VARIATIONS IN KERATOMETRIC READING USING AUTOREFRACTOR BEFORE AND AFTER CATARACT SURGERY
A STUDY DONE IN BENIN CITY

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A THESIS SUBMITTED TO THE DEPARTMENT OF OPTOMETRY, FACULTY OF LIFE SCIENCES, UNIVERSITY OF BENIN, BENIN CITY.
IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF DOCTOR OF OPTOMETRY (OD) DEGREE

JANUARY, 2023.

CERTIFICATION

This is to certify that this project work titled "**VARIATIONS IN KERATOMETRIC READING USING AUTOREFRACTOR BEFORE AND AFTER CATARACT SURGERY**" was carried out by **IFEBIGHI CHINENYE AUGUSTINA** in the Department of Optometry, Faculty of Life Science, University of Benin, in partial fulfilment of the requirement for the award of DOCTOR OF OPTOMETRY (OD) degree in the 2020/2021session.

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DEDICATION

I dedicate this project to my Creator, who has preserved my life and kept me safe and in good health throughout my journey in the University of Benin.

I also want to dedicate this project to my wonderful and ever supportive parents, Mr. and Mrs. Muoneke Ifebighi Uchenna for their love, unwavering support both morally, academically, spiritually and financially, and also my amiable siblings (especially my elder sister).

Lastly this work is dedicated to my awesome and admirable husband for his unmatched support and assistance to see that this project comes to fruition.

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ABSTRACT

This study was carried out to determine the variation in keratometric reading using autorefractor before and after cataract surgery in St Teresa Specialist and Laser Eye Center, Edo State.This was a prospective study of one hundred (n = 100) cataract patients (50 males and 50 females) aged between 35-98 years, scheduled for cataract surgery between November to January 2022. Autorefractor (with in built keratometer) was used to measure the flat meridian (K1) and steep meridian (K2). Cornea astigmatism (CA) was gotten by taking the difference in both meridian. The data collected was analyzed using the statistical package for social sciences (SPSS) version 22.0 and Descriptive statistics (frequencies, percentages, mean and standard deviation) was used to summarize the variables. There was a statistically significant variation in K1 and K2 values before cataract surgery, one and four weeks after cataract surgery.($p<0.001$ for K1 before,one week and four weeks after surgery,also $p<0.001$ for K2 before surgery,one week and four weeks after surgery.)The study also showed that there was no significant difference in cornea astigmatism (CA) before the surgery and one week after the surgery($p=0.412$). There was significant difference in CA before the surgery and four weeks after the surgery ($p=0.010$).There was also significant difference in CA one week after the surgery when compared to four weeks after the surgery ($p=0.008$).From the study,it was revealed that there is a statistically significant variation that exit in K1 and K2 values before and after cataract surgery as well as cornea astigmatism.

CHAPTER ONE

INTRODUCTION

Rabiu et al, (2012) carried out a study analysing the prevalence, methodology, causes of blindness and visual impairment and outcome of cataract surgery. It was noted that cataract has a prevalence of 43% amongst visually impaired giving a visual acuity of less than 3/60. It was also noted that the prevalence of cataract related blindness was 1.8% in a representative sample of 15027 adult above 40 years of age. According to WHO, cataract is responsible for 60% of cases of reversible blindness worldwide. Cataract surgery rate in sub-Saharan area remains among the lowest in the world, between 200 and 400 operated cases per million of inhabitants against 3500-5000 in industrialized countries.

A great deal of blindness prevention activity should therefore center around cataract surgery if we are to clear out cataract back log of over half a million individuals. Cataract is a public health problem especially in developing countries. Cataract management represents one of the first priorities of the international initiative right to sight vision-2020 with a current estimation of 16 to 20 million non-operated cases (Osahon, 2002).

A study done by *Gupta et al,* (2014) showed that cataract occurs when the normally transparent crystalline lens develops opacities. This opacity hinders the ability of the eye to converge light rays causing scattering of light and photophobia hence blurry vision. The crystalline lens contains alpha, beta and gamma crystalline protein. Once this protein begins to get denatured, they lose their characteristic transparency. Any process that results to disruption in delicate crystalline matrix that forms the lens would directly also result in hardening (sclerosis), causing the lens to lose its transparency and hence possible cataract. The only curative treatment of cataracts is surgical intervention and consists of replacing the cloudy lens by an intraocular lens (IOL). Cataract surgery may be performed by various techniques including phacoemulsification (PHACO), extracapsular cataract extraction (ECCE), intra capsular cataract extraction (ICCE) and small incisions cataract surgery (SICS).

Keratometry involves determination of curvature of the anterior cornea surface (steepest and flattest meridian), expressed in diopters or millimeters of radius of curvature. Keratometer estimates cornea refractive power indirectly by measuring the size of an image reflected by the anterior tear film. This is used to estimate the radius of cornea curvature which is then used in thin lens formula to estimate dioptric refractive power of the cornea assuming an average refractive index. After surgical management of cataract, all efforts should be focused on reducing postoperative astigmatism thus providing an excellent vision to patients.

Cataract classification system is based on where (location) and how they develop in the eyes. A cataract classification and grading system for the main purpose of cataract epidemiological studies was proposed by the Japanese cooperative cataract epidemiology study group. Cataractous opacities were classified into cortical, nuclear and subcapsular types. Gradings of cataract progression were divided into early (Grade I), moderate (II) and advanced (III) stages. The grading of cortical opacity was judged by the opaque area in a maximally dilated pupillary zone of which findings were obtained from a red-reflex image. The grading of nuclear opacity was judged from the intensity of scattering light at the nucleus. Three grading steps were based on the densitometrical analysis of photographed images. Subcapsular opacities were classified into three gradings by extensions up to the normal, moderately dilated and maximally dilated pupil size.

1.1 BACKGROUND INFORMATION

Cataract is an opacification of the crystalline lens which leads to poor vision and eventually blindness. A cataract is a cloudy area in the lens of the eye that leads to decrease in vision. Cataract often develop slowly and can affect one or both eyes. Cataract is the leading cause of blindness worldwide and is responsible for loss of vision in about 20 million people (world health organization). Cataracts cause half of the cases of blindness and 33% of visual impairment worldwide (Visual impairment and blindness fact sheet, 2014).

Cataracts mostly occur due to aging but it may also occur due to trauma or radiation exposure, be present from birth, or can occur following eye surgery for other problems. Risk factors include diabetes, longstanding use of corticosteroid medication, smoking tobacco, prolonged exposure to sunlight, and alcohol. The underlying mechanism involves accumulation of clumps of protein or yellow-brown pigment in the lens that reduces transmission of light to the retina at the back of the eye. Diagnosis is by an eye examination (Gaikwad et al., 2021).

Prevention includes wearing sunglasses and a wide brimmed hat, eating leafy vegetables and fruits, and avoiding smoking. Early on the symptoms may be improved with glasses. If this does not help, surgery to remove the cloudy lens and replace it with an artificial lens is the only effective treatment. Cataract surgery is not readily available in many countries, and surgery is needed only if the cataracts are causing problems and generally results in an improved quality of life.

About 20 million people worldwide are blind due to cataracts. It is the cause of approximately 5% of blindness in the United States and nearly 60% of blindness in parts of Africa and South America (Khairallah et al., 2015). Blindness from cataracts occurs in about 10 to 40 per 100,000 children in the developing world, and 1 to 4 per 100,000 children in the developed world.

Cataracts become more common with age. In the United States, cataracts occur in 68% of those over the age of 80 years.

In addition, they are more common in women, and less common in Hispanic and Black people.

Cataract is the gradual cloudiness of the transparent ocular lens. It is regarded as a single largest cause of reversible blindness worldwide (Ahsan et al., 2021). The development of cataract is not only genetically determined but also has to do with nutritional status and environmental influences. More blind people exist in developing countries; the majority of them live in the poor rural communities where hospitals and surgical facilities are in great deficit. Blindness from cataract increases as the elderly population increases due to increased longevity (Foster A. Vision 2020). The World Health Organization (WHO) categorizes the outcome of cataract surgeries into 3 groups: good (visual acuity of 6/ 6-6/ 18), borderline (visual acuity of <6/ 18-6/ 60) and poor (visual acuity <6/ 60). It has also recommended and set targets aimed at achieving good uncorrected visual acuity in at least 80% of surgeries and poor in less than 5% and corrected visual acuity of good in 90% of surgeries and poor in less than 5% by 2 months after surgery.

Age-related cataracts are responsible for 51% of world blindness, which represents approximately about 20 million people (Williamson, S., & Seewoodhary, R. 2013). Globally, cataracts cause moderate to severe disability in 53.8 million (2004), 52.2 million of whom are in low- and middle-income countries (Davari et al., 2015).

In many countries, surgical services are inadequate, and cataracts remain the leading cause of blindness. Even where surgical services are available, low vision associated with cataracts may still be prevalent as a result of long waits for, and barriers to, surgery, such as cost, lack of information and transportation problems.

In the United States, age-related lens changes have been reported in 42% between the ages of 52 and 64, 60% between the ages 65 and 74, and 91% between the ages of 75 and 85. Cataracts affect nearly 22 million Americans age 40 and older. By age 80, more than half of all Americans have cataracts. Direct medical costs for cataract treatment are estimated at $6.8 billion annually (Chader, & Taylor, 2013).

In the eastern Mediterranean region, cataracts are responsible for over 51% of blindness. Access to eye care in many countries in this region is limited. Childhood-related cataracts are responsible for 5–20% of world childhood blindness.

A pioneering Russian ophthalmologist Fyodorov was the first in applying the thin lens formula in calculation of intra ocular implant power (IOL). This formula has stood the test of time ever since and forms the basis of IOL power calculation in all subsequent efforts. Implant power can be calculated by knowing three variables. They are; axial length, keratometry, and "A" constant. Axial length is usually measured by applanation A- scan ultrasound, a widely used technique. A rough assessment of axial length of eyeball and cornea curvature can be made clinically. However, a post-operative effective lens position (ELP) cannot be measured, and hence predicted from pre-operative parameters. This prediction introduces the largest source of error and contributes to the majority of refractive surprises post cataract surgery. Sanders-Retzlaff-Kraff I (SRK-I) formula was the most successful linear regression formula at the time. This formula was found adequate for eyes with average axial length between 22 and 24. 5mm. However if axial length was outside the range (especially in long eyes), the formula proved incorrect due to variable ELP in these eyes. The SRK-II formula attempted to ameliorate the predictions by introducing a correction factor for the length of the eye. SRK-II improved predictive power. However, the empirical regression formula was quickly superseded by theoretical formula.

