructions in manual provided.

All patients who showed intraocular pressure of more than 21 mm of Hg by either of the techniques were subjected to further evaluation for glaucoma.

Results obtained by non-contact tonometer were then compared with those obtained using the Goldmann applanation tonometer in each of the 236 eyes of 118 patients tested to determine the sensitivity, specificity, and positive and negative predictive value of non-contact tonometer as a screening tool to detect raised IOP in myopes. Correlation coefficients for intraocular pressure as measured by the two techniques was determined.

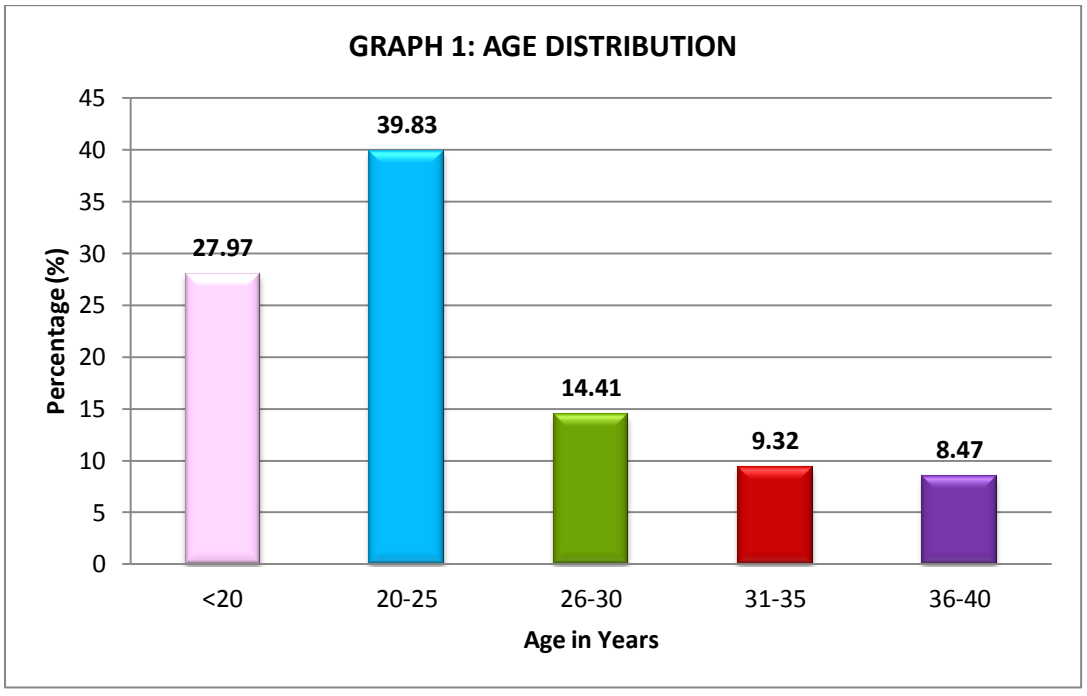
The Karls Pearson's correlation coefficients between intraocular pressure measured with both non-contact tonometer and Goldmann applanation tonometer and degree of myopia, corneal curvature, axial length, anterior chamber depth was also determined. P value of <0.05 was considered as statistically significant.

OBSERVATIONS AND RESULTS

The present study was conducted in the Department of Ophthalmology, KLE's Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum on patients with myopia during the period of 1st January 2010 to 31st December 2010. In this study, 236 eyes with myopia were studied and observations and findings were recorded and tabulated as below.

TABLE 1: AGE DISTRIBUTION

AGE (YEARS)	NO. OF SUBJECTS	PERCENTAGE (%)
<20	33	27.97
20-25	47	39.83
26-30	17	14.41
31-35	11	9.32
36-40	10	8.47
TOTAL	**118**	**100**

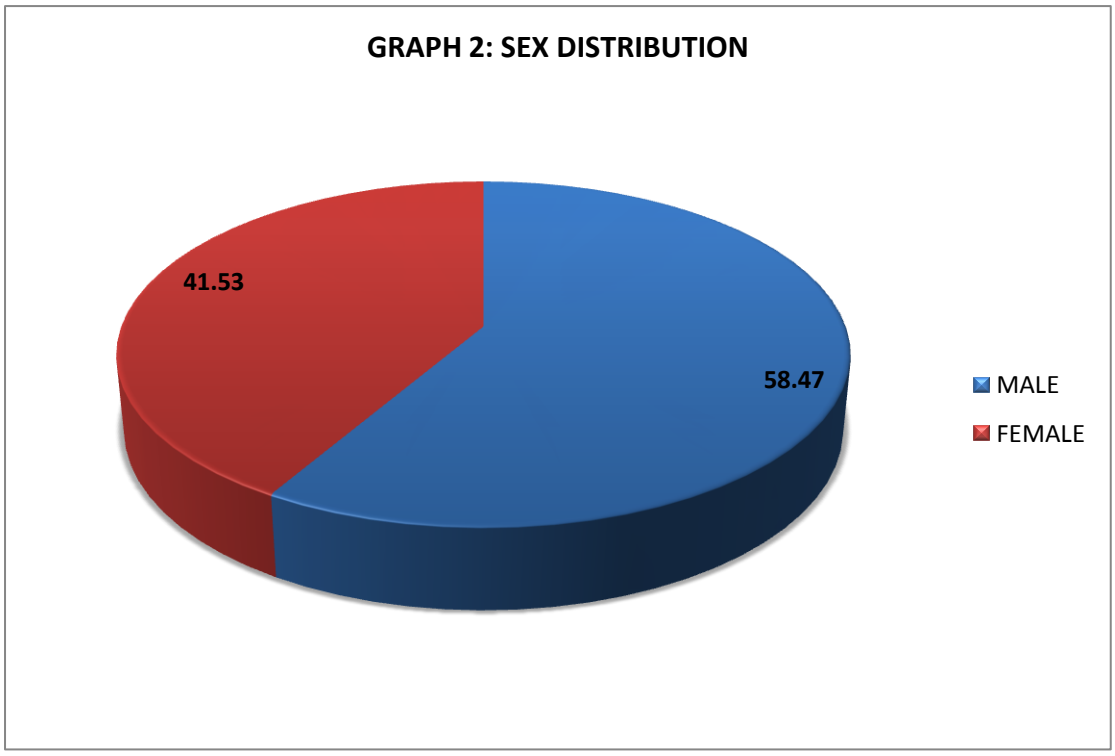


Out of the 118 patients, 33 patients belonged to the age group of less than 20 years (27.97%), 47 patients belonged to the age group between 20-25 years (39.83%), 17 patients belonged to the age group of 26-30 years (14.41%), 11 patients belonged to 31-35 years of age (9.32%) and 10 patients belonged to 36-40 years of age group (8.47%).

Mean age was 24.34 years.

TABLE 2: SEX DISTRIBUTION

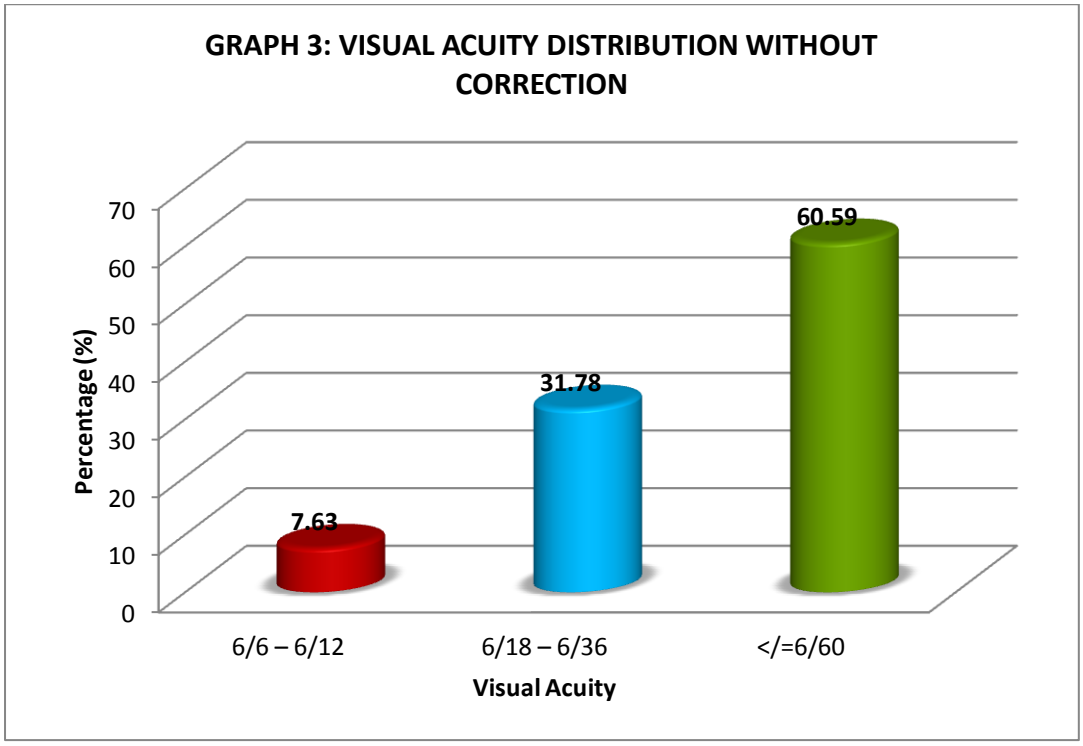
GENDER	NO.OF SUBJECTS	PERCENTAGE(%)
MALE	69	58.47
FEMALE	49	41.53
TOTAL	118	100



Out of the 118 patients, 69 (58.47%) were males and 49 patients (41.53%) were females.

TABLE 3: VISUAL ACUITY DISTRIBUTION WITHOUT CORRECTION

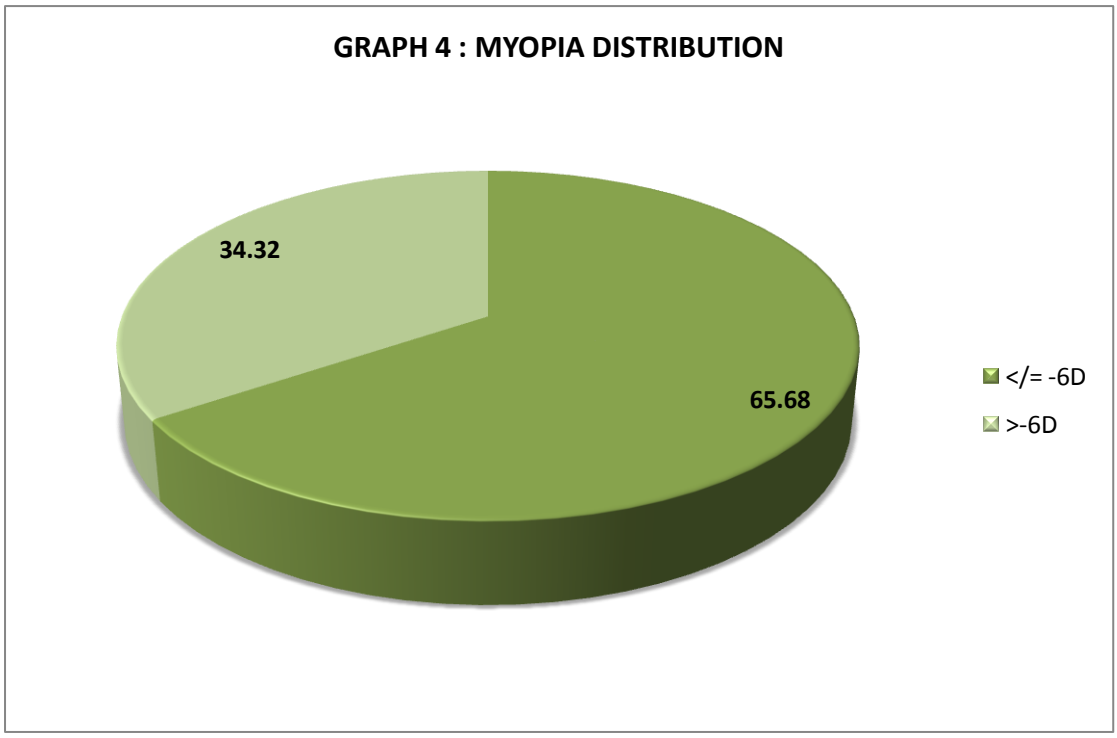
VISUAL ACUITY	NO. OF EYES	PERCENTAGE(%)
6/6 – 6/12	18	7.63
6/18 – 6/36	75	31.78
≤6/60	143	60.59
TOTAL	236	100



Out of the 236 eyes, majority, 143 (60.59%) eyes had an unaided visual acuity of less than or equal to 6/60, 75 eyes (31.78%) had a visual acuity between 6/18-6/36 and only 18 eyes (7.63%) were having visual acuity between 6/6-6/12.

TABLE 4: MYOPIA DISTRIBUTION

DEGREE OF MYOPIA	NO. OF EYES	PERCENTAGE(%)
≤-6D	155	65.68
>-6D	81	34.32
TOTAL	236	100

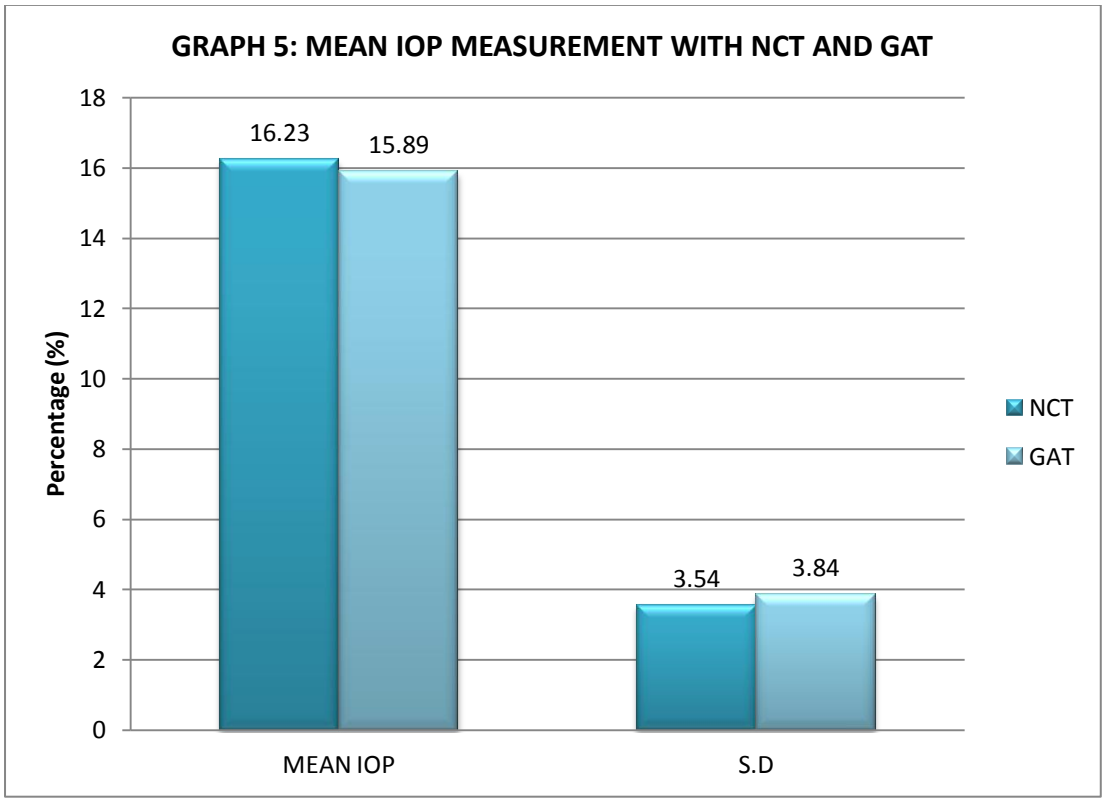


Out of the 236 eyes of 118 patients, 155 eyes (65.68%) belonged to the myopia of less than or equal to -6D group and 81 eyes (34.32%) belonged to myopia of more than -6D group.

