"CORRELATION OF THE NON CONTACT TONOMETER WITH THE PERKINS APPLANATION TONOMETER"

By

Dr. VIJAYAMAHANTESH M. BIJAPUR

Dissertation submitted to the

B.L.D.E. UNIVERSITY VIJAYAPUR, KARNATAKA

In partial fulfillment of the requirements for the degree of

MASTERS OF SURGERY

In

OPHTHALMOLOGY

Under the guidance of

Dr. VALLABHA. K M.S., DOMS.

PROFESSOR AND HEAD

DEPARTMENT OF OPHTHALMOLOGY

B.L.D.E.U'S SHRI B. M. PATIL MEDICAL COLLEGE

HOSPITAL & RESEARCH CENTRE, VIJAYAPUR,

KARNATAKA

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Date:

Place: Vijayapur

Dr. VIJAYAMAHANTESH M. BIJAPUR
Post Graduate Student,
Department of Ophthalmology,
B.L.D.E.U's Shri B. M. Patil Medical
College, Hospital & Research Centre,
Vijayapur.

B.L.D.E. UNIVERSITY'S

SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE, VIJAYAPUR

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Date:

Place: Vijayapur

Dr. VALLABHA.K **M.S., DOMS.**

Professor & Head,

Department of Ophthalmology,

B.L.D.E.U's Shri B. M. Patil Medical College,

Hospital & Research Centre, Vijayapur.

B.L.D.E. UNIVERSITY'S

SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE, VIJAYAPUR

ENDORSEMENT BY THE HEAD OF DEPARTMENT

This to certify that the dissertation entitled **"CORRELATION OF THE NON CONTACT TONOMETER WITH THE PERKINS APPLANATION TONOMETER"** is a bonafide research work done by **Dr. VIJAYAMAHANTESH M. BIJAPUR,** under the guidance of **Dr. VALLABHA. K** M.S., DOMS., Professor & Head, Department of Ophthalmology at B.L.D.E.U's Shri B. M. Patil Medical College, Hospital and Research Centre, Vijayapur.

Date:

Place: Vijayapur

DR. VALLABHA.K **M.S., DOMS.**
Professor and Head,
Department of Ophthalmology,
B.L.D.E.U's Shri B. M. Patil Medical College,
Hospital & Research Centre, Vijayapur.

B.L.D.E. UNIVERSITY'S

SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE, VIJAYAPUR

ENDORSEMENT BY THE PRINCIPAL

This to certify that the dissertation entitled **"CORRELATION OF THE NON CONTACT TONOMETER WITH THE PERKINS APPLANATION TONOMETER"** is a bonafide research work done by **Dr. VIJAYAMAHANTESH M. BIJAPUR,** under the guidance of **Dr. VALLABHA.K** M.S., DOMS., Professor & Head, Department of Ophthalmology at B.L.D.E.U's Shri B. M. Patil Medical College Hospital and Research Centre, Vijayapur.

Date**:**

Place: Vijayapur

DR. S. P. GUGGARIGOUDAR **M.S. (ENT)**

Principal,

B.L.D.E.U's Shri B. M. Patil Medical College,

Hospital & Research Centre, Vijayapur.

B.L.D.E. UNIVERSITY'S

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Date:

Place: Vijayapur

Dr. VIJAYAMAHANTESH M. BIJAPUR

Post Graduate Student,

Department of Ophthalmology,

B.L.D.E.U's Shri B. M. Patil Medical College, Hospital & Research Centre,

Vijayapur.

.

ACKNOWLEDGEMENT

This piece of work has been accomplished with the grace of almighty God and my family. It gives me immense pleasure to express my heartfelt gratitude to all. I dedicate this page to each and everyone who have helped me to explore the expanses of knowledge.

I express my profound gratitude and sincere thanks to my guide, ***Dr. Vallabha K.*** ***M.S., DOMS.,*** *Professor & Head, Department of Ophthalmology, B.L.D.E.U's Shri B. M. Patil Medical College, Vijayapur, for his constant and unfailing support, professional insight, valuable suggestions, motivation and exemplary guidance to carry out and complete this dissertation. I am deeply grateful to him for providing me necessary facilities and excellent supervision to complete this work.*

I offer my sincere thanks to ***DR. S. P. Guggarigoudar*** ***M.S.,*** *Principal, B.L.D.E.U's Shri B. M. Patil Medical College, Vijayapur, for his support and inspiration.*

My sincere thanks to our Medical Superintendent ***Dr. Vijaykumar Kalyanappagol*** *for his support and inspiration.*

I am deeply indebted and grateful to my professors, ***Dr. M. H. Patil*** ***M.S.,*** *and* ***Dr. Sunil G. Biradar*** ***M.S.,*** *Department of Ophthalmology, B.L.D.E.U's Shri B. M. Patil Medical College, Vijayapur, who with their valuable suggestions and constant guidance supported me throughout the preparation of this dissertation work.*

I am deeply indebted and grateful to ***Dr. Shadakshari S. Math*** ***M.S.,*** *Associate Professor,* ***Dr. Raghavendra Ijeri*** ***M.S., FVRS.,*** *Assistant professor, and* ***Dr Jyoti Ijeri*** ***DOMS.,*** *Senior Resident, Department of Ophthalmology, B.L.D.E.U's Shri B. M. Patil Medical College, Vijayapur, for their valuable suggestions and encouragement which have definitely helped me improve my research work.*

*I acknowledge my gratitude to**, Dr.Amithab & Dr.Priyanka** Postgraduate colleagues, Department of Ophthalmology, B.L.D.E.U's Shri B. M. Patil Medical College, Vijayapur, for their support in the preparation of this dissertation.*

*I also thank all my seniors **Dr.Shilpa**, **Dr.Darshan**, **Dr.Shravan, Dr.Gautam, Dr.Harsha, Dr.Neeta** and my juniors **Dr.Dishita, Dr.Vinit , Dr.Prashant** for their co-operation during the preparation of this dissertation.*

*I thank **Mrs. Vijaya Soraganvi** and **Mr. Mohd Shannawaz** Statisticians for their masterly guidance and statistical analysis. I sincerely acknowledge the support and kindness shown towards me by all the staff of Central Library, Shri B. M. Patil Medical College, Vijayapur, at all times.*

*I am thankful to **Mr. M.B.Hatthalli**, **Sister Tangamma**, **Mr. B.R.Gulaganji, Mr. Yallappa Gotrale**, **Mr. D.B.Patil** and all the Technical, non-teaching Staff of the Department of Ophthalmology, B.L.D.E.U's Shri B. M. Patil Medical College, Vijayapur for their co-operation.*

*I am thankful to my friend **Mr. Premanand Dhanashetti**, "RAVIKIRAN" Photo Studio Vijayapur for his fantastic photograph work.*

*It is with great pleasure I express my sincere gratitude to my parents **Sri. Mallikarjun B. Bijapur**, **Smt. Shivaleela Bijapur** and to my elder brother **Dr. Nandabasappa M. Bijapur** for their constant encouragement, inspiration and sacrifices.*

*I am grateful to Babugouda Patil **Om Sai Internet** Vijayapur for their timely and fantastic printing work. Last but not the least, my sincere thanks to all the participants of this study for their cooperation without which this study would not have been possible.*

Date:- ***Dr. Vijayamahantesh M. Bijapur***

Place:-

ABSTRACT

Background

Glaucoma is now the second leading cause of blindness globally, after cataracts, according to World Health Organization. Approximately 11.2 million Indians above 40 years suffer from glaucoma. Raised intra ocular pressure is an important risk factor for development and progression of glaucoma. Therefore, intra ocular pressure measurement is essential in ophthalmological assessment.

Perkins tonometer is portable, simple and also considered gold standard because it is based on the same principles as the Goldmann applanation tonometer. But it needs topical anaesthesia, fluorescence staining, needs a specialist to do procedure .Corneal factors, like astigmatism, corneal curvature, and central corneal thickness, affect the accuracy of applanation tonometer.

In measuring intra ocular pressure by Non-contact tonometer there is no need of anaesthetic, staining, no effect of corneal factors and can be done by a non medical or paramedical personnel.

The need of this study is to correlate intraocular pressure measured using Non-contact tonometers with Perkins applanation tonometer and to study reliability of the Non-Contact Tonometer as screening tool, considering its advantages over Perkins in Indian context where large numbers of patients have to be screened and risk of transmission of infection is high.

Aims and Objectives of this study were

- To correlate the intraocular pressure by the Non contact tonometer with the Perkins applanation tonometer.

Methods:

It is a comparative study on Patients attending outpatient Department of Ophthalmology BLDEU's Shri B M Patil Medical College, Hospital and Research Centre, Bijapur, Karnataka from December 1st 2014 to 31st March 2016. With a minimum sample size of 128, we had included 260 participants in our study. Data was collected using a proforma, with the informed consent of the patient, followed by obtaining history and routine ophthalmological examination. Patients were subjected to two methods of tonometry – Non Contact Tonometry and Perkins Applanation Tonometry (Perkins under topical anaesthesia with 0.5% Proparacaine eye drops). Non Contact Tonometer readings were recorded first, then Perkins tonometer. Three readings were taken for each method and mean calculated. The data was statistically analyzed using Paired T test and Correlation co efficient. Sensitivity and Specificity were also calculated for the Non contact tonometer.

Results:

The non contact tonometer showed excellent agreement with the Perkins tonometer. The correlation coefficient of intraocular pressure measured by Non contact tonometer and Perkins applanation tonometer is 0.879 and 0.894 for right and left eye respectively with p value of <0.05 in our study participants (both male and female), showed strong positive correlation between the intraocular pressure measured by Non contact tonometer and Perkins applanation tonometer. The non contact tonometer also scored high as an effective screening tool. The non contact tonometer showed high sensitivity 95.5 and 94.3 for right eye and left eye respectively (right eye more than left

eye) i.e. very few false negative results as well as high specificity 94.5 and 99.1 for right eye and left eye respectively (left eye more than right eye) i.e. few false positive results; thus coming across an excellent agreement with Perkins applanation tonometer, using an intraocular pressure of more than or equal to 21 mm Hg with the Perkins applanation tonometer as the standard criterion.

Interpretation & Conclusion:

The current study shows that the Non contact tonometer compares well with the Perkins applanation tonometer (hand held version of gold standard Goldmann applanation tonometer) and showing excellent agreement with it. The non contact tonometer can be used as a reliable screening tool.

Key words: Non contact tonometer, Perkins applanation tonometer, Goldmann applanation tonometer, Intraocular pressure.

LIST OF ABBREVIATIONS:-

IOP	Intra Ocular Pressure
NCT	Non Contact Tonometer
PAT	Perkins Applanation Tonometer
GAT	Goldmann Applanation Tonometer

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INTRODUCTION

Glaucoma is now the second leading cause of blindness globally, after cataracts, according to World Health Organization.[1] Approximately 11.2 million Indians above 40 years suffer from glaucoma[2] with over 90% of the cases being diagnosed only after significant vision loss has occurred. Glaucoma, previously defined as a state of raised intra ocular pressure, is today better understood to be an irreversible and progressive optic neuropathy resulting from a variety of risk factors.

The most prominent among these is raised intra ocular pressure (IOP) and is the only risk factor amenable to treatment, provided it is detected early. Thus, blindness resulting from glaucoma is largely preventable, if adequate measures to control levels of intra ocular pressure are taken early enough in the pathogenesis of the disease. This makes the early detection of glaucoma suspects and cases very crucial.

However, poor awareness among the general public and low detection rates pose a problem. Therefore, intra ocular pressure measurement is essential in ophthalmological assessment along with the examination of the optic nerve head and an assessment of the visual fields by ophthalmologists. Measurement of intra ocular pressure at the primary health care level can go a long way in detecting cases as well as screening suspects from the general population.[3]

Perkins applanation tonometer (PAT) is portable, simple and also considered gold standard because it is based on the same principles as the Goldmann applanation tonometer (GAT).[4] But it needs topical anaesthesia, fluorescence staining and a specialist to do procedure, so it is a cumbersome instrument for screening purposes. Corneal

factors, like astigmatism, corneal curvature and central corneal thickness affect the accuracy of applanation tonometer.[4,5]

Currently, in most of the developing countries, the Schiotz indentation tonometer is the favored choice for screening since it is portable and simple to use. This tonometer is not considered accurate enough and is particularly difficult to disinfect between patients in large eye camps, where large numbers of patients are to be screened.

With the advances in the field of glaucoma management, numerous advanced tonometers have been developed and these could help to overcome the shortcomings of the Schiotz tonometer and difficulties of Perkins tonometer.

One such tonometer is the Non contact tonometer (NCT), which scores above all others, in that it does not touch the ocular surface and the problem of disinfection does not arise. This is definitely advantageous in developing countries like ours where the risk of transmission of infections is high.

Moreover, in measuring IOP by NCT there is no need of anesthesia, staining and no corneal factors affect its reading. It is not operator dependent, as it records automatically, so it can be done by non ophthalmologists (Para medical or Non medical personnel).

In view of this, this study is an effort to study reliability of the Non-Contact Tonometer as screening tool, considering its advantages over Perkins Applanation Tonometer (hand held version of gold standard Goldmann's tonometer) in Indian context where large numbers of patients have to be screened and risk of transmission of infection is high.

AIMS AND OBJECTIVES

- To correlate the intraocular pressure by the Non contact tonometer with the Perkins applanation tonometer.

REVIEW OF LITERATURE

Normal intra ocular pressure is important to maintain the shape of the eye and normal visual function. Long-term high intra ocular pressure can cause irreversible damage to the retinal ganglion cells and postganglionic nerve fibers.[6] Recent epidemiologic studies show that a difference of only 1 mm Hg in the mean intra ocular pressure may be critical enough to determine the visual field prognosis in patients with glaucoma,[7] and for every 1 mm Hg reduction in intra ocular pressure , visual field damage can be reduced by 10%.[6]

Precision in the measurement of Intra ocular pressure is a prerequisite for any glaucoma care pathway. The "landmark" glaucoma studies have emphasized the importance of Intra ocular pressure in clinical decision making and management.[5]

The term glaucoma, meaning "greenish" can be traced to Hippocratic times, when it was used to describe a greenish hue of the pupil noticed in cataractous eyes, and had little to do with glaucoma as we know it today.

The link between intra ocular pressure and what was later identified as glaucoma seems to have been recognized as far back as the 10th century AD by Al-Tabari an Arabian surgeon. By 1622 Richard Banister, an English oculist, was the first to described the condition as an increased hardness of the eye with the use of the fingers by the practitioner to feel for the pressure. This is called palpation or (confusingly, given the other modern meaning of the word) 'digital' tonometry.

His teaching failed to gain any popularity till about the early 19th century when ocular hypertension was recognized as a significant component of glaucoma by

Sir William Bowman. He described a simple method of palpating the eyes to determine the state of the intraocular tension, the routine use of which he frequently advocated in all eyes with diminished vision. This method of digital tonometry was the first used technique of tonometry in the practice of ophthalmology and soon became so widely accepted and mastered, that when the mechanical tonometers were introduced later on, there was reluctance to accept the newer technology.[8]

Von Graefe (Fig.1), in 1862, attempted to design a mechanical tonometer which was eventually not. It was Donders, who, a few years later built an indentation tonometer to measure intra ocular pressure (IOP). The major shortcoming of this tonometer was the displacement of a large volume of intraocular fluid resulting in variable and inaccurate readings.[8]

Adolf Weber's applanation tonometer in 1867, overcame this since it displaced a minimal quantity of intraocular fluid. The applanation tonometer was further popularized when Alexei Maklakoff introduced his model of the applanation tonometer in 1885 at the Moscow Eye Hospital.[9] His instrument comprised a metal cylinder of a known weight with a flat base. The cylinder was required to be placed on the dye smeared cornea of the patient. On contact, dye from the applanated area of the cornea got transferred on to the cylinder and the diameter of this stained area was measured.

The intraocular pressure was then derived from the Imbert-Fick formula since the weight of the applanating device was known. However, due to the heavy weight of the tonometer, it caused the IOP to rise during the procedure, giving falsely high values.

Also, any movement of the eye or the examiner during the procedure resulted in a larger smear of dye thus altering the IOP.

Professor Hjalmar Schiotz (Fig.2), introduced the first clinically useful mechanical tonometer in 1905, an indentation model, using different weights to indent the cornea, which was quickly accepted due to its simplicity and accuracy.[9]

With innovation in its calibration, it soon became the gold standard instrument till the introduction of the Goldmann applanation tonometer. Subsequently, Balliart (1923) developed an indentation tonometer with a spiral spring instead of weights and Maurice (1958) described an electrical indentation tonometer both of which failed to make an impact. Mueller in 1960 presented an electronic tonometer, which was basically a Schiotz model, but had an attached electronic amplifier and recorder. It excluded errors due to mechanical factors and aided in the development of tonography since it could record IOP continuously.[9]

The principal objection to indentation type of tonometers (Schiotz tonometer) is that, such tonometers do not offer a direct measure of Intra ocular pressure. Moreover, measurement of Intra ocular pressure by Schiotz tonometry is significantly affected by scleral rigidity. The importance of scleral rigidity must be kept in mind when Schiotz tonometer is being used.[10] Schiotz indentation tonometry also has limitations in terms of acquiring the exact pressures. So it is insufficient for diagnosis and essentially for follow up of glaucoma patients. Although being portable it has been shown to have limited value as a screening tool.[4] The indentation tonometers took a back seat with the invention of the applanation tonometer.

This novel invention caused simple flattening of the cornea instead of the truncated deformation produced by the indentation tonometers. Thus it did not displace a large amount of intraocular fluid and the measured intraocular pressure was almost equal to the actual pressure.

Almubrad TM, found that the Goldmann applanation tonometer estimates the pressure by measuring the force required to applanate a fixed area of the cornea based on the Imber-Fick Principle. However, it requires a slit lamp microscope and topical anesthetic agents, which have a slight decreasing effect on Intra ocular pressure and can record pressures only in sitting posture.[4]

Based on the principles of the applanation tonometer, a host of newer portable tonometers have been introduced into the arena of glaucoma practice. Prominent among these is Perkins applanation tonometer.

The Portable Perkins tonometer is also considered gold standard because it is based on the same principles as the Goldmann applanation tonometry.[4] The Perkins tonometer was devised as a portable handheld applanation tonometer, for use in children, patients unable to cooperate for slit lamp examination, anesthetized and bedridden patients.[5]

Arora R et al., (2014) reports that the Perkins applanation tonometer measures intra ocular pressure to a much closer level of comparability than other tonometer types and suggest that Perkins applanation tonometer may be permissible for Intra ocular pressure measurement, as part of care pathways for open angle glaucoma and ocular hypertension.[5]

Perkins tonometer is portable, simple and capable of measuring IOP in all positions. Its disadvantage is in the initial slow learning phase, or else it could be considered as a reliable alternative to Goldmann.[9] It needs topical anaesthesia and corneal factors, like astigmatism, corneal curvature, and central corneal thickness, affect its accuracy.[4]

Non contact tonometer (NCT) was introduced by Dr Grolman in 1971 at the Annual meeting of the American Academy of Optometry and as is suggested by its name, does not come into direct contact with the ocular surface like all other known tonometers. Its popularity in the recent years stems from the fact that it minimizes the limitations of the applanation tonometer to a large extent although the correlation observed between it and other conventional tonometers has been far from good.[7,11-13]

Back in 1980, it had been observed that the non contact tonometer poorly correlated with applanation pressures in higher pressure ranges. Moreover, it was found to be inaccurate in eyes with abnormal corneas or poor fixation. However its biggest advantage was that it could be used reliably by paramedical personnel and was therefore a valuable screening tool.[14,15] Moseley et al., adopted a screening criterion of greater than or equal to 21mm Hg and reported that the NCT had a sensitivity of 85% and a specificity of 95%. They concluded that NCT readings were useful clinically.

Ogbuehi and Almubrad conducted a masked prospective clinical study on 72 eyes, to evaluate the accuracy and reliability of the non contact tonometer in a normotensive population. The Goldman applanation tonometer was used as the standard. Two sets of IOP were recorded for each tonometer a week apart and within-session and

test-retest repeatability were assessed for both tonometers. The mean difference in average IOP between both methods was not statistically significant ($p>0.05$). So also the within – session differences in IOP were within ±2mm Hg in both sessions. The test – retest repeatability coefficients for both tonometers were comparable, with the test – retest difference being within ±3mm Hg.

Non contact tonometer was found to be accurate and reliable as inferred from the observations given above, and could therefore be useful in monitoring IOP in normotensive individuals. It was a suitable alternative to Goldmann tonometry although it could not be used interchangeably with the latter, which was found to be more reliable.[16,17]

They also noted that the non contact tonometer tended to give slightly higher readings than the applanation tonometer as had been previously noted by Parker et al.,and others, but like most conventional non contact tonometers, recorded IOP across the spectrum of measurable pressures fairly accurately.[16,18-22]

Hsu et al., in their study on 62 subjects found no significant differences between the non contact tonometer and the applanation tonometer as compared to the dynamic contour tonometer and the Tono-Pen, both of which showed significant differences with applanation pressures. They too found that the IOP readings with the non contact tonometer were higher than the applanation readings.[23]

Both, the applanation and non contact readings correlated positively with corneal thickness, in fact corneal thickness affected non contact tonometry more than it affected

applanation tonometry.[23,24] Some studies, in contrast to the above mentioned studies, detected the non contact tonometer to read lower than the applanation tonometer.[16,25-27]

One study on the non contact tonometer showed that this tonometer gave readings slightly higher than the applanation values for pressures less than 15 mm Hg and slightly lower than the applanation values for pressures greater than 15 mm Hg. Inspite of these variations, the readings corresponded well with applanation readings in the range of 10 to 24 mm Hg.