Change in cornea curvature after an incision is continuous until the wound stabilizes; the rate, magnitude and duration of this change have not been quantified for common incision for cataract. The average response of the cornea to an incision is predictable as a function of time after surgery (the time it takes the cataract to heal) and also the type of cataract surgery that is being done. The astigmatism induced after cataract surgery and upon healing tends to totally eliminate the astigmatism or reduces it depending on how long it takes the cataract to heal.

Cataracts can be classified in numerous ways:

According to maturity;

1. Incipient cataract, this is of little significance and can only be seen during slit lamp examination.
2. Immature cataract, where the lens is partially opaque and patient can distinguish letters at lines better than 20)200.
3. Mature cataract; where all the lens protein is completely opaque, patient cannot read better than 20)200.
4. Hypermature cataract; here there is a shrunken anterior capsule due to leakage of lens proteins. Patients generally see worse than count fingers or hand motion.
5. Morgagnian cataract; is a hypermature cataract in which total liquefaction of the cortex has allowed the nucleus to sink inferiorly in the capsular bag.

According to location;

1. Nuclear sclerosis or nuclear cataract; this develops in the centre of the lens and can induce myopia. Here some elderly patients may be able to read again without spectacles

(second sight). It is characterized by a yellowish hue in its early days, but advanced stages present with a brown colour (brunescent cataract).

2. Cortical cataracts; these are wedge shaped opacities formed in the anterior, posterior or equatorial cortex of the lens. These opacities cause light scatter and the patients usually complain of glare.
3. Posterior subcapsular cataracts; lie in front of the lens capsule and manifest as grain like appearance. It has more profound effect on vision due to its location on the nodal part of the eye. Patients are particularly troubled under conditions of miosis.

Other classifications include;

1. Congenital cataract; detected in newborns, are large dense cataracts that usually presents as leukocoria (white pupil). Not all congenital cataract affect vision.
2. Acquired cataract; it may be unilateral or bilateral and occurs later in life and may be due to trauma, diabetes, drugs or infections.

ETIOLOGY

The following can cause cataract;

1. Trauma; either blunt or penetrating.
2. Drugs e.g. steroids, amiodarone etc.
3. Diabetes mellitus.
4. Angle closure glaucoma.
5. Pathological myopia.
6. Hereditary diseases.
7. Ultraviolet light exposure.
8. Cigarette (tobacco) smoke.

Symptoms of cataract include;

1. Decreased visual acuity.
2. Glare
3. Myopic shift.
4. Monocular diplopia.
5. Cloudy vision.

MANAGEMENT OF CATARACTS

1. Spectacle lens; these are adequate for patients with incipient cataracts, but patients with posterior subcapsular cataracts will benefit from photochromic lenses because this will aid to reduce glare.
2. Surgical techniques; these include intracapsular cataract extraction, extracapsular cataract extraction, phacoemulsification.

Phacoemulsification is the commonly used as the others are old method of cataract removal. In phacoemulsification, the lens nucleus is extracted through an opening in the anterior capsule and an ultrasonically driven needle is used to fragment the nucleus, the lens substrate is then aspirated through a needle port via a small limbal or scleral incision. IOL is used in combination with each of these techniques.

ASTIGMATISM

Astigmatism is a type of refractive error wherein the refraction varies in the different meridians. Consequently, the rays of light entering in the eye cannot converge to a point focus but form focal lines. Broadly, there are two types of astigmatism: regular and irregular.

Regular astigmatism

The astigmatism is regular when the refractive power changes uniformly from one meridian to another (i.e., there are two principal meridians).

Etiology

1. Corneal astigmatism is the result of abnormalities of curvature of cornea. It constitutes the most common cause of astigmatism.
2. Lenticular astigmatism is rare. It may be:
    a. Curvature due to abnormalities of curvature of lens as seen in lenticonus.
    b. Positional due to tilting or oblique placement of lens as seen in subluxation.
    c. Index astigmatism; this may occur rarely due to variable refractive index of lens in different meridians.
3. Retinal astigmatism due to oblique placement of macula may also be seen occasionally.

Depending upon the axis and the angle between the two principal meridians, regular astigmatism can be classified into the following types:

With-the-rule astigmatism. In this type the two principal meridians are placed at right angles to one another but the vertical meridian is more curved than the horizontal.

Against-the-rule astigmatism. refers to an astigmatic condition in which the horizontal meridian is more curved than the vertical meridian.

Oblique astigmatism. is a type of regular astigmatism where the two principal meridians are not the horizontal and vertical though these are at right angles to one another (e.g., 45° and 135°).

Bi oblique astigmatism. In this type of regular astigmatism, the two principal meridians are not at right angle to each other e.g., one may be at 30° and other at 100°.

Depending upon the position of the two focal lines in relation to retina, the regular astigmatism is further classified into three types:

Simple astigmatism. wherein the rays are focused on the retina in one meridian and either in front (simple myopic astigmatism) or behind (simple hyperopic astigmatism) the retina in the other meridian

Compound astigmatism. In this type the rays of light in both the meridians are focused either in front (compound myopic) or behind (compound hyperopic) the retina.

Mixed astigmatism refers to a condition where the light rays in one meridian are focused in front and in another meridian behind the retina. Thus, in one meridian eye is myopic and in another hyperopic.

Symptoms of regular astigmatism include: defective vision, blurring of objects, objects appear distorted, asthenopic symptoms, these consist of a dull ache in the eyes, headache, early tiredness of eyes and sometimes nausea and even drowsiness.

Signs include;

1. Different power in two meridians revealed on refraction.
2. An oval or tilted optic disc may be observed on ophthalmoscopy in patients with high astigmatism.
3. Head tilt. The astigmatic patients may (very exceptionally) develop a torticollis in an attempt to bring their axes nearer to the horizontal or vertical meridians.

Treatment

Optical treatment of regular astigmatism comprises the prescribing appropriate spectacle cylindrical lens correction.

Contact lenses. Rigid contact lenses may correct up to 2-3 of regular astigmatism, while soft contact lenses can correct only little astigmatism. For higher degrees of astigmatism toric contact lenses are needed.

Irregular astigmatism

In this type, the principal meridians are not perpendicular to one another.

Etiology

1. Curvature astigmatism is found in patients with extensive corneal scars or keratoconus.
2. Index irregular astigmatism due to different refractive index in different parts of the crystalline lens.

Symptoms of irregular astigmatism include: Defective vision, distortion of objects, and polyopia.

Treatment

1. Optical treatment of irregular astigmatism consists of contact lens which replaces the anterior surface of the cornea for refraction.
2. Phototherapeutic keratectomy (PTK) performed with excimer laser may be helpful in patients with superficial corneal scar responsible for irregular astigmatism.

1.2 STATEMENT OF PROBLEM

The visual outcome after cataract extraction/surgery is usually less than 90% for best corrected visual acuity. There is need for biometry in order to improve visual outcome post operatively.

1.3 AIM AND OBJECTIVES

1.3.1 Aim of the Study

To determine the variations that exist (in terms of cornea curvature) before and after cataract surgery using autorefractor.

1.3.2 Objectives of the Study

1. To ascertain how significant the cornea astigmatism changes are after cataract surgery.
2. To determine the variation that exist between keratometric readings/cornea astigmatism in male and female adults between the ages of 35-98 years.
3. To determine the significant difference in cornea astigmatism before and after cataract surgery.
4. To determine the relationship that exist in male and female in terms of k-values in one week and four weeks after surgery.

1.4 HYPOTHESIS

1.4.1 Null Hypothesis

There is no significant variation in keratometric reading using autorefractor before and after cataract surgery.

1.4.2 Alternate Hypothesis

There is significant variation in keratometry reading using autorefractor before and after cataract surgery.

1.5 SIGNIFICANCE OF STUDY

1. This study will help eye care practitioners to make better biometric assessment, both for cataract and non-cataract patient.
2. This study will help eye surgeons to know the best point of incision during cataract surgery to minimize significant cornea astigmatism.
3. It will also add to preexisting knowledge on the variation in keratometric reading before and after cataract surgery.
4. To reduce phobia associated with cataract surgeries.

1.6 DEFINITION OF TERMS

Visual acuity (VA); the measurement of the threshold of discrimination of two spatially separated targets (Khurana, 2012).

• Cataract- Cataract is the gradual cloudiness of the transparent ocular lens. (Ahsan, et al., 2021)

• Cataract surgery- also called lens replacement surgery, is the removal of the natural lens of the eye (crystalline lens) that has developed an opacification, which is referred to as a cataract and its replacement with an intraocular lens.

CHAPTER TWO

LITERATURE REVIEW

Olsen, (2007) stated that a 0.1 mm error in keratometric values corresponds to a refractive error of about 0.57 D in the spectacle plan. He stated that an unprecise keratometric readings may influence the preoperative IOL calculations and that the three main sources of IOL power prediction errors are; incorrect measurements of axial length (AL), corneal power (keratometric values) and estimation of postoperative anterior chamber depth (ACD) accounting for 36%, 22% and 42% of the errors, respectively.

Addisu and Solomon, (2007) stated that the expectations from patients undergoing cataract surgery have changed during the past 20 years. Previously, a postoperatively improved corrected visual acuity was accepted. Today, cataract surgery is also a refractive procedure and many patients expect spectacle independence as well as improved visual acuity. Patient's satisfaction for a given treatment is an important clinical outcome because a satisfied patient is more likely to comply with treatments, attend follow-ups and advocate the service to others. Therefore, knowing patients' expectations before a planned procedure or treatment and the actual level of satisfaction and fulfillment of their initial expectations thereafter is much helpful.