Mean spherical equivalent in less than or equal to -6D group was -3.56 D with a S.D of 1.22D and in more than -6D group was -11.06D with a S.D of 4.43D.

TABLE 5: MEAN IOP MEASUREMENT WITH NCT AND GAT

TECHNIQUE	MEAN IOP	S.D
NCT	16.23	3.54
GAT	15.89	3.84



The mean IOP when measured with non-contact tonometer in 236 eyes was 16.23mmHg with a S.D. of 3.54mmHg and that with Goldmann applanation tonometer was 15.89mmHg with a S.D of 3.84mmHg.

The correlation coefficient between the two instruments was 0.880 ($p < 0.0001$).

TABLE 6: SENSITIVITY AND SPECIFICITYOF NCT

The sensitivity and specificity of the Non-contact Autotonometer was calculated in detecting raised intraocular pressure and was compared with that of standard Goldmann applanation tonometer.

	NO. OF EYES SHOWING IOP with GAT >21mm Hg	**NO. OF EYES SHOWING IOP with GAT <21mm Hg**	**TOTAL**
NO.OF EYES SHOWING IOP with NCT >21mm Hg	a (True Positives) **32**	b (False Positives) **08**	a+b **40**
NO.OF EYES SHOWING IOP with NCT<21mm Hg	c (False Negatives) **06**	d (True Negatives) **190**	c+d **196**
TOTAL	a + c **38**	b + d **198**	a + b + c + d **236**

$$\text{Sensitivity} = \frac{\text{True positives}}{\text{(True positives+ false negatives)}} \times 100 = 84.21\%$$

$$\text{Specificity} = \frac{\text{True negatives}}{\text{(True Negatives + False Positives)}} \times 100 = 95.96\%$$

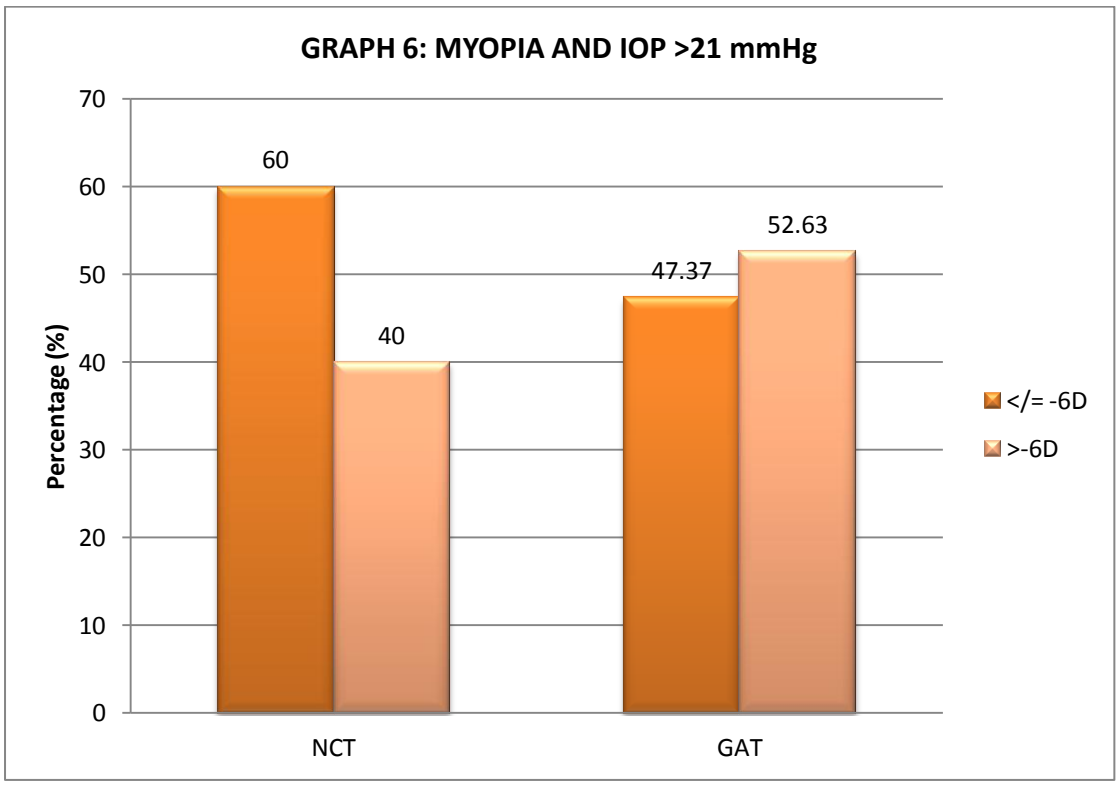
$$\text{Positive Predictive value} = \frac{\text{True Positives}}{\text{(True positives + False Positives)}} \times 100 = 80\%$$

$$\text{Negative Predictive value} = \frac{\text{True Negatives}}{\text{(True Negatives + False negatives)}} \times 100 = 96.94\%$$

Diagnostic accuracy of the test = 94.07%

TABLE 7a: MYOPIA AND IOP >21 mmHg

MYOPIA DEGREE	EYES WITH IOP >21 mmHg			
	NCT	PERCENTAGE(%)	GAT	PERCENTAGE(%)
≤-6D	24	60	18	47.37
>-6D	16	40	20	52.63
TOTAL	40	100	38	100



Out of the 40 eyes showing IOP >21mmHg with non-contact tonometer , 24 eyes (60%) had myopia of </= -6 D and 16 eyes (40%) had myopia of > -6 D .

Those with Goldmann applanation tonometer showing IOP >21 mmHg , 18 eyes (47.37%) had myopia of </= -6 D and 20 eyes (52.63%) had myopia of >-6D .

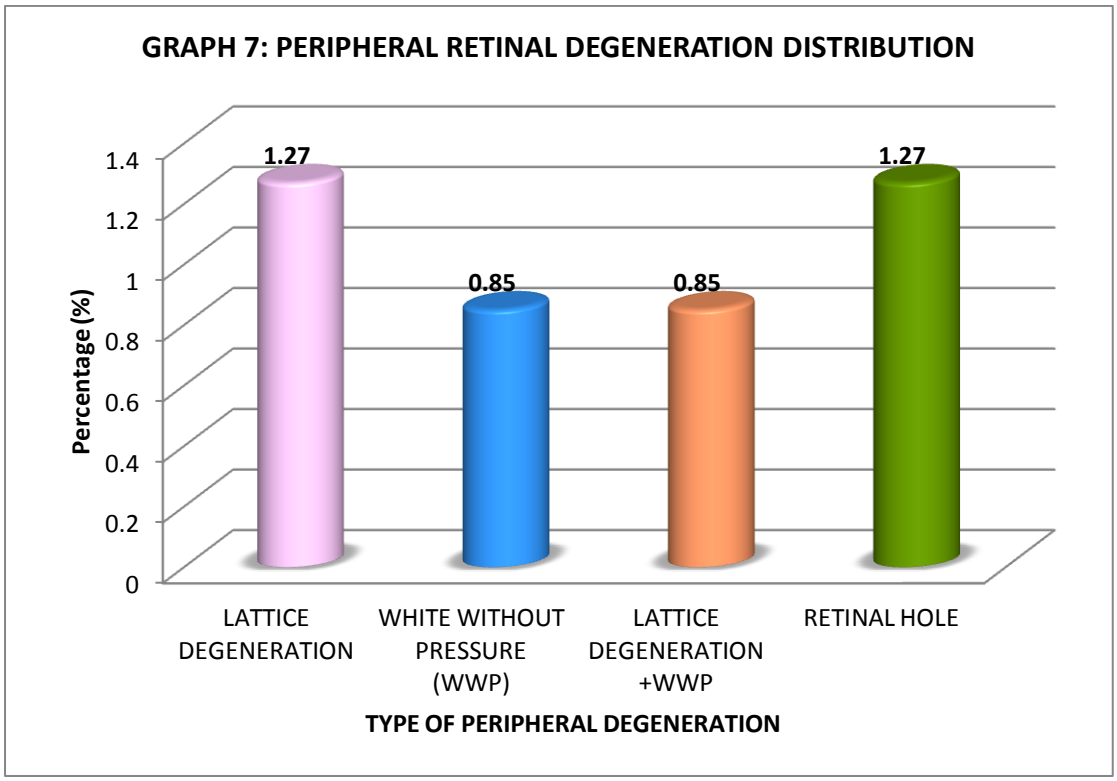
TABLE 7b: FOR 236 EYES CORRELATION BETWEEN DEGREE OF MYOPIA AND IOP AS MEASURED WITH NCT AND GAT

CORRELATION BETWEEN	KARLS PEARSON's CORRELATION COEFFICIENT (r)	p VALUE
DEGREE OF MYOPIA AND IOP MEASURED WITH NCT	0.2771	<0.0001 (S)
DEGREE OF MYOPIA AND IOP MEASURED WITH GAT	0.2528	=0.0001 (S)

The above table shows a positive correlation between degree of myopia and IOP as measured with both non-contact tonometer and Goldmann applanation tonometer.

TABLE 8: PERIPHERAL RETINAL DEGENERATION DISTRIBUTION

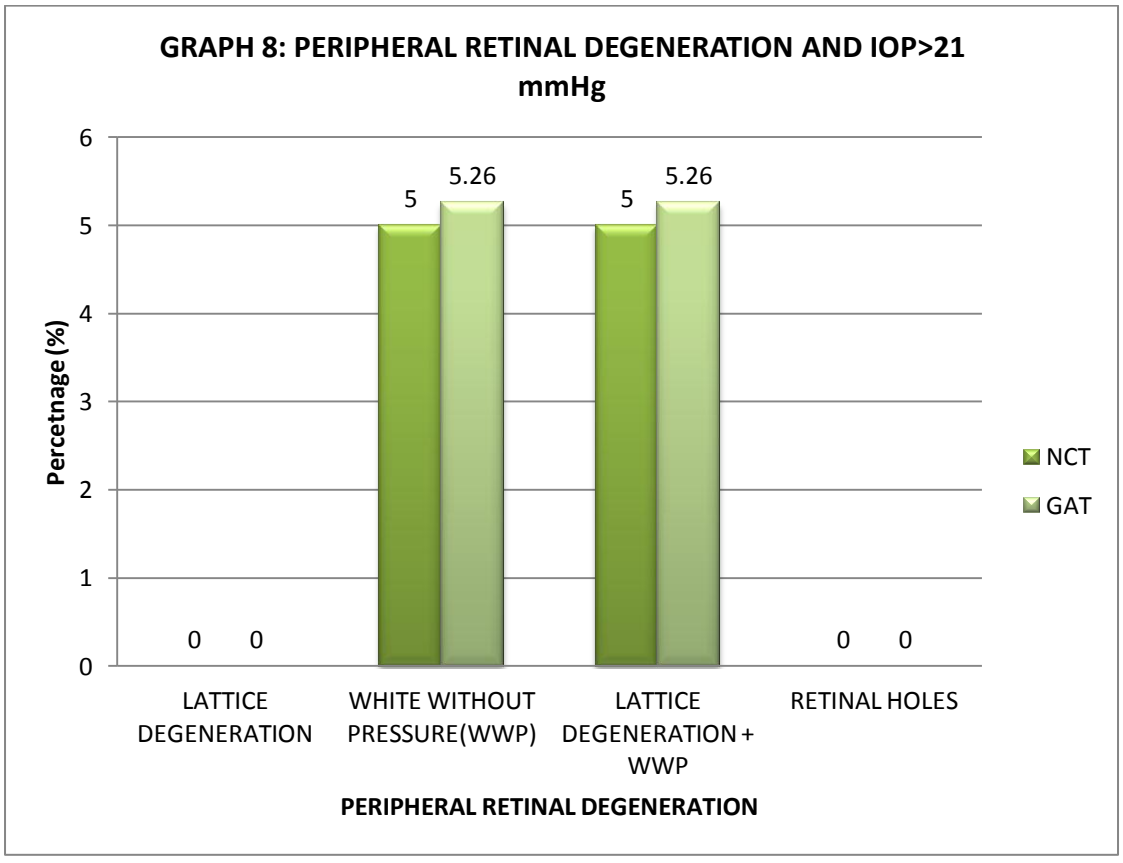
TYPE OF PERIPHERAL DEGENERATION	NO. OF EYES	PERCENTAGE(%)
LATTICE DEGENERATION	03	1.27
WHITE WITHOUT PRESSURE (WWP)	02	0.85
LATTICE DEGENERATION + WWP	02	0.85
RETINAL HOLE	03	1.27



On indirect ophthalmoscopic fundus examination, out of 236 eyes, 03 eyes (1.27%) showed lattice degenerative changes, 2 eyes (0.85%) showed white without pressure changes and 2 eyes (0.85%) showed lattice degeneration with white without pressure and 3 eyes (1.27%) showed retinal holes in the peripheral retina.