Extrapolating their data for a applanation IOP of 30 mm Hg, they inferred that the non contact tonometer would read about 6% (1.7 mm Hg) lower than this IOP. Similar findings have been reported by many others in their studies on various models of the non contact tonometer suggesting that the non contact tonometer read higher for pressures within the normal range and lower for pressures higher than normal.[12,15,16,27-29]

Contradictory to this, Jose M M et al., in their study found the non contact tonometer (Reichert AT550) to underestimate lower applanation pressures while overestimating higher applanation pressures.[7]

They attributed this to corneal thickness, with overestimation in eyes with thicker corneas and underestimation in eyes with thinner corneas,[19] thus making it unsuitable for eyes which have undergone corneal surgeries. Although the pressures correlated well with applanation readings, the IOP differences with the applanation readings exceeded the accepted levels set by the ISO 8612 norms.[7]

Two other studies on the Reichert AT550 non contact tonometer have shown excellent agreement between it and the Goldmann tonometer not only in normal eyes, but in glaucomatous eyes as well.[19,20]

Mackie et al., studied the non contact tonometer and the American Optical MkII tonometers and compared them to the Goldmann tonometer, but unlike others their study involved glaucomatous eyes. They observed that the non contact tonometer read slightly higher and the MkII read slightly lower than the Goldmann tonometer. They also tested both tonometers for repeatability and found the non contact tonometer to show significantly larger variations than the MkII. They thus inferred that at least four readings per eye must be recorded when the non contact tonometer is used.[21]

Another prospective study comparing the portable PT100 non contact tonometer with the Goldmann tonometer showed no significant differences between the two tonometers. 92.8% of the eyes were in agreement by ≤3mm Hg. Also the PT100 identified a majority of eyes with IOP >21mm Hg.[30]

One of the problems experienced with the applanation tonometry post keratoplasty is the irregularity of the corneal surface and hence pooling of fluorescein dye especially at the sutures. This makes approximation of the inner surfaces of the fluorescent semicircles difficult.

In the quest for an alternate solution to this problem, Lisle and Ehlers studied the non contact (Xpert) tonometer on post keratoplasty eyes. They studied 43 eyes that had undergone penetrating keratoplasty in the recent 13 months. The non contact tonometer was found to show considerable variation from the reference Goldmann values.

Moreover, one had to be careful while using this tonometer in post operative eyes due to the risk of introducing air bubbles in to the anterior chamber during the procedure.[31]

However the Xpert tonometer was found to have fairly good agreement with the Goldmann applanation tonometer in normal corneas,[23,26,28,32,33] Abbasoglu et al., however found the non contact tonometer to be comparable to the applanation tonometer in myopic eyes after photorefractive keratectomy.[34]

The non contact tonometer was also found to correlate well with the applanation tonometer in gas filled vitrectomized eyes as evidenced by Patikulsila et al., in a prospective trial they conducted on 38 eyes that had previously undergone pars plana vitrectomy. However there was a significant underestimation of pressures in eyes with elevated IOP.[35-37]

While the non contact tonometer proved its fair reliability, it remained to be seen if IOP readings showed variations on repeated testing. Stephen Vernon addressed this issue, when he studied three sets of IOP recordings in 100 individuals, recorded within a 15min time period using the non contact tonometer. He observed that the first reading tended to be significantly higher than the subsequent readings on the same patient with the same instrument. This tendency increased significantly as the pressures approached the upper limit of normal IOP.[13]

The readings stabilized from the second reading onwards and the second and third readings did not differ significantly. He attributed this variation to patient apprehension when first exposed to the device. He thereby concluded that once the initial readings had

stabilized, the Pulsair had acceptable reproducibility, passing the British standard for reproducibility of a standard test.[13]

Non Contact Tonometer is based on the principle that the IOP is determined from the time taken for the air jet/puff to applanate the cornea without actually touching the corneal surface, which in turn is proportional to the power of the air sprayed from the instrument, so does not require a topical anaesthetic.[4]

This unique advantage of the non contact tonometer over the other tonometers along with the ease of use has given it wide acceptance. But, as history teaches us, further advances in the field like the dynamic contour tonometer, a recent on the glaucoma scene are certain.

Different studies conducted by Derka et al., Yucel AA., Sturmer J., Glorr B., Lagerlof., Brencher., Kohl., Reinke proved that non contact tonometer read low readings across the entire range of IOP.[38] Studies by Draeger, Jessen and Haselmann and Buscemi, Capoferri, Garavagllia, Nassivera and Nucci have shown that the non contact tonometer is a valuable choice for screening purposes.[10]

INTRAOCULAR PRESSURE

IOP refers to the pressure exerted by intraocular fluids on the coats of the eye ball.[37] Normal IOP is essentially maintained by the dynamic equilibrium between the rate at which aqueous humor enters the eye (inflow) and the rate at which it leaves the eye (outflow). When inflow equals outflow, a steady state exists, and the pressure remains constant.

The control of IOP, therefore, depends on:

1. Production of aqueous humor.

2. Resistance to aqueous humor outflow.

3. Episcleral venous pressure.

WHAT IS NORMAL INTRAOCULAR PRESSURE? Leydhecker and co-workers, in 1958, measured the IOP in 10,000 individuals in an attempt to study the distribution of IOP in the general population. Their results showed Gaussian distribution of IOP, but with a skew to the right i.e. they found two subgroups, a larger one with "normal" pressures and a smaller group with pressures in the higher range. The mean IOP was found to be 15.5 ± 2.57 mm Hg. However due to the skew a fixed numerical upper limit could not be taken by adding two standard deviations to the mean. Thus a definite cut off value for abnormal IOP could not be fixed. Normal IOP is thus an ill defined entity which varies from person to person and depends on how a particular eye responds to a particular pressure. Given these limitations, normal IOP may be defined as that pressure at which glaucomatous damage of the optic nerve head does not occur.[37]

FACTORS INFLUENCING INTRAOCULAR PRESSURE

The following factors are believed to exert variable degrees of influence on IOP.

DEMOGRAPHIC FACTORS

1. Age - IOP tends to rise with age. Children usually have pressures in the lower ranges compared to the normal population. In adults however there are conflicting reports, with some studies suggesting that IOP increases with age, although this has been thought to be an apparent rise linked to increasing blood pressure, increasing pulse rate and obesity associated with increasing age. This phenomenon could also be due to skew in pressures towards the higher range with increasing age. Although aqueous production decreases with age, the cause for the age-related increase in IOP is probably due to the decrease in uveoscleral outflow and other outflow facilities. Some other studies especially in the Japanese population have shown a decrease in pressures with increasing age.[37,38]

2. Gender - While the IOP is almost equal in males and females up to the age of 40, women above the age of 40 have higher pressures coinciding with the onset of menopause. The Barbados Eye Study showed that women tended to have higher IOPs with no glaucomatous optic nerve damage and males had more risk of open angle glaucoma.[37,38,39]

3. Heredity - IOP is possibly inherited in a polygenic, multifactorial fashion. It has been seen to be higher in the first degree relatives of patients with primary open angle glaucoma.[37,40]

4. Race - People with African or Asian descent were found to have higher mean pressures than those of American or European origin.[40]

SYSTEMIC FACTORS

1. Diurnal variation - IOP is not constant throughout the day and fluctuates within a range of 3 to 6 mm Hg. While a fluctuation of more than 10 mm Hg is pathological, glaucomatous eyes can show variations ranging up to 30 mm Hg and even 50 mm Hg in some cases. Most people have the maximum pressure reading during the morning hours, but some do show afternoon peaks and a few show short - term fluctuations throughout the day. These swings are more pronounced in patients with open angle glaucoma and ocular hypertensives.[37,38] These fluctuations are caused by variations in the rate of aqueous formation and probably result in response to levels of circulating catecholamines. The diurnal variation of glucocorticoids has also been found to parallel the IOP variation with the peak IOP occurring around 3-4 hours after the plasma cortisol peak. Thus, a single reading of IOP will not give an accurate picture and in the clinical set up, an attempt must be made to record pressures at various times of the day. It would be ideal to obtain a 24 hour diurnal variation curve, but this is not always practical. A modified "office" diurnal curve has been suggested, wherein recordings are made approximately every two hours from the early morning hours up to the evening. Subsequent follow - ups should be timed to coincide with the time of the highest reading.

2. Postural variation - A change in posture from sitting to supine causes a rise in IOP by 0.3 to 6 mm Hg. This response is marked in glaucomatous eyes compared to normal eyes. When the supine posture is maintained, compensatory mechanisms come into play in

young, healthy individuals, something that is probably absent in ocular hypertensives. The Trendelenburg posture on lying supine further raises the IOP and this response is also greater in glaucomatous eyes.[38] The rise in IOP occurs rapidly and is thought to reflect changes in the arterial and venous pressures, particularly the episcleral venous pressure.

3. Exercise - Strenous exercise and prolonged physical activity cause a lowering of IOP, the postulated mechanisms being metabolic acidosis, hypocapnia, increased blood lactate levels and altered serum osmolality. Extremely heavy physical activity like weight lifting or straining associated with the Valsalva maneuver or while playing wind instruments raises the IOP and this is attributed to increased orbicularis tone, increased episcleral venous pressure and even increased intracranial tension which is transmitted to the periocular venous system. This is clinically significant with respect to obese patients who may strain to lean forward on the slit lamp and thus falsely high pressures may be recorded as a consequence.[37,38]

4. Blood Pressure - There is positive correlation between systemic hypertension, especially the systolic blood pressure level and IOP.[41,42]

5. Temperature - Systemic hyperthermia has been shown to cause an increased IOP. Exposure to cold air reduces IOP, apparently as a result of a decrease in episcleral venous pressure.[43]

6. Hormones - Apart from hormonal influence on diurnal variation of IOP, it may increase in response to Adrenocorticotrophic hormone (ACTH), glucocorticoids and growth hormone and may decrease in response to progesterone, estrogen, chorionic

gonadotropin and relaxin.[44] The IOP is also higher in patients with hypothyroidism and lower in those with hyperthyroidism.[37,38] Diabetes patients have higher pressures than the rest of the population, while fall in IOP is seen during acute hypoglycemia in patients with insulin - dependent diabetes.[4,45]

7. Ocular factors influencing IOP - Eyelid closure raises IOP even up to 90 mm Hg with hard lid squeezing. Voluntary widening of the lid fissure and up-gaze also tend to raise the IOP and this is particularly prominent in patients with Grave's ophthalmopathy. It is therefore necessary to make sure patients are relaxed and looking in primary gaze while performing tonometry. The pressure can also get elevated with movement of the eye against mechanical resistance as in restrictive strabismus.[37,38] Intraocular pathologies such as uveitis and rhegmatogenous retinal detachment are associated with a fall in IOP. IOP has also been observed to rise with increasing degrees of myopia as well as higher axial lengths.

8. Systemic factors influencing IOP - Systemic hypertension, especially systolic, shows a positive correlation with IOP. Elevations in episcleral venous pressure cause an equal amount of rise in IOP by causing the Schlemm's canal to collapse and increasing the outflow resistance.[46] Obesity, increased pulse rate and hemoglobin concentration are also thought to influence IOP.[37]

9. Lifestyle - Alcohol intake and fat free diets tend to lower pressures, whereas smoking and consumption of caffeine are associated with elevations in the IOP.

10.Drugs - A large number of drugs influence IOP and only a few are discussed here. General anesthetic agents with the exception of ketamine and trichloroethylene, lower the

IOP in proportion to the depth of anesthesia. Systemic anticholinergics have no influence on IOP, whereas topically instilled cyclopentolate has been seen to elevate pressures in some patients with open angle glaucoma. Steroids raise the IOP, the effect being more prominent in glaucomatous eyes.[37]

HISTORY OF TONOMETERS [47]

The importance of ocular tension measurements was emphasized way back in the 1826 by Sir William Bowman. According to him, medical men already possessed an educated sense of touch, hence very little practice would suffice to successfully apply it to the eye and estimate the tension in the eye.[8] Soon afterwards, digital tonometry became an essential clinical skill necessary to be mastered by all ophthalmologists.

Mechanical tonometry was first introduced in the late 1800s. Von Grafe made the first attempts to create instruments, that mechanically measured IOP in the early 1860s. But his proposed instruments were neither designed nor built. Donders, in the mid 1860s designed the first instrument capable of estimating IOP, albeit not accurately. The principle behind Donder's instrument was to displace intraocular fluid by contact with the sclera.

The ophthalmologist first measured the curvature of the sclera at the site of contact, and then used this measurement as a reference plane to measure the depth of indentation. Smith and Lazerat refined this technology in the 1880s. Carl Koller discovered the anaesthetic properties of cocaine in 1884.[48] The discovery of this powerful corneal anaesthetic paved the way for corneal impression tonometry soon thereafter.

Corneal tonometry became the definitive choice of IOP measurement, because it offered a well defined and uniform site of impression when compared with the sclera. But the impression tonometer displaced a lot of fluid upon contact with the eye, hence the measured readings were highly variable and mostly inaccurate. This was the major drawback of impression tonometers.

A major breakthrough was achieved when Adolf Weber designed the first applanation tonometer in 1867, which gave a highly defined applanation point without indentation. A lot of doubts were voiced about the value and accuracy of the applanation tonometers. Their value was rediscovered two decades later when Alexei Maklakoff and others introduced new versions of the applanation tonometers. Maklakoff's 1892 model is the basis of applanation tonometry today. However, digital tonometry still remained the gold standard among most ophthalmologists in the early 1900s.

The first clinically useful mechanical tonometer was designed and introduced by a4 Norwegian ophthalmologist Hjalmar Schiotz in the early 1900s. The instrument was simple, easy to use and highly precise. It was quickly accepted and became the new gold standard in the early 1910s, although the IOP recording using Schiotz tonometer is influenced by scleral rigidity.

An adjustment for ocular rigidity was introduced by Goldmann in the 1950s which led to the development of Goldmann applanation tonometers. The Goldmann tonometers displace very little fluid and hence variations in ocular rigidity are mostly negligible. The electronic and non contact tonometers used today rely heavily on the principles and instrumentation first introduced by Maklakoff, Schiotz and Goldmann.

Today, for most part, digital tonometry has been replaced by sophisticated technologies to estimate IOP. The newer instruments are incredibly accurate and easy to use.

TONOMETRY [37]

Tonometry refers to the indirect estimation of intraocular pressure by measuring resistance of the eye to indentation by an applied force. At the most crude level, palpation of the eyeball with the fingertips and estimating turgidity is a form of tonometry. More accurately, and more safely, intraocular pressure is estimated with a variety of instruments called "Tonometers", that mechanically deform the globe of the eye and measure the IOP by relating the deformation of the globe to the force responsible for this deformation or the area of eye deformed by the force.

All clinical tonometers measure the IOP by relating a deformation of the globe to the force responsible for the deformation. The two basic types of tonometers differ according to the shape of the deformation: Indentation and Applanation (flattening).

METHODS OF MEASURING IOP

I. Direct method (Invasive technique).

II. Indirect method (Non-invasive technique).

I. <u>Direct method (Invasive technique)</u>:

Manometry is an invasive technique but is the only available direct method of measuring IOP. The anterior chamber is cannulated through a selfsealed, corneal puncture. The needle is connected to a reservoir of fluid through tubing. The height of the column of fluid in the tubing reflects the IOP. Owing to its invasive nature, it is used only

for experimental purposes in cadaveric eyes. The ethical use of this procedure in the living eye is restricted to eyes undergoing enucleation or intraocular surgery.[38,39,49]

Disadvantages of direct method of tonometry (Manometry) are:

1. Unsuitable for clinical practice.
2. Not practical for use in human beings.
3. Cannulation causes breakdown of the blood - aqueous barrier and releases prostaglandins which alter the IOP.

II. Indirect method (Non-invasive technique):

i. Digital tonometry

ii. Instrumental tonometry

Digital tonometry: Tactile finger applanation over closed eyelid by a skilled eye doctor is an age old traditional method utilized by experienced practitioners. The impressibility of the ocular coats is estimated by the sense of fluctuation perceived by the palpation by the two index fingers. Hence it is not an accurate method. The primitive palpation of the eye ball through the lid gives only the subjective estimate of how firmly is the eye distended.

Instrumental Tonometry: An indirect method of measuring the IOP with the help of specially designed instruments, called "Tonometers".

Classification of Instrumental Tonometers:

There are two types of tonometers:

i) Contact tonometers

- ✓ Indentation tonometers
- ✓ Applanation tonometers

ii) Non - contact tonometers.

INDENTATION TONOMETERS

Indentation tonometers, as the name suggests, deform the cornea with a known force by indenting it to form a truncated cone. The degree of indentation depends on the intraocular pressure, eyes with higher pressures resisting indentation to a greater extent than eyes with lower pressures which will indent more easily. Since indentation results in displacement of a large volume of intraocular fluid, conversion tables are needed to derive the IOP.[9,37] Von Graefe's indentation tonometer, in 1862, was the first indentation tonometer invented. Monnik, Donders, Snellen, Schiotz and Dor attempted to improve upon it.

Hjalmar Schiotz's tonometer (Fig.3), developed in 1905, is the only one to have stood the test of time and is still one of the most widely used tonometers today.[50] When the tonometer indents the cornea it displaces a certain volume of intraocular fluid. There is a linear logarithmic relationship between the volume change in the eye and the pressure.

Friedenwald developed a formula for this, which has a numerical constant, coefficient of ocular rigidity (K), which is an expression of the distensibility of the eye. He estimated the K value to be 0.0245, based on which he developed a conversion table in 1948. He then revised the K value to 0.0215 in 1955 and produced a new conversion table.

Comparative studies with the Goldmann applanation tonometer have shown the 1948 tables to be more accurate.[50] The instrument consists of a metal plunger traversing a metal shaft which ends in the form of a concave footplate, curved to match the average corneal curvature. The needle riding on the top of the plunger moves along a scale to indicate the amount of indentation. For every 0.05mm movement of the plunger, the needle moves one scale unit. The plunger is permanently attached with a 5.5g weight. Loose weights are provided with the apparatus to increase the weight of indentation to 7.5g, 10g or 15g. [4,5]

Procedure: After the instillation of topical anaesthetic drops, the lids of the patient lying down supine are retracted gently with the examiner's hand such that no pressure is exerted on the globe. The patient is instructed to look in primary gaze and the footplate of the Schiotz tonometer is slowly lowered onto the centre of the cornea. The amount of deflection of the needle on the scale is noted and converted into IOP based on the weight used referring the conversion nomogram. Excursions of the needle maybe seen due to ocular pulsations, in which case the average reading between the excursions must be taken as the scale reading.

Higher IOP values are compressed toward the lower end of the scale and therefore any scale reading of less than 3 does not give an accurate idea of the IOP but is only an indicator that IOP is higher than the normal range. In such situations, the IOP should be recorded with the higher weights.[9]

Sources of error: When Schiotz introduced the tonometer, he assumed that all eyes had a similar ocular rigidity and based his nomograms on an average scleral rigidity value. This does not hold true always and myopic eyes with lower rigidity permit a higher degree of indentation and therefore a proportional underestimation of the IOP. Conversely, hyperopic eyes and eyes with corneal scars show an overestimated IOP.[51] Expulsion of intraocular blood during the procedure may also influence the IOP value.[52]

Disinfection: The tonometer must be disinfected with every use as per the recommendations of the American Academy of Ophthalmology by unscrewing the plunger from the shaft and cleaning each separately.[37]

APPLANATION TONOMETERS

These tonometers deform the eye by simple flattening. They measure the IOP by either measuring the force required to flatten a fixed area (the fixed area tonometers) or the area flatted by a fixed force (the fixed force tonometers). Both these however are based on a modification of the Imbert - Fick law which states that the external force against a sphere equals the pressure in the sphere times the area flattened by the external force. Since the law required the sphere to be perfectly spherical, dry, infinitely thin and perfectly flexible; modifications were made to accommodate for the lack of flexibility, asphericity and moisture of the cornea.[37]

MAKLAKOV APPLANATION TONOMETER (Fig.4)

Description of Tonometer: Maklakoff developed the first clinically and practically usable applanation tonometer, introduced in 1885 which worked by flattening the cornea. It is a fixed force tonometer, which records the IOP by determining the volume of fluid displaced by a constant force on the eye.

Basic Concept: Maklakov introduced the concept in which IOP is estimated by measuring the area of cornea that is flattened by a known weight. A dumb - bell shaped metal cylinder which has flat endplates of polished glass on either end with diameters of 10 mm. A set of four such instruments is available, weighing 5,7.5,10,15 grams and a cross action wire handle is supplied to support the instrument on the cornea. Posner designed a plastic disposable version of the Maklakov later in the 1960s. This later type, made in 1962, included an ink pad (in the metal case) for colouring the footplate. An imprint could then be obtained on paper after the applanation. This tonometer is no longer used in clinical practice.[9]

THE GOLDMANN APPLANATION TONOMETER (Fig.5)

Fick in 1888, developed the Goldmann Applanation tonometer.[53] It is a fixed area tonometer, which is the most reliable tonometer devised till date and is the standard by which other tonometers are judged.[9] The instrument comprises a slit lamp mounted housing with a plastic biprism as the applanation device. The biprism produces an applanation area of 7.35mm on the internal surface of the cornea when it applanates an area with a diameter of 3.06mm on the external surface of the cornea.[8] The beam splitting

biprism optically converts the area of applanation into two semicircles, the edges of which overlap when an 3.06mm of the cornea is flattened.[37]

Procedure: The patient is seated comfortably at a slit lamp, after the instillation of topical anesthetic and sodium fluorescein with both eyes in primary gaze. The plastic biprism under cobalt blue light is brought into gentle contact with the cornea and the fluorescein stained tear film meniscus is visualized through the prism as two semicircles. The force knob on the housing is adjusted till the inner edges of the semicircles just touch and the IOP read off the scale on the tonometer housing (Fig.6).[9,37] In some instances, the pulse pressure causes oscillation of the mires, in which case the excursions must be averaged to give the desired endpoint.