Roh et al. (2015) stated the means of detecting irregular astigmatism was diagnosed with scissors movement on retinoscopy and/or deformation of the mires during manual keratometry. Keratometry provides information on corneal image forming properties, such as corneal astigmatism. They emphasized on the importance of assessment of cornea curvature and reproducibility of data gotten. Keratometry is a very important procedure in determining the precise estimation of cornea power and astigmatism

Alpins *et al.* (2015) noted that the fundamental concept underpinning the vectorial analysis of astigmatism are straight forward and intuitive, easily understood by employing a simple golf-putting analogy. The Alpins methodology utilizes three principal vectors and the various ratios between them to provide an aggregate analysis for astigmatic change with parallel indices for spherical correction. A comparative analysis employing both arithmetic and vectorial means together with necessary nomogram adjustments for refining both spherical and astigmatic treatments can also be derived. These advanced techniques together with suitability for statistically analysis, comprehensively addresses the outcome analysis requirement of the entire corneal and the eye refractive correction for the purpose of examining success in cataract and refractive surgery.

Kamiya *et al.* (2012) demonstrated from the clinical and optical viewpoints that corneal or refractive astigmatism does not significantly contribute to apparent accommodation after cataract surgery. They therefore suggested that it may be of less significance that the astigmatism is consciously retained in consideration of this accommodation in astigmatic eyes. Surgically induced astigmatism (SIA) may contribute to postoperative patient dissatisfaction, especially with multifocal implants.

Stanley *et al.,* (2022) carried out a study on the Visual outcome of cataract surgery from a free outreach camp among rural areas of Southern-Kaduna, Nigeria. The objectives of the study were to assess the visual outcome of those who underwent free cataract surgery in southern senatorial zone of Kaduna State between September and November 2018, and to identify the causes of poor visual outcome (Visual acuity [VA] <6/60 Post operatively), suggest ways of improving it and comparing findings of this study with other studies.

Srivannaboon *et Al*., (2019) carried out a study to compare the refractive outcomes following cataract surgery using conventional keratometry (K) and total keratometry (TK) for intraocular lens (IOL) calculation in the SRK/T, HofferQ, Haigis, and Holladay 1 and 2, as well as Barrett and Barrett TK Universal II formulas. Sixty eyes of sixty patients from Siriraj Hospital, Thailand, were prospectively enrolled in this comparative study. Eyes were assessed using a swept-source optical biometer (IOLMaster 700; Carl Zeiss Meditec, Jena, Germany). Posterior keratometry, K, TK, central corneal thickness, anterior chamber depth, lens thickness, axial length, and white-to-white corneal diameter were recorded. Emmetropic IOL power was calculated using K and TK in all formulas. Selected IOL power and predicted refractive outcomes were recorded. Postoperative manifest refraction was measured 3 months postoperatively. Mean absolute errors (MAEs), median absolute errors (MedAEs), and percentage of eyes within ± 0.25, ± 0.50, and ± 1.00 D of predicted refraction were calculated for all formulas in both groups. The results showed that the mean difference between K and TK was 0.03 D (44.56 ± 1.18 vs. 44.59 ± 1.22 D), showed excellent agreement (ICC = 0.99, all $p < 0.001$). Emmetropic IOL powers in all formulas for both groups was very similar, with a trend toward lower MAEs and MedAEs for TK when compared with K. The Barrett TK Universal II formula demonstrated the lowest MAEs. Proportion of eyes within ± 0.25, ± 0.50, and ± 1.00 D of predicted refraction were slightly higher in the TK group. In conclusion, conventional K and TK for IOL calculation showed strong agreement with a trend toward better refractive outcomes using TK. The same IOL constant can be used for both K and TK.

Tansu *et al*., (2012) carried out a study to compare the keratometric values measured by the automated keratometer, two Placido-based computerized topography systems (Dicon CT 200 [Vismed Inc] and Allegro Topolyzer [WaveLight Inc]), and Scheimpflug analysis (Pentacam

[Oculus Optikgeräte GmbH]). The keratometric data of 200 eyes from 200 patients evaluated for refractive surgery were reviewed retrospectively. Mean simulated keratometry (Sim K) and mean corneal astigmatism measured by the four devices were compared using repeated measures analysis of variance with Bonferroni correction. The analysis of agreement between two measurements was assessed using the method of Bland and Altman. The results showed a mean Sim K as measured by the automated keratometer, Dicon CT 200, Allegro Topolyzer, and Pentacam was 43.39±1.50 diopters (D), 43.55±1.50 D, 43.45±1.50 D, and 43.43±1.45 D, respectively. The Dicon CT 200 measured the mean Sim K to be steeper and the automated keratometer measured the mean Sim K to be flatter than the other devices. Significant differences in corneal astigmatism were noted among the four devices except Dicon CT 200 versus Allegro Topolyzer and Allegro Topolyzer versus Pentacam comparisons ($P<.013$). For mean Sim K, the 95% limits of agreement between the Pentacam and other three devices were significantly wider than the other comparisons. In Bland-Altman plots comparing the Pentacam to the other devices, extreme outliers were present in 11 (5.5%) eyes. It was concluded that because of the wide distribution range and presence of extreme outliers, Pentacam data should be used cautiously in IOL power calculation and astigmatic keratotomy procedures.

D Rex Hamilton and David R Hardten (2003) stated that as the number and types of keratorefractive procedures increase and as the baby boomer population moves into the "cataractous decades," the number of patients requiring cataract surgery following refractive surgery grows larger each year. While technological advances in surgical instrumentation and intraocular lens (IOL) design allow us to perform cleaner, faster, and more reliable cataract extractions, the ultimate postoperative refraction depends primarily on calculations performed before surgery. Third-generation IOL formulas (e.g., Haigis, Hoffer Q, Holladay 2, or SRK/T) provide outstanding accuracy when used for eyes with physiologic, prolate corneas. In addition, most instruments used today for measuring corneal curvature and power were designed before the era of refractive surgery. These formulas and instruments make assumptions about the anatomy and refractive properties of the cornea that are no longer valid following most keratorefractive procedures. These breakdowns in IOL calculation often result in a “refractive surprise” after cataract surgery, which may require subsequent surgical correction.

CHAPTER THREE

METHODOLOGY

3.1: RESEARCH DESIGN

This is a prospective, cross sectional research study.

3.2: SAMPLING TECHNIQUE

A convenient sampling technique was used.

3.3: STUDY POPULATION

The study consisted of cataract patient within the ages of 35-98 years of age who fulfill the inclusion criteria. A total number of 100 patient was seen.

3.3.1: Study Location

The study was carried out at St Teresa's Specialist and Laser Eye Centre, Benin- city, Edo state.

3.3.2: Study Location

The study was carried out within the period of three (4) months. (November-February)

3.3.3: Sample Size

A sample size of 100 cataract patient was used.

3.4: STUDY MATERIALS

Auto refractor keratometer (RM 9000)

Visual acuity chart

Slit lamp biomicroscope

Retinoscope

Ophthalmoscope

3.5: DESCRIPTION OF PROCEDURE

Ethical clearance was obtained from the ethical committee in the University of Benin, and approved consent from St Teresa's Specialist and Laser Eye Centre Benin City, Edo State. Convenient sampling technique was used to get the number of participants for the study.

A keratometer measures the curvature of the anterior cornea surface based on the power of the reflecting surface. It does this by measuring the size of image reflected from two paracentral point and utilizes doubling prism to stabilize the image enabling a more accurate focusing.

Cornea curvature determines the power of the cornea. Difference in power across the cornea (opposite meridian) results in astigmatism therefore keratometer measure astigmatism.

K readings was used to calculate intra-ocular lens (IOL)power. Flat meridian is the vertical meridian (K1) while the steep meridian is the horizontal meridian (K2).

Patients who had cataract was selected with informed written consent to undergo cataract surgery, as well as for participating in the study was taken.

Keratometry reading was measured using autorefractor prior to the surgery and at various intervals (one week and one month) after the surgery.

Biometry was done with keratometric values using auto refractor for each patient.

All cases had at least 2 consistent keratometry measurements. Any eyes that developed any complications after the surgery was excluded. Keratometry values was recorded at intervals on the first and fourth week (one month).

At each time interval, the pre-operative horizontal keratometry reading was subtracted from the post-operative horizontal keratometry reading, and similarly for the vertical keratometry. A positive result indicated that the meridian has steepened and a negative result indicated that the meridian has become flatter. Mean change on each meridian was computed for each post-operative time.

3.5.1 Inclusion Criteria

1. Cataract patient that was scheduled for cataract surgery within the study duration.
2. Cataract patient between the ages of 38-98 years.
3. Uncomplicated cataract surgery procedure

3.5.2 Exclusion Criteria

1. Cataract patient below 35 years.

3.6: STATISTICAL ANALYSIS

The data collected was analyzed using the statistical package for social sciences (SPSS) version 22.0. Descriptive statistics (frequencies, percentages, mean and standard deviation) was used to summarize the variables. Continuous variables were expressed as the mean ± standard deviation for those that displayed normal distribution. Association between the categorical parameters was analyzed using the Pearson correlation (X2) test. The p-values less than 0.05 was considered statistically significant.

3.7: LIMITATIONS OF THE STUDY

1. Inability of patients to show up on their scheduled appointment date.

CHAPTER FOUR

RESULTS

Table 4.1: Gender Distributions and Descriptive Statistics of Subjects.

	Gender		
Age group	Male	Female	Total
31-40	1	0	1
41-50	0	1	1
51-60	13	8	21
61-70	17	22	39
71-80	13	13	26
81-90	5	5	10
91-100	1	1	2
Total	50	50	100

Table 4.1: Shows the gender distribution and descriptive statistics of participants age are summarized in Table 1. There was a total of 100 participant used in this study. They comprise of 50 males and 50 females.

Table 4.2: Age distribution of subjects.

Age group	Frequency	Percent	Valid Percent	Cumulative Percent
31-40	1	1.0	1.0	1.0
41-50	1	1.0	1.0	2.0
51-60	21	21.0	21.0	23.0
61-70	39	39.0	39.0	62.0
71-80	26	26.0	26.0	88.0
81-90	10	10.0	10.0	98.0
91-100	2	2.0	2.0	100.0
Total	100	100.0	100.0	

Table 4.2: Shows the most predominant age group was 61 – 70 years with frequency of 39 (39.0%), followed by 71 – 80 years age group with frequency of 26 (26.0%) while the least age group was 31 – 40 years with frequency of 1 (1.0%).

Table 4.3: Variation in terms of cornea astigmatism (CA) before surgery, one and four weeks after surgery.