TABLE 9: PERIPHERAL RETINAL DEGENERATION AND IOP>21 mmHg

PERIPHERAL RETINAL DEGENERATION	NO. OF EYES WITH IOP>21 mmHg			
	NCT	PERCENTAGE (%)	GAT	PERCENTAGE (%)
LATTICE DEGENERATION	00	00	00	00
WHITE WITHOUT PRESSURE(WWP)	02	05	02	5.26
LATTICE DEGENERATION + WWP	02	05	02	5.26
RETINAL HOLES	00	00	00	00



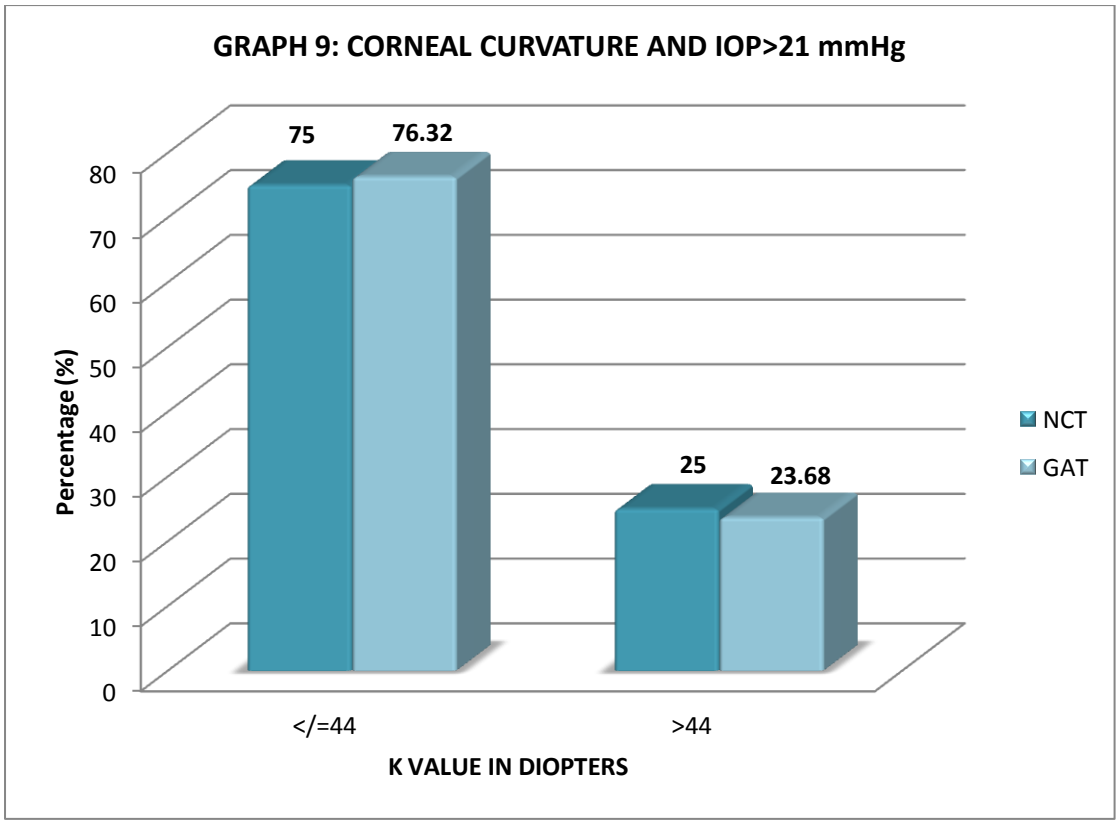
Out of the 40 eyes with IOP >21mmHg amongst those measured by non-contact tonometer 2 eyes (5%) showed white without pressure and 2 eyes (5%) showed lattice with white without pressure.

Out of the 38 eyes with IOP > 21mmHg amongst those measured by Goldmann applanation tonometer, 2 eyes (5.26%) showed white without pressure and 2 eyes (5.26%) showed lattice with white without pressure.

No eye with IOP >21 mmHg with either of the technique, showed the presence of retinal holes or lattice degeneration.

TABLE 10a: CORNEAL CURVATURE AND IOP>21 mmHg

K VALUE IN DIOPTERS	NO. OF EYES WITH IOP > 21 mmHg			
	NCT	PERCENTAGE(%)	GAT	PERCENTAGE(%)
≤44	30	75.0	29	76.32
>44	10	25.0	09	23.68
TOTAL	40	100	38	100



Out of the 236 eyes, majority 165 eyes (69.92%) had an average corneal curvature of less than or equal to 44D .

Out of the 40 eyes with IOP more than 21mmHg measured with non-contact tonometer, 30 eyes (75%) had an average corneal curvature of less than or equal to 44D and 10 eyes(25%) had an average corneal curvature of more than 44D.

Similarly, out of the 38 eyes showing IOP more than 21 mmHg with the Goldmann applanation tonometer, 29 eyes (76.32%) had an average corneal curvature of less than or equal to 44D and 9 eyes (23.68%) had an average corneal curvature of more than 44D.

Mean corneal curvature was 43.57D $\pm$1.18D.

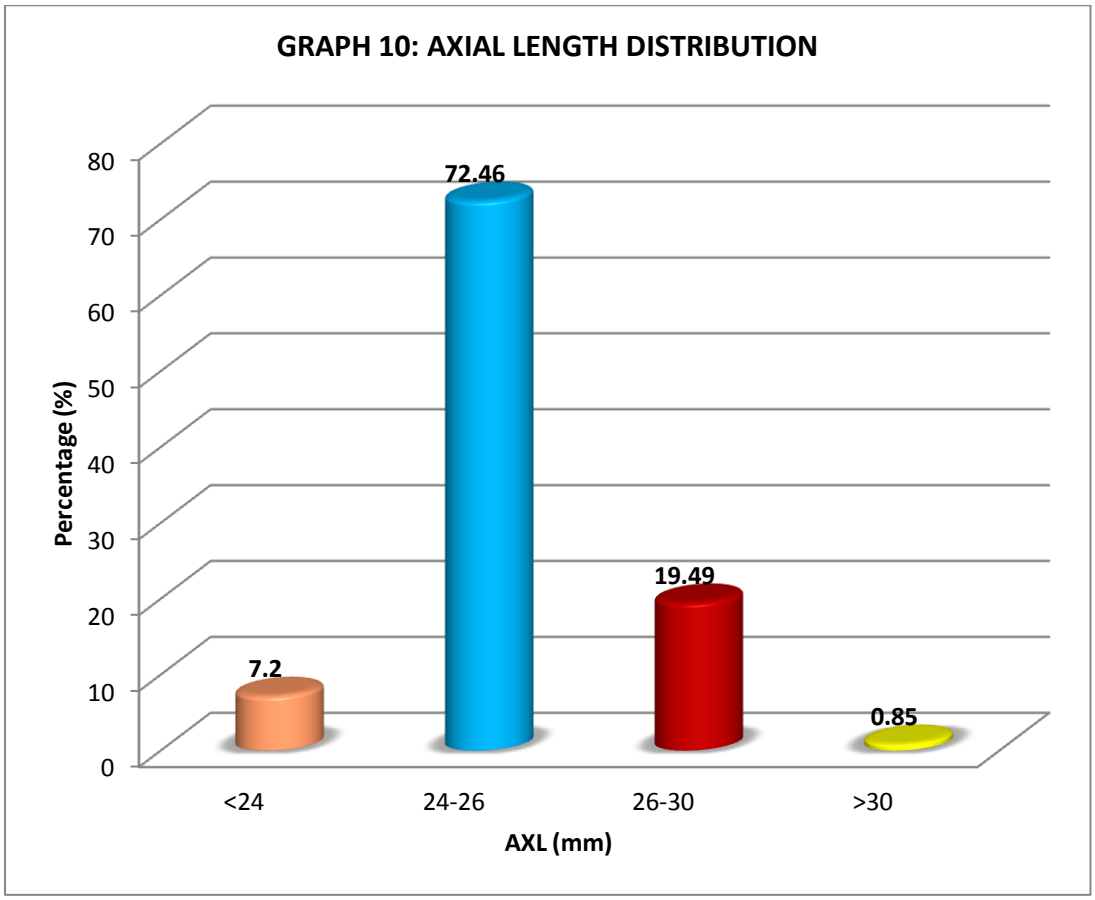
TABLE 10b: FOR 236 EYES CORRELATION BETWEEN CORNEAL CURVATURE AND IOP MEASURED WITH NCT AND GAT:

CORRELATION BETWEEN	KARLS PEARSON's CORRELATION COEFFICIENT (r)	p VALUE
CORNEAL CURVATURE AND IOP MEASURED WITH NCT	O.1035	=0.1128(NS)
CORNEAL CURVATURE AND IOP MEASURED WITH GAT	0.0604	= 0.3558(NS)

The above table shows that the correlation coefficients are negligibly small with non-significant values of p.

TABLE 11: AXIAL LENGTH DISTRIBUTION

AXL (mm)	NO. OF EYES	PERCENTAGE(%)
<24	17	7.20
24-26	171	72.46
26-30	46	19.49
>30	02	0.85
TOTAL	236	100

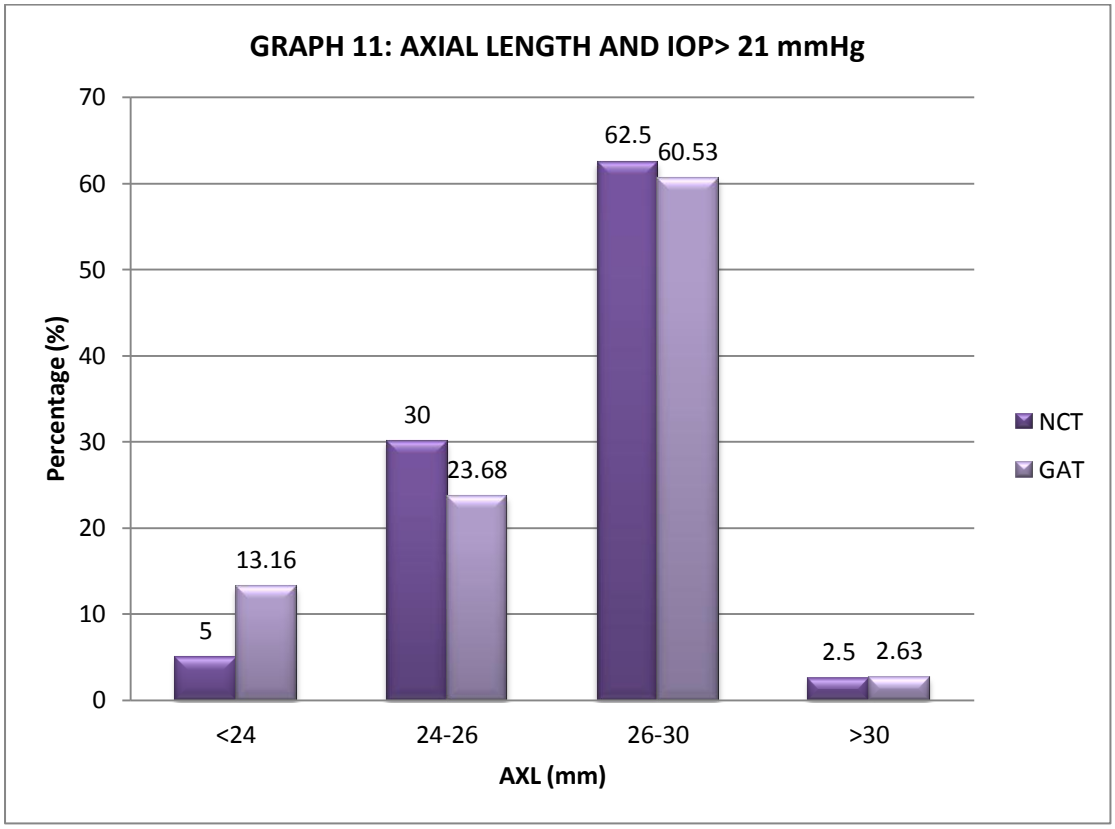


Out of the 236 eyes, 17 eyes (7.20%) had an axial length of less than 24 mm, 171 eyes (72.46%) had an axial length between 24-26 mm, 46 eyes (19.49%) had an axial length between 26-30 mm and 2 eyes (0.85%) had an axial length of more than 30 mm.

Mean axial length was 25.27 mm $\pm$1.30 mm.

TABLE 12a: AXIAL LENGTH AND IOP> 21 mmHg

AXL(mm)	NO. OF EYES WITH IOP >21 mmHg			
	NCT	PERCENTAGE(%)	GAT	PERCENTAGE(%)
<24	02	5.0	05	13.16
24-26	12	30.0	09	23.68
26-30	25	62.5	23	60.53
>30	01	2.5	01	2.63
TOTAL	40	100	38	100



Out of the 40 eyes with IOP more than 21mmHg measured with non-contact tonometer, majority 25 eyes (62.5%) had an axial length between 26-30mm and only 1 eye (2.5%) had an axial length more than 30mm.

Similarly, out of the 38 eyes showing IOP more than 21 mmHg with the Goldmann applanation tonometer, majority 23 eyes (60.53%) had an axial length between 26-30 mm and only 1 eye (2.63%) had an axial length more than 30 mm.

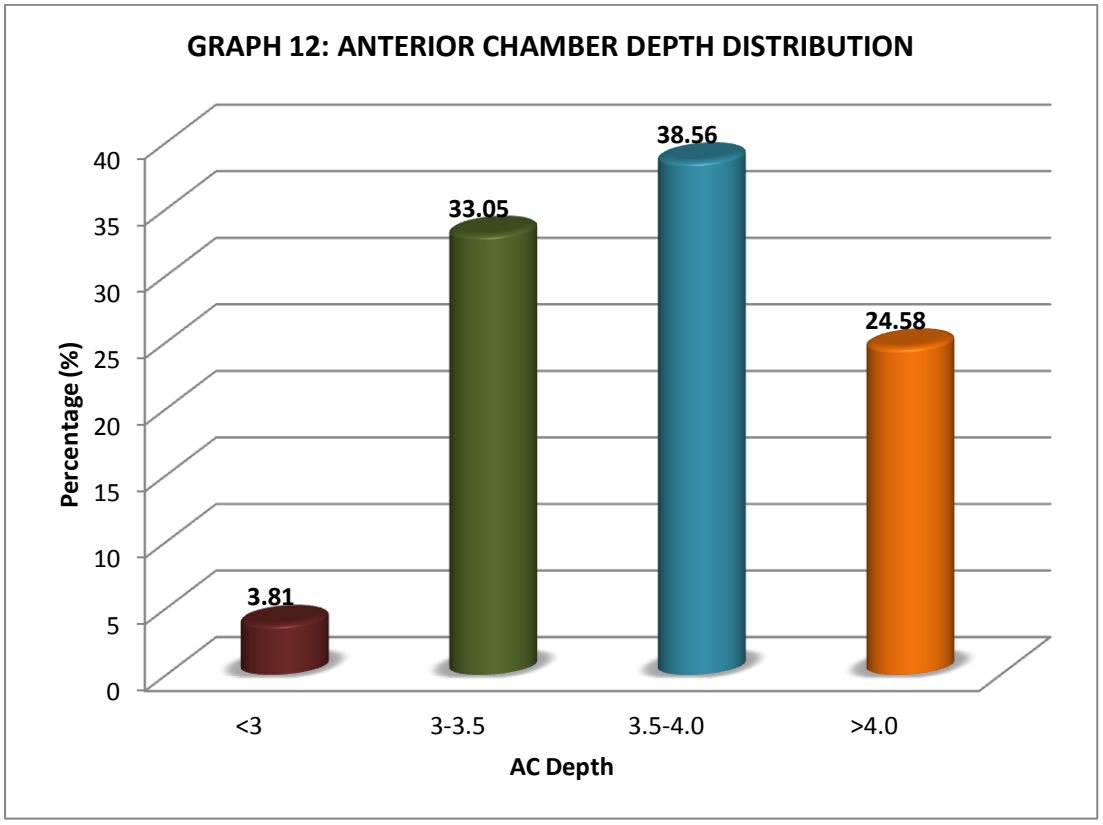
TABLE 12b: FOR 236 EYES CORRELATION BETWEEN AXIAL LENGTH AND IOP MEASURED WITH NCT AND GAT:

CORRELATION BETWEEN	KARLS PEARSON's CORRELATION COEFFICIENT (r)	p VALUE
AXIAL LENGTH AND IOP MEASURED WITH NCT	O.3750	<0.0001(S)
AXIAL LENGTH AND IOP MEASURED WITH GAT	0.4239	<0.0001(S)

The above table shows a positive correlation between axial length and intraocular pressure measured by non-contact tonometer as well as Goldmann applanation tonometer.