Sources of error: The tonometer was initially calibrated assuming the corneal thickness to be 0.5mm. Since studies have shown that corneal thickness influences the IOP reading with thicker corneas resulting in falsely higher readings of IOP, with IOP increasing by around 0.19 mm Hg per 10µm increase in central corneal thickness.[54] Corneas post refractive surgery undergo significant thinning and consequently result in underestimation of IOP.[37] The thickness of the menisci also alters the IOP reading with wider menisci causing the read IOP to be falsely higher.[37,55] Vertical mal alignment of the semicircles also causes false elevation of the IOP value.[37,56] High corneal astigmatism beyond 3 diopters also induces significant errors in IOP estimation. In these cases, the area of corneal contact is elliptical and the biprism in the usual orientation results in underestimation of IOP for with the rule astigmatism and overestimation of IOP for against-the-rule astigmatism.[57] Therefore in such cases the prism should be rotated to an angle of 45 degrees from the major axis of astigmatism measured in the minus cylinder,

to give a more accurate estimate of IOP. Alternately, the average of the readings taken with the prism horizontally and vertically can be used.[37,56,57]

Corneas with abnormal elasticity such as edematous and scarred corneas are associated with falsely low Goldmann IOP readings.[58,59] Inspite of its various shortcomings the Goldmann Applanation tonometer is considered the gold standard.

Handheld, portable models, the Perkins and Draeger tonometers are now commonly used with the advantage that they can be used both in sitting and supine positions and are therefore handy in the operating room as well as for bed ridden patients.[9,60,61]

Disinfection: Being a contact method of tonometry, there is always the risk of transmitting infectious agents from eye to eye. Disinfection therefore is a vital part of the clinical procedure, especially in view of the risk of transmission of the dreaded Human Immunodeficiency virus and the Hepatitis B virus. The American Academy of Ophthalmology has recommended soaking the tonometer head in 70% isopropyl alcohol or 0.5% sodium hypochlorite or 3% hydrogen peroxide for 5 minutes. Wiping the tip with 70% isopropyl alcohol is also equally efficacious. Care must be taken to remove the disinfecting agent completely from the contact surface before the next use to avoid corneal toxicity from the disinfectant.[9,37]

PERKINS APPLANATION TONOMETER(Fig.7)

The Perkins tonometer is a very popular handheld applanation tonometer used. This device uses a Goldmann prism (3 mm double prism) that is adjusted during

tonometry to form fluorescein semicircles from a small blue light source, powered by battery.[9,62]

Procedure: IOP was recorded by Perkins tonometer after instilling 0.5% Proparacaine (topical anesthetic) eye drops and staining the tear film with a fluorescein strip. The forehead rest was adjusted and the gearwheel slightly rotated so that the doubling prism could be released and centered on the corneal apex. The stained tear film was lit in a brilliant green by two cobalt blue bulbs incorporated below the prism, which appeared as mirror-imaged hemispherical mires. The pressures were directly measured by gently rotating the gearwheel further until the inner sides of the two hemispherical mires coincided. This was taken as the endpoint of the IOP measurement. Each small graduation on the rotating wheel equaled 0.2 multiplied by Ten would give the correct pressure levels.[4] The readings are consistent.

Correct position of Perkins applanation tonometer (Fig.8 A): The edges of both semi circular rings meet exactly in the centre. The inner edges of the fluorescein rings touch each other. Gives accurate pressure and precise focusing of the measuring prism.[60]

Advantages of Perkins applanation tonometer over Goldmann applanation tonometer:

1. Perkins applanation tonometer is Handheld.
2. With Perkins applanation tonometer IOP can be measured in Horizontal as well as vertical.
3. Perkins applanation tonometer can measure IOP in Infants, children, patients in operation theatre and recumbent patients also.

Sources of error: [60]

1. The fluorescein ring is too wide in case the measuring prism was not dried after cleaning, or the eyelids came into contact with the measuring prism whilst measuring, and is corrected by withdrawing tonometer; the measuring prism dried with a cotton wool swab and repeat the measuring procedure (Fig.8 B).

2. The fluorescein ring is too narrow in case of lacrimal fluid has dried, corrected by asking the patient close the eyes once or twice. Then repeat the measuring procedure (Fig.8 C).

3. No semi circular rings appear, only the centre line, in case the measuring prism is not touching the cornea, occurs when the patient withdraw their head slightly, the irregular pulsations will occur and the prism will only contact the eye intermittently, when patient withdraw the head further, then the fluorescein rings will disappear altogether, corrected by making patient's head steady(Fig.8 D).

4. Both of the too large semi circular rings appear partly in case the tonometer being moved forward towards the patient, or the patient move towards the tonometer whilst the measurement is being taken, then the feeler arm will come into contact with a sprung stop piece. The applanation surface is then too large. The image will not change when turning the milled thumb wheel. Corrected by withdrawing the tonometer until the regular pulsations of a corresponding smaller applanation surface indicate the correct measuring position and pressure changes lead to immediate applanation surface changes(Fig.8 E).

5. The upper semi circular ring appears partly in case of the measuring prism is not focused on the eye. The eye is too far on the right. Corrected by moving the tonometer to the right (Fig.8 F).

6. The upper semi circular ring appears completely – the lower ring partly in case of the measuring prism is not focused on the eye. The eye is still too far on the right. Corrected by moving the tonometer to the right (Fig.8 G).

7. The lower semi circular ring appears completely – the upper ring partly in case of the measuring prism is not focused on the eye. The eye is still too far on the left. Corrected by moving the tonometer to the left (Fig.8 H).

8. The lower semi circular ring appears partly in case when measuring prism is not focused on the eye. The eye is too far on the left. Corrected by moving the tonometer to the left(Fig.8 I).

9. A semi circular ring appears partly in the upper half, in case when the measuring prism is not focused on the eye. The eye is too far up. Corrected by moving the tonometer upwards (Fig.8 J).

10. The ring appears completely in the upper half in case when the measuring prism is not focused on the eye. The eye is still too far up. Corrected by moving the tonometer upwards. Corrected by moving the tonometer upwards (Fig.8 K).

11. The ring appears almost completely in the upper half, and partly cut in the lower half in case when the measuring prism is not focused on the eye. The eye is still too far up. Corrected by moving the tonometer upwards (Fig.8 L).

12. Two partly cut rings appear, the large one in the upper half in case when the measuring prism is not focused on the eye. The eye is still too far up. Corrected by moving the tonometer upwards (Fig.8 M).

13. The outer edges of the fluorescein rings touch each other when Pressure is too strongly reduced. Corrected by increasing the pressure by turning the milled thumb wheel (Fig.8 N).

14. The fluorescein rings coincide and form a line when the pressure is reduced corrected by increasing the pressure by turning the milled thumb wheel (Fig.8 O).

15. The fluorescein rings do not touch each other when the pressure is too strongly increased. Corrected by reducing the pressure by turning the milled thumb wheel (Fig.8 P).

Disinfection: Being a contact method of tonometry, there is always the risk of transmitting infectious agents from eye to eye. Disinfection therefore is a vital part of the clinical procedure, especially in view of the risk of transmission of the dreaded Human Immunodeficiency virus and the Hepatitis B virus. The American Academy of Ophthalmology has recommended soaking the tonometer head in 70% isopropyl alcohol or 0.5% sodium hypochlorite or 3% hydrogen peroxide for 5 minutes. Wiping the tip with 70% isopropyl alcohol is also equally efficacious. Care must be taken to remove the disinfecting agent completely from the contact surface before the next use to avoid corneal toxicity from the disinfectant.[9,37]

THE NON CONTACT TONOMETER

This tonometer works on the same principle as the Goldmann tonometer and uses a puff of air to applanate a known and reproducible area of the cornea. At the point of flattening, the cornea acts as a plane mirror and reflects light which is recorded by a receiver. A microcomputer then calculates the IOP from the force required to applanate the cornea and the area applanated and gives a digital display of the IOP.

The instrument comprises an alignment system, which optically aligns the cornea vertically, horizontally and axially; a pneumatic system which generates a puff of room air and a monitoring system which transmits light onto the cornea and receives parallel light rays reflected from the cornea. [9,37] Non contact tonometers are available in a table mounted form as in the SHIN NIPPON NCT 200 (Fig.9) and Nidek & Reichert AT tonometers and a portable form as in the Pulsair EasyEye tonometers (Fig.10 Keeler Pulsair Easy Eye NCT)

Procedure: The procedure is performed with the patient seated and observing an internal target. The operator aligns the cornea by superimposing a reflection of the target on the patient's cornea. When the cornea is accurately aligned, the operator presses a button which triggers a puff of air onto the cornea. In the SHIN NIPPON NCT 200, X-pert NCT and the Keeler Pulsair EasyEye Tonometer, the air puff is automatically triggered once the alignment is centered.

Sources of error: Like with the Goldmann applanation tonometer, non contact tonometry is also affected by corneal thickness and corneal surface irregularities. It becomes inaccurate as the level of intraocular pressure increases. Error is also caused by abnormal

corneas or the inability of the patient to fix the eye. The air puff is random with respect to the phases of the cardiac cycle and thus the ocular pulse becomes a significant variable resulting in poor reliability if few readings are taken. It is therefore recommended that a minimum of three readings within 3mm Hg be taken and averaged.

Disinfection: The non contact tonometer is the only tonometer that does not come into contact with the ocular surface, thus disinfection is not a consideration for this tonometer. Nevertheless it has been feared that the part of the instrument facing the patient may get contaminated with tear film dispersed at the time of air impact.

OCULAR RESPONSE ANALYZER (Fig.11)

The biomechanical properties of the cornea influence the recording of IOP. While the effect of corneal thickness has been evaluated in depth, the other properties of the cornea, especially corneal viscosity and elasticity were not considered until the Reichert Ocular Response Analyzer (ORA) was introduced. It measures the physical properties of the cornea by deforming the cornea with an air puff and monitoring the deformation caused.[63] Due to its viscoelastic properties, the cornea absorbs energy from the air impulse and causes a time delay in the inward and outward applanation events, termed as corneal hysteresis. A precisely metered collimated air pulse is used to applanate the cornea and further depress it to a slight concavity. On applanation the air pump shuts off causing the cornea to return to its original contour during which it passes through a second outward applanation. Due to the dynamic nature of the air pulse and the viscoelastic properties of the cornea, the viscous corneal damping leads to a delay between the inward and outward applanation, giving two applanation values. The average

of these values forms the Goldmann-correlated IOP value (IOPG), the difference between the two denotes the corneal hysteresis. Cornea compensated IOP (IOPCC) utilizes information on the corneal viscosity and elasticity and also gives an estimate of the deformability of the cornea.

Measurements of IOP with the ORA are like with other tonometers affected by corneal thickness. The tonometer has not yet been compared to intraocular manometry and its absolute accuracy is still in question.[9,64,65] However the ORA scores over the other tonometers in one particular aspect – it measures corneal deformability, which could possibly be used for the identification of corneal diseases, especially Keratoconus, Fuch's endothelial dystrophy and in the detection of refractive surgery candidates who could be at a higher risk of developing post-LASIK ectasia.[66]

DYNAMIC OBSERVING TONOMETRY

The dynamic observing tonometer, also known as the SmartLens, is a diagnostic lens with a trifold function – it can be used for recording the IOP, viewing the posterior pole of the fundus and the anterior chamber angle at the same time. The contact surface of the lens has a central applanation zone of 2.5mm diameter and the body of the lens contains a piezo-electric pressure sensor which records IOP over a period of time. The instrument is fairly reliable but the technique is difficult to master and the inter-observer reliability is low.[64,66]

COMBINED INDENTATION APPLANATION TONOMETERS

THE MACKAY-MARG TONOMETER (Fig.12)

The unit comprises a micro plunger 1.5 mm in diameter protruding from a sleeve, 3mm in diameter, connected to a sensitive transducer which converts the plunger displacement into an electric signal which is recorded on a paper. As the plunger touches the cornea, the tracing begins to rise and reaches a crest when the full diameter of the plunger, i.e. 1.5 mm comes into contact with the cornea. When the plunger becomes flush with the sleeve, the force bending the cornea is transferred to the sleeve and the tracing dips to a trough. Further flattening induces a rise in the IOP which is recorded as a second rise in the tracing. The IOP is read as the distance from baseline to the trough.[9,37]

TONOPEN (Fig.13)

This hand held, portable tonometer is based on the Mackay-Marg tonometer model. It has a built-in microprocessor which detects several acceptable waveforms and averages them to give a digital readout. In addition, it also displays the percentage of variability between the lowest and highest readings.[9,37] The TonoPen can be reliably used in scarred, irregular or oedematous corneas, especially those of post keratoplasty eyes. It is also one of the few tonometers which can be used over a contact lens.[67] Disinfection is not bothersome as the tip is to be covered with a disposable latex cover which must be changed with every use.

THE PNEUMATIC TONOMETER (Fig.14)

This tonometer is similar to the Mackay-Marg tonometer in principle and uses air pressure as a sensor to measure IOP. It is a hand held, pen like device which has a central air chamber within a membrane covered nozzle through which pressurised air exhausts. The pressure of the air depends on the resistance to its exhaust and an electronic transducer converts the air pressure to a tracing on a paper strip. When the nozzle touches the cornea, the tracing begins to rise as the area of corneal contact increases till the area of flattened cornea equals that of the central chamber. This height of the tracing represents the IOP and the force required to bend the cornea. With further corneal contact, the bending force is transmitted to the nozzle and the tracing begins to fall to a trough which represents the IOP.[37]

Although designed as an applanation tonometer, the pneumatic tonometer acts in part as an indentation tonometer by deforming the cornea and displacing a large amount of intraocular fluid. It tends to overestimate Goldmann IOP values by around 2-4 mm Hg.[9]

DYNAMIC CONTOUR TONOMETRY (Fig.15)

This novel tonometer works on a principle entirely different from those of the applanation and indentation tonometers dealt with so far. It finds its basis in the fact that if a sphere or a part of it is surrounded by object which matches its contour, the pressure on the outside matches the pressure on the inside.[38]

The dynamic contour tonometer head consists of cylindrical tip, the contour of which is nearly similar to the corneal contour. It has a radius of curvature of 10.5mm, a

contact surface of 7 mm diameter and rests on the cornea with a constant force of 1g. The tip contains a piezoelectric sensor with a diameter of 1.2mm which measures the IOP about one hundred times per minute. The IOP is recorded during both the systolic and diastolic phases of the cardiac cycle. The difference between the systolic and diastolic IOPs is the Ocular Pulse Amplitude (OPA), which is an indicator of the choroidal perfusion.

A liquid crystal display gives a digital readout of the diastolic IOP in mm Hg, the OPA in mm Hg and a quality score Q. The Q score is graded from Q1 to Q5, with Q1 representing a good measurement and Q5 a poor measurement. It provides an indicator of the reliability of the readings.[38,64] The dynamic contour tonometer is less affected by corneal variants such as thickness [68-74] or post refractive surgery status.[75,76]

Its reliability in scarred corneas, oedematous corneas and irregular surfaced corneas is yet to be studied. While studies are still going on regarding its usefulness in clinical situations, the dynamic contour tonometer holds a lot of promise in the management of ocular hypertension and glaucoma.

REBOUND TONOMETER (Fig.16)

The rebound tonometer is a handheld device that detects the bounce motion of an object on its rebound after hitting the cornea. This principle was first talked about in 1931 by Obbink, but did not arouse much interest back then. The currently used rebound tonometer, marketed as the iCARE tonometer was introduced in 1997. It utilizes a magnetized stainless steel wire probe with a radius of 0.9mm, covered with a plastic cap. When a button on the instrument is pressed, the probe hits the central cornea and a

microprocessor analyses the deceleration of the probe as it touches the cornea. Higher the IOP, shorter is the duration of impact.[9,77] The tonometer has been shown to slightly overestimate the Goldmann IOP by about 1.34 mm Hg.

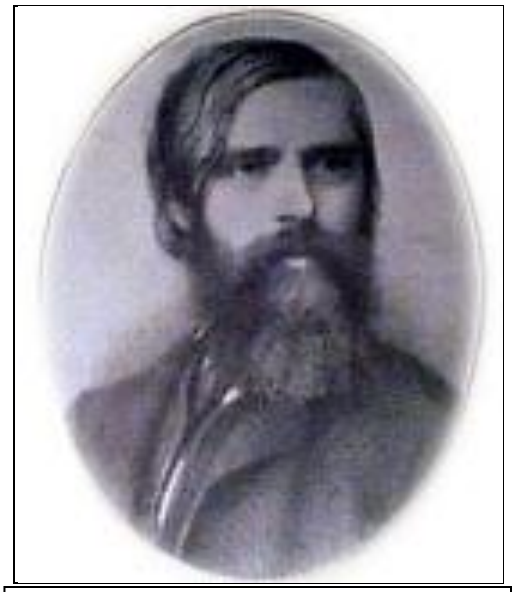


Fig No. 1: Von Graefe 1828-1870

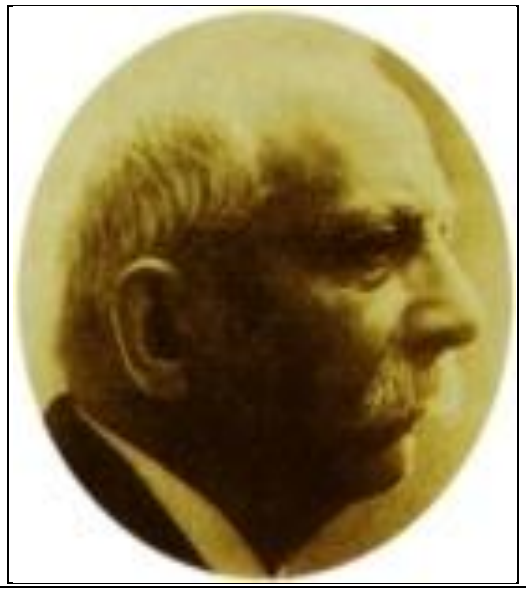


Fig No. 2: Professor Hjalmar Schiotz

Fig No. 3: The Schiotz indentation tonometer

Fig No. 4: Maklakov Applanation Tonometer

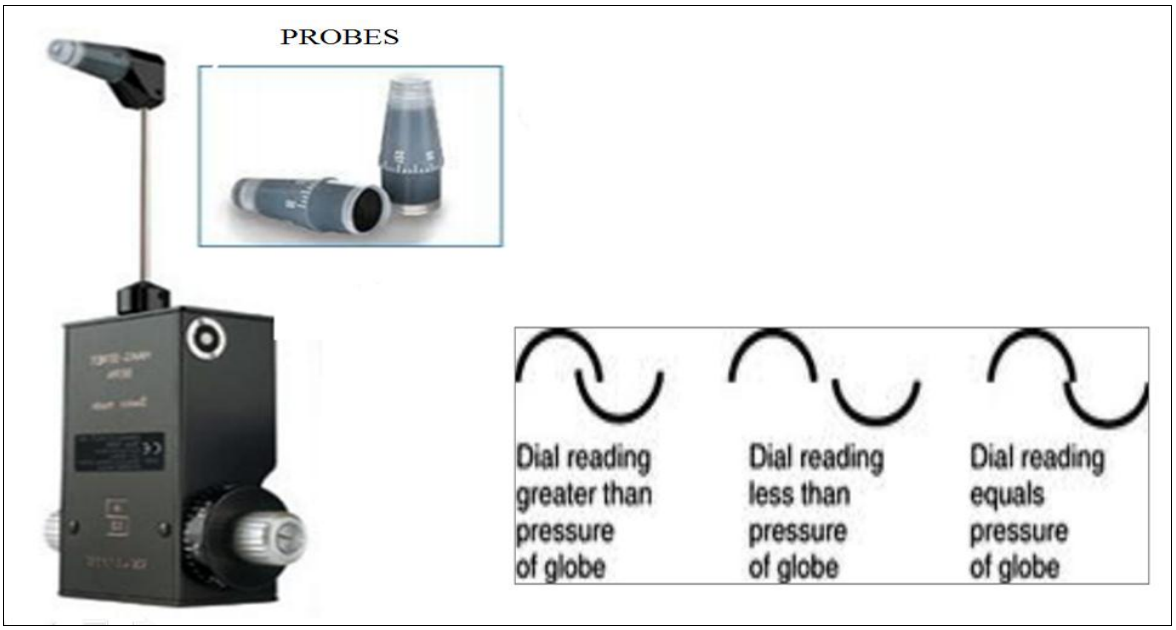


Fig No. 5: Goldmann Applanation Tonometer with Probes

Fig No. 6: Various appearances of the menisci and their relationship to the IOP in GAT