Variables	CA before Mean±SE	CA One Week After Mean±SE	CA Four Weeks After Mean±SE
CA Before		-0.085±0.104 (p=0.412)	-0.328±0.124 (p=0.010)
CA One Week After	0.085±0.104 (p=0.412)		-0.242±0.089(p=0.008)
CA Four Weeks After	0.328±0.124 (p=0.010)	0.242±0.089(p=0.008)	

(Mean difference, SE=standard error), $p<0.05$

Table 4.3.1: **Distribution of cornea astigmatism values (CA) before surgery among participant.**

CA	Frequency	Percent	Valid Percent	Cumulative Percent
< -1.00	40	40.0	40.0	40.0
-1.01 to -2.00	39	39.0	39.0	79.0
-2.01 to -3.00	11	11.0	11.0	90.0
-3.01 to -4.00	6	6.0	6.0	96.0
-4.01 to -5.00	2	2.0	2.0	98.0
> -5.01	2	2.0	2.0	100.0
Total	100	100.0	100.0	

Table 4.3.1: Shows the frequency distribution and percentage of cornea astigmatism values (CA) before surgery among participant with the highest frequency of 40% <-1.00 and lowest frequency of 2% > -5.01.

Figure 4.3.1: Distribution of study sample according to cornea astigmatism before surgery.

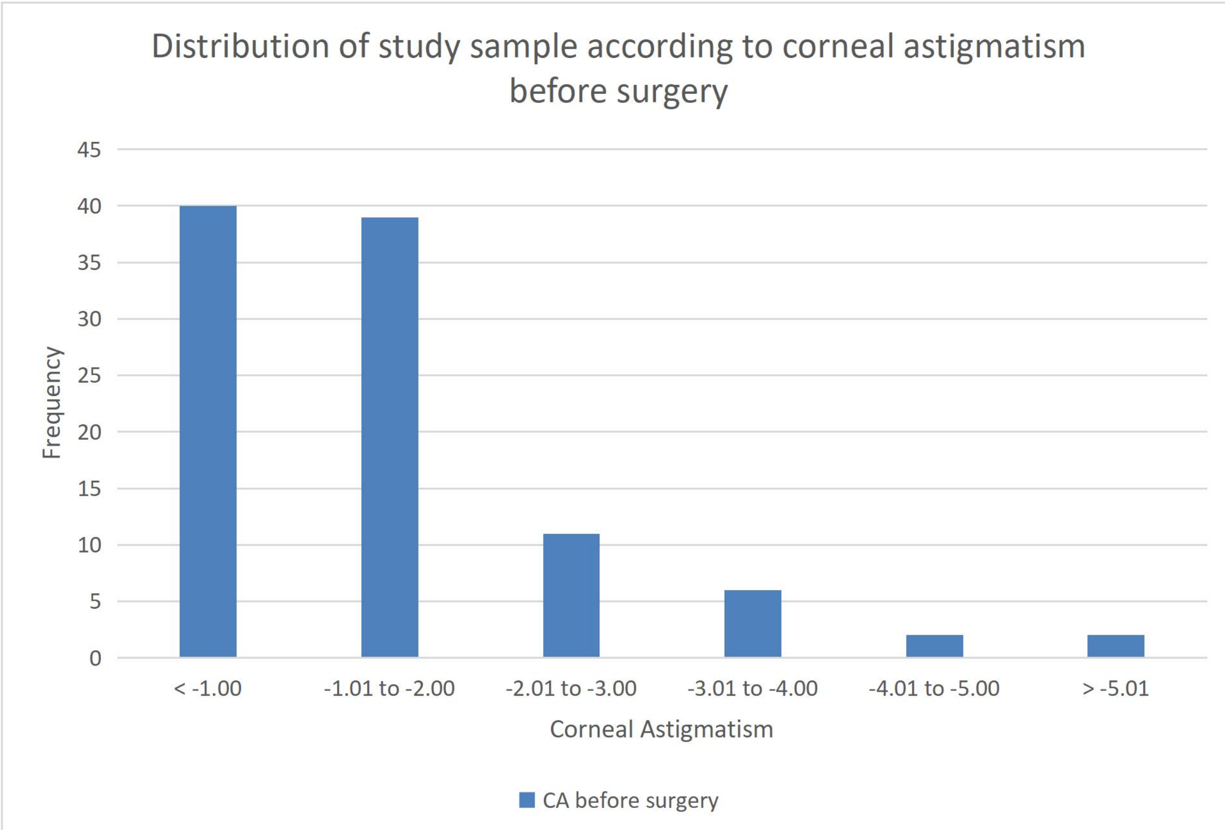

Table 4.3.1: Shows the frequency distribution of CA among participants with about 40% participants have the lowest CA of < -1.0 and about 2% having the highest CA of > -5.01.

Table 4.3.2: Distribution of cornea astigmatism values (CA) one week after surgery among participant.

CA	Frequency	Percent	Valid Percent	Cumulative Percent
< -1.00	36	36.0	36.0	36.0
-1.01 to -2.00	36	36.0	36.0	72.0
-2.01 to -3.00	19	19.0	19.0	91.0
-3.01 to -4.00	4	4.0	4.0	95.0
-4.01 to -5.00	3	3.0	3.0	98.0
> -5.01	2	2.0	2.0	100.0
Total	100	100.0	100.0	

Table 4.3.2: Shows the frequency distribution and percentage of cornea astigmatism values (CA) one week after surgery among participant with the highest frequency of 36% <-1.00 and lowest frequency of 2% > -5.01.

Table 4.3.3: Distribution of cornea astigmatism values (CA) four weeks after surgery among participant.

CA	Frequency	Percent	Valid Percent	Cumulative Percent
< -1.00	29	29.0	29.0	29.0
-1.01 to -2.00	32	32.0	32.0	61.0
-2.01 to -3.00	22	22.0	22.0	83.0
-3.01 to -4.00	10	10.0	10.0	93.0
-4.01 to -5.00	3	3.0	3.0	96.0
> -5.01	4	4.0	4.0	100.0
Total	100	100.0	100.0	

Table 4.3.3: Shows the frequency distribution and percentage of cornea astigmatism values (CA) four week after surgery among participant with the highest frequency of 29% <-1.00 and lowest frequency of 4% > -5.01.

Table 4.3.4: Distribution of cornea astigmatism (CA) before surgery, one week and four weeks after surgery.

	CA before surgery	CA One Week	CA four weeks
< -1.00	40.0	36.0	29.0
-1.01 to -2.00	39.0	36.0	32.0
-2.01 to -3.00	11.0	19.0	22.0
-3.01 to -4.00	6.0	4.0	10.0
-4.01 to -5.00	2.0	3.0	3.0
> -5.01	2.0	2.0	4.0

Table 4.3.4: Shows the frequency distribution and percentage of cornea astigmatism values (CA) before the surgery, one week and four weeks after surgery among participant with the highest frequency of 40%, 36% and 29% <-1.00 respectively and lowest frequency of 2%,2% and 4% > -5.01 respectively.

Figure 4.3.4: Distribution of study sample according to cornea astigmatism before surgery,one week and four weeks after surgery.

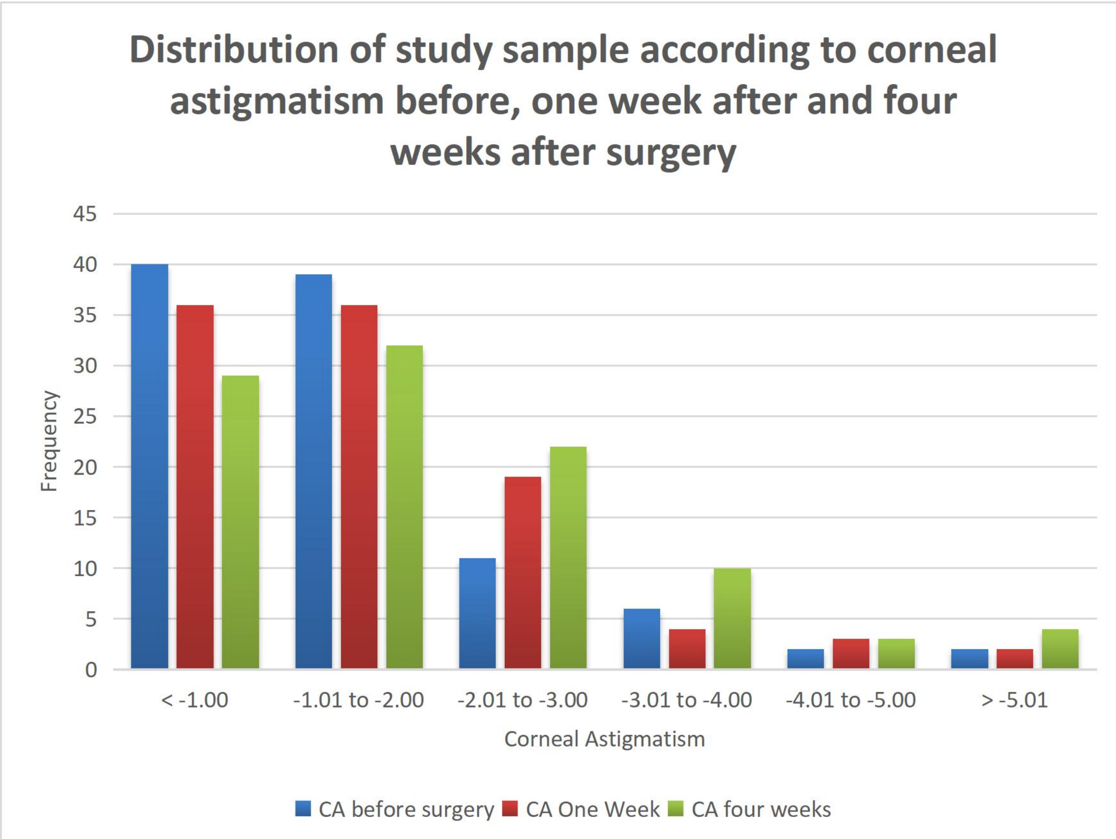

Figure 4.3.4: Shows the frequency distribution and percentage of cornea astigmatism values (CA) before the surgery, one week and four weeks after surgery among participant with the highest frequency of 40%, 36% and 29% <-1.00 respectively and lowest frequency of 2%,2% and 4% > -5.01 respectively.