TABLE 13: ANTERIOR CHAMBER DEPTH DISTRIBUTION

AC DEPTH	NO. OF EYES	PERCENTAGE(%)
<3	09	3.81
3-3.5	78	33.05
3.5-4.0	91	38.56
>4.0	58	24.58
TOTAL	236	100

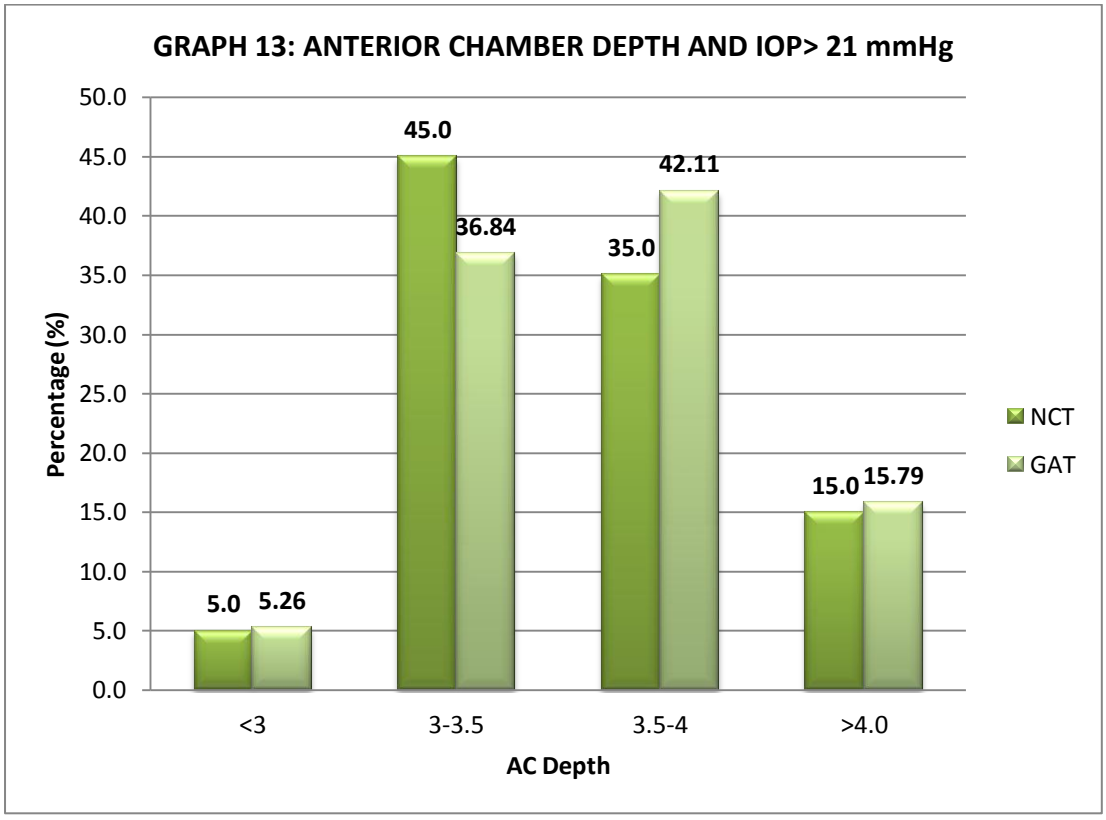


Out of the 236 eyes, 78 eyes (33.05%) showed an anterior chamber depth between 3-3.5 mm, 91 eyes (38.56%) showed average anterior chamber depth between 3.5-4.0mm .

Mean anterior chamber depth was 3.68mm $\pm$0.37mm.

TABLE 14a: ANTERIOR CHAMBER DEPTH AND IOP> 21 mmHg

AC DEPTH (mm)	NO. OF EYES WITH IOP >21mmHg			
	NCT	PERCENTAGE(%)	GAT	PERCENTAGE(%)
<3	02	5.0	02	5.26
3-3.5	18	45.0	14	36.84
3.5-4	14	35.0	16	42.11
>4.0	06	15.0	06	15.79
TOTAL	40	100	38	100



Out of the 40 eyes with IOP > 21 mm Hg as measured with non-contact tonometer, 18 eyes (45%) showed an average AC depth between 3-3.5 mm, 14 eyes (35%) showed between 3.5-4.0 mm .

Similarly, out of the 38 eyes with IOP >21 mmHg as measured with Goldmann applanation tonometer, 14 eyes (36.84%) showed an average AC depth between 3-3.5 mm, 16 eyes (42.11) between 3.5-4.0mm .

TABLE 14b: FOR 236 EYES CORRELATION BETWEEN ANTERIOR CHAMBER DEPTH AND IOP MEASURED WITH NCT AND GAT:

CORRELATION BETWEEN	KARLS PEARSON's CORRELATION COEFFICIENT (r)	p VALUE
AC DEPTH AND IOP MEASURED WITH NCT	-0.0765	= 0.2419(NS)
AC DEPTH AND IOP MEASURED WITH GAT	-0.0160	=0.8072(NS)

The above table shows that the correlation coefficients are negligibly small with non significant values of p.

DISCUSSION

The present study was conducted as a descriptive observational study to find out the sensitivity, specificity, positive and negative predictive values of non-contact tonometer in detecting IOP> 21 mmHg in eyes with myopia. The study included patients who attended the Out-Patient Department of Ophthalmology at KLE's Dr. Prabhakar Kore Hospital and MRC, Belgaum. The study consisted of 236 eyes of 118 patients having the refractive error of myopia more than -2D.

We studied patients in the age group of 18-40 years. Mean age was 24.34 years with majority of the patients (39.83%) being in the 20-25 age group. The age limit was chosen to be 40 years as index myopia sets in after the age of 40 years and also that there is an increase in the scleral rigidity observed after 40 years of age. Hence we did not emphasise on correlating age with IOP.

There were 69 male patients and 49 female patients included in our study. IOP is equal between the sexes in age group between 20 to 40 years and it has been reported that women have higher IOPs than men, especially after age 40 years.[28] Hence we did not emphasise on correlating sex with IOP as our patients were between the age of 18-40 years.

In a given patient there can be a difference of IOP and refractive error between the two eyes of the same individual. Hence we analysed each eye separately in an individual.

Out of the 236 eyes, majority, 143 (60.59%) eyes had an unaided visual acuity of less than or equal to 6/60. But as the visual acuity does not affect the IOP measurement, it was noted down in our study for the follow up of the patient and as a prognostic value.

In our study, 65.68% had myopia of less than or equal to - 6D and 34.32% had more than -6D. Mean spherical equivalent was -6.14D with a S.D. of 4.54D.

In myopic eyes, scleral rigidity is lower than average. During Schiotz tonometry the cornea is deformed by indentation and this involves a displacement in volume which distends the remainder of the globe and brings into play elastic tensile forces raising the internal pressure from its initial value P_o to a considerably higher level P_t. This tensile force varies with the elasticity of the corneo-sclera and has a component tangential to the walls of the globe; at the site of corneal indentation it therefore acts outwards and upwards tending to raise the plunger. Hence in case of indentation tonometry, the scale reading on the Schiotz tonometer is related to corresponding Pt values that is the artificially elevated pressure which exist in the eye when the tonometer is applied and the volume of fluid displaced from beneath the cornea by application of tonometer. [74]

The elevation of pressure caused by Goldmann applanation tonometry is negligible so it can be considered that this instrument measures P_o without any error due to abnormal ocular rigidity.[6] Goldmann applanation tonometer is considered the gold standard instrument in IOP measurement. As the Non-contact tonometry works on the applanation principle, hence is not affected by ocular rigidity.

Hence considering the advantages of non-contact tonometer, the present study was conducted to find out the accuracy of non-contact tonometer in measurement of IOP in eyes with myopia.

Mean IOP when measured with non-contact tonometry in 236 eyes was 16.23mmHg with a S.D. of 3.54 mmHg and that with Goldmann applanation tonometer was 15.89mmHg with a S.D of 3.84 mmHg. Clinically we found a little

large value of mean IOP when measured with non-contact tonometer than Goldmann applanation tonometer.

In our study the correlation coefficient between the two instruments was 0.880 ($p< 0.0001$) which is highly significant indicating comparable performance between the two instruments.

Patikulsila D et al in their study for comparison of intraocular pressure measured by non-contact air puff versus Goldmann applanation tonometers in gas-filled vitrectomized eyes showed a high correlation between the two instruments with a correlation coefficient (r) = 0 .908, $p<0.005$. They concluded that in gas-filled vitrectomized eyes, IOP measurements obtained by an air puff tonometer correlated well with those obtained by GAT, especially when the IOP was within normal range. However, in eyes with elevated IOP, the air puff tonometer significantly underestimated the IOP measurement when compared to the gold standard, Goldmann applanation tonometer.[(75)]

In a study conducted by Viney Gupta et al, to compare the intraocular pressure (IOP) measurements by the Goldman applanation tonometer (GAT), non- contact tonometer (NCT) and the ocular blood flow (OBF) pneumotonometer in different IOP ranges in glaucomatous eyes, there was a significant correlation between the NCT and OBF-pneumotonometer and GAT ($r=0.88$, $P <0.001$ and $r=0.86$, $P <0.001$ respectively). The results of the study suggested that IOP measurements using the NCT and OBF-pneumotonometer closely agree with those of GAT even in high IOP ranges. [(76)]

The sensitivity and specificity of the non-contact tonometer was calculated in detecting raised IOP in myopes and was compared to that of standard Goldmann applanation tonometer.

Sensitivity measured the proportion of actual positives which are correctly identified as such. Specificity measured the proportion of negatives which are correctly identified. Positive predictive value is the probability that the IOP may be >21mmHg with Goldmann applanation tonometer when the non-contact tonometer measured IOP>21mmHg and the negative predictive value is the probability that the IOP may be < 21mmHg with Goldmann applanation tonometer when the non-contact tonometer measured IOP < 21mmHg.

In our study, the non-contact tonometry correctly identified 32 out of 38 eyes showing IOP of more than 21 mmHg for a sensitivity of 84.21%. Specificity and positive predictive value for the non-contact tonometer were 95.96% and 80% respectively. Non- contact tonometry correctly identified 190 out of 198 eyes showing an IOP of less than 21 mmHg for a negative predictive value of 96.94%.The number of false positive eyes as determined by non-contact tonometer were 8 and those identified as false negatives were 6 eyes.

Stephen A Vernon in his study of non-contact tonometry in postoperative eye, compared the use of non-contact tonometer with the Goldmann applanation tonometer in measurement of IOP more than 21 mmHg post operatively and found out a sensitivity of 100% and specificity of 88%. He concluded that non-contact tonometer, with its associated low cross infection risk, may be used to screen for postoperative ocular hypertension with high sensitivity and specificity and good patient compliance.[77]

In another study by Mark E. Ralston et al , conducted to demonstrate the practicality of non-contact tonometry as an adjunct screening tool for glaucoma in the primary care setting found out a sensitivity, specificity, positive and negative predictive value of 92.3%, 73%, 54.5%,96.4% respectively. They concluded that non-contact tonometry was a valid screening tool for elevated IOP because it is highly sensitive when compared to Goldmann applanation tonometry. (78)

In our study we also found a positive correlation between degree of myopia and IOP measured with both non-contact tonometer and Goldmann applanation tonometer.

Kawase K et al in their study to evaluate the distribution of and factors related to applanation IOP in a population-based study in Japan showed higher myopia (B = 0.055/dioptres, p = 0.0043) significantly correlated with higher IOP. They concluded that a positive correlation between IOP and myopia was present. (79)

Kirsti Grodum et al in their study to study the association between refractive error, glaucoma damage and IOP in a large population found out that the mean IOP increased gradually with increasing myopia in eyes with moderate to high myopia($p < 0.0001$) .(80)

A positive correlation between degree of myopia and IOP supports the proposed theory of increased prevalence of primary open angle glaucoma in increasing degrees of myopia and longer axial length. Myopia has been found to influence IOP, with myopia associated with a higher IOP than emmetropia and hyperopia.(61) The optic nerve head in myopic eyes may be more susceptible than non-myopic eyes to glaucomatous damage from elevated or normal IOP. (81)

When screened for peripheral retinal degenerative changes with an indirect ophthalmoscope, out of 236 eyes, 03 eyes (1.27%) showed lattice degenerative changes, 2 eyes (0.85%) showed white without pressure changes and 2 eyes (0.85%) showed lattice degeneration with white without pressure and 3 eyes (1.27%) showed retinal holes.

In our study we observed that out of the 40 eyes which showed IOP more than 21 mmHg with non-contact tonometer, 2 eyes (5%) each had white without pressure and lattice degeneration with white without pressure.

Similarly out of the 38 eyes which showed IOP more than 21 mmHg with Goldmann applanation tonometer, 2 eyes (5.26%) each had white without pressure and lattice degeneration with white without pressure. Hence our study showed that patients having white without pressure in myopic eyes have more chances of having higher IOP and hence require thorough evaluation for glaucoma.

In our study we did not find any correlation between corneal curvature and intraocular pressure. There was no difference between IOP measured by non-contact tonometer and Goldmann applanation tonometer in eyes with different corneal curvatures. Hence in our study non-contact tonometer and Goldmann applanation tonometer were believed to be not influenced by the corneal curvature. However IOP does not change with the change in corneal curvature.

In a study conducted by Eysteinsson T et al showed no establishment of any relationship between the radius of corneal curvature and IOP. Linear regression analysis showed no relationship between the radius of corneal curvature and IOP. [(82)]

A study conducted by Matsumoto T et al showed no statistically significant correlation between non-contact/ Goldmann applanation tonometer and the radius of

corneal curvature (p= 0.30). They concluded that non-contact and Goldmann applanation tonometer was believed to be not influenced by the corneal curvature. [83]

In our study we also found a positive correlation between axial length and intraocular pressure measured by non-contact tonometer as well as Goldmann applanation tonometer. ($p<0.0001$)

In a study by Scott Read et al to investigate the Diurnal Variation of Axial Length, Intraocular Pressure, and Anterior Eye Biometrics they found a significant positive correlation between change in axial length and change in IOP ($r=0.370$, $p=0.001$). [84]

In another study by Foster PJ et al, to describe the distribution and determinants of intraocular pressure (IOP) and indices of corneal biomechanics in an adult British population, there was a significant positive association between IOP and axial length of the eye. [85]

In another study by Pärssinen O, the relationship between intraocular pressure and ocular refraction and axial length were studied in a follow-up of myopic children and in a cross-section sample of school children which found out that **t**here was also a significant positive correlation between intraocular pressure and axial length at the end of the follow-up among the boys but not among the girls.[86]

Shearing forces exerted by scleral tension across the lamina cribrosa may be crucial to the mechanism of glaucomatous damage.[87] Investigators have calculated that myopic eyes have higher scleral tension across the lamina than eyes with a shorter axial length, even when IOP is the same.[88]

This difference becomes even more marked in eyes with thinner sclera. Similar connective tissue changes may also occur in glaucoma and myopia.[89]

Our finding that axial length was significantly associated with IOP which is one of the risk factors in causing glaucoma largely explains the association between myopia and POAG and may support a theory involving connective tissue changes being associated with longer axial dimensions as a potential mechanism for POAG.