Fig No. 7: Perkins Applanation Tonometer

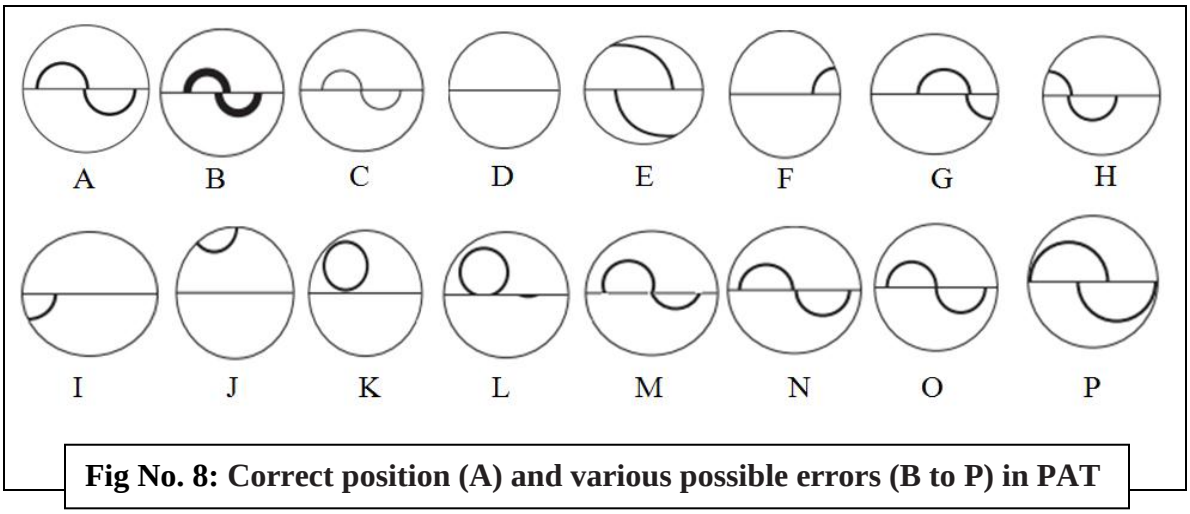


Fig No. 8: Correct position (A) and various possible errors (B to P) in PAT

Fig No. 9: SHIN NIPPON Non Contact Tonometer

Fig No. 10: Easy Eye NCT

Fig No. 11: Ocular Response Analyzer

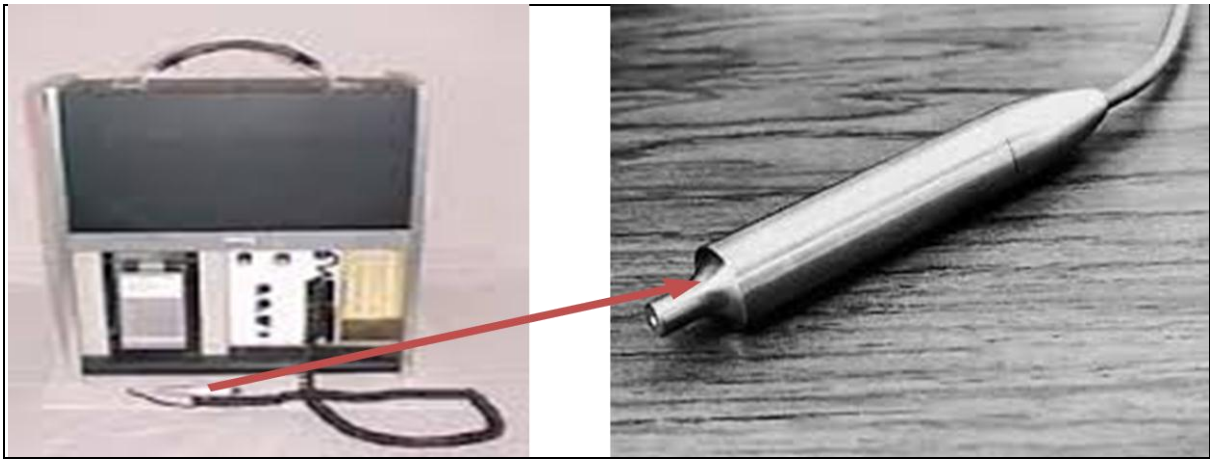


Fig No. 12: The Mackay-Marg Tonometer and its Probe in magnified view

Fig No. 13: Tonopen

Fig No. 14: The Pneumatic Tonometer, The Tonometer Pencil is resting on the table and is connected to the Base unit by a Hallow tubing that carries air to the tip of Pencil.

Fig No. 15: Dynamic Contour Tonometer

Fig No. 16: Rebound Tonometer

MATERIALS AND METHODS

SOURCE OF DATA

This was a prospective, comparative study on Patients attending outpatient Department of Ophthalmology BLDEU's Shri B M Patil Medical College, Hospital and Research Centre, Bijapur, Karnataka from December 1st 2014 to 31st March 2016.

METHOD OF COLLECTION OF DATA

Data was collected using a proforma, with the informed consent of the patient. A detailed history was obtained from each patient followed by routine ophthalmological examination including visual acuity testing, anterior segment and fundus examination. Patients were subjected to two methods of tonometry – Non Contact Tonometry and Perkins Applanation Tonometry (Perkins under topical anaesthesia with 0.5% Proparacaine eye drops). Non Contact Tonometer readings were recorded first, then Perkins tonometer. Three readings were taken for each method and mean calculated.

SAMPLE SIZE:

According to a study [4], the Mean and SD of intraocular pressure measured by non contact tonometer are 14.53 +/- 3.36 and of perkins tonometer are 13.06+/-2.69 with average standard deviation of 3.025 and difference between two mean is 1.47 and considering 99% confidence level and with the power 90% the minimum calculated sample size was 128 using the following statistical formula.

$$n = \frac{(Z\alpha + Z\beta)^2 \times SD^2}{d^2}$$

n = Sample size

$Z\alpha$ = 99% Confidence level.

$Z\beta$ = Power 90%.

SD = Common Standard Deviation.

d = difference between two means.

With a minimum sample size of 128, we had included 260 participants in our study.

STATISTICAL ANALYSIS:

Data was analyzed using following statistical method

- Diagrammatic presentation.
- Mean ± SD
- Sensitivity and Specificity
- Paired T test
- Correlation coefficient.

RESEARCH HYPOTHESIS:

It was a comparative study to know the correlation of Non Contact Tonometer with the Perkins Applanation Tonometer.

SELECTION CRITERIA

INCLUSION CRITERIA :

- Both males and females
- Age >40 years

EXCLUSION CRITERIA:

- Age < 40 years.
- A diagnosed case of glaucoma.
- Scarred or hazy corneas.
- History of previous corneal surgery including refractive surgery.
- Microphthalmos.
- Blepharospasm.
- Manifest nystagmus.
- Keratoconus.
- Any current conjunctival or corneal infections.

In this study following Investigations / Interventions were done on the participants :

- Slit Lamp Examination.
- Visual Acuity test and Fundus Examination.
- IOP measurement by Non contact tonometer and Perkins applanation tonometer.

(PHOTOGRAPHS OF EXAMINATION→ ANNEXURE IV)

This study was done after obtaining Ethical clearance from our Institution.

OBSERVATIONS AND RESULTS

This comparative study was conducted on a total 260 consecutive participants attending our institute. All participants were subjected to the two methods of tonometry – Non contact tonometry and Perkins applanation tonometry.

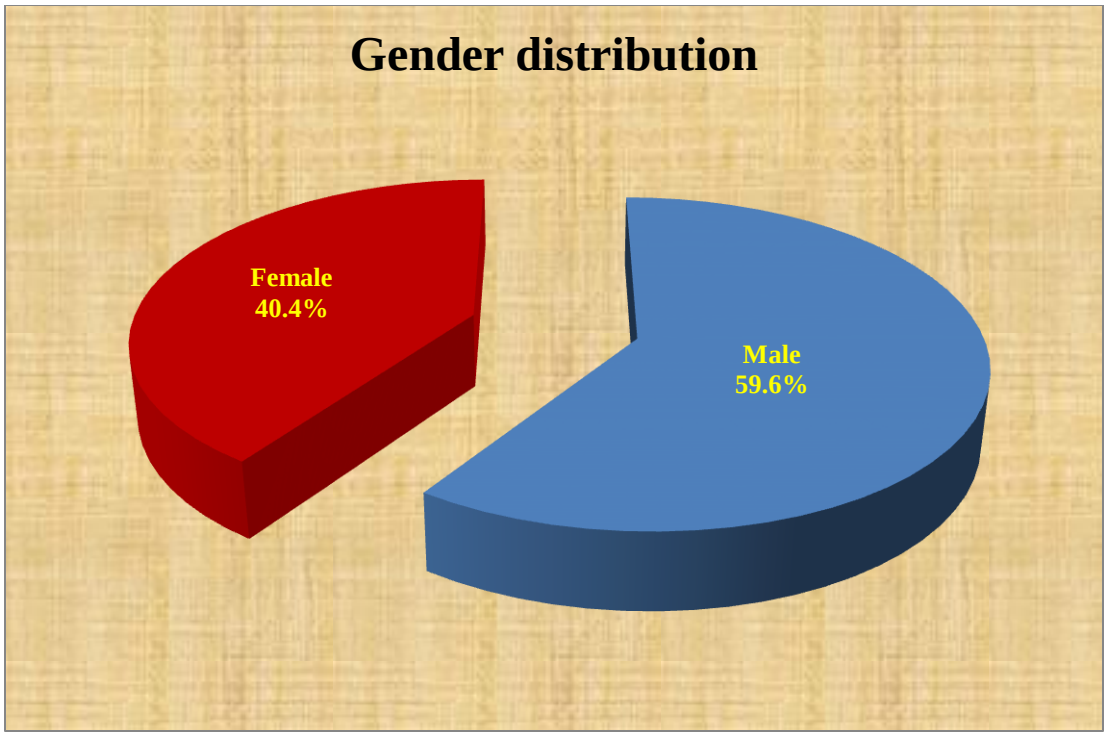
The analysis of the data obtained showed the following results:

GENDER DISTRIBUTION

From a total of 260 participants, 155 (59.6%) were males, while 105 (40.4%) constituted females. [Table No. 1 and Graph No. 1]

Table No. 1: Distribution of participants according to Gender

Gender	Number of Participants	Percent
Male	155	59.6
Female	105	40.4
Total	260	100



Graph No. 1: Distribution of participants according to Gender

AGE DISTRIBUTION

Table No. 2: Mean Distribution of participants according to age

Number of Participants	Minimum	Maximum	Mean
260	41	85	55.3

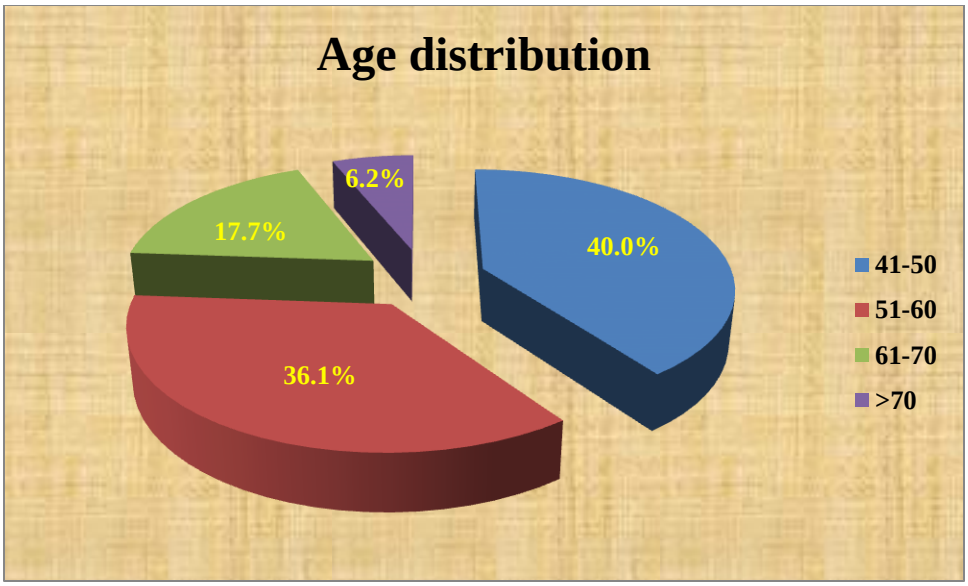
Table No. 2 shows that the mean age of the participants was 55.3 years, the youngest participant being 41 years of age and the oldest was 85 years old.

Table No. 3: Distribution of participants according to Age

Age (Yrs)	Number of Participants	Percent
41-50	104	40.0
51-60	94	36.1
61-70	46	17.7
>70	16	6.2
Total	260	100.0

In this study the total participants were divided into 4 groups based on age for analysis purpose, as participants aged 41-50 years, 51-60 years, 61-70 years, more than 70 years.

Table No. 3 and Graph No. 2 shows that, of the 260 participants maximum number of participants i.e. 104 (40.0%) were in 41-50 years age group. 94 (36.1%) participants were in 51-60 years group, 46 (17.7%) participants were in 61-70 years age group and remaining 16 (6.2%) participants were in the more than 70 years age group.

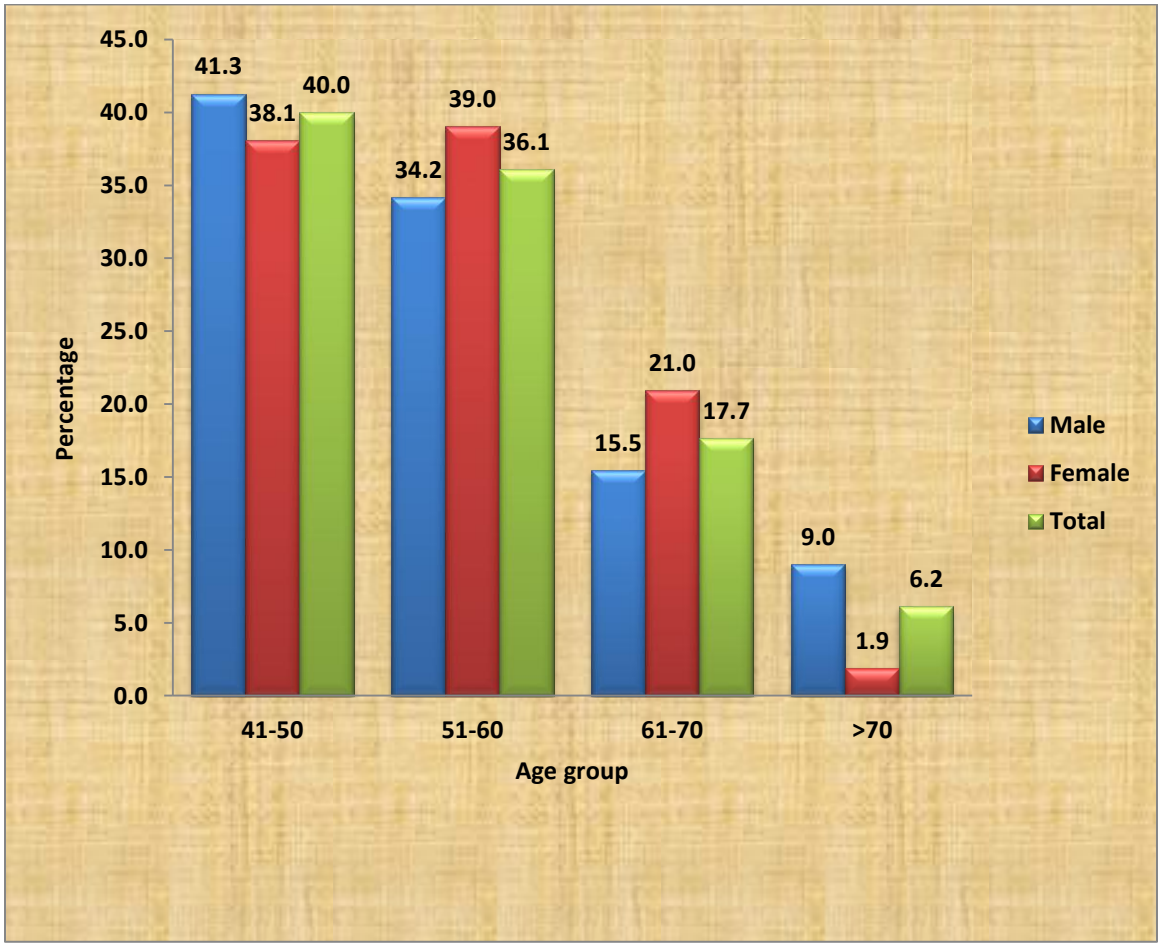


Graph No. 2: Distribution of participants according to Age

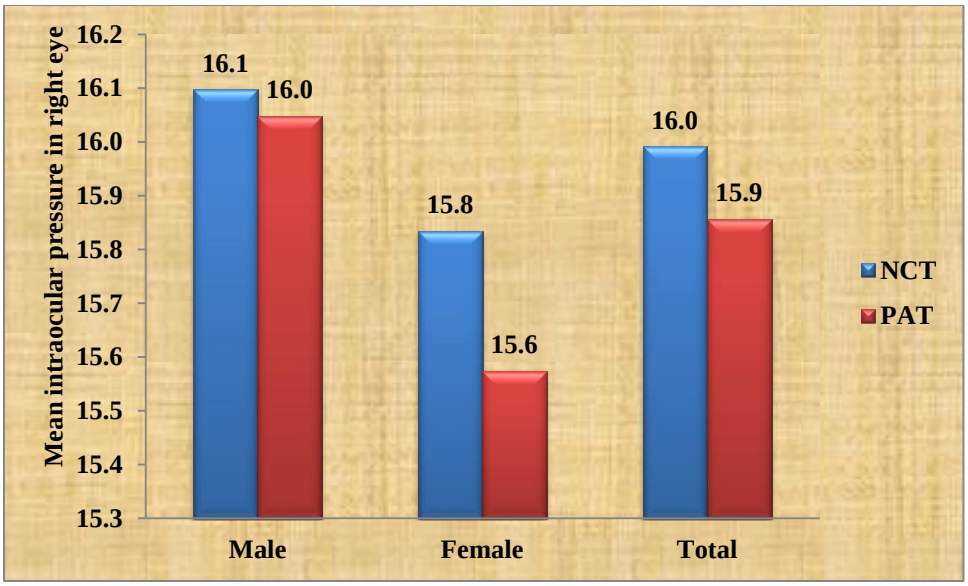
Table No. 4: Mean Distribution of participants according to gender and age

Age (In Years)	Male		Female		Total	
	Number of participants	Percent	Number of participants	Percent	Number of participants	Percent
41-50	64	41.3	40	38.1	104	40
51-60	53	34.2	41	39.0	94	36.1
61-70	24	15.5	22	21.0	46	17.7
>70	14	9.0	2	1.9	16	6.2
Total	155	100.0	105	100.0	260	100

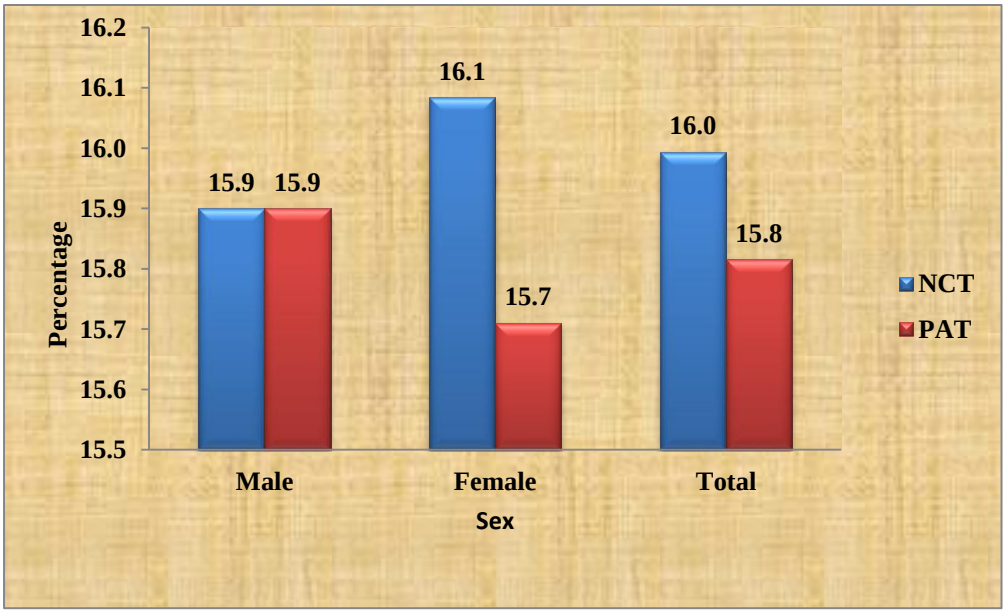
Table No. 4 and Graph No. 3 shows the gender wise and age wise distribution of all participants. Maximum number of participants were males and maximum participants were in the age group of 41-50 years.



Graph No. 3: Mean Distribution of participants according to gender and age



Graph No. 4: Mean Intraocular Pressure between NCT and PAT (in mm Hg) in right eye by gender



Graph No. 5: Mean Intraocular Pressure between NCT and PAT (in mm Hg) in left eye by gender

Table No. 5: Mean Intraocular Pressure between NCT and PAT (in mm Hg) among males

Intraocular Pressure	Method	Mean	SD	p value
Right eye	**NCT**	16.1	3.7	0.671
	PAT	16.0	3.2	
Left eye	**NCT**	15.9	3.7	0.68
	PAT	15.9	3.4	

Table No. 5 and Graph No. 4,5 shows that the mean IOP for right eye with NCT and PAT were 16.1 mm Hg and 16.0 mm Hg respectively with p value of 0.671, for left eye with NCT and PAT were 15.9 mm Hg and 15.9 mm Hg respectively with p value of 0.68, showed that there was no significant difference between the intraocular pressure measured by the both instruments and suggest fair agreement between NCT and PAT among males.