Table 4.4: Variation in keratometric reading (Steep meridian, K2) before surgery, one and four weeks after cataract surgery.

Variables	K2 Before Surgery Mean±SE	K2 One Week After Mean±SE	K2 Four Weeks After Mean±SE
K2 Before Surgery		0.178±0.084(p<0.036)	1.757±0.102(p<0.001)
K2 One Week After	-0.178±0.084(p<0.001)		1.579±0.062(p<0.001)
K2 Four Weeks After	-1.757±0.102(p<0.001)	-1.579±0.062(p<0.001)	

(Mean difference, SE=standard error), $p<0.05$

Table 4.4.1: Distribution of keratometric values (K2) before surgery among participants.

K2	Frequency	Percent	Valid Percent	Cumulative Percent
<41.50	6	6.0	6.0	6.0
41.51-42.51	6	6.0	6.0	12.0
42.52-43.52	20	20.0	20.0	32.0
43.53-44.53	21	21.0	21.0	53.0
44.54-45.54	26	26.0	26.0	79.0
>45.55	21	21.0	21.0	100.0
Total	100	100.0	100.0	

Table 4.4.1: Shows the frequency distribution and percentage of K2 values before surgery among participant with the highest frequency of 21% >45.55 and lowest frequency of 6% <41.50.

Figure 4.4.1: Distribution of study sample according to K2 values before surgery.

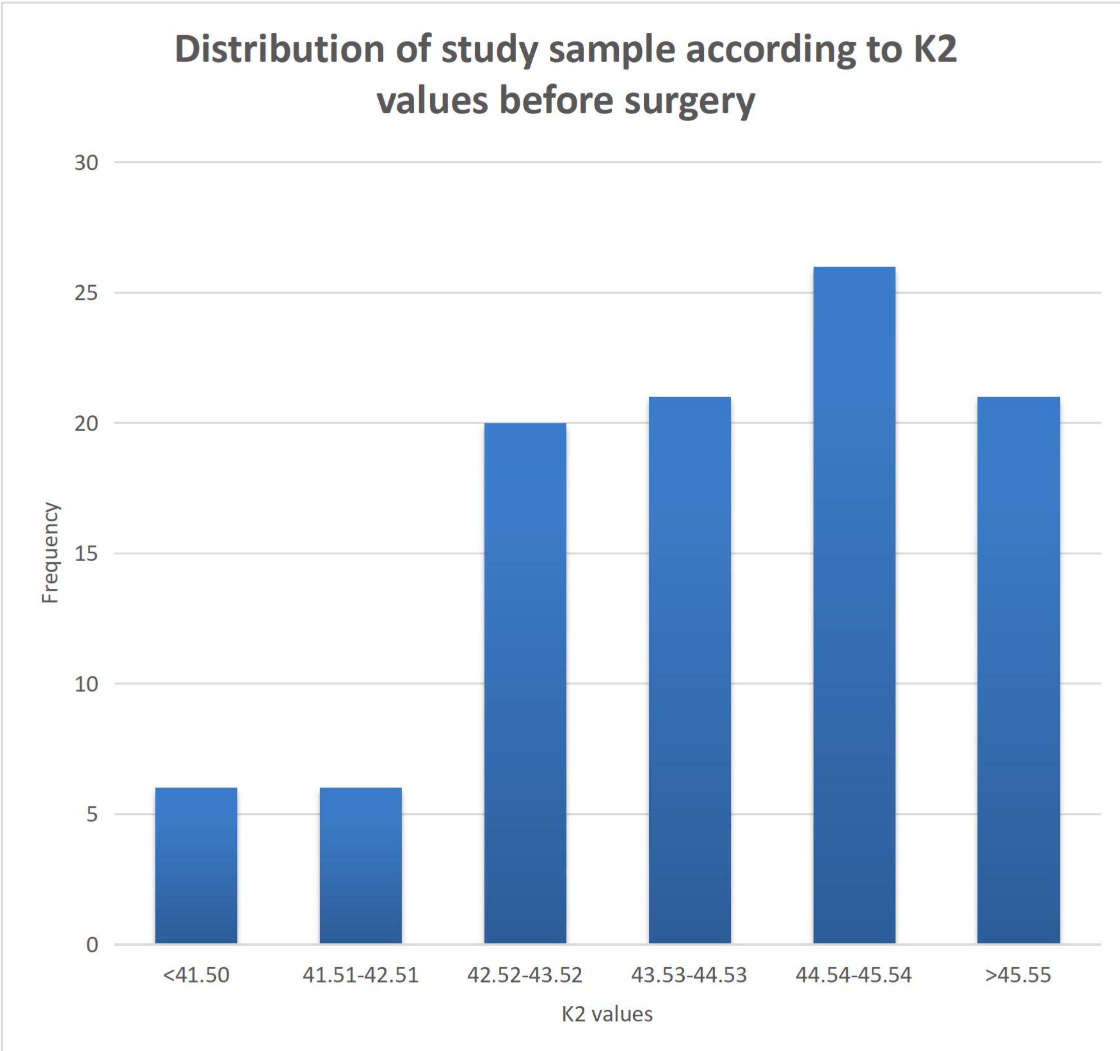

Table 4.4.1: Shows the frequency distribution of K2 values among participants with about 26% participants have the highest K2 values of 44.54-45.54 and about 6% having the lowest K2 values of <41.50.

Table 4.4.2: Distribution of keratometric values (K2) one week after surgery among participants.

K2	Frequency	Percent	Valid Percent	Cumulative Percent
<41.50	5	5.0	5.0	5.0
41.51-42.51	12	12.0	12.0	17.0
42.52-43.52	20	20.0	20.0	37.0
43.53-44.53	20	20.0	20.0	57.0
44.54-45.54	25	25.0	25.0	82.0
>45.55	18	18.0	18.0	100.0
Total	100	100.0	100.0	

Table 4.4.2: Shows the frequency distribution and percentage of K2 values one week after surgery among participant with the highest frequency of 18% >45.55 and lowest frequency of 5% <41.50.

Table 4.4.3: Distribution of keratometric values (K2) four weeks after surgery among participants.

K2	Frequency	Percent	Valid Percent	Cumulative Percent
<41.50	27	27.0	27.0	27.0
41.51-42.51	21	21.0	21.0	48.0
42.52-43.52	28	28.0	28.0	76.0
43.53-44.53	16	16.0	16.0	92.0
44.54-45.54	5	5.0	5.0	97.0
>45.55	3	3.0	3.0	100.0
Total	100	100.0	100.0	

Table 4.4.3: Shows the frequency distribution and percentage of K2 values four weeks after surgery among participant with the highest frequency of 27% <41.50 and lowest frequency of 3% >45.55.

Table 4.4.4: Distribution of keratometric readings (K2) before surgery, one week and four weeks after surgery.

	K2 Before	K2 After One Week	K2 After Four Weeks
<41.50	6.0	5.0	27.0
41.51-42.51	6.0	12.0	21.0
42.52-43.52	20.0	20.0	28.0
43.53-44.53	21.0	20.0	16.0
44.54-45.54	26.0	25.0	5.0
>45.55	21.0	18.0	3.0

Table 4.4.4: Shows the frequency distribution and percentage K2 values before the surgery, one week and four weeks after surgery among participant with the highest frequency of 26%, 25% and 28% respectively and lowest frequency of 6%,5% and 3%. respectively.

Figure 4.4.4: Distribution of study samples according to K2 values before surgery, one week and four weeks after surgery.

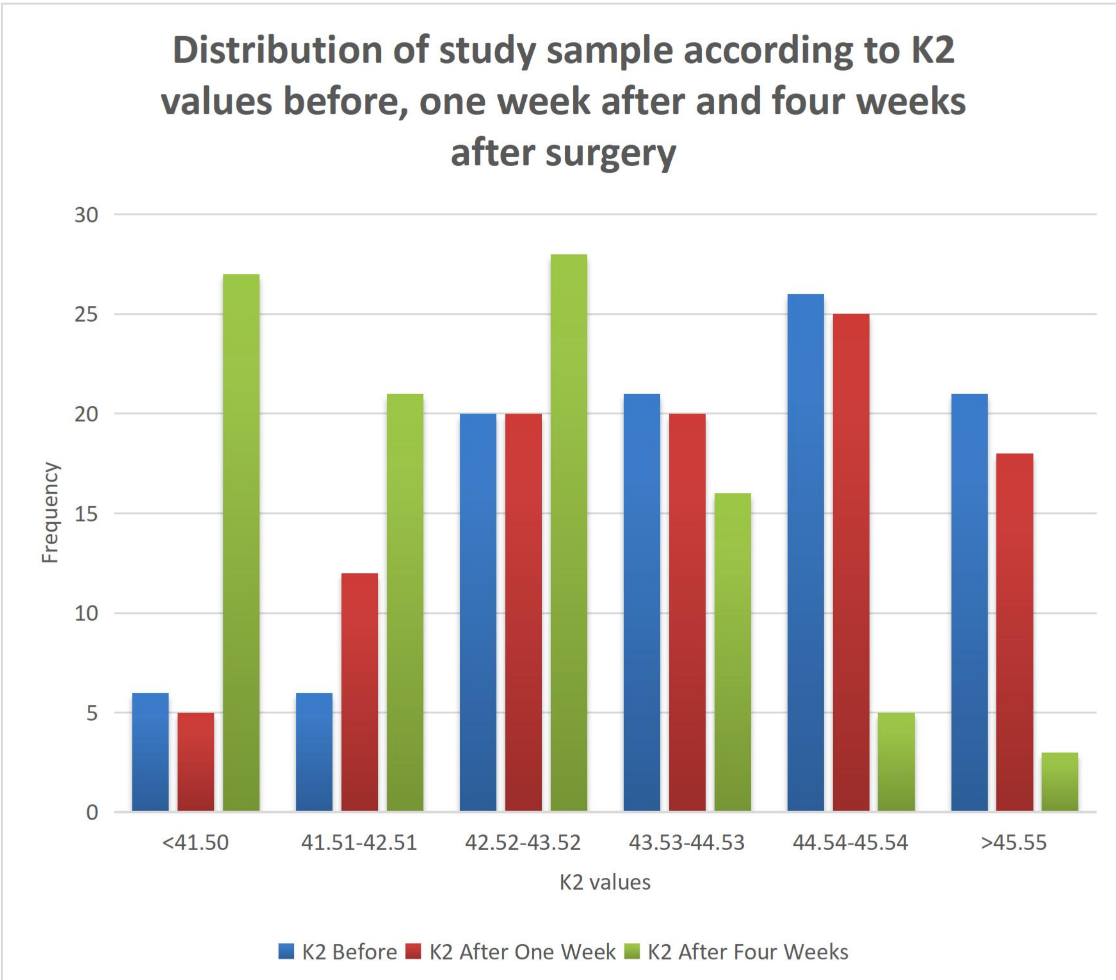

Figure 4.4.4: Shows the frequency distribution and percentage K2 values before the surgery, one week and four weeks after surgery among participant with the highest frequency of 26%, 25% and 28% respectively and lowest frequency of 6%,5% and 3%. respectively.