In our study we found out a negative correlation between anterior chamber depth and IOP measured with both non-contact tonometer and Goldmann applanation tonometer. Hence anterior chamber depth was found out to be independent of IOP measured with non-contact and Goldmann applanation tonometer .

Ni-Wen Kuo et al, in his study to investigate the difference of ocular biometric and corneal topographic characteristics of high-anisometropic adults in Taiwan showed a weak positive correlation between the IOP and ACD (more myopic: r= 0.35, p = 0.02; less myopic eye: r=0.26, p=0.07).[90]

Hence our study showed a comparable performance of non-contact tonometer against Goldmann applanation tonometer which is considered to be the gold standard instrument for measuring the IOP. Also the sensitivity of non-contact tonometer was 84.21% and specificity was 95.96% .Positive and the negative predictive values were 80% and 96.94%.

We also found a positive correlation of degree of myopia and axial length with IOP and a negative correlation of anterior chamber depth, and corneal curvature with IOP as measured with Goldmann applanation tonometer and non-contact tonometer.

CONCLUSION

Eventhough, Goldmann applanation tonometer is considered to be the gold standard for measurement of IOP, non-contact tonometer with its reliable, practical, associated low cross infection risk, with high sensitivity and a specificity, comparable performance with Goldmann applanation tonometer and good patient compliance, it can be used to screen the myopes who are likely to be associated with raised IOP and primary open angle glaucoma.

Degree of myopia and axial length were seen to have an influence on IOP with a positive correlation, while a negative correlation of corneal curvature and anterior chamber depth with IOP as measured with non-contact autotonometer and Goldmann applanation tonometer was observed.

Hence it was concluded from the present study that irrespective of degree of myopia, axial length, corneal curvature and anterior chamber depth, non-contact autotonometer can provide a reliable and an accurate measurement of IOP when compared to the standard Goldmann applanation tonometer.

A limitation of our study was the relatively small number of eyes for analysis of measurement of increased IOP, and the possible effects of central corneal thickness (CCT) on IOP measurements with the two instruments. Although this study was not intended to evaluate the influence of CCT on IOP measurements, non-contact tonometer has shown to be affected more by CCT than Goldmann applanation tonometer.

SUMMARY

A one year descriptive observational study was done to compare the Goldmann applanation tonometer with non-contact tonometer in eyes with myopia at KLE's Dr. Prabhakar Kore Hospital and MRC, Belgaum.

A total of 236 eyes of 118 patients fulfilling the inclusion criteria were studied. Each eye had undergone subjective refraction testing, IOP measurement with NCT and GAT, and then measurement of corneal curvature, axial length, anterior chamber depth was done A thorough funduscopic examination was done.

The summary of the results obtained is as follows:

236 eyes of 118 patients having refractive error of myopia were studied.

The mean age was 24.34 years.

58.47% were males and 41.53% were females.

Majority, 60.59% had a visual acuity without correction of </=6/60.

Out of the 236 eyes of 118 patients, 155eyes (65.68%) belonged to myopia of less than or equal to -6D group and 81 eyes (34.32%) belonged to myopia more than -6D group.

Mean spherical equivalent in less than or equal to -6D group was -3.56 D with a S.D of 1.22D and in more than -6D group it is -11.06D with a S. D of 4.43D.

The mean IOP when measured with non-contact tonometer in 236 eyes was 16.23 mmHg with a S.D. of 3.54 mmHg and that with Goldmann applanation tonometer was 15.89 mmHg with a S.D of 3.84 mmHg.

Clinically we found a little large value of mean IOP when measured with non-contact tonometer compared to Goldmann applanation tonometer.

The correlation coefficient between the two instruments was 0.880 ($p < 0.0001$) which is highly significant indicating comparable performance between the two instruments.

The sensitivity, specificity, positive and negative predictive values of non-contact tonometer were 84.21%, 95.96%, 80% , 96.94%.

Out of the 40 eyes showing IOP >21mmHg with non-contact tonometer, 24 eyes(60%) had myopia of </= -6 D and 16 eyes (40%) had myopia of > -6 D .

Those with Goldmann applanation tonometer showing IOP >21 mmHg, 18 eyes(47.37%) had myopia of </= -6 D and 20 eyes (52.63%) had myopia of >-6D .

We found a positive correlation between degree of myopia and IOP measured with both non-contact tonometer and Goldmann applanation tonometer.

Out of the 40 eyes with IOP more than 21mmHg measured with non-contact tonometer, 30 eyes (75%) had an average corneal curvature of less than or equal to 44D.

Similarly, out of the 38 eyes showing IOP more than 21 mmHg with the Goldmann applanation tonometer, 29 eyes(76.32%) had an average corneal curvature of less than or equal to 44D.

Mean corneal curvature was 43.57D +/- 1.18.

The correlation coefficients were found to be negligibly small with non-significant values of p.

Hence corneal curvature was found to be independent of IOP measured with non-contact or Goldmann applanation tonometer.

Mean axial length in our study was 25.27 mm $\pm$1.30mm.

Out of the 40 eyes with IOP more than 21mmHg measured with non-contact tonometer, majority, 25 eyes (62.5%) had an axial length between 26-30mm.

Similarly, out of the 38 eyes showing IOP more than 21 mmHg with the Goldmann applanation tonometer, majority, 23 eyes (60.53%) had an axial length between 26-30mm.

A positive correlation between axial length and intraocular pressure measured by non-contact tonometer as well as Goldmann applanation tonometer was also found out.

Mean anterior chamber depth was 3.68mm +/- 0.37mm.

Out of the 40 eyes with IOP > 21 mm Hg as measured with non-contact tonometer, majority 18 eyes (45%) showed an average ACD between 3-3.5 mm.

Similarly, out of the 38 eyes with IOP >21 mmHg as measured with Goldmann applanation tonometer, majority, 16 eyes (42.11%) had an average AC depth between 3.5 and 4.0mm.

The correlation coefficients were negligibly small with non-significant p values . Hence anterior chamber depth was found to be independent of IOP measured with non-contact and Goldmann applanation tonometer.

Thus in this study we found out a good sensitivity and high specificity, positive and a negative predictive values of non-contact tonometer in detecting IOP

>21 mmHg in eyes with myopia when compared to the standard Goldmann applanation tonometer.

We also found a high correlation of non-contact tonometer with Goldmann applanation tonometer indicating a comparable performance between the two instruments.

Our study also showed a positive correlation between degree of myopia and IOP axial length with IOP suggesting a possible association of myopia and POAG. But no correlation was found between anterior chamber depth, corneal curvature and IOP indicating that both were independent of IOP measured with non-contact tonometer and Goldmann applanation tonometer. Hence it was concluded from the present study that, irrespective of degree of myopia, axial length, corneal curvature and anterior chamber depth, non-contact tonometer can provide a reliable and an accurate measurement of IOP when compared to the standard Goldmann applanation tonometer.

BIBLIOGRAPHY

1. Myron Yanoff and Jay S Duker .Ophthalmology .Second edition: MOSBY Elsevier Publishers; Year 2009. Pg. 1096, 1119, 674.
2. A.K. Khurana and Indu Khurana. Anatomy and Physiology of Eye. Second edition, CBS publishers and distributors; Year 2006 , pg 71.
3. Becker – Shaffer's. Diagnosis and Therapy of the Glaucomas. 8th edition: MOSBY Elsevier Publishers; year 2009 pg. 47, 52. 55.
4. Thomas Duane. Clinical Ophthalmology. Revised Edition 1986: Harper and Row Publishers; volume 3, pg 5-6.
5. David Abrams. Duke –Elder's Practice Of Refraction, 10th edition, Elsevier Publishers, 2006, pg 53.
6. Bruce Shield. Shields' Textbook of Glaucoma. 5th edition: Jaypee brothers medical publishers.
7. Goldmann H, Schmidt TH, Ueber. Applanation tonometry. Ophthalmolgica. 1957; 134-221.
8. Moses RA. The Goldmann applanation tonometer. Am J Ophthalmol 1958; (46): 865.
9. Krakau CET, Wilke K. On repeated tonometry, Acta Ophthalmol Scand Suppl 1971; (49): 611.
10. Moses RA. Repeated applanation tonometry , Ophthalmologica1963; (142):663.
11. Moltolko MA, Feldman F, Hyde M, Hudy D. Sources of variability in the results of applanation tonometry. Can J Ophthalmol 1982; Jun, 17 (3): 93-5.

12. Ehlers N, Bramsen T, Sperling S. Applanation tonometry and central corneal thickness. Acta Ophthalmol Scand Suppl1975; 53:34.

13. Herndon LW, Choudhri SA, COXT, Damji KF, Shields MB,Allingham RR. et al. Central corneal thickness in normal, glaucomatous and ocular hypertensive eyes .Arch Ophthalmol 1997Sept; 115(9):1137-41.

14. Wolfs R C, Klaver CC, Vingerling JR, Grabbee DF, Hofman A, de Jong PT et al. Distribution of central corneal thickness and its association with intraocular pressure The Rotterdam study. Am J Ophthalmol 1997 Jun; 123(6): 767-72.

15. Shimmyo M, Ross AJ, Moy A, Mostatavi R et al.Intraocular pressure, Goldmann applanation tension ,corneal thickness and corneal curvature in Caucasians, Asians, Hispanics and African Americans. AmJ ophtalmol 2003 Oct; 136(4):603-13.

16. Schipper I, Senn P, Niesen U. Are we measuring the right intraocular pressure after excimer laser photorefractive laser keratoplasty in myopia? Klin Monatsbi Augenheilkd 1995 ; 206:322-324.

17. Holladay JT, Allison ME, Prager TC. Goldmann applanation tonometry in patients with regular corneal astigmatism , AM J Ophthalmol 1983; 96(1):90-3 .

18. Britt J M, Clifton BC, Barnebey HS, Mills RP. Microaerosal formation in non-contact air –puff tonometry, Arch Ophthalmology 1991 FEB ; 109(2): 225.

19. Piltz JR, Starita R, Miron M, Henkind P. Momentary fluctuations of intraocular pressure in normal and glaucomatous eyes. Am J Ophthalmolgy1985; 99, 333.

20. McCaghrey GE, Matthews FE. The pulsair 3000 tonometer – how many readings need to be taken to ensure accuracy of the average? Ophthalmic Physiol Opt 2001; 21, 334.

21. Mackie SW, Jay JL, Ackerley R, Walsh et al. Clinical comparison of the keeler pulsair 2000, American Optical MK2 and Goldmann applanation tonometers. Ophthalmic physiol opt 1996 march;, vol 16(2): pg 171-7.

22. Cho P, Lui T. Comparison for the performance of the Nidek NT-2000 non-contact tonometer with the keeler Pulsair 2000 and the Goldmann applanation tonometer. Optom vis Sci 1997 jan; vol 74(1): 51-8.

23. Lawson – Kopp W De Jong A, Yudcovitch L , Williams S , Kohi P, Yolton RL et al. Clinical evaluation of the Keeler Pulsair 3000 non-contact tonometer. Optometry 2002 feb; 73(2): 81-90.

24. Popovich KS, Shields MB. Comparison of intraocular pressure measurements with the XPERT noncontact tonometer and Goldmann applanation tonometry, Journal Glaucoma 1997 feb; vol 6(1): 44-46.

25. Drance SM. The coefficient of scleral rigidity in normal and glaucomatous eyes. Arch Ophthalmol 1960; 63: 668.

26. Harbin TS Jr, Laikam SE, Lipsitt K, Jarrett Wh 2nd , Haglen WS et al. Applanation – Schiotz disparity after retinal detachment surgery utilizing cryopexy. Ophthalmology1979 Sep; 86(9): 1609-12.

27. Aronowitz JD, Brubaker RF. Effect of intraocular gas on intraocular pressure. Arch Ophthalmol 1976; 94: 1191.

28. Armaly MF. On the distribution of applanation pressure .I. Statistical features and the effect of age, sex, and family history of glaucoma. Arch Ophthalmol 1965; 73: 11.

29. Gassterland D, Kupfer C, Milton R, Ross K , Mc Clain L, Machellan H. Studies of the aqueous humour dynamics in man. VI, Effect of age upon parameters of intraocular pressure in normal human eyes .Exp Eye Res 1978 June; 26: 651.

30. Klein BE ,Klein R. Intraocular pressure and cardiovascular risk variables. Arch Ophthalmol 1981; 99: 837.

31. Levene R Z. Tonometry and tonography in a group health population. Arch Ophthalmol 1961;66:42.

32. Bengtsson B. Some factors affecting the distribution of intraocular pressure in a population. Acta Ophthalmol Scand Suppl 1972; 50:33.

33. Carel R S Korcyzn AD, Rock M, Goyal et al. Association between ocular pressure and certain health parameters .Ophthalmology 1984; 91: 311.

34. Leske MC, Anthea M.S. Connell, Suh- Yuh WU, Leslie Hyman, Andrew P, Schachat et al. Distribution of intraocular pressure . The Barbados Eye Study, Arch Ophthalmol 1997; 115:1051.

35. Kass MA Zimmerman TJ, Alton E, Lemon L, Becker B. et al. Intraocular pressure and glaucoma in the Zuni Indians. Arch Ophthalmol 1978; 96 : 2212.

36. R David, L Zangwill, D Briscoe, M Dagan , R Yagev, Y Yassur et al. Diurnal intraocular pressure variations ;an analysis of 690 diurnal curves . Br.J Ophthalmol 1992; 76: 280.

37. Kitazawa Y,Horie T. Diurnal variation of intraocular pressure in primary open angle glaucoma . Am J Ophthalmol 1975; 79: 557.

38. Hirvela H, Tuulonen A, Laatikainen I. Intraocular pressure and prevalence of glaucoma in elderly people in Finland ;a population –based study, Int Ophthalmol 1994; 18: 299.

39. Topper JE, Brubaker RF. Effects of timolol, epinephrine and acetazolamide on aqueous humour flow during sleep, Invest Ophthalmol Vis Sci 1985; 26:1315.

40. Asrani S, Zeimer R, Wilensky J, Gieser D , Vitale S, Lindermuth K et al. Large diurnal fluctuations in intraocular pressure are an independent risk factor in patients with glaucoma. J Glaucoma 2000; 9: 134.

41. Follman P, Mucsi G, Gati J. Distribution of normal intraocular pressures , Trans Ophthalmol Soc UK 1977; 96: 683.

42. Bulpitt CJ ,Hodes C, Everitt MG. Intraocular pressure and systemic blood pressure in the elderly. Br J Ophthalmol 1975; 59:717.

43. Langham ME ,To Mey KF. A clinical procedure for the measurement of ocular pulse –pressure relationship and the ophthalmic arterial pressure. Exp Eye Res 1978; 27: 17.

44. Yoshida M, Masao Yashida, Mamoru Ishikawa, Akatsuki Kokaze , Yasuko Sekin, Naomi Matsunaga et al. Association of life –style with intraocular pressure in middle –aged and older Japanese residents. Jpn J Ophthalmol 2003; 47:191.

45. Friberg TR, Sanborn G, Weinreb R N. Intraocular and episcleral venous pressure increase during inverted posture. Am J Ophthalmol 1987; 103: 523.

46. Blondeau P, Tetrault JP, Papamarkakis C. Diurnal variation of episcleral venous pressure in healthy patients , a pilot study . J Glaucoma 2001; 10; 18.