Table No. 6: Mean Intraocular Pressure between NCT and PAT (in mm Hg) among females

Intraocular Pressure	Method	Mean	SD	p value
Right eye	**NCT**	15.8	4.1	0.249
	PAT	15.6	3.4	
Left eye	**NCT**	16.1	4.6	0.104
	PAT	15.7	3.9	

Table No. 6 and Graph No. 4,5 shows that the mean IOP for right eye with NCT and PAT were 15.8 mm Hg and 15.6 mm Hg respectively with p value of 0.249, for left eye with NCT and PAT were 16.1 mm Hg and 15.7 mm Hg respectively with p value of 0.104, showed that there was no significant difference between the intraocular pressure measured by the both instruments and suggest fair agreement between NCT and PAT among females.

Table No. 7: Mean Intraocular Pressure between NCT and PAT (in mm Hg) among total (both male and female) participants

Intraocular Pressure	Method	Mean	SD	p value
Right eye	**NCT**	16.0	3.8	0.239
	PAT	15.9	3.3	
Left eye	**NCT**	16.0	4.1	0.118
	PAT	15.8	3.6	

Table No. 7 and Graph No. 4,5 shows that the mean IOP for right eye with NCT and PAT were 16.0 mm Hg and 15.9 mm Hg respectively with p value of 0.239, for left eye with NCT and PAT were 16.0 mm Hg and 15.8 mm Hg respectively with p value of 0.118, showed that there was no significant difference between the intraocular pressure measured by the both instruments and suggest fair agreement between NCT and PAT.

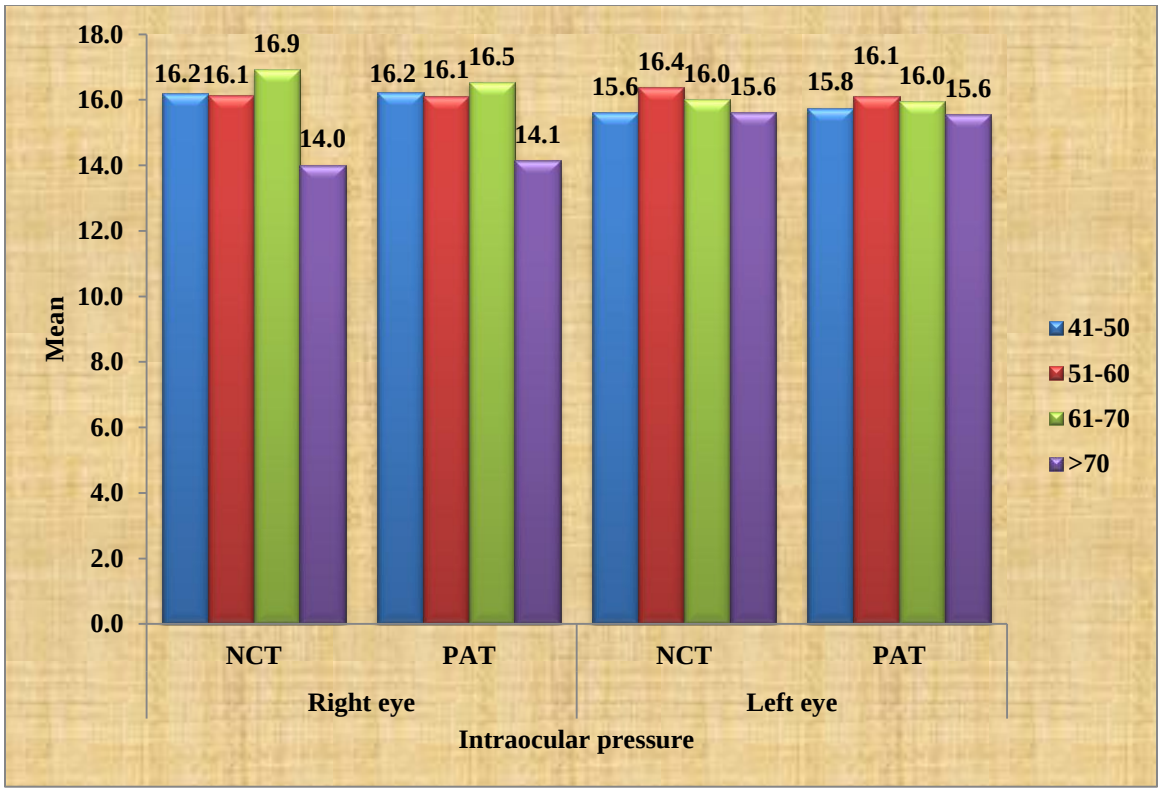
Table No. 8: Mean Intraocular Pressure between NCT and PAT (in mm Hg) among males by age

Age(Yrs)	Right eye					Left eye				
	NCT		PAT		p value	NCT		PAT		p value
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
41-50	16.2	3.7	16.2	3.1	0.969	15.6	3.3	15.8	2.9	0.272
51-60	16.1	3.5	16.1	3.3	0.947	16.4	3.9	16.1	3.6	0.234
61-70	16.9	3.9	16.5	3.6	0.294	16.0	4.1	16.0	4.1	0.844
>70	14.0	2.9	14.1	2.1	0.837	15.6	4.5	15.6	4.3	0.921

Table No. 8 and Graph No. 6 shows that the mean intraocular pressure in right eye for males in age groups of 41-50 years, 51-60 years, 61-70 years, more than 70 years with non contact tonometer and perkins applanation tonometer were 16.2 mm Hg, 16.1mm Hg, 16.9 mm Hg, 14.0 mm Hg and 16.2 mm Hg,16.1 mm Hg,16.5 mm Hg,14.1 mm Hg respectively for both tonometers with standard deviation of 3.7,3.5,3.9,2.9 and 3.1,3.3,3.6,2.1 with p values of 0.969,0.947,0.294 ,0.837 respectively, showed there was no significant difference between two tonometers and also a good agreement between two tonometers.

Table No. 8 and Graph No. 6 shows that the mean intraocular pressure in left eye for males in age groups of 41-50 years, 51-60 years, 61-70 years, more than 70 years with non contact tonometer and perkins applanation tonometer were 15.6 mm Hg, 16.4mm

Hg, 16.0 mm Hg,15.6 mm Hg and 15.8 mm Hg,16.1 mm Hg,16.0 mm Hg,15.6 mm Hg respectively for both tonometers with standard deviation of 3.3,3.9,4.1,4.5 and 2.9,3.6,4.1,4.3 with p values of 0.272,0.234,0.844,0.921 respectively, showed there was no significant difference between two tonometers and also a good agreement between two tonometers.



Graph No. 6: Mean Intraocular Pressure between NCT and PAT (in mm Hg) among males by age

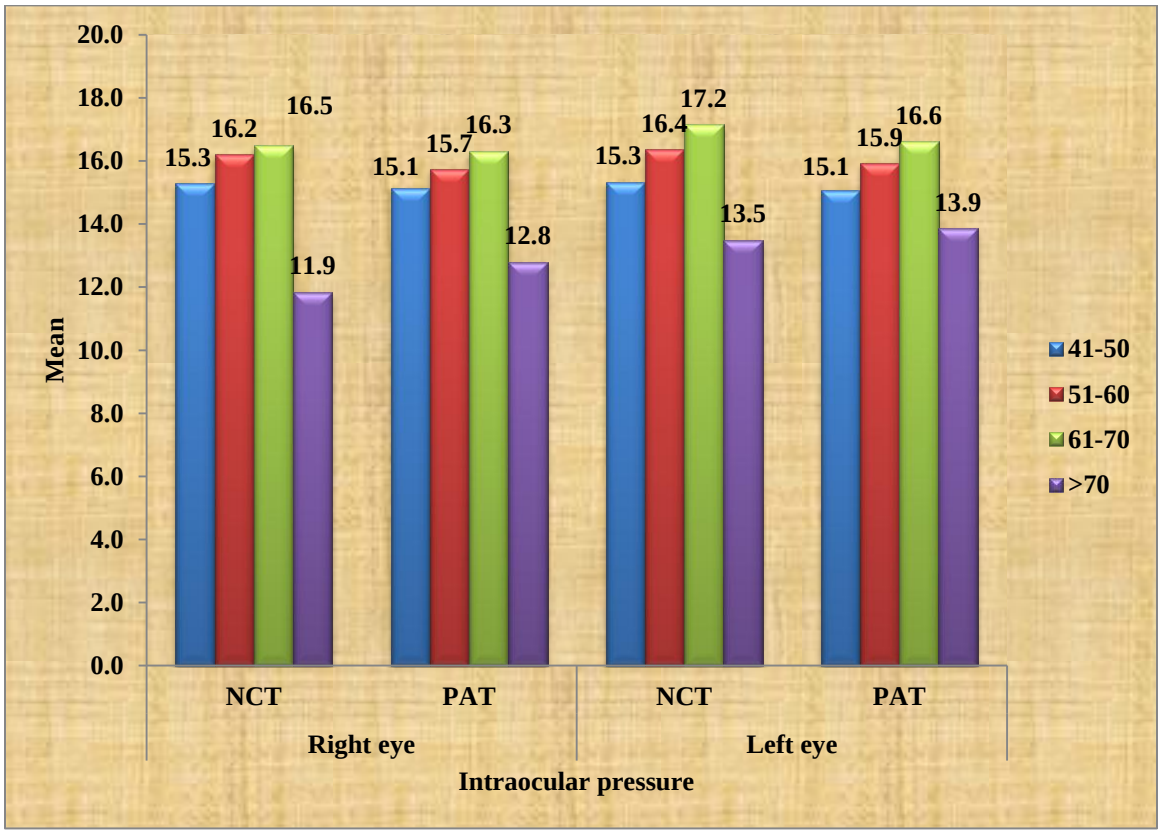
Table No 9: Mean Intraocular Pressure between NCT and PAT (in mm Hg) among females by age

Right eye						Left eye				
Age(Yrs)	NCT		PAT		p value	NCT		PAT		p value
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
41-50	15.3	3.0	15.1	2.7	0.576	15.3	3.6	15.1	3.1	0.367
51-60	16.2	4.5	15.7	3.0	0.257	16.4	4.4	15.9	3.0	0.255
61-70	16.5	4.9	16.3	4.9	0.773	17.2	6.4	16.6	6.2	0.435
>70	11.9	3.0	12.8	2.1	0.382	13.5	4.9	13.9	4.0	0.686

Table No. 9 and Graph No. 7 shows that the mean intraocular pressure in right eye for females in age groups of 41-50 years, 51-60 years, 61-70 years, more than 70 years with non contact tonometer and perkins applanation tonometer were 15.3 mm Hg, 16.2mm Hg, 16.5 mm Hg, 11.9 mm Hg and 15.1 mm Hg,15.7 mm Hg,16.3 mm Hg,12.8 mm Hg respectively for both tonometers with standard deviation of 3.0,4.5,4.9,3.0 and 2.7,3.0,4.9,2.1 with p values of 0.576,0.257,0.773,0.382 respectively, showed there was no significant difference between two tonometers and also a good agreement between two tonometers.

Table No. 9 and Graph No. 7 shows that the mean intraocular pressure in left eye for females in age groups of 41-50 years, 51-60 years, 61-70 years, more than 70 years with non contact tonometer and perkins applanation tonometer were 15.3 mm Hg, 16.4mm Hg, 17.2 mm Hg,13.5 mm Hg and 15.1 mm Hg,15.9 mm Hg,16.6 mm Hg,13.9

mm Hg respectively for both tonometers with standard deviation of 3.6,4.4,6.4,4.9 and 3.1,3.0,6.2,4.0 with p values of 0.367,0.255,0.435,0.686 respectively, showed there was no significant difference between two tonometers and also a good agreement between two tonometers.



Graph No. 7: Mean Intraocular Pressure between NCT and PAT (in mm Hg) among females by age

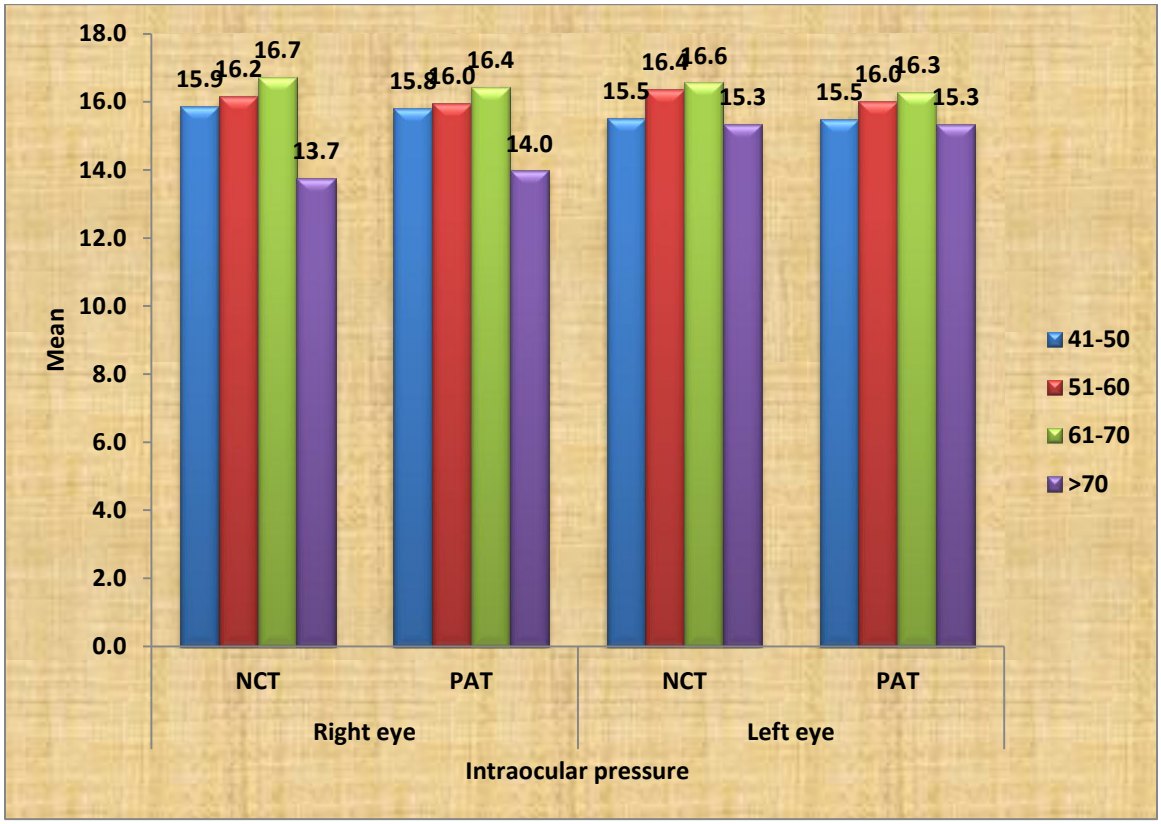
Table No. 10: Mean Intraocular Pressure between NCT and PAT (in mm Hg) among total participants by age

Age(Yrs)	Right eye					Left eye				
	NCT		PAT		p value	NCT		PAT		p value
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
41-50	15.9	3.5	15.8	3.0	0.705	15.5	3.4	15.5	3.0	0.914
51-60	16.2	4.0	16.0	3.1	0.299	16.4	4.1	16.0	3.3	0.102
61-70	16.7	4.4	16.4	4.3	0.396	16.6	5.3	16.3	5.1	0.423
>70	13.7	2.9	14.0	2.1	0.676	15.3	4.4	15.3	4.2	0.99

Table No. 10 and Graph No. 8 shows that mean intraocular pressure in right eye for both male and females in age groups of 41-50 years, 51-60 years, 61-70 years, more than 70 years with non contact tonometer and perkins applanation tonometer were 15.9 mm Hg, 16.2mm Hg, 16.7 mm Hg ,13.7 mm Hg and 15.8 mm Hg,16.0 mm Hg,16.4 mm Hg,14.0 mm Hg respectively for both tonometers with standard deviation of 3.5.4.0,4.4,2.9 and 3.0,3.1,4.3,2.1 with p values of 0.705,0.299,0.396,0.676 respectively, showed there was no significant difference between two tonometers and also a good agreement between two tonometers.

Table No. 10 and Graph No. 8 shows that mean intraocular pressure in left eye for both males and females in age groups of 41-50 years, 51-60 years, 61-70 years, more than 70 years with non contact tonometer and perkins applanation tonometer were 15.5 mm Hg, 16.4mm Hg, 16.6 mm Hg,15.3 mm Hg and 15.5 mm Hg,16.0 mm Hg,16.3 mm Hg,15.3 mm Hg respectively for both tonometers with standard deviation of 3.4,4.1,5.3,4.4 and 3.0,3.3,5.1,4.2 with p values of 0.914,0.102,0.423,0.99 respectively,

showed there was no significant difference between two tonometers and also a good agreement between two tonometers.



Graph No. 8: Mean Intraocular Pressure between NCT and PAT (in mm Hg) among total participants by age

Table No. 11: Correlation coefficient of Intraocular Pressure between NCT and PAT

Intraocular Pressure	Method	Male		Female		Total	
		r value	p value	r value	p value	r value	p value
Right eye	NCT / PAT	0.919	<0.05	0.83	<0.05	0.879	<0.05
Left eye	NCT / PAT	0.928	<0.05	0.862	<0.05	0.894	<0.05

Table No. 11 shows, the correlation coefficient of intraocular pressure measured by Non contact tonometer and Perkins applanation tonometer were 0.919 and 0.928 for right and left eye respectively with p value of <0.05 in males, showed strong positive correlation between the intraocular pressure measured by NCT and PAT among males.

Table No. 11 shows, the correlation coefficient of intraocular pressure measured by Non contact tonometer and Perkins applanation tonometer were 0.83 and 0.862 for right and left eye respectively with p value of <0.05 in females, showed strong positive correlation between the intraocular pressure measured by NCT and PAT among females.

Table No. 11 shows, the correlation coefficient of intraocular pressure measured by Non contact tonometer and Perkins applanation tonometer were 0.879 and 0.894 for right and left eye respectively with p value of <0.05 in our study participants (both male and female), showed strong positive correlation between the intraocular pressure measured by NCT and PAT among total (both male and female) participants.

Table No. 12: Correlation coefficient of Intraocular Pressure between NCT and PAT among males

Eye	Age (Yrs)	r value	p value
Right eye	41-50	0.95	<0.05
	51-60	0.937	<0.05
	61-70	0.89	<0.05
	>70	0.612	<0.05
Left eye	41-50	0.958	<0.05
	51-60	0.917	<0.05
	61-70	0.938	<0.05
	>70	0.885	<0.05

Table No. 12 shows that, the the non contact tonometer on the right eyes and left eyes compared well with the Perkins applanation tonometer among males in all age groups.

Table No. 13: Correlation coefficient of Intraocular Pressure between NCT and PAT among females

Eye	Age (Yrs)	r value	p value
Right eye	41-50	0.95	<0.05
	51-60	0.937	<0.05
	61-70	0.89	<0.05
	>70	Due to only 2 female participants in this age group r value and p value cannot be calculated	
Left eye	41-50	0.958	<0.05
	51-60	0.917	<0.05
	61-70	0.938	<0.05
	>70	Due to only 2 female participants in this age group r value and p value cannot be calculated	

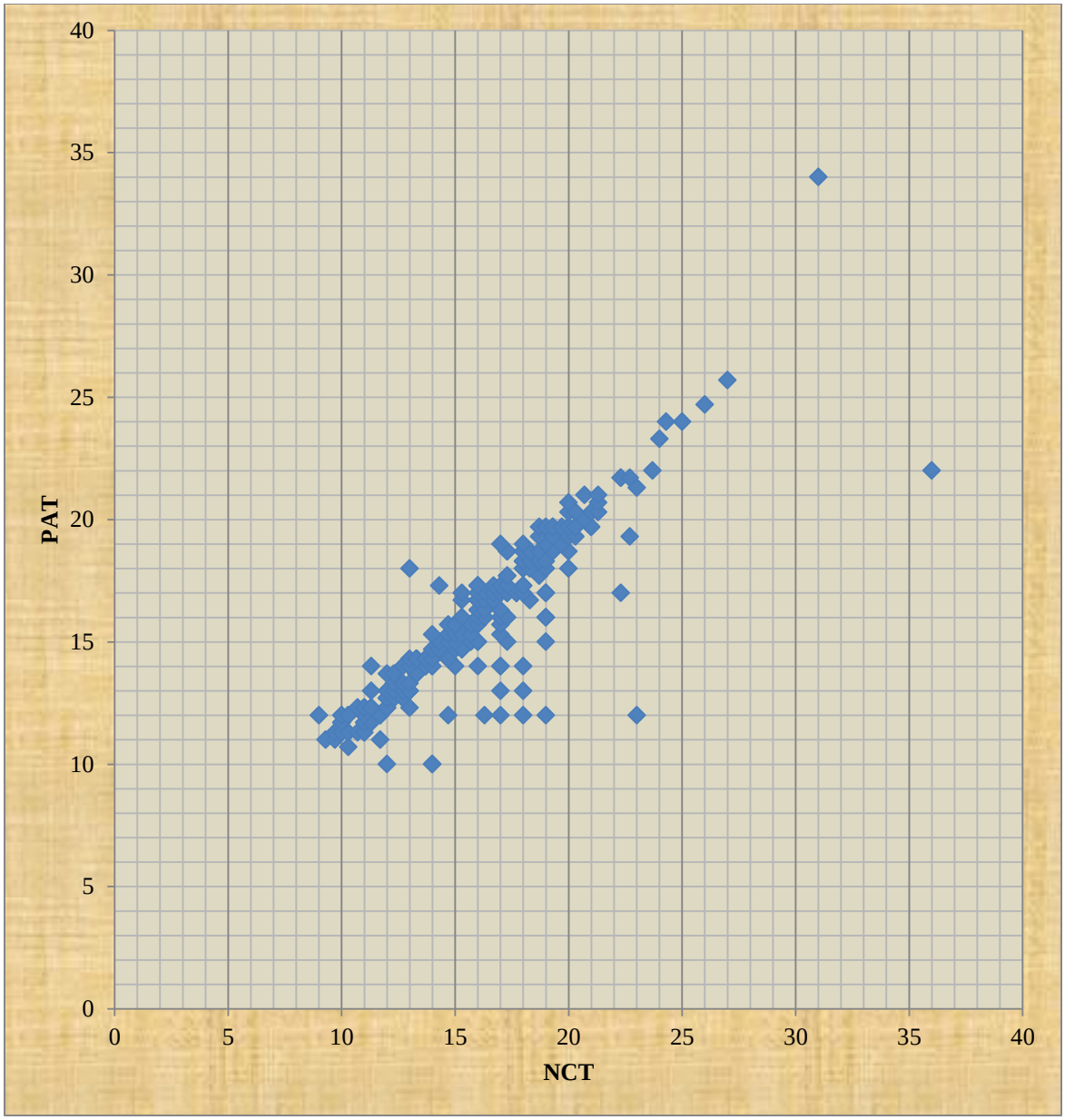
Table No. 13 shows that, the non contact tonometer on the right eyes and left eyes compared well with the Perkins applanation tonometer among females in all age groups..