Table 4.5: Variations in keratometric reading (flat meridian, K1) before cataract surgery, one and four weeks after cataract surgery.

Variables	K1 Before Mean±SE	K1 One Week Mean±SE	K1 Four Weeks Mean±SE
K1 Before		0.263±0.071(p<0.001)	2.084±0.076(p<0.001)
K1 One Week	-0.263±0.071(p<0.001)		1.821±0.064(p<0.001)
K1 Four Weeks	-2.084±0.076(p<0.001)	-1.821±0.064(p<0.001)	

(Mean difference, SE=standard error), $p<0.05$

Table 4.5.1: Distribution of keratometric values (K1) before surgery among participants.

K1	Frequency	Percent	Valid Percent	Cumulative Percent
<41.50	23	23.0	23.0	23.0
41.51-42.51	20	20.0	20.0	43.0
42.52-43.52	21	21.0	21.0	64.0
>43.53	36	36.0	36.0	100.0
Total	100	100.0	100.0	

Table 4.5.1: Shows the frequency distribution and percentage of K1 values before surgery among participant with the highest frequency of 36% >43.53 and lowest frequency of 20% 41.51-42.51.

Figure 4.5.1: Distribution of study sample according to K1 values before surgery.

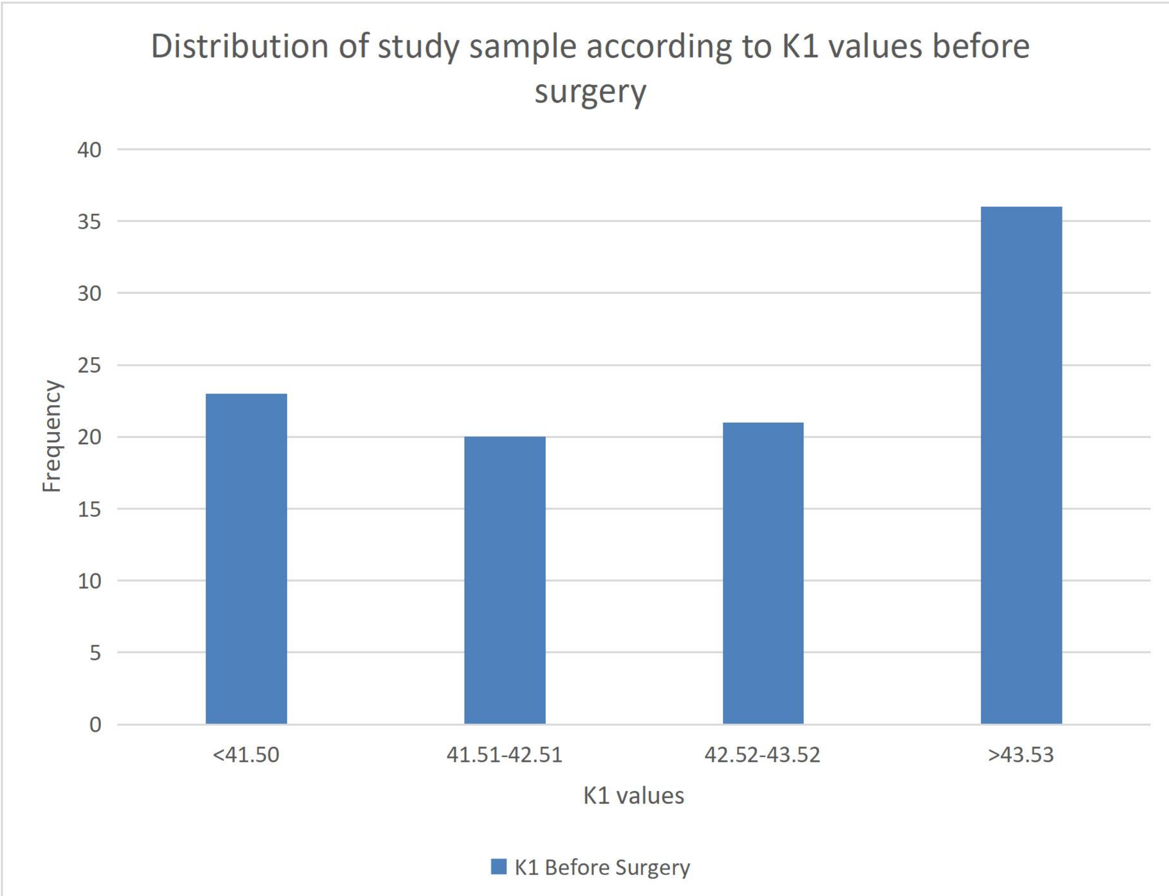

Table 4.5.1: Shows the frequency distribution of K1 values among participants with about 36% participants have the highest K1 values of >43.53 and about 20% having the lowest K1 values of <41.50.

Table 4.5.2: Distribution of keratometric values (K1) one week after surgery among participants.

K1	Frequency	Percent	Valid Percent	Cumulative Percent
<41.50	26	26.0	26.0	26.0
41.51-42.51	25	25.0	25.0	51.0
42.52-43.52	19	19.0	19.0	70.0
>43.53	30	30.0	30.0	100.0
Total	100	100.0	100.0	

Table 4.5.2: Shows the frequency distribution and percentage of K1 values one week after surgery among participant with the highest frequency of 30% >43.53 and lowest frequency of 19% 42.52-43.52.

Table 4.5.3 Distribution of keratometric values (K1) four weeks after surgery among participants.

K1	Frequency	Percent	Valid Percent	Cumulative Percent
<41.50	67	67.0	67.0	67.0
41.51-42.51	18	18.0	18.0	85.0
42.52-43.52	11	11.0	11.0	96.0
>43.53	4	4.0	4.0	100.0
Total	100	100.0	100.0	

Table 4.5.3: Shows the frequency distribution and percentage of K1 values four weeks after surgery among participant with the highest frequency of 67% <41.50 and lowest frequency of 4% >43.53.

Table 4.5.4: Distribution of keratometric readings (K1) before surgery, one week and four weeks after surgery.

	K1 Before Surgery	K1 One Week After	K1 Four Weeks After
<41.50	23.0	26.0	67.0
41.51-42.51	20.0	25.0	18.0
42.52-43.52	21.0	19.0	11.0
>43.53	36.0	30.0	4.0

Table 4.5.4: Shows the frequency distribution and percentage K1 values before the surgery, one week and four weeks after surgery among participant with the highest frequency of 36%, 30% and 67% respectively and lowest frequency of 20%,19% and 4%. respectively.

Figure 4.5.4: Distribution of study sample according to K1 values before surgery, one week and four weeks after surgery.

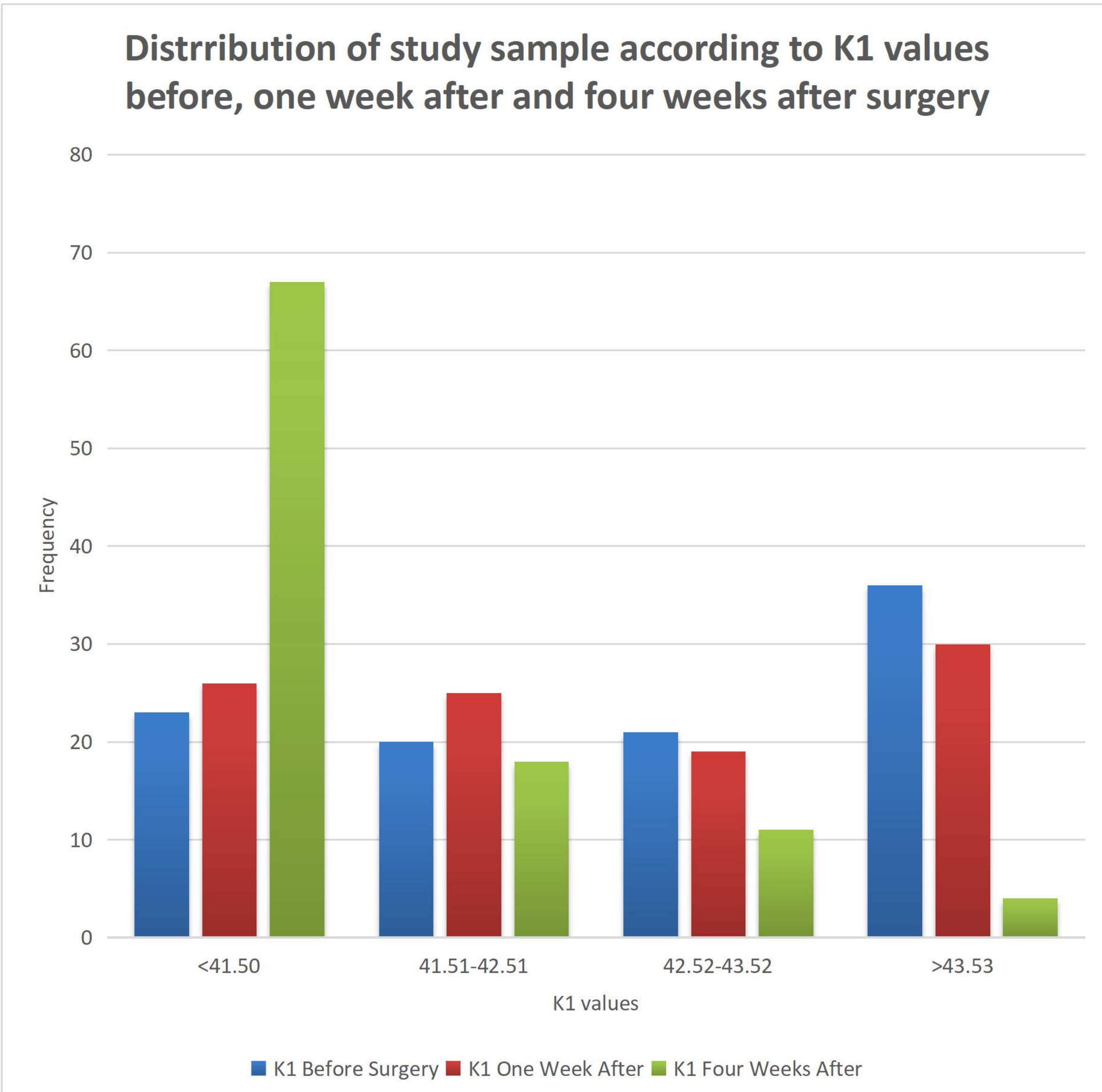

Figure 4.5.4: Shows the frequency distribution and percentage K1 values before the surgery, one week and four weeks after surgery among participant with the highest frequency of 36%, 30% and 67% respectively and lowest frequency of 20%,19% and 4%. respectively.