47. Shapiro A, Shoenfeld Y, Shapiro Y. The effect of standardized submaximal work load on intraocular pressure, Br J Ophthalmol 1978; 62: 679.

48. Duke Elder S. Pathologic refractive errors. System of ophthalmology .vol5, Ophthalmic Optics and refraction. Louis, Mosby; 1970: 297-373.

49. AGIS Investigators: The Advanced Glaucoma Intervention Study(AGIS) 12;baseline risk factors for sustained loss of visual field and visual acuity in patients with advanced glaucoma . Am J Ophthalmol, 2002, 134(4):499-512.

50. Fong DS, Epstein DL, Allingham RR. Glaucoma and myopia : Are they related? Int Ophthalmol Clin.1990; 30(3):215-218.

51. Gordon MO, Beiser JA, Brandt JD, Heuer D K, Higginbotham EJ, Johnson CA et al. The Ocular Hypertension Treatment Study: baseline factors that predict the onset of primary open-angle glaucoma. Arch Ophthalmol 2002, 120(6): 714-720.

52. Grodum K, Heiji A, Bengtsson B. Refractive error and glaucoma. Acta Ophthalmol Scand 2001; 79(6):560-566.

53. Knapp A. Glaucoma in myopic eyes. Trans Am Ophthalmol Soc.1925; 23:61-70

54. Podos SM, Becker B, Morton WR. High myopia and primary open angle glaucoma .Am J Ophthalmol.1966; 62(6): 1038-1043.

55. Abdalla MI, Hamdi M. Applanation ocular tension in myopia and emmetropia. Br J Ophthalmol 1970 ; 54(2): 122-125.

56. Perkins ES, Phelps CD. Open angle glaucoma , ocular hypertension , low-tension glaucoma , and refraction . Arch Ophthalmol 1982; 100(9):1464-1467.

57. Daubs JG, Crick RP. Effect of refractive error on the risk of ocular hypertension and open angle glaucoma. Trans Ophthalmol Soc U K. 1981; 101(1):121-126.

58. David R, Zangwill LM, Tessler Z, Yassur Y. The correlation between intraocular pressure and refractive status. Arch Ophthalmol. 1985; 103(12):1812-1815.

59. Seddon JM, Schwartz B, Flowerdew G. Case-control study of ocular hypertension. Arch Ophthalmol. 1983; 101(6): 891-894.

60. Tomlinson A, Phillips CI. Applanation tension and axial length of the eyeball. Br J Ophthalmol. 1970; 54(8):548-553.

61. Mitchell P, Hourihan F, Sandbach J, Wang JJ. The relationship between glaucoma and myopia: the Blue Mountains Eye Study. Ophthalmology. 1999; 106 (10):2010-2015.

62. Wu SY, Nemesure B, Leske MC. Refractive errors in a black adult population: the Barbados Eye Study. Invest Ophthalmol Vis Sci. 1999; 40(10):2179-2184.

63. Wong TY, Klein BE, Klein R, Knudtson M, Lee KE. Refractive errors, intraocular pressure, and glaucoma in a white population. Ophthalmology. 2003; 110(1): 211-217.

64. Xu L, Wang Y, Wang S, Wang Y, Jonas JB. High myopia and glaucoma susceptibility the Beijing Eye Study. Ophthalmology. 2007; 114(2):216-220.

65. Saw SM, Shih-Yen EC, Koh A, Tan D. Interventions to retard myopia progression in children: An evidence based update. Ophthalmology 2002; 109: 415–421.

66. Kennedy RH, Dyer JA, Kennedy MA, Parulkar S, Kurland LT, Herman DC et al. Reducing the progression of myopia with atropine: a long term cohort study of Olmsted County Students. Binocul Vis Strabismus O 2000; 15(3): 281–304.

67. Fan DS, Lam DS, Chan CK, Fan AH, et al. Topical atropine in retarding myopia progression and axial length growth in children with moderate to severe myopia: a pilot study. Jpn J Ophthalmol 2007; 51: 27–33.

68. A K Khurana. Theory And Practice of Optics And Refraction. Elsivier Publishers; 71-72.

69. American Academy of Ophthalmology. Pathologic myopia .In: Retina and vitreous, basic and clinical science course. San Fransisco . American Academy Of Ophthalmology 2003; 74.

70. Rada J A, Shelton S, Norton TT. The Sclera and myopia, Exp Eye Res 2006; 82:185-200.

71. Hyams SW, Neumann E. Peripheral retinal in myopia. With particular reference to retina breaks. Br J Ophthalmol 1969; 53: 300–306.

72. Jack J Kanski. Clinical Ophthalmology Sixth edition. Butterworth Heinemann Elsevier Publishers; Year 2007. Pg. 382.

73. Ramanjit Sihota, Radhika Tandon. Parsons' Diseases of the Eye. 20th edition: Elsevier publishers ; year 2008 ; pg 310.

74. Sir Stewart Duke Elder. The Foundations Of Ophthalmology , vol 7, year 1968, The C.V. Mosby Company, St. Louis, pg 343-344.

75. Patikulsila D, Taweemankongsab S, Ngamtipakorn S. Comparison of intraocular pressure measured by non-contact air puff versus Goldmann applanation tonometers in gas-filled vitrectomized eyes. J Med Assoc Thai. 2003 May; 86(5):467-72.

76. Viney Gupta, Parul Sony, Harish C Agarwal, Ramanjit Sihota, Ajay SharmaInter-instrument agreement and influence of central corneal thickness on measurements with Goldmann, pneumotonometer and noncontact tonometer in glaucomatous eyes. Indian journal of ophthalmology year 2006; vol 54 issue 4: page 261-265.

77. Stephen A Vernon. Non- contact tonometry in the postoperative eye. British Journal of Ophthalmology 1989; 73: 247-249.

78. Mark E, Ralston, Choplin NT , Hollenbach KA, Applegate BJ, Henn TW et al. Glaucoma screening in primary care : the role of noncontact tonometry. Journal of Family Practice .Jan 1992; 34(1): 73-7.

79. Kawase K, Tomidokoro A, Araie M, Iwase A, Yamamoto T. Ocular and systemic factors related to intraocular pressure in Japanese adults: the Tajimi study. Br J Ophthalmol. 2008 Sep; 92(9):1175-9.

80. Kirsti Grodum, Anders Heijl and Bo Bengtsson. Refractive error and glaucoma. Acta Ophthalmol. Scand. 2001; 79: 560-566.

81. Chihara E, Liu X, Dong J Taka Shima Y, Akimoto M, Hangai M et al . Severe myopia as a risk factor for progressive visual field loss in primary open-angle glaucoma. Ophthalmologica. 1997; 211 (2): 66-71.

82. Eysteinsson, T., Jonasson, F., Sasaki, H., Arnarsson, A., Sverrisson, T., Sasaki, K., Stefánsson, E. and Reykjavik Eye Study Group , Central corneal thickness, radius of the corneal curvature and intraocular pressure in normal subjects using non-contact techniques, Reykjavik Eye Study. Acta Ophthalmologica Scandinavica, 2002; 80: 11–15.

83. Matsumoto T, Makino H, Uozato H, Saishin M, Miyamoto S.. The influence of corneal thickness and curvature on the difference between intraocular pressure measurements obtained with a non-contact tonometer and those with a Goldmann applanation tonometer. Nihon Ganka Gakkai Zasshi 2000 May; 104(5): 317-23.

84. Scott A. Read, Michael J. Collins, and D. Robert Iskander: Diurnal Variation of Axial Length, Intraocular Pressure, and Anterior Eye Biometrics Investigative Ophthalmology & Visual Science, 2008 July; Vol. 49 No. 7: 2911-18.

85. Foster PJ,Broadway DC,Garway-Heath DF,Yip JL,Luben R,Hayat S,Dalzell N,Wareham NJ,Khaw KT Intraocular Pressure and Corneal Biomechanics in an Adult British Population - The EPIC-Norfolk Eye Study. Intraocular Pressure and Corneal Biomechanics in an Adult British Population - The EPIC-Norfolk Eye Study. Invest Ophthalmol Vis Sci SEP-2011.

86. Pärssinen O Intraocular pressure in school myopia. Acta Ophthalmol (Copenh). 1990 Oct; 68(5):559-63.

87. Quigley HA. Reappraisal of the mechanisms of glaucomatous optic nerve damage. Eye (Lond). 1987; 1(Pt 2): 318-322.

88. Cahane M, Bartov E. Axial length and scleral thickness effect on susceptibility to glaucomatous damage: a theoretical model implementing Laplace's law. Ophthalmic Res. 1992; 24(5): 280-284.

89. Curtin BJ, Iwamoto T, Renaldo DP. Normal and staphylomatous sclera of high myopia: an electron microscopic study. Arch Ophthalmol. 1979; 97(5): 912-915.

90. Ni-Wen Kuo , Chia-Jung Shen , Shwu- Jiuan Sheu : The ocular biometric and corneal topographic characteristics of high-anisometropic adults in Taiwan. Journal of the Chinese Medical Association 2011; 74: 310-315.

ANNEXURE – I : PROFORMA

GOLDMANN APPLANATION TONOMETER VERSUS NONCONTACT AUTOTONOMETER IN MEASUREMENT OF INTRAOCULAR PRESSURE IN EYES WITH MYOPIA– A DESCRIPTIVE OBSERVATIONAL STUDY.

PATIENT OPD NO. ☐ PATIENT ID NO. : ☐

NAME:_____

AGE: ☐ yrs SEX: ☐ (1-male, 2-female)

OCCUPATION:_____DATE:_____

IS THE PATIENT ELIGIBLE FOR STUDY: ☐ 1-YES 2-NO

HAS INFORMED CONSENT BEEN GIVEN? ☐ 1-YES 2-NO

COMPLAINTS:

1. DIMINUTION OF VISION: ☐ (1- YES , 2- NO)

HISTORY OF PRESENT ILLNESS :

2. DIMINUTION OF VISION ☐ (1- RIGHT EYE, 2- LEFT EYE, 3- BOTH EYES)

3. DIMINUTION OF VISION ☐ (1- DISTANCE, 2-NEAR, 3- BOTH)

4. H/O OF WEARING SPECTACLES ☐ (1-YES, 2-NO)

IF YES SPECIFY DURATION ____MONTHS/YEARS

5. H/O OF WEARING SPECTACLES ☐ (1-DISTANCE, 2-NEAR, 3-BOTH)

6. H/O REDNESS : ☐ (1- YES, 2- NO)

7. H/O WATERING : ☐ YES, 2- NO)

8. H/O DISCHARGE FROM EYES ☐ (1- YES, 2- NO)

PAST HISTORY :

9. PAST HISTORY OF ☐ 1- DIABETES, 2- HYPERTENSION, 3- BOTH,

4- ANY OTHER MEDICAL DISORDER, 5- NIL

IF 4 PLEASE SPECIFY : _____

PERSONAL HISTORY:

10. PERSONAL HISTORY OF ☐ 1- SMOKING, 2-ALCOHOLISM, 3-BOTH, 4- NIL

GENERAL PHYSICAL EXAMINATION

11. PALLOR ☐ (1- PRESENT, 2- ABSENT)

12. OEDEMA ☐ (1- PRESENT, 2- ABSENT)

13. LYMPHADENOPATHY ☐ (1- PRESENT, 2- ABSENT)

14. PULSE :_____/ MINUTE

15. BP :_____mmHg

16. TEMPERATURE :_____°C ☐

17. CVS: ☐ (1-Normal, 2-Abnormal, If Abnormal, specify : _____

18 RS: ☐ (1-Normal, 2-Abnormal, If Abnormal, specify : _____

19. CNS: ☐ (1-Normal, 2-Abnormal, If Abnormal, specify : _____

20 PER ABDOMEN : ☐ (1-Normal, 2-Abnormal, If Abnormal, specify : _____

OCULAR EXAMINATION:

	RIGHT EYE	LEFT EYE
22.VISUAL ACUITY		
a) DISTANT VISION	☐	☐
1- 6/6		
2- 6/9		
3- 6/12		
4-6/18		
5-6/24		
6-6/36		
7-6/60		
8-<6/60		
b) PINHOLE	☐	☐
1- 6/6		
2- 6/9		
3- 6/12		
4-6/18		
5-6/24		
6-6/36		
7-6/60		
8-<6/60		
c) WITH SPECTACLES (IF ANY)	☐	☐
1- 6/6		
2- 6/9		
3- 6/12		
4-6/18		
5-6/24		
6-6/36		
7-6/60		
8-<6/60		
d) NEAR VISION	☐	☐
1- N6		
2- N8		
3- N10		
4- N12		
5- N18		
6-N36		

23 Adnexa

(1-Normal; 2-Abnormal, if abnormal specify : _____)

24 Sclera

(1-Normal; 2-Congested)

25. Conjunctiva

(1-Normal; 2-Conjunctival congestion , 3-ciliary congestion, 4- Chemosis)

26. Cornea

(1-Normal; 2-Opacity, 3- Vascularization)

27. Anterior Chamber

(1-Normal death ; 2-Shallow,3-Deep)

28. Iris

(1-Normal colour and pattern ; 2-Abnormal) If abnormal, specify

29. Pupil

(1-Round and regular ; 2-Abnormal)

Reaction : (1-Present, 2- Absent)

30. Lens

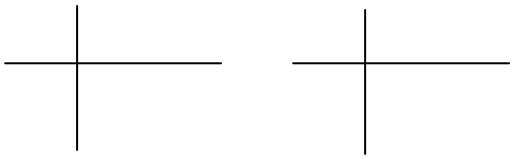
(Cataract : 1-Nuclear ; 2-Cortical, 3- Mixed; 4-Others, 5 - Clear)

31. ANTERIOR VITREOUS

(1-Normal, 2-Abnormal) If abnormal, specify

32. REFRACTION

a) RETINOSCOPY



- CYCLOPLEGIA, DILATATION/DRY REFRACTION

- DRUG USED

b) SUBJECTIVE CORRECTION

	RIGHT			**LEFT**		
	SPH	**CYL**	**AXIS**	**SPH**	**CYL**	**AXIS**
D						
N						

33. FUNDUS EXAMINATION

	RIGHT EYE	**LEFT EYE**
a. GLOW	☐	☐
(1-GOOD GLOW, 2-FAINT GLOW, 3- NO GLOW)		
b. MEDIA	☐	☐
(1- CLEAR, 2- HAZY)		
c. DISC	☐	☐
(1- NORMAL, 2a- large, 2b- temporal crescent, 2c- peripapillary atrophy, 2d- tilted,2e- Glaucomatous)		
d. C:D RATIO	☐	☐
(**1**-0.3, **2**-0.4, **3**-0.5, **4**-0.6, **5**-0.7, **6**-0.8, **7**-0.9)		
e. VESSELS	☐	☐
(1- NORMAL, 2- ABNORMAL)		

IF ABNORMAL SPECIFY _____

f. BACKGROUND ☐ ☐

(1- Normal, 2a-Tessellated, 2b- Chorioretinal atrophy, 2c- Lacquer crack)