Table No. 14: Correlation coefficient of Intraocular Pressure between NCT and PAT among total participants

Eye	Age (Yrs)	r value	p value
Right eye	41-50	0.92	<0.05
	51-60	0.87	<0.05
	61-70	0.87	<0.05
	>70	0.66	<0.05
Left eye	41-50	0.92	<0.05
	51-60	0.88	<0.05
	61-70	0.90	<0.05
	>70	0.90	<0.05

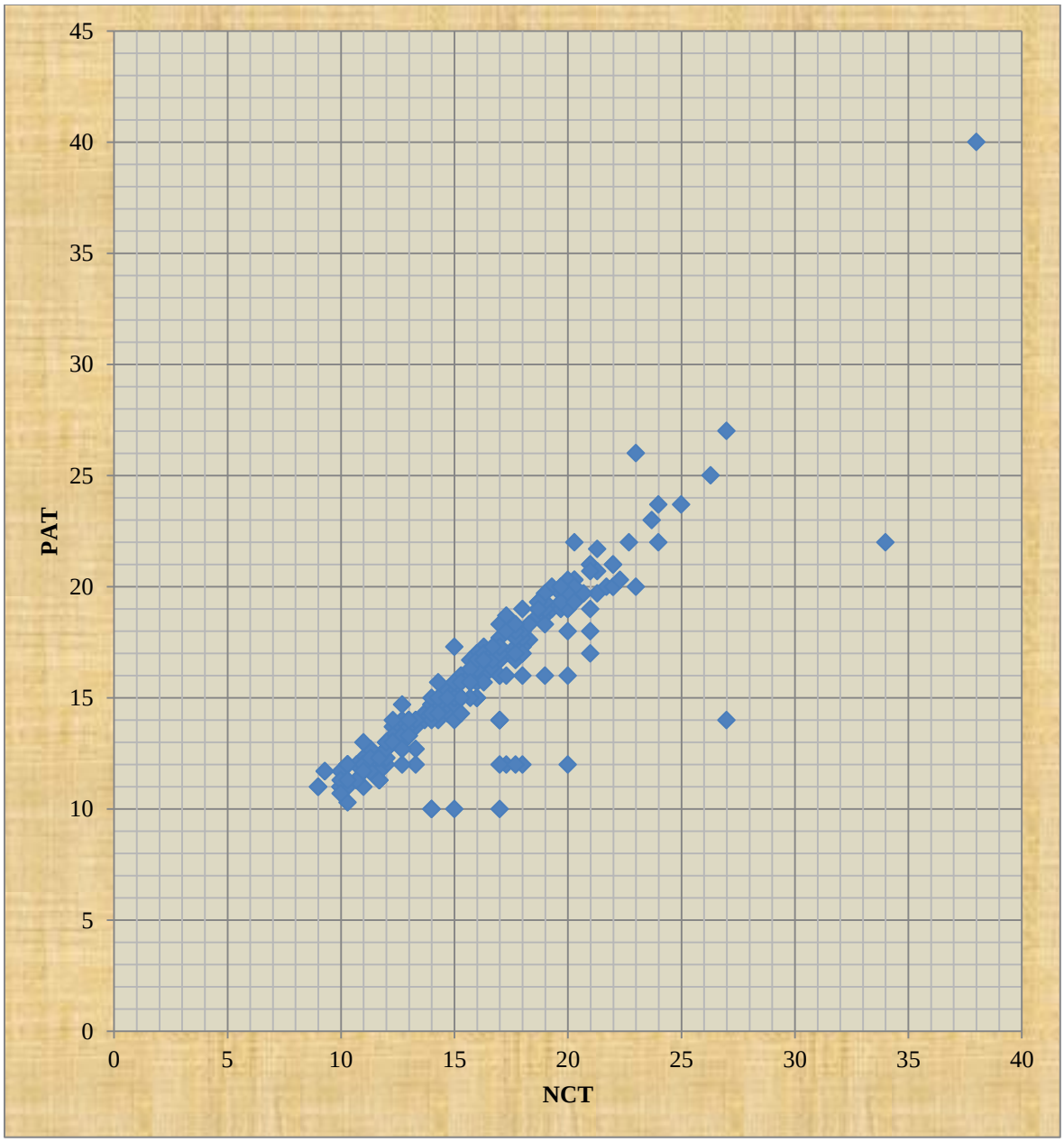
Table No. 14 shows that, the Non contact tonometer on the right eyes, compared well with the Perkins applanation tonometer as evidenced by a r values of 0.92,0.87,0.87,0.66 with a P value <0.05 for correlation, for both male and females in age groups of 41-50 years, 51-60 years, 61-70 years, more than 70 years respectively, showed significant correlation between tonometers in all age groups..

Table No. 14 shows that, the Non contact tonometer on the left eyes, compared well with the Perkins applanation tonometer as evidenced by a r values of 0.92,0.88,0.90,0.90 with a P value <0.05 for correlation, for both male and females in age groups of 41-50 years, 51-60 years, 61-70 years, more than 70 years respectively, showed significant correlation between tonometers in all age groups..



Graph No. 9: Scattered plot of right eye intraocular pressure between PAT and NCT

Above scattered plot (Graph No. 9) shows strong positive correlation between the intraocular pressure measured by NCT and PAT for right eye.



Graph No. 10: Scattered plot of Left eye intraocular pressure between PAT and NCT

Above scattered plot (Graph No. 10) shows strong positive correlation between the intraocular pressure measured by NCT and PAT for left eye.

SENSITIVITY AND SPECIFICITY OF NON CONTACT TONOMETER WITH PERKINS APPLANATION TONOMETER

The sensitivity and specificity for the non contact tonometer were calculated, using an intraocular pressure of more than or equal to 21 mm Hg with the Peerkins applanation tonometer (hand held version of gold standard Goldmann's tonometer) as the standard criterion. The results obtained were tabulated below.

Table No. 15: Sensitivity and Specificity of Non contact tonometer with Perkins applanation tonometer

Eye	Sensitivity	Specificity
Right eye	95.5	94.5
Left eye	94.3	99.1

Table No. 15 shows that, the Non contact tonometer showed high sensitivity 95.5 and 94.3 for right eye and left eye respectively (right eye more than left eye) i.e. very few false negative results as well as high specificity 94.5 and 99.1 for right eye and left eye respectively (left eye more than right eye) i.e. few false positive results; thus coming across an excellent agreement with Perkins applanation tonometer.

DISCUSSION

The current understanding of glaucoma is inclusive of three entities – the optic nerve head, the visual field and intraocular pressure. While optic nerve head damage and a consequent field loss are pre-requisites for the diagnosis of glaucoma, raised intraocular pressure while commonly being associated with glaucoma, is not necessary for designating an eye as glaucomatous.

Visual field loss and degenerative optic neuropathy can occur without an elevation in intraocular pressure as seen in the normotensive glaucoma patients. Conversely, a good number of eyes with pressures above the accepted normal of 21mm Hg have failed to demonstrate glaucomatous optic nerve head changes or visual field defects

However, raised intraocular pressure has been demonstrated to cause damage to the optic nerve head and its reduction has consequently retarded the progression of such damage.[78-80] Thus tonometry has gained importance and has become the mainstay of glaucoma screening and monitoring. .

Perkins tonometer has potential benefits of portability and non requirement of slit lamp but it has disadvantages of touching the cornea, staining with fluoresceine, risk of infection, risk of corneal abrasion and need for a skilled examiner.[81]

At the same time NCT does not require touching the cornea and can be used safely in early post operative cases, as the risk of infection is minimal and any resident or health care personal (a non ophthalmologist) can be trained to measure IOP with NCT.

In this study, with the principle aim to correlate the intraocular pressure by the Non contact tonometer with the Perkins applanation tonometer, total 260 participants

aged more than 40 years were included. According to a study by George R et al.,[2] approximately 11.2 million Indians above 40 years suffer from glaucoma, supports our study to include all participants above the age of 40 years.

All 260 participants were subjected to two methods of tonometry – Non Contact Tonometry and Perkins Applanation Tonometry (Perkins under topical anaesthesia with 0.5% Proparacaine eye drops). Non Contact Tonometer readings were recorded first, then Perkins tonometer. Three readings were taken for each method and mean calculated. This was done keeping in mind the non contact tonometer which records randomly with respect to the cardiac cycle and at very short intervals. Since, the scope for fluctuations is higher and it has been recommended that a minimum of three readings be taken and averaged to give the IOP. [21, 82, 83]

Statistical Analysis: All characteristics were summarized descriptively. For continuous variables, the summary statistics of N, mean, standard deviation (SD) were used. For categorical data, the number and percentage were used in the data summaries. Bivariate correlation analysis using Pearson's correlation coefficient (r) was used to test the strength and direction of relationships between the interval levels of variables.

For continuous data, the differences of the mean analysis variables were tested with the paired t-test. If the p-value is > 0.05, then the results, i.e., the difference between the intraocular pressure measured by non contact tonometer and Perkins tonometer were considered to be not significant, shows excellent agreement between the tonometers . Sensitivity- specificity analysis was done to check relative efficiency. Data was analyzed using SPSS software.

Out of 260 participants, 155 (59.6%) were males and 105 (40.4%) were females. Maximum number of participants 104 (40.0%) were in 41-50 years age group. 94 (36.2%) participants were in 51-60 years group, 46 (17.7%)participants in 61-70 years age group and remaining 16 (6.2%) participants in the more than 70 years age group.

Mean IOP of right eye with NCT and PAT in males were 16.1 mm Hg and 16.0 mm Hg respectively with p value of 0.671, for left eye with NCT and PAT were 15.9 mm Hg and 15.9 mm Hg respectively with p value of 0.68, showed that there was no significant difference between the intraocular pressure measured by the both instruments and suggest fair agreement between NCT and PAT among males. These findings are comparable with a study done by Prabhakar SK et al.[4]

Mean IOP of right eye with NCT and PAT in females were 15.8 mm Hg and 15.6 mm Hg respectively with p value of 0.249, for left eye with NCT and PAT were 16.1 mm Hg and 15.7 mm Hg respectively with p value of 0.104, showed that there was no significant difference between the intraocular pressure measured by the both instruments and suggest fair agreement between NCT and PAT among females. These findings are comparable with a study done by Prabhakar SK et al.[4]

Mean IOP of right eye with NCT and PAT were 16.0 mm Hg and 15.9 mm Hg respectively with p value of 0.239, for left eye with NCT and PAT were 16.0 mm Hg and 15.8 mm Hg respectively with p value of 0.118, showed that there was no significant difference between the intraocular pressure measured by the both instruments and suggest fair agreement between NCT and PAT among total participants (both males and females). These findings are comparable with a study done by Prabhakar SK et al.[4]

Mean intraocular pressure in right eye for both male and females in age groups of 41-50 years, 51-60 years, 61-70 years, more than 70 years with NCT and PAT were 15.9 mm Hg, 16.2mm Hg, 16.7 mm Hg ,13.7 mm Hg and 15.8 mm Hg,16.0 mm Hg,16.4 mm Hg,14.0 mm Hg respectively for both tonometers with standard deviation of 3.5,4.0,4.4,2.9 and 3.0,3.1,4.3,2.1 respectively with p values of 0.705,0.299,0.396,0.676, showed there was no significant difference between two tonometers and also a good agreement between two tonometers. These findings are comparable with a study done by Prabhakar SK et al.[4]

Mean intraocular pressure in left eye for both males and females in age groups of 41-50 years, 51-60 years, 61-70 years, more than 70 years with NCT and PAT were 15.5 mm Hg, 16.4mm Hg, 16.6 mm Hg,15.3 mm Hg and 15.5 mm Hg,16.0 mm Hg,16.3 mm Hg,15.3 mm Hg respectively for both tonometers with standard deviation of 3.4,4.1,5.3,4.4 and 3.0,3.3,5.1,4.2 respectively with p values of 0.914,0.102,0.423,0.99 showed there was no significant difference between two tonometers and also a good agreement between two tonometers. These findings are comparable with a study done by Prabhakar SK et al.[4]

In this study, the non contact tonometer on the right eyes for both males and females, compared well with the Perkins applanation tonometer as evidenced by a Correlation coefficient (r) values of 0.919,0.83 with a P value <0.05 for correlation respectively, showed significant correlation between tonometers.

In this study, the non contact tonometer on the left eyes for both males and females, compared well with the Perkins applanation tonometer as evidenced by a

Correlation coefficient (r) values of 0.928,0.862 with a P value <0.05for correlation respectively, showed significant correlation between tonometers.

In this study, the the non contact tonometer on the right eyes, compared well with the Perkins applanation tonometer as evidenced by a Correlation coefficient (r) values of 0.92,0.87,0.87,0.66 with a P value <0.05 for correlation, for both male and females in age groups of 41-50 years, 51-60 years, 61-70 years, more than 70 years respectively, showed significant correlation between tonometers.

In this study, the the non contact tonometer on the left eyes, compared well with the Perkins applanation tonometer as evidenced by a Correlation coefficient (r) values of 0.92,0.88,0.90,0.90 with a P value <0.05 for correlation, for both male and females in age groups of 41-50 years, 51-60 years, 61-70 years, more than 70 years respectively, showed significant correlation between tonometers.

In this study, the non contact tonometer on the both eyes compared well with the Perkins applanation tonometer as evidenced by a Correlation coefficient (r) values of 0.879 and 0.894 with a P value <0.05 for correlation respectively, showed significant correlation between tonometers. These findings are comparable with a study done by Prabhakar SK et al.[4]

The non contact tonometer was the first of the tonometers the participants were exposed to. Moreover, all the participants were being exposed to tonometry for the first time. Inspite of being aware of the procedure involved, a certain amount of apprehension and therefore some squeezing of the eyelids in anticipation of the air puff occurred as expected. These factors could be attributed to the minor differences in the correlation coefficient in right and left eye for males, females, and in various age groups. The study

by Stephen Vernon addressed this issue and he also attributed these variations in his study to apprehension on first exposure to the non contact tonometer.[13]

An essential criterion for a good screening test is high specificity and high sensitivity. The non contact tonometer has been shown to be a reliable screening tool by Shields[14] and Moseley et al.[15]

In this study, a screening criterion of more than or equal to 21 mm Hg with the Perkins applanation tonometer (hand held version of gold standard Goldmann's tonometer) as the standard was used to study the sensitivity and specificity, the non contact tonometer showed high sensitivity 95.5 and 94.3 for right eye and left eye respectively (right eye more than left eye) i.e. very few false negative results as well as high specificity 94.5 and 99.1 for right eye and left eye respectively (left eye more than right eye) i.e. few false positive results; thus coming across an excellent agreement with Perkins applanation tonometer. Our results are comparable with study done by Moseley M. J et al.,[15] who adopted screening criterion of greater than or equal to 21 mm Hg, and reported that NCT has sensitivity of 85% and specificity of 95%.

The Non contact tonometer gains further credentials as a screening tool since it is easy to operate and can be operated by non medical and paramedical personnel without any observer bias since it records pressures automatically. Being a non contact method, the need for disinfection is obviated, thus giving it additional value in mass screening programmers. Its only drawback is its cost.

Thus the non contact tonometer was found to compare well with the Perkins tonometer (hand held version of gold standard Goldmann applanation tonometer) and confirmed the finding of previous researchers Hsu et al.,[23] and Ogbuehi and Almubrad.[16]

LIMITATIONS OF THE STUDY

1. Central corneal thickness, which influences the intraocular pressure was not taken into consideration.
2. All participants were exposed to the tonometry methods for the first time and therefore were poorly accustomed to the procedure and apprehensive, especially with the non contact tonometer.
3. The non contact tonometer was compared to the Perkins tonometer as it is Hand held version of gold standard Goldmann applanation tonometer, but the value of Goldmann applanation tonometer as a gold standard is being questioned since the introduction of the dynamic contour tonometer. Manometry being a direct method would have been superior to the Goldmann tonometer.

CONCLUSION

The current study showed that, the Non contact tonometer compares favorably with the Perkins applanation tonometer (hand held version of gold standard Goldmann applanation tonometer) and has an excellent agreement with it. The non contact tonometer can be used as a reliable screening tool.

SUMMARY

The study aimed to compare the non contact tonometer the Perkins tonometer (hand held version of gold standard Goldmann applanation tonometer – the current gold standard tonometer).

260 participants – 155 males and 105 females with the mean age of 55.3 years ranging from 41-85 years, were subjected to the above methods of tonometry.

The non contact tonometer showed excellent agreement with the Perkins tonometer (hand held version of gold standard Goldmann applanation tonometer).

Minor differences in the correlation in right and left eye for males, females, and in various age groups of males and females could be probably due to the apprehension of the patient on first exposure to the air puff.

The non contact tonometer proved to be an excellent screening tool with near perfect sensitivity and specificity.

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ANNEXURE I

ETHICAL CLEARANCE

B.L.D.E. UNIVERSITY'S
SHRI.B.M.PATIL MEDICAL COLLEGE, BIJAPUR-586 103
INSTITUTIONAL ETHICAL COMMITTEE

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Ethical Committee of this college met on 22-11-2014 *at* 3-30pm. *to scrutinize the Synopsis of Postgraduate Students of this college from Ethical Clearance point of view. After scrutiny the following original/corrected & revised version synopsis of the Thesis has been accorded Ethical Clearance.*

Title "Correlation of the Non Contact Tonometer with the Perkins Applanation Tonometer"

Name of P.G. student Dr. Vijaya Mahantesh M. Bijapur.
Dept of Ophthalmology

Name of Guide/Co-investigator Dr Vallabha. K. Prof & HOD
Dept of Ophthalmology

for
DR.TEJASWINI. VALLABHA
CHAIRMAN
INSTITUTIONAL ETHICAL COMMITTEE
BLDEU'S, SHRI.B.M.PATIL
MEDICAL COLLEGE, BIJAPUR.

Following documents were placed before E.C. for Scrutinization
1) Copy of Synopsis/Research project.
2) Copy of informed consent form
3) Any other relevant documents.

ANNEXURE II

SAMPLE INFORMED CONSENT FORM

Title of the Project : **"CORRELATION OF THE NON CONTACT TONOMETER WITH THE PERKINS APPLANATION TONOMETER"**

Principal Investigator : **DR. VIJAYAMAHANTESH M BIJAPUR**

DEPARTMENT OF OPHTHALMOLOGY

Email – vijaymbijapur@yahoo.com

P.G. GUIDE NAME : **DR.VALLABHA.K** **M.S, DOMS**

PROFESSOR AND HOD

DEPARTMENT OF OPHTHALMOLOGY

B.L.D.E.U'S, SHRI B.M. PATIL MEDICAL

COLLEGE, HOSPITAL AND RESEARCH CENTRE,

BIJAPUR, KARNATAKA.

1: PURPOSE OF RESEARCH:

I have been informed that this study will determine Correlation of the Non Contact Tonometer with the Perkins Applanation Tonometer. I have been explained about the reason for doing this study and selecting me/my ward as a subject for this study. I have also been given free choice for either being included or not in the study.

2: PROCEDURE:

I/My ward will be subjected to detailed history and ocular examination. I/My ward will then be subjected to investigation (Non contact tonometry and Perkins applanation tonometry.)

3: RISK AND DISCOMFORTS:

I understand this study which determines Correlation of the Non Contact Tonometer with the Perkins Applanation Tonometer will not cause any discomfort to me and do not involve any risk to my health.

4: BENEFITS:

I understand that I/my wards participate in this study will help to identify correlation of intraocular pressure measured by Non Contact Tonometer with the Perkins Applanation Tonometer.

5: CONFIDENTIALITY:

I understand that medical information produced by this study will become part of institutional records and will be subject to the confidentiality and privacy regulation of the said institute / hospital. Information of a sensitive personal nature will

not be a part of medical record, but will be stored in investigator's research file and identified only by a code number. The code key connecting name to numbers will be kept in a separate secured location.

If the data to be used for publication in the medical literature and for teaching purpose no names will be used and other identities such as photographs, audio and video tapes will be used only with my special written permission. I understand I may see the photographs and the video tapes and have the audio tapes before giving this permission.