Table 4.6: Descriptive Statistics values K1 before cataract surgery, one and four weeks after cataract surgery.

	Mean	Std. Deviation	N
K1_Before	42.7293	1.85050	100
K1_After1	42.4661	1.90495	100
K1_After4	40.6448	1.87331	100

Table 4.6: Shows the descriptive statistics value of K1 mean and standard deviation before surgery, one week and four weeks after surgery.

Table 4.7: Descriptive Statistics values K2 before cataract surgery, one and four weeks after cataract surgery.

	Mean	Std. Deviation	N
K2_Before	44.3172	1.78640	100
K2_After2	44.1395	1.78096	100
K2_After4	42.5603	1.78186	100

Table 4.7: Shows the descriptive statistics value of K2 mean and standard deviation before surgery, one week and four weeks after surgery.

Table 4.8: Descriptive Statistics Values for cornea astigmatism before cataract surgery, one and four weeks after cataract surgery.

	Mean	Std. Deviation	N
CA before	1.5879	1.29847	100
CA after1	1.6734	1.41090	100
CA After Four	1.9155	1.51471	100

Table 4.8: Shows the descriptive statistics value of CA mean and standard deviation before surgery, one week and four weeks after surgery.

CHAPTER FIVE

5.0: DISCUSSION

This study was done to determine the variations in keratometric reading using autorefractor before and after cataract surgery in St Teresa's specialist and laser eye center in Edo State. This was a cross sectional study that was carried out to help us ascertain/determine how significant the variations that exist in keratometric readings (in terms of cornea astigmatism) using autorefractor before and after cataract surgery and also in terms of variation with age and gender.

From the obtained result of the study, a total of 100 subjects comprising of 50 males and 50 females was used. Their age range was 35-98 with a mean age of 68.71 years (SD ± 10.246).

This study showed that there was a significant difference in cornea astigmatism values as well as K1 and K2 readings before and after cataract surgery. This is similar to the study done by Isyaku M *et al* (2014) which showed that there is a significant difference in cornea astigmatism before and after cataract surgery.

The study showed that there was a significant difference in K2 readings one week after surgery when compared to before the surgery($p<0.001$).It also showed that there was a significant difference in K2 reading four weeks after surgery when compared to before the surgery($p<0.001$).There was also a significant difference in K2 readings one week after the surgery when compared to four weeks after surgery ($p<0.001$).The study also showed a significant difference in K1 readings one week after surgery when compared to before the surgery($p<0.001$).It also showed that there was a significant difference in K1 reading four weeks after surgery when compared to before the surgery($p<0.001$).There was also a significant difference in K1 readings one week after the surgery when compared to four weeks after surgery ($p<0.001$).This is similar to a study done by Hassan H *et al* (2021) which noted a significant difference in keratometric values. The study also showed that there was no significant difference in cornea astigmatism (CA) before the surgery and one week after the surgery(p=0.412).The study also showed that there was a significant difference in cornea astigmatism before the surgery and four weeks after the surgery (p=0.010).There was also a significant difference in cornea astigmatism one week after the surgery when compared to four weeks after the surgery (p=0.008). A study done by Delfi *et al* (2018) showed no statistically significant variation in cornea astigmatism before and after cataract surgery and hence not in agreement with this study.

The flat keratometric meridian (K1) has a mean value of 42.7293 and a standard deviation of 1.8505 before the surgery, one week after the surgery showed a mean value of 42.4661, standard deviation of 1.90495, four weeks after the surgery showed a mean value of 40.6448, standard deviation of 1.87331. The steep meridian (K2) has a mean value of 44.3172 and standard deviation of 1.78640 before the surgery, one week after the surgery showed a mean value of 44.1395, standard deviation of 1.78096, four weeks after the surgery showed a mean value of 42.5603, standard deviation of 1.78186.Cornea astigmatism has a mean value of 1.5879 and standard deviation of 1.29847 before the surgery, one week after the surgery showed a mean value of 1.6734 and standard deviation of 1.41090, four weeks after surgery showed a mean value of 1.9155 and standard deviation of 1.5147. This is similar to the study done by Heena C *et al* (2017) which shows a statistically significant difference in the mean values and standard deviation in keratometric values before and after cataract surgery.

CHAPTER SIX

6.0 CONCLUSIONS

From the result, it was observed that there was a significant difference in cornea astigmatism one week and four weeks after cataract surgery. It was also observed that there is a correlation between the amount of cornea astigmatism difference before and after cataract surgery. Also, keratometric difference was seen across board from before the surgery, one week and four weeks after the surgery.

6.1: RECOMMENDATIONS

In line with this study on the variations that exists in keratometric reading using auto refractor before and after cataract surgery in patients seen at St Theresa's Specialist Eye Center Benin City, Edo state Nigeria, the following recommendations were made;

1. More research should be carried out on this study to evaluate how significant cornea astigmatic changes is likely to occur after cataract surgery and to what extent is the astigmatic difference.

2. This study will help eye care practitioners to make better biometric assessment for cataract patient so as to improve on the quality or the outcome of cataract surgery,hence proper follow up after surgery should be encouraged.

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APPENDIX

Descriptive statistics showing age of the patient

	N	Minimum	Maximum	Mean	Std. Deviation
Age	100	35	98	68.71	10.246
Valid N (listwise)	100				

Age distribution

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	35	1	1.0	1.0	1.0
	50	1	1.0	1.0	2.0
	52	3	3.0	3.0	5.0
	54	1	1.0	1.0	6.0
	55	2	2.0	2.0	8.0
	56	3	3.0	3.0	11.0
	57	1	1.0	1.0	12.0
	58	2	2.0	2.0	14.0
	59	2	2.0	2.0	16.0
	60	7	7.0	7.0	23.0
	61	2	2.0	2.0	25.0
	62	4	4.0	4.0	29.0
	63	1	1.0	1.0	30.0
	64	1	1.0	1.0	31.0
	65	7	7.0	7.0	38.0
	66	5	5.0	5.0	43.0
	67	4	4.0	4.0	47.0

68	2	2.0	2.0	49.0
69	5	5.0	5.0	54.0
70	8	8.0	8.0	62.0
71	1	1.0	1.0	63.0
72	3	3.0	3.0	66.0
73	3	3.0	3.0	69.0
74	3	3.0	3.0	72.0
75	5	5.0	5.0	77.0
76	1	1.0	1.0	78.0
77	4	4.0	4.0	82.0
78	2	2.0	2.0	84.0
79	2	2.0	2.0	86.0
80	2	2.0	2.0	88.0
81	1	1.0	1.0	89.0
82	2	2.0	2.0	91.0
83	3	3.0	3.0	94.0
84	1	1.0	1.0	95.0
87	2	2.0	2.0	97.0
88	1	1.0	1.0	98.0
97	1	1.0	1.0	99.0
98	1	1.0	1.0	100.0
Total	100	100.0	100.0	

Age and gender crosstabulation

		Gender		
		Male	Female	Total
Age	35	1	0	1
	50	0	1	1
	52	2	1	3
	54	0	1	1
	55	2	0	2
	56	2	1	3
	57	0	1	1
	58	2	0	2
	59	1	1	2

	60	4	3	7
	61	1	1	2
	62	1	3	4
	63	0	1	1
	64	1	0	1
	65	3	4	7
	66	3	2	5
	67	2	2	4
	68	0	2	2
	69	2	3	5
	70	4	4	8
	71	0	1	1
	72	2	1	3
	73	0	3	3
	74	2	1	3
	75	3	2	5
	76	0	1	1
	77	4	0	4
	78	1	1	2
	79	1	1	2
	80	0	2	2
	81	0	1	1
	82	2	0	2
	83	1	2	3
	84	1	0	1
	87	0	2	2
	88	1	0	1
	97	0	1	1
	98	1	0	1
Total		50	50	100

Pairwise Comparison

Measure: MEASURE_CA

(I) CA	(J) CA	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	-.085	.104	.412	-.291	.120
	3	-.328*	.124	.010	-.574	-.081
2	1	.085	.104	.412	-.120	.291
	3	-.242*	.089	.008	-.419	-.065
3	1	.328*	.124	.010	.081	.574
	2	.242*	.089	.008	.065	.419

Based on estimated marginal means:

The mean difference is significant at 0.05 levels

Adjustment for multiple comparison:Least significant difference (equivalent to no adjustment).

Pairwise Comparison

Measure: MEASURE_K2

(I) Ktwo	(J) Ktwo	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	.178*	.084	.036	.012	.344
	3	1.757*	.102	.000	1.554	1.959
2	1	-.178*	.084	.036	-.344	-.012
	3	1.579*	.062	.000	1.456	1.702
3	1	-1.757*	.102	.000	-1.959	-1.554
	2	-1.579*	.062	.000	-1.702	-1.456

Based on estimated marginal means:

The mean difference is significant at 0.05 levels

Adjustment for multiple comparison:Least significant difference (equivalent to no adjustment).