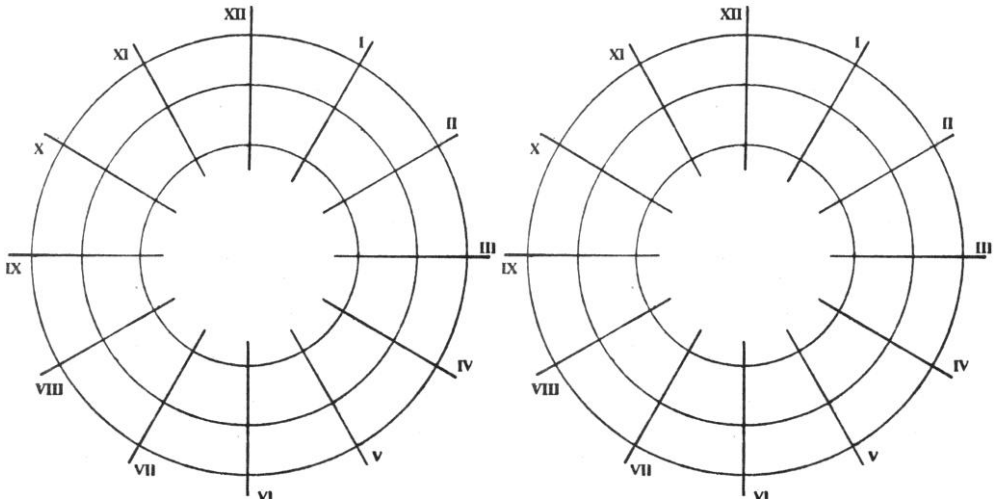
g. PERIPHERY ☐ ☐

(1- Normal, 2a- Lattice degeneration,2b- Retinal hole,2c- WWP)

h. MACULA ☐ ☐

(1- FOVEAL REFLEX +, 2-FOVEAL REFLEX DULL)

FUNDUS DIAGRAM



RIGHT EYE **LEFT EYE**

34. KERATOMETRY	**RE**	**LE**
K1	☐	☐
K2	☐	☐

35. AXIAL LENGTH	**RE**	**LE**
	☐	☐

36. ANTERIOR CHAMBER DEPTH **RE** **LE**

☐ ☐

37. TONOMETRY

a) NONCONTACT AUTOTONOMETER

IOP IN mmHg -

-

-

AVERAGE:

b) GOLDMANN APPLANATION TONOMETER

IOP IN mmHg -

-

-

AVERAGE:

38. CONCLUSION:

- TYPE OF MYOPIA

39. FINAL DIAGNOSIS :

ANNEXURE – II: CONSENT FORM

CONSENT FOR PARTICIPATION IN RESEARCH STUDY

Mr/Mrs/Ms:_____

You are invited to participate in our research study titled **GOLDMANN APPLANATION TONOMETER VERSUS NONCONTACT AUTOTONOMETER IN MEASUREMENT OF INTRAOCULAR PRESSURE IN EYES WITH MYOPIA – A DESCRIPTIVE OBSERVATIONAL STUDY.** conducted by **Dr. Mrunali Dhavalikar**, Post Graduate in M.S. OPHTHALMOLOGY under the guidance of **Dr.Mahesh .I. Magdum** Professor, Department of Ophthalmology, J.N. Medical college , Belgaum.

Respected sir/ madam. We request you to enroll yourself to participate in our study as you are eligible for doing so.

Your participation in research is voluntary your decision whether or not to participate in the study will not affect your relationship with J.N.MEDICAL COLLEGE .If you decide to participate you are free to withdraw at anytime.

Purpose of the study:

The purpose of research is to compare the sensitivity and specificity of the noncontact autotonometer with Goldmannapplanation tonometer in myopia..

Procedure involved:

If you agree to enroll yourself in this study I will ask your present, past and family history. Then you will be clinically examined in detail by slit lamp examination, fundoscopy. Then you will undergo refraction testing. Finally your intraocular pressure will be measured with two different types of tonometers first with noncontact autotonometer then with Goldmann applanation tonometer.

Risks and benefits:

Rare complications of noncontact autotonometer can be remote possibility of infection due to micro aerosol formation for which all necessary precautions will be taken.

Your participation may benefit you and others suffering from same ailment in future by helping us learn more about the disease process and better treatment modalities.

Cost for participation in this research:

There will not be any extra cost incurred by the participant. The participant will however have to pay for the investigations which are part of the existing management protocol for this ailment. There is no commitment for reimbursement or any other compensation for the participant.

Privacy and confidentiality:

The only people to know that you are a research subject are members of the research team. No information about you or information provided by you during the research will be disclosed to others without your written permission.

Authorization to publish results:

When the results of the research are published or discussed in a conference no information will be displayed that would disclose your identity. Any information that is obtained in connection with this study and that can be identified with you will remain confidential.

Questions:

If you have any questions about the research you may please contact

1) Chief Investigator- Dr. Mrunali Dhavalikar PG Department of Ophthalmology JNMC Belgaum. PH .no. 9164103104
2) Dr.Mahesh.I.Magdum, Professor, Guide, Department of Ophthalmology, JNMC, Belgaum. PH NO: 9845507509.
3) Dr.V.D.Patil, Principal, JNMC, Belgaum and chairman of institutional Ethics committee Ph. No. 0831-2471350

CONSENT FOR PARTICIPATION IN RESEARCH TRIAL

I, Mr/Ms/Mrs voluntarily agree for the participation as a subject of study. By signing this consent form I am not giving up any of my legal rights .I may withdraw from the study anytime. I am signing the consent form after having read or been read for me in vernacular language, including the risks and the benefits and having all my questions answered.

Subject Name :_____

Signature or the left thumb print of subject:_____

Witness Name :_____

Signature of Witness :_____

Investigators Name: Dr. Mrunali Dhavalikar

Signature of investigator:_____

Date: Place:

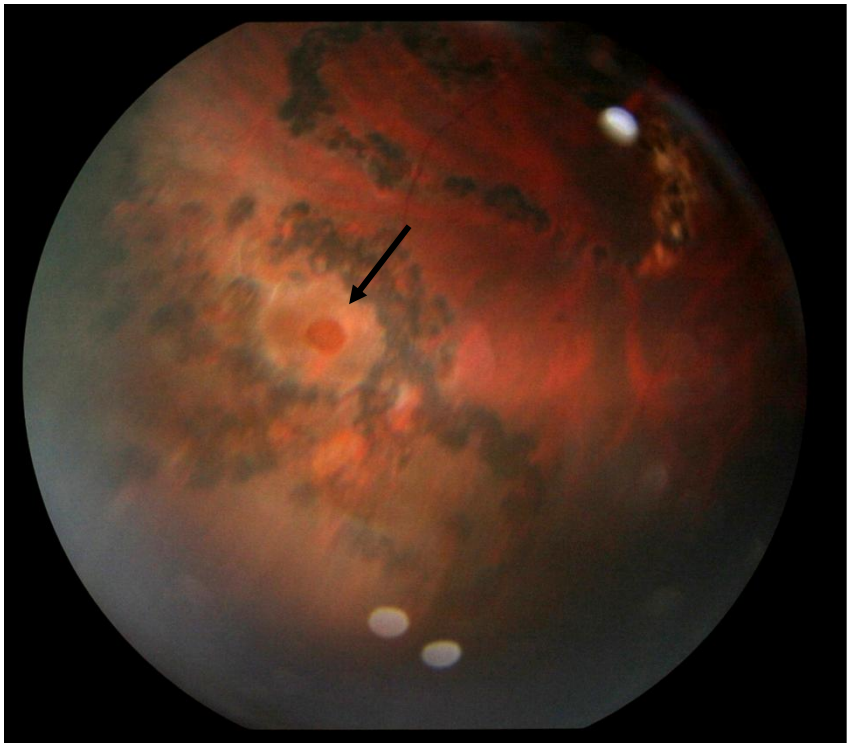
Name of Guide :_____

Signature of Guide :_____

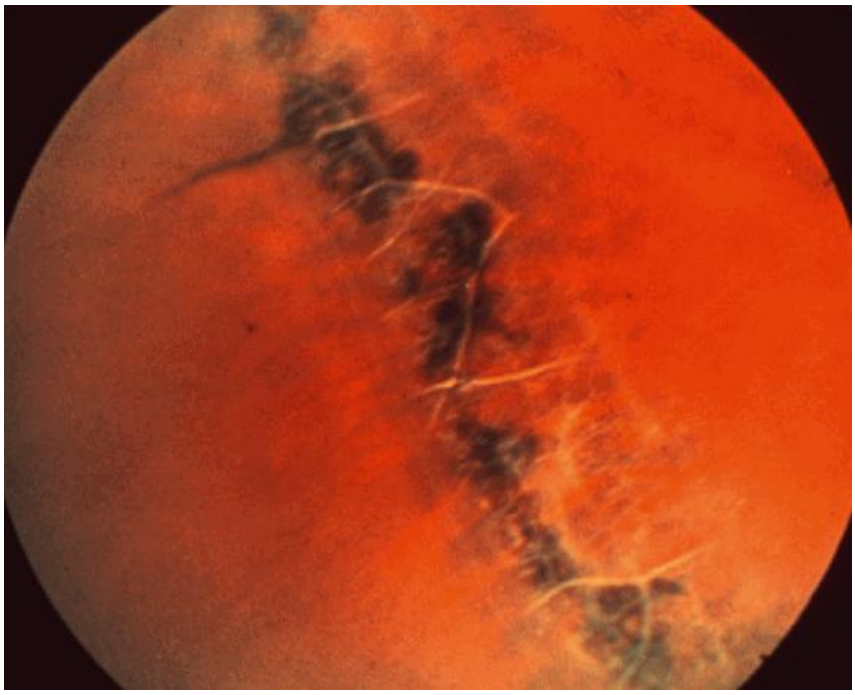
ANNEXURE – III : PHOTOGRAPHS

Photograph No.1: Patient undergoing Goldmann applanation tonometry.

Photograph No.2: Patient undergoing Non-contact autotonometry.



Photograph No.3: Fundus photograph showing Retinal Hole with Barrage laser marks.



Photograph No.4: Fundus photograph showing Lattice Degeneration.

ANNEXURE –IV: MASTER CHART

SR.NO	OP NO.	AGE	SEX	VISUAL ACUITY RE	VISUAL ACUITY LE	SPH. EQ.RE	SPH. EQ LE	PERIPHERY RE	PERIPHERY LE	RE -K	LE -K	RE-AXL	LE-AXL	ACDEPTH RE	AC DEPTH LE	NCT-RE	NCT-LE	GAT-RE	GAT-LE	DIAGNOSIS
1	659408	20	M	<6/60	<6/60	-5.5	-6.5	N	N	43.5	44.87	25.04	25.23	3.44	3.25	16.5	15	13	13	S
2	1244524	19	M	6/24	6/24	-4.5	-4	N	N	44.12	44.12	24.32	24.27	3.93	4.13	13.4	11.8	11.5	10	S
3	1260766	40	M	6/36	6/36	-3.5	-3	N	N	43.5	44	25	24.99	3.44	3.44	18.5	18	13	13	S
4	1155954	19	F	<6/60	<6/60	-5.5	-5.5	N	N	44.12	44.12	24.34	24.32	3.44	3.44	15.1	16.1	14	14	S
5	1299487	26	M	6/18	6/9	-4.5	-4	N	N	44.25	44.37	25.04	25.23	3.44	3.25	12.7	11.5	12.3	10.6	S
6	1307294	38	M	6/60	6/18	-2.5	-3	N	N	43.12	43.12	25	25	3.44	3.25	23.3	23.3	24	24	S
7	1307044	39	M	6/36	6/60	-2.3	-2.75	N	N	43.12	43.37	24	24	3.25	3.25	13	13.7	10.6	11	S
8	968445	22	M	<6/60	<6/60	-16	-13	L	N	43.25	43.37	25.04	25.23	3.93	4.13	12.1	8.6	10.6	10.6	S
9	1313481	23	F	<6/60	6/60	-4.8	-4.25	N	N	43.62	43.12	24.32	24.27	3.25	3.25	12.8	13.4	12	12	S
10	1316710	28	M	<6/60	<6/60	-4.3	-4.25	N	N	44.12	43.62	23.9	24	3.44	3.25	13.7	14.3	14	14	S
11	1317480	18	M	6/36	6/36	-2.1	-1.75	N	N	45.75	45	22.93	23.08	3.36	3.36	18.4	18.3	22	22	S
12	992849	24	M	<6/60	<6/60	-3.3	-2.5	N	N	44.5	44.5	23.91	23.78	3.74	2.96	20.4	20.4	16	16	S
13	1192566	19	M	<6/60	<6/60	-8.3	-8.25	N	N	44.12	44	26.08	26.07	3.88	3.52	23.2	23.1	25	25	S
14	1192460	25	M	<6/60	<6/60	-10	-6	R	R	42.5	42.25	27.1	25.62	3.29	3.13	13	12	13	13	S
15	803569	35	F	6/60	6/36	-2.4	-2.37	N	N	42.25	42.5	24.86	24.82	3.83	3.78	14.4	14.8	12	12	S
16	1322919	28	M	6/60	6/60	-5.4	-4.37	N	N	43.12	43.12	24.32	24.27	3.44	3.25	17.1	17.6	13	14	S
17	1325772	26	F	6/60	6/60	-5.4	-5.25	N	N	46.25	46.87	25.73	23.97	4.2	4.06	28.4	29.5	30	28	HG
18	1172679	20	F	6/60	6/60	-2.8	-2.37	N	N	43.5	43.37	23.69	23.76	3.52	3.57	11.9	11	11	11	S
19	958089	20	F	6/12	6/24	-2.5	-2.37	N	N	40.87	41.37	24.24	23.86	3.51	3.17	19.7	18.9	18	18	S