6: REQUEST FOR MORE INFORMATION:

I understand that I may ask more questions about the study at any time. **DR. VIJAYAMAHANTESH M BIJAPUR** is available to answer my questions or concerns. I understand that I will be informed of any significant new findings discovered during the course of this study which might influence my continued participation.

If during the study or later, I wish to discuss my participation in all concerns regarding this study with a person not directly involved, I am aware that the social worker of the hospital is available to talk with me. A copy of this consent form will be given to me to keep for careful re-reading.

7: REFUSAL OR WITHDRAWAL OF PARTICIPATION:

I understand that my participation is voluntary and may refuse to participate or may withdraw my consent and discontinue participation in the study at any time without prejudice to my present or future care at this hospital. I also understand that **DR. VIJAYAMAHANTESH M BIJAPUR** may terminate my participation in this

study at any time after he/she has explained the reasons for doing so and had helped arrange for my continued care by my physician or physical therapist if this is appropriate.

8: <u>INJURY STATEMENT</u>

I understand that in unlikely event of injury to me resulting directly from my participation in this study, if such injury were reported promptly, then medical treatment will be available to me, but no further compensation will be provided.

I understand that by my agreement to participate in this study I am not waiving any of my legal rights.

I have explained to _____(patient's/relevant guardian) the purpose of the research, the procedure required and the possible risk and benefits to the best of my ability in patient's own language.

Date:

DR VALLABHA K	**DR. VIJAYAMAHANTESH M BIJAPUR**
(Guide)	**(Investigator)**

9: <u>STUDY SUBJECT CONSENT STATEMENT</u>

I confirm that **DR. VIJAYAMAHANTESH M BIJAPUR** has explained to me the purpose of research, the study procedure that I will undergo, and the possible risk and discomforts as well as benefits that I may experience. Alternative to my participation in the study, I have also been to give my consent form. Therefore, I agree to give consent to participate as a subject in this research project.

Signature of Participant **Date:**

Signature of witness **Date**

ANNEXURE III

PROFORMA

PATIENT DETAILS

NAME

AGE:

SEX:

OP/IP No:

ADDRESS:

History of previous corneal surgery Y/N

Known case of glaucoma Y/N

PRESENTING COMPLAINTS:

CLINICAL EXAMINATION:

1. GENERAL PHYSICAL EXAMINATION

2. SYSTEMIC EXAMINATION

3.OCULAR EXAMINATION

RIGHT EYE		LEFT EYE
	EXTRA OCULAR MOVEMENTS	
	LIDS AND ADNEXA	
	CONJUNCTIVA	
	CORNEA	
	ANTERIOR CHAMBER	
	IRIS	
	PUPIL	
	LENS	
	FUNDUS	
	VISION	
	ANY OTHER	

INTRAOCULAR PRESSURE

NON CONTACT TONOMETER	RIGHT EYE	LEFT EYE
Reading 1		
Reading 2		
Reading 3		

PERKINS APPLANATION TONOMETER	RIGHT EYE	LEFT EYE
Reading 1		
Reading 2		
Reading 3		

ANNEXURE IV

PHOTOGRAPHS OF EXAMINATION

1. SLIT LAMP EXAMINATION

2. FUNDUS EXAMINATION (UNDILATED)

3. NON CONTACT TONOMETRY

4. PERKINS APPLANATION TONOMETRY

ANNEXURE V

KEYS TO MASTER CHART

SI NO	Serial Number
M	Male
F	Female
OP NO	Out Patient registration number
IP NO	In Patient registration number
NCT	Non Contact Tonometer
PAT	Perkins Applanation Tonometer
OD	Right eye
OS	Left eye
AVG	Average

.

ANNEXURE VI

MASTER CHART

SI. NO.	NAME	AGE (in years)	SEX M/F	OP/IP NO	NCT								PAT							
					OD				OS				OD				OS			
					1	2	3	AVG	1	2	3	AVG	1	2	3	AVG	1	2	3	AVG
1	Shankaragouda P	72	M	383321	16	16	16	**16**	17	17	19	**17.7**	13	17	15	**15**	12	12	12	**12**
2	Irappa B	53	M	442615	17	17	17	**17**	17	18	19	**18**	17	17	17	**17**	17	17	18	**17.3**
3	S A Reshmi	54	M	422510	20	20	20	**20**	21	21	21	**21**	18	18	18	**18**	17	19	18	**18**
4	Gourakka	50	F	422928	16	16	16	**16**	10	12	14	**12**	15	15	17	**15.7**	13	13	13	**13**
5	Nimbaji Chavan	70	M	433775	16	16	16	**16**	15	17	19	**17**	14	14	14	**14**	14	14	14	**14**
6	M C Kori	78	M	433875	17	17	17	**17**	16	16	16	**16**	12	13	14	**13**	15	14	16	**15**
7	Kaseem D A	60	M	433737	18	17	19	**18**	17	17	17	**17**	13	13	13	**13**	12	14	16	**14**
8	Kalavati Biradar	53	F	437821	19	19	19	**19**	18	18	18	**18**	18	18	18	**18**	18	19	17	**18**
9	Lata Biradar	50	F	437820	19	19	19	**19**	20	20	20	**20**	19	19	19	**19**	19	19	19	**19**
10	Shashi Kolur	50	F	918	17	15	19	**17**	17	17	17	**17**	15	14	16	**14**	14	14	14	**14**
11	Chandram	65	M	920	20	18	18	**18.7**	20	19	20	**19.7**	19	20	20	**19.7**	20	18	20	**19.3**
12	Chandamma	77	F	917	14	15	13	**14**	15	18	18	**17**	13	16	14	**14.3**	18	17	15	**16.7**
13	Sushila	53	F	11773	34	36	38	**36**	32	34	36	**34**	22	22	22	**22**	21	22	23	**22**
14	Irawwa Biradar	65	F	12775	12	14	13	**13**	14	13	12	**13**	11	13	15	**13**	14	14	14	**14**
15	Neelappa Kinagi	84	M	35607	18	16	20	**18**	23	24	22	**23**	14	14	14	**14**	28	26	24	**26**
16	Mala Vandal	41	F	40231	20	19	18	**19**	20	20	20	**20**	12	12	12	**12**	12	11	13	**12**
17	Chandappagouda	64	M	54964	16	17	18	**17**	19	17	21	**19**	12	12	12	**12**	16	16	16	**16**
18	Basamma	60	F	54974	17	17	17	**17**	18	20	22	**20**	15	16	17	**16**	14	16	18	**16**
19	Kamaladevi	67	F	74087	17	17	17	**17**	14	14	14	**14**	16	18	14	**16**	10	10	10	**10**
20	Suvarna K	67	F	75467	22	23	24	**23**	27	27	27	**27**	10	12	14	**12**	14	14	14	**14**
21	Manappa Hunasagi	55	M	101590	14	14	14	**14**	16	18	20	**18**	10	10	10	**10**	12	12	12	**12**
22	Masanababi	51	F	104607	15	16	18	**16.3**	16	17	19	**17.3**	12	11	13	**12**	12	12	12	**12**
23	A A Mulla	70	M	104684	20	23	21	**21.3**	13	13	13	**13**	20	21	22	**210**	12	14	16	**14**
24	Rukamabai	55	F	104719	15	17	19	**17**	17	18	19	**18**	14	14	14	**14**	16	16	16	**16**
25	Mallappa	58	M	104729	13	15	17	**15**	16	17	18	**17**	14	14	14	**14**	10	10	10	**10**
26	Shrishail	48	M	104753	19	19	19	**19**	18	17	19	**18**	16	16	16	**16**	17	17	17	**17**
27	Ayesha	45	F	109911	11	11	11	**11**	12	12	12	**12**	12	12	12	**12**	12	13	11	**12**
28	Umabai	65	F	104835	12	14	16	**14**	15	15	15	**15**	14	14	14	**14**	14	14	14	**14**
29	Basamma	60	F	105311	18	18	18	**18**	17	17	17	**17**	12	12	12	**12**	12	11	13	**12**
30	Monakka	44	F	109095	18	19	20	**19**	20	20	20	**20**	14	15	16	**15**	18	18	18	**18**
31	Shrishail	65	M	109055	14	13	15	**14**	14	14	14	**14**	10	10	10	**10**	10	10	10	**10**
32	Mahadevi Pujari	45	F	109538	19	19	19	**19**	22	24	26	**24**	17	17	17	**17**	22	21	23	**22**
33	Ramjanbi	70	F	208280	29	31	33	**31**	38	37	39	**38**	34	34	34	**34**	40	43	37	**40**
34	Shankara Gouda	79	M	113121	16	16	16	**16**	16	16	16	**16**	16	16	16	**16**	16	17	18	**17**
35	Amaramma P	70	F	143585	19	19	19	**19**	23	24	22	**23**	16	15	17	**16**	20	20	20	**20**
36	Shantabai K	50	F	185238	12	12	12	**12**	18	15	12	**15**	10	10	10	**10**	10	10	10	**10**
37	Basamma Muttagi	53	F	185241	18	18	18	**18**	18	18	18	**18**	18	17	19	**18**	18	17	16	**17**
38	S.S.Patil	72	M	153226	11	13	15	**13**	22	22	22	**22**	17	18	19	**18**	18	20	22	**20**
39	Shantabai T	45	F	351918	13	12	11	**12**	11	12	11	**11.3**	12	12	13	**12.3**	12	13	13	**12.7**
40	Indirabai Biradar	42	F	351188	16	16	14	**15.3**	16	14	15	**15**	16	17	18	**17**	17	17	18	**17.3**
41	Huchappa D	47	M	351856	22	23	22	**22.3**	20	20	23	**21**	16	17	18	**17**	17	17	17	**17**
42	Susalabai Tarapur	52	F	355752	15	16	13	**14.7**	16	18	17	**17**	14	15	16	**15**	16	16	16	**16**
43	Hanamanthrayy H	50	M	355781	15	15	14	**14.7**	13	13	14	**13.3**	12	12	12	**12**	12	12	12	**12**
44	Kashibai Thamoddi	47	F	355826	19	16	16	**17**	17	19	19	**18.3**	14	15	17	**15.3**	17	18	18	**17.6**
45	Annarao Javagi	63	M	356565	17	17	17	**17**	18	17	16	**17**	16	16	15	**15.7**	17	18	18	**17.7**
46	Bhalabhim Biradar	55	M	356572	20	18	18	**18.7**	18	20	19	**19**	18	18	17	**17.7**	20	20	18	**19.3**
47	Suresh Shivanagi	50	M	356643	19	20	21	**20**	19	21	21	**20.3**	20	21	18	**19.7**	20	19	19	**19.3**
48	Vijay Beankei	45	M	355891	21	24	24	**23**	20	17	20	**19**	22	19	23	**21.3**	20	18	21	**19.7**
49	Vittal Pujari	70	M	356745	20	19	19	**19.3**	17	20	19	**18.7**	20	18	18	**18.7**	20	18	20	**19.3**
50	G M Prameshwra	61	M	356734	16	17	16	**16.3**	16	16	18	**16.7**	17	17	14	**16**	16	16	18	**16.7**
51	Mudhakappa M	47	M	356819	19	18	19	**18.7**	23	22	23	**22.7**	19	19	20	**19.3**	20	24	22	**22**
52	M N Pathak	75	M	344240	14	16	16	**15.3**	19	19	18	**18.7**	14	14	16	**14.7**	19	19	18	**18.7**
53	Shankrewwa	65	F	358866	20	20	18	**19.3**	19	19	19	**19**	19	20	20	**19.7**	19	20	18	**19**
54	Shanta N Math	63	F	359079	17	18	17	**17.3**	21	21	22	**21.3**	17	17	18	**17.3**	22	22	21	**21.7**
55	Sunil Biradar	56	M	358749	21	22	19	**20.7**	17	18	18	**17.7**	20	19	21	**20**	18	19	18	**18.3**
56	Prakash Torat	52	M	358767	19	17	16	**17.3**	16	14	15	**15**	17	18	18	**17.7**	17	14	16	**15.7**
57	Gangabai Patil	55	F	358757	18	16	16	**16.7**	14	14	14	**14**	17	17	16	**16.7**	14	15	16	**15**
58	Gunasagarmma R	55	F	358991	14	14	15	**14.3**	14	15	16	**15**	15	15	14	**14.7**	14	14	16	**14.7**
59	S I Sarawad	64	M	358964	17	20	18	**18.3**	18	17	16	**17**	20	18	18	**18.7**	17	19	19	**18.3**
60	Siddanna Biradar	62	M	359051	20	19	21	**20**	18	20	19	**19**	20	20	19	**19.7**	20	19	19	**19.3**
61	Naganna Pallad	44	M	359259	15	17	18	**16.7**	13	14	13	**13.3**	17	17	17	**17**	12	13	13	**12.7**
62	Arjun Siddappa K	50	M	360411	17	20	19	**18.7**	18	19	18	**18.3**	18	19	19	**18.7**	19	18	18	**18.3**

63	Gouramma B	50	F	360318	18	17	17	**17.3**	18	18	18	**18**	17	17	17	**17**	18	19	17	**18**
64	Nanagouda N	60	M	360345	16	15	17	**16**	17	15	16	**16**	17	20	15	**17.3**	16	17	17	**16.7**
65	Bhimasi Butanal	55	M	360412	19	19	19	**19**	14	16	15	**15**	18	17	19	**17**	15	14	16	**15**
66	Seetabai Butanal	55	F	360418	23	20	21	**21.3**	21	21	21	**21**	21	21	20	**20.7**	21	21	21	**21**
67	Siddalingayya M	60	M	360179	17	15	16	**16**	18	19	19	**18.7**	14	15	16	**15**	19	19	19	**19**
68	Neelawwa Bisanal	60	F	360462	17	18	19	**18**	18	19	20	**19**	19	19	18	**18.7**	19	18	18	**18.3**
69	Prabu Bosale	47	M	360524	15	15	15	**15**	21	20	20	**20.3**	15	16	16	**15.7**	20	20	21	**20.3**
70	Chanamma H	48	F	360579	14	15	17	**15.3**	15	16	15	**15.3**	17	17	16	**16.7**	15	14	16	**15**
71	Putalibai Somaling	50	F	360621	19	17	18	**18**	15	15	16	**15.3**	18	18	18	**18**	15	16	16	**15.7**
72	Basamma Irappa B	64	F	360628	19	19	18	**18.7**	19	19	20	**19.3**	18	18	19	**18.3**	19	19	19	**19**
73	Malakajappa	70	M	363437	22	22	24	**22.7**	24	24	24	**24**	21	22	22	**21.7**	24	24	23	**23.7**
74	Rukmabai Talawar	60	F	363284	14	16	16	**15.3**	15	15	15	**15**	15	14	14	**14.7**	15	15	15	**15**
75	Kusumavati Jatti	60	F	363363	21	19	21	**20.3**	21	19	19	**19.7**	20	20	19	**19.7**	20	20	20	**20**
76	Bheemanagouda B	44	M	363501	18	17	18	**17.7**	18	18	18	**18**	17	17	17	**17**	18	18	17	**17.7**
77	Kishor Kumar	55	M	363261	18	17	18	**17.7**	15	18	16	**16.3**	17	17	17	**17**	15	16	16	**15.7**
78	Kamala Gandhi	50	F	362937	16	15	13	**14.7**	15	16	18	**16.3**	14	14	15	**14.3**	16	16	16	**16**
79	Basanna Bhoravati	66	M	362854	28	27	26	**27**	27	27	27	**27**	26	26	25	**25.7**	27	27	27	**27**
80	Mahadevi Hiremath	65	F	371885	13	12	14	**13**	16	17	16	**16.3**	12	12	13	**12.3**	17	17	18	**17.3**
81	Manthappa Dombal	55	M	372334	12	11	10	**11**	11	11	11	**11**	11	11	12	**11.3**	11	11	11	**11**
82	Ningappa Awati	55	M	372313	14	17	17	**16**	18	18	18	**18**	16	17	17	**16.7**	17	17	18	**17.3**
83	Sayabanna N D	55	M	372287	12	15	12	**13**	15	14	15	**14.7**	13	13	14	**13.3**	14	15	15	**14.7**
84	S B Choudari	49	M	372451	13	15	13	**13.7**	15	13	14	**14**	14	14	14	**14**	15	14	14	**14.3**
85	Bhimu Jadhav	58	M	371760	13	12	15	**13.3**	13	15	15	**14.3**	14	14	13	**13.7**	14	14	14	**14**
86	Sharadabai	60	F	373730	14	12	15	**13.7**	15	13	14	**14**	14	14	15	**14.3**	15	15	14	**14.7**
87	Shivangouda B	77	M	373464	15	16	18	**16.3**	13	14	11	**12.7**	16	17	17	**16.7**	12	12	14	**12.7**
88	Laxman Bajantari	45	M	373314	12	13	11	**12**	11	13	11	**11.7**	13	12	12	**12.3**	11	12	12	**11.7**
89	Lslu B Rajaput	50	M	376991	18	16	16	**16.7**	13	14	16	**14.3**	17	17	16	**16.7**	15	16	16	**15.7**
90	S A Biradar	58	M	382862	18	18	18	**18**	20	20	20	**20**	19	19	19	**19**	21	20	20	**20.3**
91	G Y Yalagi	55	M	382884	19	19	19	**19**	18	20	19	**19**	20	20	19	**19.7**	19	19	19	**19**
92	Hanamanthraya H	48	M	384602	13	14	11	**12.7**	14	15	12	**13.7**	14	13	12	**13**	14	14	15	**14.3**
93	M Y Honnakasturi	58	M	388258	18	18	16	**17.3**	17	17	19	**17.7**	19	19	18	**18.7**	17	17	17	**17**
94	Shivagouda Patil	60	M	390829	13	13	13	**13**	15	17	16	**16**	14	15	14	**14.3**	16	17	17	**16.7**
95	Wala Chimmalagi	62	M	391400	16	16	15	**15.7**	14	16	15	**15**	16	16	15	**15.7**	15	15	15	**15**
96	S C Bagali	60	M	404070	14	14	13	**13.7**	12	14	12	**12.7**	14	14	15	**14.3**	12	14	13	**13**
97	Subaray Mulimani	85	M	404599	12	13	12	**12.3**	11	12	12	**11.7**	13	13	12	**12.7**	12	12	13	**12.3**
98	Kusumabai Raju C	45	F	404595	19	18	17	**18**	14	17	16	**15.7**	19	19	18	**18.7**	15	16	16	**15.7**
99	Sumitra Badiger	58	F	404612	15	12	14	**13.7**	13	14	13	**13.3**	14	14	14	**14**	14	13	14	**13.7**
100	S C Kembhavi	56	M	404072	20	21	19	**20**	26	27	26	**26.3**	20	21	21	**20.7**	24	25	26	**25**
101	Shanta Biradar	64	F	404525	25	25	22	**24**	20	18	18	**18.7**	23	23	24	**23.3**	19	19	19	**19**
102	Malakanna	65	M	404600	16	14	15	**15**	12	13	14	**13**	16	15	15	**15.3**	13	14	13	**13.3**
103	Madhumati K	55	F	404197	17	15	16	**16**	13	15	14	**14**	17	17	17	**17**	14	14	15	**14.3**
104	A M Galappagol	57	M	404083	17	18	20	**18.3**	19	19	18	**18.7**	19	19	18	**18.7**	19	19	19	**19**
105	Anusuyamma C	43	F	405581	21	20	21	**20.7**	22	20	22	**21.3**	21	21	21	**21**	21	21	20	**20.7**
106	Laxmibai Somanal	50	F	406018	11	12	10	**11**	10	10	11	**10.3**	11	11	12	**11.3**	10	10	11	**10.3**
107	K D Achanur	59	M	405430	16	18	18	**17.3**	14	16	17	**15.7**	18	18	17	**17.7**	16	16	17	**16.3**
108	Sunanda Jadhav	47	F	406549	15	13	14	**14**	11	13	13	**12.3**	14	14	15	**14.3**	12	13	14	**13**
109	Nirmala Kore	65	F	406610	17	15	18	**16.7**	20	18	19	**19**	17	17	17	**17**	19	19	18	**18.7**
110	Bismilla Alamel	50	F	408001	18	17	18	**17.7**	15	15	15	**15**	17	17	17	**17**	15	15	16	**15.3**
111	P M Patil	44	M	408153	16	17	18	**17**	17	18	16	**17**	20	18	19	**19**	17	17	18	**17.3**
112	S S Ullagaddi	59	M	408169	17	17	18	**17.3**	12	13	13	**12.7**	17	17	17	**17**	13	13	12	**12.7**
113	H D Rathod	52	M	408168	18	17	19	**18**	18	18	15	**17**	18	18	19	**18.3**	15	16	17	**16**
114	C S Bajantri	46	M	408174	15	15	17	**15.7**	16	15	15	**15.3**	16	16	15	**15.7**	16	16	16	**16**
115	Raibai Bhosale	60	F	408896	12	11	12	**11.7**	13	10	11	**11.3**	11	11	11	**11**	12	12	11	**11.7**
116	Basavaraj S G	51	M	409576	20	20	20	**20**	20	21	20	**20.3**	19	19	20	**19.3**	20	20	20	**20**
117	G R Somaradya	56	M	409678	16	15	16	**15.7**	16	14	15	**15**	16	15	15	**15.3**	15	15	16	**15.3**
118	S M Hanagandi	52	M	409480	18	15	16	**16.3**	15	17	15	**15.7**	16	16	16	**16**	15	16	17	**16**
119	Dayanand	48	M	409482	19	20	18	**19**	14	11	12	**12.3**	19	18	20	**19**	12	14	16	**14**
120	Abdul Rahis	53	M	409923	23	25	25	**24.3**	24	23	24	**23.7**	24	24	24	**24**	22	23	24	**23**
121	K H Mayavamshi	49	M	409475	19	17	18	**18**	18	18	15	**17**	18	18	19	**18.3**	17	17	17	**17**
122	Dattareya Jamadar	48	M	409476	21	19	18	**19.3**	19	17	17	**17.7**	20	20	19	**19.7**	17	18	19	**18**
123	S R Dawali	47	M	409477	25	25	25	**25**	22	19	20	**20.3**	24	24	24	**24**	21	22	23	**22**
124	M D Amjad	44	M	409479	14	16	16	**15.3**	16	14	14	**14.7**	15	16	17	**16**	15	15	16	**15.3**
125	S S Pujari	45	M	410374	20	20	23	**21**	22	21	23	**22**	21	20	20	**20.3**	22	21	20	**21**
126	Mahajanbi B	50	F	411143	17	14	16	**15.7**	14	13	15	**14**	14	15	16	**15**	14	14	14	**14**
127	Limba Rathod	65	M	411164	10	12	12	**11.3**	11	11	12	**11.3**	11	12	12	**11.7**	11	12	12	**11.7**
128	Shakuntala P	60	F	411109	21	21	22	**21.3**	20	21	18	**19.7**	20	20	21	**20.3**	20	20	20	**20**
129	A C Jakanur	52	M	414742	12	12	12	**12**	13	12	11	**12**	12	13	14	**13**	12	12	13	**12.3**
130	A A Mulla	69	M	415238	18	18	16	**17.3**	11	10	10	**10.3**	15	16	17	**16**	11	11	12	**11.3**
131	Sidraya M Gadyal	65	M	415738	12	14	15	**13.7**	13	12	13	**12.7**	14	14	14	**14**	12	12	12	**12**
132	Subash	48	M	415594	13	11	13	**12.3**	11	9	10	**10**	12	13	13	**12.7**	11	11	10	**10.7**
133	Ravi Nimbalakar	42	M	416797	24	24	23	**23.7**	18	18	20	**18.7**	22	22	22	**22**	19	19	20	**19.3**
134	Suprita	47	F	416880	13	15	12	**13.3**	18	18	16	**17.3**	14	14	13	**13.7**	17	17	17	**17**
135	Anil Hunasagi	45	M	416923	17	17	15	**16.3**	16	15	16	**15.7**	16	16	17	**16.3**	16	17	17	**16.7**
136	Bharati R	41	F	417017	14	14	15	**14.3**	15	18	15	**16**	14	15	15	**14.7**	16	16	17	**16.3**
137	S F Honagekar	50	M	417493	13	16	15	**14.7**	13	13	13	**13**	14	14	15	**14.3**	14	13	14	**13.7**