20	1329943	18	M	6/9	6/9	-2	-2.25	N	N	42	42	24.84	23.98	3.43	3.4	17.3	18.1	17	16	S
21	1309400	24	F	6/18	6/18	-3	-3.5	N	N	42	41	24.1	24.05	3	3.05	18	16	13	14	S
22	846494	20	F	6/36	6/36	-4.3	-5.75	N	N	43	42.25	25.05	24.98	3.53	3.53	15.2	14	16	16	S
23	854846	25	F	<6/60	6/60	-3.8	-3.25	N	N	43.25	43.5	25.2	24.98	3.46	3.53	14.7	12.9	17.5	16	S
24	1337247	26	M	6/18	6/9	-3.5	-1.25	N	N	44	44.5	24.98	25.02	3.43	3.46	18.1	17.4	18	18	S
25	1349674	24	F	<6/60	<6/60	-6	-12	N	N	40.87	41.75	26.2	26.81	3.53	4.01	23	23	24	24	HG
26	1349760	19	M	<6/60	<6/60	-1.8	-3.5	N	N	43	42.25	24.84	23.98	3.46	3.53	13	13.4	14	14	S
27	4495200	39	F	6/24	6/24	-8	-16	N	N	42.5	42.12	28.55	28.36	3.31	3.45	22.8	23	24	24	S
28	4495276	20	F	6/60	6/60	-5.8	-5.25	N	N	44.12	44.12	24	24.98	3.53	3.46	14	13	14	14	S
29	757789	20	F	<6/60	<6/60	-3	-3.12	N	N	42	42	24.93	24.12	1.87	3.5	13.6	14.8	14	14	S
30	1347535	24	F	<6/60	<6/60	-6	-6.5	N	N	43.5	44.87	25.04	25.23	3.44	3.25	16.5	15	13	13	S
31	13500443	20	F	6/36	6/36	-5.5	-4.5	N	N	44.12	44.12	24.32	24.27	3.93	4.13	13.4	11.8	11.5	10	S
32	1352894	21	M	6/36	6/24	-2.8	-1.25	N	N	45	45	24.08	23.22	4.15	3.62	15	15.4	14	14	S
33	1352924	18	F	6/60	6/60	-6.5	-5.5	N	N	45	45	24.73	25.1	3.43	3.72	17.5	14.8	15	15	S
34	707363	30	M	6/12	6/12	-2.5	-2.37	N	N	46.62	46.62	23.3	23.29	3.57	3.93	19.5	19.6	16	16	S
35	1145200	18	F	6/36	6/24	-9	-9	N	N	43	43	27.1	26.16	3.66	3.88	18	18.4	22	22	H
36	1145284	18	F	<6/60	<6/60	-3	-3	N	N	40.75	40.25	24.98	24.5	3.1	3.53	14.4	13.8	13	13	S
37	1358929	20	F	<6/60	<6/60	-17	-16	N	N	46.87	46.87	27.31	27.3	2.99	2.99	17.7	17.7	14	14	S
38	1374369	37	M	<6/60	<6/60	-6	-6.37	N	N	43.75	44	25.51	25.17	2.77	2.88	21.3	21.5	22	22	S
39	1378547	28	M	6/36	6/60	-7.5	-7.37	N	N	43.75	44	25.51	25.17	2.77	2.88	13.4	13	13	13	S
40	1382378	32	F	<6/60	<6/60	-5	-7	N	N	42.37	42.37	24.3	25	3.52	3.33	15.5	15.6	14	14	S
41	867061	19	F	<6/60	<6/60	-5	-4.5	N	N	43.62	43.62	25.98	26	4.12	4.14	16	16	15	15	S
42	1387802	24	M	<6/60	<6/60	-20	-21.5	W	W	42.75	42.75	28.65	29.91	3.48	3.61	22	22	24	23	S
43	1389529	29	F	6/36	6/36	-18	-20	N	N	43.75	43.5	28.95	29.33	3.22	3.26	21.3	21.6	18.2	18.4	S
44	726595	22	M	<6/60	<6/60	-4	-3.75	N	N	44.12	44.25	24.56	24.32	3.59	3.63	18.4	18.8	18.5	19.5	S

45	726680	26	M	6/60	6/60	-2.4	-2.37	N	N	42.37	43.25	24.71	24.6	3.51	3.62	12	12	12	12	S
46	1337357	18	M	<6/60	<6/60	-8	-17	N	N	43	43.75	26.78	27.01	4.01	3.53	21.4	21.6	22	22	S
47	1346178	30	F	6/36	6/24	-3.5	-3.75	N	N	42.12	42.87	24	23.65	3.53	3.46	16.4	16.6	14	14	S
48	1335763	29	M	6/24	6/60	-4.5	-8.5	N	N	43.25	43.5	27.32	27.08	3.46	3.53	22.3	22.1	22	22	S
49	938139	20	F	<6/60	<6/60	-6.3	-6.25	N	N	43.12	43.12	25.8	25.4	4.02	4.02	18	18	18	18	S
50	1435197	21	F	6/60	6/60	-2.8	-2.75	N	N	43.75	43.75	25	25	4.02	4	15.6	15.6	17	17	S
51	1442483	25	M	<6/60	6/36	-4	-4	N	N	44	44	24.28	24.3	4.02	4.02	14	14	14.3	14	S
52	1443993	21	M	6/60	6/60	-2	-2.5	N	N	44	44	24.48	24.4	3.38	3.74	14.9	14	14	15	S
53	1451497	30	F	<6/60	<6/60	-6.5	-6.5	N	N	46.87	46.62	24.98	24.84	4.2	3.95	19.5	19.4	18	18	S
54	1454409	18	M	<6/60	6/36	-10	-5.25	N	N	44	43.75	26	26	4.02	4	16.3	16.3	17	16.6	S
55	1458321	18	F	6/60	6/36	-16	-14	N	N	46	46	27.6	26.54	3.35	3.26	21.8	22	18	18	S
56	1460321	23	M	<6/60	<6/60	-4	-4	L	N	41.37	41.25	25	25	3.35	3.26	12	12.9	13	12	P
57	1462798	33	F	6/36	6/36	-11	-8	N	N	45.5	45.37	27.29	26.57	3.78	3.69	14	15	16	16	H
58	1462797	25	F	<6/60	6/60	-8.5	-12.8	N	N	42.5	42	28.97	30.93	3.79	3.75	21.5	21.4	22	22	H
59	820113	18	M	6/60	<6/60	-5	-5.75	N	N	43.62	43.62	25.98	26	4.12	4.14	16	17	15	15	S
60	1300158	19	M	<6/60	<6/60	-6.3	-5.62	N	N	45.75	45.87	25.98	26	4.12	4.14	16.9	15.6	16	17	S
61	1042942	19	M	<6/60	<6/60	-3.3	-3.25	N	N	44	44	24.52	23.56	3.54	3.47	18.3	18.9	22	24	S
62	856313	19	M	6/24	6/60	-3.3	-3.25	N	N	44	43.75	25.5	25.5	4.2	4.2	12.9	12.7	14	14	S
63	856400	26	F	6/36	6/12	-3.4	-2.12	N	N	44	44	24.52	23.56	3.54	3.47	21.6	21.8	22	22	S
64	990341	20	F	6/60	6/60	-7	-7	N	N	43.62	43	26	25.5	4.2	4.2	11.7	11.9	12.5	12	S
65	14033302	22	M	6/36	6/60	-2.3	-4	N	N	41.37	41.25	25	25	3.35	3.26	12	12.9	13	12	S
66	1484899	34	M	<6/60	<6/60	-21	-20.5	N	L	46	46	27.6	26.54	3.35	3.26	18.2	18.4	16	16	S
67	1492797	27	M	6/36	6/6/94	-3.5	-4	N	N	43.12	43.12	25	25	3.94	3.9	16	16	14	14	S
68	1062280	18	M	<6/60	<6/60	-14	-9	LW	LW	42.25	41.75	29.61	28.01	3.75	3.97	21.8	21.5	22	22	P
69	1504559	20	M	<6/60	<6/60	-4	-3.5	N	N	43.62	43	25.05	24.03	4.27	3.93	15.1	14.4	13	13	S
70	1512586	18	F	6/60	6/60	-3.5	-4.5	N	N	44.5	44.75	24.97	24.79	3.42	3.46	12.3	11.7	13	13	S

71	1514051	21	M	<6/60	<6/60	-18	-14	N	N	44.5	44.75	24.97	24.79	3.42	3.46	12.3	11.7	13	13	H
72	1451445	19	M	<6/60	<6/60	-7.5	-7	N	N	44.5	44.75	24.97	24.79	3.42	3.46	12.3	11.7	14	14	S
73	1160614	34	M	6/36	6/36	-3	-2.75	N	N	42.5	42	25.97	26.93	3.79	3.75	14.2	13.6	13	13	S
74	1579114	23	M	<6/60	<6/60	-8	-9	N	N	42.5	42.12	26.1	26.18	3.49	3.49	14.2	14.2	13	13	S
75	1578645	35	M	<6/60	<6/60	-15	-10.5	R	N	42	42	30.45	28.71	3.49	3.49	13.4	13.9	15	15	S
76	757686	26	M	6/60	6/60	-8.5	-9.88	N	N	42.5	42.12	26.1	26.18	3.49	3.49	23	23.4	24	24	S
77	1581419	24	M	<6/60	<6/60	-5	-5	N	N	44	44	24.28	24.3	4.02	4.02	14	14	14.3	14.3	S
78	1581676	29	M	6/36	6/36	-2.8	-2.75	N	N	44.12	44.12	24.84	24.84	4.1	4.1	16	16	15	15	S
79	1591493	20	M	6/18	6/18	-3.3	-2.75	N	N	42.25	42.5	24.84	24.86	4.1	4.1	18	18	16	16	S
80	1594121	22	F	<6/60	<6/60	-5.3	-5.25	N	N	43.12	43.12	25.21	25.21	4.1	4.1	18	18	17	17	S
81	1613552	39	F	<6/60	<6/60	-22	-18	N	N	42	42.12	26	26	4	4.1	16	15	18	18	P
82	1613966	24	F	6/36	6/36	-2	-2	N	N	44	43.62	25.5	25	3.78	3.69	14	15	16	16	S
83	1646626	18	F	6/12	6/12	-2.1	-2.37	N	N	43.75	43.5	25.5	25.5	3.5	3.5	14	14	14	14.6	S
84	1641925	19	M	6/18	6/18	-2.3	-2.12	N	N	44.25	44	24.28	24.28	3.99	3.95	14	14	14	14	S
85	1651533	18	F	<6/60	<6/60	-10	-10.9	N	N	43.75	43.5	25	25	4.19	4.19	15	15	16	16	H
86	1570513	24	M	6/18	6/18	-2	-2	N	N	44.12	44.12	24.99	24.99	3.99	3.99	15.1	15.1	16	16	S
87	1175796	21	M	6/24	6/24	-4.8	-4.5	N	N	43.37	43.5	24.5	24.59	3.99	3.99	14	14	14	14	S
88	1656918	18	F	<6/60	<6/60	-7.3	-9	N	N	44.37	45.12	24.99	24.99	3.99	3.99	14.6	14.6	14	14	H
89	1657746	19	F	6/24	6/24	-3	-3	N	N	43	42.25	24.84	24	4.1	4	13.4	13.4	14	16	S
90	1663182	36	F	<6/60	<6/60	-13	-7.5	N	N	43.12	43.12	25	25.1	3.93	3.99	14	14	12	12	H
91	1663248	18	F	6/24	6/24	-4.3	-5	N	N	42.12	42.25	24.84	24.84	3.93	3.5	14.4	14.4	14	14	S
92	1663200	20	M	6/12	6/12	-2.8	-2.87	N	N	44.62	44.62	24.89	24.5	3.99	3.99	14.5	14.5	14	14	S
93	1673527	35	F	<6/60	<6/60	-6.5	-6.5	N	N	44.12	43.5	24.84	24.58	4.06	4.2	13.4	13.4	14	14	S
94	422237	25	F	<6/60	<6/60	-7	-4	N	N	43.62	43.12	25	24.99	4.1	4.1	14	14.6	14	14	H
95	422400	23	F	6/12	6/12	-3	-3	N	N	43.12	43.12	24.99	24.99	4.1	4.1	18.6	16.3	16	16	S

96	1680187	31	F	<6/60	<6/60	-8.5	-8.75	N	N	44.75	44.75	24.99	24.59	3.99	3.99	21.6	21.7	22	22	H
97	945662	18	F	6/60	6/60	-3.3	-3.38	N	N	43.12	43	24.99	24.59	3.5	3.99	15.8	14.9	14	14	S
98	1421977	18	M	6/18	6/18	-3.5	-3	N	N	43.12	43.12	24.99	24.99	4.1	4.1	14.6	14.6	14	14	S
99	1683216	23	M	<6/60	<6/60	-14	-13.5	N	N	45	45	25	25	3.99	3.99	14.6	14.6	14	14	S
100	1684902	20	M	<6/60	<6/60	-7.5	-9.25	N	N	43.12	43.37	24.99	24.36	4.1	4.1	14.3	14.6	14	14	S
101	1071867	20	M	6/60	6/60	-4.8	-4.5	N	N	45	45	24.99	24.99	3.99	3.99	14.6	14.6	14	14	S
102	1686609	34	M	6/24	6/24	-3.3	-3.25	N	N	43.12	43.12	24.99	24.84	3.99	3.99	14.6	14.6	14	14	S
103	1687266	31	M	6/12	6/12	-3.5	-4.25	N	N	43.12	43.12	24.99	24.99	4.1	4.1	14	14	14	14	S
104	1687300	29	M	6/60	6/60	-3.9	-4.5	N	N	44.5	44.12	24.84	24.84	3.99	3.99	11.5	11.5	12	14	S
105	1294033	25	M	6/36	6/24	-2	-2	N	N	43.12	43.12	24.99	24.84	3.99	3.99	16.8	16.7	16	16	S
106	1392936	38	F	<6/60	6/36	-14	-13	N	N	43.75	43.75	28.64	27.73	3.16	2.97	21.4	21.1	22	22	S
107	1556134	39	M	<6/60	<6/60	-10	-8.25	N	N	43.25	43.25	24.88	24.88	3.99	3.99	14.6	14.6	14	14	H
108	174032	20	M	<6/60	<6/60	-5	-5.5	N	N	44.12	44.12	27.8	28	4.1	4.1	24.1	24.8	28	28	P
109	917856	18	M	6/12	6/12	-2.8	-4	N	N	43.75	43.75	24.99	24.99	3.99	3.99	15	15	15	15	S
110	1704780	33	F	<6/60	<6/60	-12	-13	N	N	43.12	42.75	25.91	25.35	3.99	3.46	13.8	13.8	14	14	S
111	1705169	19	M	6/18	6/18	-2.8	-2.25	N	N	43.12	43.12	24.99	24	3.46	3.41	12.2	12.2	12	12	S
112	1705200	25	M	6/18	6/18	-2	-2	N	N	43.12	43.12	24.84	24.41	3.41	3.41	15.6	15.6	16	16	S
113	1705480	25	M	6/18	6/18	-2.3	-3	N	N	44.12	44.12	24.84	24.84	3.14	3.14	12.2	13.8	14	14	S
114	1705920	25	M	6/60	6/60	-6	-7	N	N	42.87	43.12	24.84	24.84	3.01	3.25	21.4	21.2	19	19	H
115	1409337	36	M	6/18	6/18	-2	-2.12	N	N	44.12	44.12	24.48	24.41	3.88	3.84	13.2	14	12	12	S
116	1409430	18	F	6/60	6/60	-7	-5	N	N	43.75	43.5	25	25	4.1	4.1	15.6	14.8	14	14	S
117	1414563	18	M	<6/60	<6/60	-15	-17	N	N	43.12	43.12	25	25	3.99	3.93	23	23.4	19	19	H
118	1720812	18	M	6/24	6/24	-2.5	-2.5	N	N	44	43.87	24.56	24.8	3.56	3.4	14.8	14.1	15	15	S

KEY TO MASTER CHART

OP NO	Out-patient no
Sph. Eq RE	Spherical equivalent right eye
Sph. Eq LE	Spherical equivalent left eye
RE –K	Right eye keratometry reading
LE –K	Left eye keratometry reading
RE AXL	Right eye axial length
LE AXL	Left eye axial length
ACD RE	Anterior chamber depth right eye
ACD LE	Anterior chamber depth left eye
NCT RE	Non-contact tonometry right eye
NCT LE	non-contact tonometry left eye
GAT RE	Goldmann applanation tonometry right eye
GAT LE	Goldmann applanation tonometry left eye
M	Male
F	Female
N	Normal
L	Lattice degeneration
W	White without pressure
R	Retinal hole
S	Simple myopia
H	High myopia
HG	High myopia with POAG
P	Pathological myopia