138	N D Ramagond	50	M	417489	17	15	18	**16.7**	17	16	15	**16**	16	17	17	**16.7**	16	14	15	**15**
139	S S Kusabi	42	M	417502	10	12	10	**10.7**	14	11	14	**13**	11	11	12	**11.3**	14	14	13	**13.7**
140	Jayaram	49	M	417492	20	18	21	**19.7**	20	19	21	**20**	20	19	18	**19**	20	20	19	**19.7**
141	B C Shanmukhmth	52	M	417491	11	10	10	**10.3**	12	12	11	**11.7**	11	11	10	**10.7**	11	11	12	**11.3**
142	D R Hotagar	47	M	417494	19	19	16	**18**	17	17	19	**17.7**	19	19	18	**18.7**	18	18	17	**17.7**
143	Chandrashekhar P	48	M	417497	17	18	19	**18**	17	14	15	**15.3**	19	18	18	**18.3**	14	15	16	**15**
144	V K Kolur	53	M	417487	12	12	11	**11.7**	13	14	12	**13**	12	12	12	**12**	13	14	15	**14**
145	R A Kayipalle	49	M	417495	12	13	14	**13**	11	12	12	**11.7**	14	13	12	**13**	11	11	12	**11.3**
146	Shankar Chinnakali	57	M	417984	15	15	18	**16**	19	21	18	**19.3**	17	17	16	**16.7**	19	20	21	**20**
147	Rajeshri Patil	42	F	418024	18	19	17	**18**	23	21	22	**22**	18	17	17	**17.3**	20	21	22	**21**
148	B S Budhyal	54	M	419056	27	25	26	**26**	24	25	26	**25**	24	25	25	**24.7**	24	24	23	**23.7**
149	Kareppa	47	M	422533	16	17	19	**17.3**	13	12	15	**13.3**	17	17	17	**17**	14	15	13	**14**
150	M D Mustak	50	M	422523	16	14	16	**15.3**	19	16	16	**17**	15	16	17	**16**	17	16	18	**17**
151	N A Kori	46	M	437831	17	16	18	**17**	14	15	14	**14.3**	16	16	17	**16.3**	14	15	15	**14.7**
152	Bouramma H	65	F	438038	17	14	14	**15**	16	18	17	**17**	16	16	15	**15.7**	17	18	15	**16.7**
153	Shuresh Patil	60	M	438443	18	16	16	**16.7**	15	14	14	**14.3**	17	17	17	**17**	14	15	16	**15**
154	Sangappa Angadi	56	M	438440	11	12	12	**11.7**	12	12	11	**11.7**	12	12	12	**12**	11	12	12	**11.7**
155	Z M Mulla	42	M	437874	14	16	15	**15**	14	14	15	**14.3**	16	16	15	**15.7**	15	15	14	**14.7**
156	Vijaylakshmi G	53	F	438552	16	14	13	**14.3**	17	17	17	**17**	15	15	14	**14.7**	17	17	18	**17.3**
157	Shantabai S Hotkar	60	F	438611	20	19	18	**19**	18	20	21	**19.7**	19	18	18	**18.3**	19	19	19	**19**
158	Sivaby Googadaddi	55	F	441278	11	13	10	**11.3**	13	13	12	**12.7**	12	12	13	**12.3**	13	13	13	**13**
159	Rajashree H	46	F	441629	23	21	23	**22.3**	21	21	21	**21**	22	22	21	**21.7**	21	21	20	**20.7**
160	Siddamma L	60	F	441460	15	15	15	**15**	16	17	15	**16**	14	15	16	**15**	16	17	18	**17**
161	Rayagondappa M.	60	M	442026	14	17	14	**15**	16	15	16	**15.7**	15	15	16	**15.3**	16	16	16	**16**
162	S S Salutagi	42	M	443160	20	20	19	**19.7**	19	16	17	**17.3**	20	20	19	**19.7**	18	18	18	**18**
163	Basanagouda Patil	56	M	444098	10	10	10	**10**	10	10	10	**10**	11	11	12	**11.3**	12	11	12	**11.7**
164	Laxmi Neelakanth	55	F	442608	20	21	20	**20.3**	18	19	19	**18.7**	20	20	19	**19.7**	20	19	18	**19**
165	Parasappa Harajan	48	M	444128	12	11	11	**11.3**	12	13	13	**12.7**	12	12	13	**12.3**	14	13	12	**13**
166	Malakappa N	50	M	444133	11	11	11	**11**	11	11	11	**11**	12	12	13	**12.3**	12	12	13	**12.3**
167	Suresh Shankar T	48	M	444469	16	14	13	**14.3**	17	18	18	**17.7**	14	15	16	**15**	17	18	19	**18**
168	Bhimashi Teali	55	M	444464	10	11	10	**10.3**	9	9	9	**9**	11	12	13	**12**	10	11	12	**11**
169	Y S Donur	65	M	444495	16	15	17	**16**	18	18	17	**17.7**	17	17	16	**16.7**	18	18	17	**17.7**
170	B Y Waggyannavar	50	M	444657	23	22	22	**22.3**	24	22	21	**22.3**	22	22	21	**21.7**	21	20	20	**20.3**
171	Sayad Hapij Husen	50	M	444656	13	13	13	**13**	12	11	10	**11**	14	13	12	**13**	11	12	13	**12**
172	Mahadevapa H	55	M	445063	12	11	10	**11**	10	11	10	**10.3**	12	12	11	**11.7**	11	12	13	**12**
173	Siddu Handiganur	48	M	445082	17	15	14	**15.3**	15	14	17	**15.3**	16	15	15	**15.3**	16	16	16	**16**
174	Gururaj	41	M	445160	14	14	12	**13.3**	11	12	12	**11.7**	14	14	15	**14.3**	12	12	13	**12.3**
175	Aravind Panchanan	49	M	446274	23	21	24	**22.7**	21	22	20	**21**	20	19	19	**19.3**	20	19	18	**19**
176	Basavaraj Kumbar	50	M	446394	13	15	15	**14.3**	12	14	11	**12.3**	15	14	16	**15**	12	13	14	**13**
177	Suvarana Algur	60	F	446734	19	19	17	**18.3**	17	17	16	**16.7**	19	17	18	**18**	17	16	17	**16.7**
178	Kashibai Honnutagi	70	F	446732	16	17	14	**15.7**	13	14	13	**13.3**	16	16	15	**15.7**	14	15	13	**14**
179	H R Koppad	45	M	448311	13	12	12	**12.3**	16	16	16	**16**	13	14	13	**13.3**	15	16	16	**15.7**
180	P S Garasangi	47	M	448313	13	12	11	**12**	16	13	15	**14.7**	12	13	12	**12.3**	14	15	14	**14.3**
181	Shivalling K	45	M	449782	11	11	14	**12**	11	10	11	**10.7**	13	13	12	**12.7**	11	12	13	**12**
182	Mallikarjun Parade	62	M	450151	14	13	15	**14**	11	12	13	**12**	14	15	14	**143.**	12	13	14	**13**
183	I M Nagarabavadi	45	M	449695	11	11	11	**11**	12	10	13	**11.7**	12	12	11	**11.7**	10	12	14	**12**
184	H B Bajantri	51	M	449694	13	13	12	**12.7**	11	13	12	**12**	13	13	14	**13.3**	12	12	13	**12.3**
185	Rukumma G	50	F	450233	15	13	14	**14**	11	11	11	**11**	14	15	13	**14**	12	12	11	**11.7**
186	I C Pathan	56	M	449710	16	16	16	**16**	19	20	22	**20.3**	17	16	16	**16.3**	20	21	20	**20.3**
187	Basavaraj Ganager	52	M	450188	17	16	15	**16**	13	15	14	**14**	16	17	16	**16.3**	14	15	15	**14.7**
188	Tayawwa Bosale	45	F	450380	16	16	18	**16.7**	15	15	18	**16**	17	17	16	**16.7**	16	16	17	**16.3**
189	Basavaraj	57	M	451644	20	18	17	**18.3**	21	19	20	**20**	16	17	17	**16.7**	20	21	19	**20**
190	Renuka	41	F	451642	16	17	16	**16.3**	13	12	15	**13.3**	17	17	17	**17**	14	15	13	**14**
191	Basavaraj H	73	M	452203	12	12	12	**12**	12	15	14	**13.7**	13	12	12	**12.3**	14	14	15	**14.3**
192	Babu Rathod	43	M	453111	21	20	20	**20.3**	15	15	14	**14.7**	20	20	19	**19.7**	15	15	15	**15**
193	Vasant	58	M	453493	17	17	14	**16**	12	13	12	**12.3**	17	17	16	**16.7**	13	13	13	**13**
194	Dinesh Porwal	49	M	453534	12	14	14	**13.3**	15	14	14	**14.3**	14	14	13	**13.7**	15	15	14	**14.7**
195	Kavitha Porwal	42	F	453536	16	15	14	**15**	15	14	17	**15.3**	14	15	15	**14.7**	16	15	14	**15**
196	Baramawwa W	55	F	454268	16	14	14	**14.7**	20	20	20	**20**	15	15	16	**15.3**	20	19	18	**19**
197	S H Baragani	42	M	453678	16	18	17	**17**	16	15	15	**15.3**	18	17	16	**17**	14	14	15	**14.3**
198	T Y Yadahalli	50	M	453664	17	18	15	**16.7**	18	15	16	**16.3**	17	17	18	**17.3**	17	18	16	**17**
199	Somappa S Handi	43	M	453679	13	10	11	**11.3**	12	12	13	**12.3**	14	13	12	**13**	12	14	14	**13.3**
200	Lingaraj	50	M	454207	12	13	12	**12.3**	15	18	15	**16**	14	13	12	**13**	16	15	14	**15**
201	S H Biradar	49	M	457338	13	11	12	**12**	13	12	11	**12**	13	13	12	**12.7**	14	13	12	**13**
202	Sonabai Pawar	55	F	459588	17	18	17	**17.3**	20	22	19	**20.3**	16	14	15	**15**	20	20	19	**19.7**
203	T S Khanapur	56	M	462866	12	13	12	**12.3**	12	11	11	**11.3**	12	13	14	**13**	12	12	11	**11.7**
204	Rayappa Y	75	M	459259	10	13	11	**11.3**	14	16	15	**15**	12	12	13	**12.3**	16	16	15	**15.7**
205	Neelakka Patil	70	F	442591	18	18	19	**18.3**	18	17	19	**18**	18	19	18	**18.3**	17	18	19	**18**
206	Sugalabai Chatti	55	F	469461	10	10	10	**10**	11	11	11	**11**	11	12	11	**11.3**	10	12	13	**11.7**
207	Indirabai Basargi	60	F	469031	15	13	14	**14**	12	13	13	**12.7**	14	14	15	**14.3**	13	13	14	**13.3**
208	Somashekar	49	M	471732	21	20	22	**21**	22	21	22	**21.7**	20	20	19	**19.7**	21	20	19	**20**
209	Gurulingappa	70	M	474065	15	15	13	**14.3**	16	15	16	**15.7**	17	18	17	**17.3**	14	15	16	**15**
210	Chidamabar K	49	M	476476	21	20	19	**20**	18	19	17	**18**	19	19	20	**19.3**	18	19	20	**19**
211	Rajanna	56	M	2667	20	19	22	**20.3**	21	22	23	**22**	20	20	21	**20.3**	21	20	19	**20**
212	Kamalabai H	65	F	4384	12	14	14	**13.3**	13	14	14	**13.7**	14	14	15	**14.3**	15	14	13	**14**

213	J A Tharakar	58	M	9307	19	21	20	**20**	21	21	21	**21**	20	21	20	**20.3**	21	21	21	**21**
214	Suvarana C	52	F	39132	18	17	20	**18.3**	16	19	17	**17.3**	19	19	18	**18.7**	16	15	17	**16**
215	Dastagir Golasangi	48	M	23065	17	20	17	**18**	16	16	17	**16.3**	17	17	18	**17.3**	17	17	16	**16.7**
216	Uma Hiremath	51	F	39164	17	17	17	**17**	16	17	17	**16.7**	17	17	18	**17.3**	18	17	16	**17**
217	Babybai	45	F	39211	14	11	13	**12.7**	15	15	15	**15**	13	14	15	**14**	16	15	14	**15**
218	Basavanth Uppar	45	M	39273	17	20	20	**19**	17	17	16	**16.7**	20	19	18	**19**	17	17	18	**17.3**
219	Adevappa Kasiker	50	M	39230	10	10	10	**10**	11	12	13	**12**	11	12	13	**12**	12	13	13	**12.7**
220	Revappa Hadachad	75	M	39110	10	10	10	**10**	10	9	9	**9.3**	11	12	13	**12**	12	11	12	**11.7**
221	Chavalabai Rathod	60	F	39239	11	14	14	**13**	15	16	17	**16**	13	14	15	**14**	16	16	17	**16.3**
222	Shakuntala Patil	60	F	39581	14	13	15	**14**	11	11	11	**11**	14	15	15	**14.7**	11	13	15	**13**
223	Ramesh N	43	M	39689	11	10	13	**11.3**	13	14	11	**12.7**	12	14	16	**14**	13	14	15	**14**
224	S G Kori	53	M	39728	20	20	21	**20.3**	21	19	20	**20**	20	19	19	**19.3**	20	20	19	**19.7**
225	Baby Zalaki	52	F	39665	20	21	19	**20**	20	21	21	**20.7**	19	19	18	**18.7**	20	20	19	**19.7**
226	Rukmabai Shankar	60	F	39237	17	18	17	**17.3**	17	16	16	**16.3**	18	19	19	**18.7**	16	17	17	**16.7**
227	Suvarna Sankad	42	F	39749	16	16	16	**16**	17	16	18	**16.3**	17	17	16	**16.7**	17	17	16	**16.7**
228	Jaibun Shaikh	55	M	41283	16	15	16	**15.7**	19	17	17	**17.7**	16	16	15	**15.7**	17	17	18	**17.3**
229	G S Kumbar	77	M	41339	19	16	18	**17.7**	23	21	20	**21.3**	18	17	16	**17**	20	20	19	**19.7**
230	Satish Halli	53	M	41426	10	9	10	**9.7**	9	11	10	**10**	10	11	12	**11**	10	12	11	**11**
231	Parasappa Pujari	65	M	41442	9	9	9	**9**	10	11	10	**10.3**	10	12	14	**12**	10	11	12	**11**
232	Prakash Boleshetti	58	M	42006	15	17	16	**16**	18	19	16	**17.7**	18	17	17	**17.3**	17	17	16	**16.7**
233	Bharati Maggurale	45	F	42045	13	11	14	**12.7**	13	13	13	**13**	13	13	12	**12.7**	14	13	13	**13.3**
234	Danamma Bidari	68	F	41572	16	15	17	**16**	18	17	15	**16.7**	17	17	18	**17.3**	16	16	17	**16.3**
235	Y B Sarur	62	M	42999	23	20	20	**21**	18	18	16	**17.3**	20	20	19	**19.7**	18	18	19	**18.7**
236	Renuka Soragavi	48	F	43055	18	20	17	**18.3**	17	17	17	**17**	19	19	18	**18.7**	17	17	18	**17.3**
237	Savitri Dharwad	42	F	43058	14	13	15	**14**	12	12	12	**12**	15	16	15	**15.3**	12	13	13	**12.7**
238	Kamala Hiremath	43	F	43105	13	15	15	**14.3**	16	15	17	**16**	14	15	16	**15**	16	17	17	**16.7**
239	Ratnabai	55	F	43036	21	19	18	**19.3**	18	21	20	**19.7**	19	20	19	**19.3**	20	20	19	**19.7**
240	Parasappa Pujari	70	M	42894	19	18	17	**18**	15	14	14	**14.3**	18	17	16	**17**	14	14	15	**14.3**
241	Gouravva R B	65	F	42274	15	13	12	**13.3**	12	12	14	**12.7**	14	14	15	**14.3**	12	13	14	**13**
242	Srikant M	65	M	41830	15	13	12	**13.3**	12	12	14	**12.7**	14	14	15	**14.3**	15	15	14	**14.7**
243	Neelawwa Heduri	66	F	48060	14	15	15	**14.7**	13	12	11	**12**	15	16	16	**15.7**	13	13	12	**12.7**
244	Peerappa	50	M	104058	11	13	13	**12.3**	12	11	11	**11.3**	13	14	14	**13.7**	12	12	13	**12.3**
245	Pramilabai D	76	F	101692	10	10	9	**9.7**	10	10	10	**10**	11	12	11	**11.3**	10	11	12	**11**
246	Laximbai	50	F	104088	11	13	10	**11.3**	11	11	11	**11**	12	12	13	**12.3**	11	12	13	**12**
247	Akkubai J	60	F	104133	10	9	9	**9.3**	10	9	9	**9.3**	10	11	12	**11**	12	12	11	**11.7**
248	Suvarana Kanti	68	F	104995	10	11	10	**10.3**	9	9	9	**9**	11	11	12	**11.3**	10	11	12	**11**
249	Mantawwa Biradar	60	F	105049	12	12	10	**11.3**	11	14	12	**12.3**	12	12	13	**12.3**	14	14	13	**13.7**
250	Girish Kanti	75	M	104996	11	11	11	**11**	11	10	11	**10.7**	12	13	12	**12.3**	11	12	11	**11.3**
251	Bouramma Angadi	60	F	105110	11	11	14	**12**	11	10	10	**10.3**	14	14	13	**13.7**	11	12	13	**12**
252	Madivalappa C K	80	M	105145	10	11	10	**10.3**	10	11	11	**10.7**	11	12	13	**12**	11	11	12	**11.3**
253	Madiwalamma	62	F	105242	10	9	11	**10**	10	10	10	**10**	12	12	11	**11.7**	10	11	12	**11**
254	Drakashani B S	46	F	105579	11	10	12	**11**	12	11	12	**11.7**	12	12	13	**12.3**	11	11	12	**11.3**
255	Shakuntala B C	61	F	105578	10	10	10	**10**	12	11	11	**11.3**	11	12	12	**11.7**	12	12	13	**12.3**
256	Neelawwa S	42	F	109136	10	11	11	**10.7**	10	11	10	**10.3**	12	12	13	**12.3**	11	12	13	**12**
257	Suma Gokavi	45	F	109174	10	10	10	**10**	11	11	12	**11.3**	11	12	12	**11.7**	12	12	11	**11.7**
258	Vimalabai	55	F	109167	10	10	10	**10**	10	10	11	**10.3**	11	12	12	**11.7**	11	12	13	**12**
259	Anasuya Gurav	55	F	109562	10	12	10	**10.7**	11	12	10	**11**	12	12	13	**12.3**	11	12	13	**12**
260	Prema Patil	45	F	115101	14	11	11	**12**	12	9	9	**10**	13	12	12	**12.3**	11	11	12	**11.3**