Pairwise Comparison

Measure: MEASURE_K1

(I) Kone	(J) Kone	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	2	.263*	.071	.000	.122	.405
	3	2.084*	.076	.000	1.934	2.235
2	1	-.263*	.071	.000	-.405	-.122
	3	1.821*	.064	.000	1.694	1.948
3	1	-2.084*	.076	.000	-2.235	-1.934
	2	-1.821*	.064	.000	-1.948	-1.694

Based on estimated marginal means:

The mean difference is significant at 0.05 levels

Adjustment for multiple comparison:Least significant difference (equivalent to no adjustment).

Pairwise comparison (simplified version)

Measure: MEASURE_C.A

Variables (CA)	Mean Difference	P- values (0.05)
2	-0.085	0.412
3	-0.328	0.010
1	0.085	0.412
3	-0.242	0.008
1	0.328	0.010
2	0.242	0.008

The mean difference is significant at p less than 0.05($p<0.05$)

Pairwise comparison (simplified version)

Measure: MEASURE_K1

Variables (K1)	Mean Difference	P- values (0.05)
2	0.263	0.001
3	2.084	0.001
1	-0.263	0.001
3	1.821	0.001
1	-2.084	0.001
2	-1.821	0.001

The mean difference is significant at p less than 0.05($p<0.05$)

Pairwise comparison (simplified version)

Measure: MEASURE_K2

Variable (K2)	Mean Difference	P- values (0.05)
2	0.178	0.036
3	1.757	0.001
1	-0.178	0.036
3	1.579	0.001
1	-1.757	0.001
2	-1.579	0.001

The mean difference is significant at p less than 0.05($p<0.05$)

Measure: MEASURE_1

Ktwo	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	44.317	.179	43.963	44.672
2	44.139	.178	43.786	44.493
3	42.560	.178	42.207	42.914

RAW DATA

AGE	SEX	IOL POWER	KERATOMETRIC VALUE (K) BERORE CATARACT SURGERY (K1)	KERATOMETRIC VALUE (K) BEFORE CATARACT SURGERY(K2)	KERATOMETRIC VALUE (K) 1 WEEK AFTER CATARACT SURGERY (K1)	KERATOMETRIC VALUE (K) 1 WEEK AFTER CATARACT SURGERY (K2)	KERATOMETRIC VALUE (K) 4 WEEKS AFTER CATARACT SURGERY (K1)	KERATOMETRIC VALUE (K) 4 WEEKS AFTER CATARACT SURGERY (K2)
66	1	22.50	43.37 x 161	53.00	42.62 x 19	52.50	41.25 x 84	49.75
70	1	24.50	43.00 x 67	44.62	43.12 x 104	45.12	42.37 x 108	41.12
75	1	15.00	40.87 x 20	42.00	40.62 x 15	42.75	38.00 x 30	41.35
59	1	24.00	46.62 x 77	47.50	46.25 x 97	42.37	44.25 x84	46.76
52	1	24.00	38.75 x 50	40.62	37.50 x 91	40.30	35.12 x 97	39.62
65	2	19.50	43.12 x 132	43.62	42.25 x 111	44.00	40.00 x 115	43.00
60	1	22.00	43.00 x 96	43.87	44.50 x 111	45.00	42.62 x 91	44.12
73	2	19.00	42.75 x 55	43.75	42.12 x 98	44.37	40.00 x 93	43.00
71	2	19.50	43.12 x 128	43.87	42.25 x 81	42.25	40.50 x 91	41.62
75	2	19.00	44.37 x 117	45.50	43.17 x 97	46.00	41.12 x 75	45.12
97	2	22.50	44.62 x 80	45.37	43.62 x 81	48.12	41.75 x 95	47.00
62	1	19.00	35.50 x 159	42.00	35.00 x 110	42.00	34.00 x 105	41.00
65	1	17.00	42.25 x 81	43.25	41.50 x 77	43.00	40.00 x 94	41.62
68	2	22.00	43.37 x 38	44.75	43.75 x 130	45.00	41.75 x 115	43.87
64	1	22.00	43.62 x 106	44.87	43.87 x 120	45.37	41.25 x 105	43.78
57	2	22.50	39.37 x 97	43.12	40.37 x 105	44.12	38.50 x 110	43.00
61	1	24.50	39.50 x 91	41.62	40.62 x 56	42.12	39.00 x 47	41.00
60	2	25.00	41.37 x 109	44.75	40.12 x 121	44.25	38.37 x 119	42.96
83	1	21.50	41.50 x 87	42.87	41.00 x 81	42.50	40.00 x 78	40.75
77	1	21.50	43.50 x 100	44.50	43.12 x 161	45.62	41.87 x 157	44.25
70	1	23.00	45.00 x 76	45.62	44.87 x 77	45.00	42.62 x 76	43.87
54	2	24.00	44.87 x 37	45.00	44.00 x 20	44.50	42.87 x 47	43.62
77	1	24.00	43.87 x 96	45.75	43.50 x 95	44.87	41.50 x 97	42.87
50	2	23.50	41.50 x 91	42.37	41.62 x 19	42.87	39.37 x 82	41.25
69	1	24.50	41.25 x 93	42.50	40.00 x 76	42.00	38.35 x 97	40.50
67	1	19.00	41.50 x 96	45.62	42.12 x 41	43.00	41.12 x 77	41.37
70	2	18.00	40.75 x 90	44.00	40.87 x 116	44.37	39.25 x 94	42.75

56	2	17.50	40.12 x 84	43.37	40.00 x 82	42.82	38.25 x 81	41.25
65	1	22.50	44.50 x 84	43.37	44.87 x 49	45.25	43.17 x 56	44.12
65	1	21.50	42.50 x 85	44.00	42.12 x 116	44.25	41.25 x 119	43.12
78	2	23.50	43.87 x 76	45.00	43.87 x 96	44.25	41.87 x 110	45.37
75	2	18.50	44.00 x 108	45.62	42.87 x 97	44.75	40.25 x 98	43.25
66	2	20.50	42.37 x 104	45.12	42.00 x 105	44.50	41.00 x 110	43.00
75	1	21.00	44.00 x 109	45.12	43.27 x 97	44.75	42.12 x 93	42.87
66	2	17.00	40.87 x 64	42.62	40.00 x 68	42.00	39.87 x 79	41.12
77	1	18.50	44.72 x 12	45.12	44.45 x 5	45.00	42.35 x 30	43.87
81	2	19.50	44.62 x 15	45.12	44.00 x 30	45.00	42.75 x 49	48.50
83	2	19.50	43.37 x 115	44.37	43.12 x 100	43.75	41.00 x 120	42.12
56	1	23.00	43.87 x 60	44.37	42.50 x 100	47.12	40.35 x 97	45.37
78	1	22.50	45.00 x 81	47.00	44.25 x 76	45.62	42.37 x 84	43.25
58	1	21.00	43.57 x 140	44.62	43.25 x 155	44. 12	41.00 x 127	42.75
74	1	22.00	42.12 x 61	42.75	41.75 x 45	42.00	40.00 x 64	41.12
72	1	21.50	42.12 x 66	43.25	41.37 x 99	44.25	39.75 x 102	42.00
73	2	18.00	43.50 x 100	45.50	43.00 x 115	45.12	41.35 x 108	43.00
58	1	21.00	43.12 x 41	43.75	43.00 x 37	43.25	41.75 x 49	41.50
62	2	21.50	44.00 x 104	45.37	44.25 x 176	45.62	42.87 x 155	43.87
60	2	23.00	42.50 x 34	46.62	45.50 x 132	44.75	39.50 x 84	42.50
59	2	21.50	42.37 x 25	42.87	42.00 x 35	42.50	40.00 x 97	40.00
60	2	25.50	46.00 x 113	47.00	45.75 x 54	46.75	44.25 x 108	45.12
69	2	21.50	42.75 x 10	44.12	42.62 x 17	44.00	40.00 x 30	42.50
66	1	19.00	42.12 x 71	43.50	41.75 x 54	43.12	40.00 x 84	42.25
55	1	20.00	45.75 x 77	46.25	45.25 x 79	45.62	43.25 x 84	43.25
70	2	20.00	44.00 x 26	45.50	43.37 x 120	45.62	41.12 x 155	43.87
82	1	20.00	39.00 x 29	41.50	39.75 x 103	41.75	38.00 x 102	39.37
65	2	25.50	44.62 x 73	45.62	44.50 x 76	44.75	42.00 x 99	42.87
67	1	24.50	44.12 x 92	45.87	43.75 x 61	46.25	41.12 x 76	44.25
83	2	23.50	41.37 x 62	42.62	42.37 x 55	43.12	40.25 x 64	41.12
65	1	22.50	41.25 x 106	43.00	41.12 x 103	42.25	39.50 x 108	41.00
70	2	23.50	42.87 x 97	44.37	42.25 x 107	44.52	40.12 x 115	42.50
88	1	23.50	42.75 x 100	44.37	42.25 x 115	46.75	44.25 x 108	45.12
60	1	24.50	45.50 x 33	46.12	45.25 x 79	45.60	43.37 x 71	43.37
52	1	19.50	41.37 x 107	43.62	41.75 x 12	43.62	40.00 x 58	41.87
66	1	19.50	42.50 x 71	43.75	41.75 x 32	43.25	39.67 x 64	41.55
77	1	17.00	42.37 x 80	42.87	42.12 x 97	43.72	40.75 x 108	39.87
67	2	21.50	41.75 x 122	43.87	42.12 x 133	43.50	40.00 x 155	41.50
62	2	19.50	43.87 x 106	45.50	44.12 x 120	45.50	42.12 x 91	43.37
73	2	23.50	43.62 x 45	44.37	43.12 x 71	44.00	41.62 x 65	42.12
61	2	21.00	39.37 x 90	41.37	39.62 x 102	40.72	38.00 x 108	40.00
74	2	21.00	40.25 x 79	41.12	40.00 x 79	40.75	39.00 x 129	38.87
60	1	21.00	42.50 x 70	43.25	42.00 x 78	43.00	40.37 x 69	42.00
65	2	21.50	41.87 x 84	42.87	40.75 x 112	43.37	38.62 x 101	41.87
79	2	24.50	43.75 x 62	45.12	44.12 x 98	45.75	42.25 x 100	43.87
70	1	20.50	43.75 x 155	47.25	43.25 x 147	45.00	41.25 x 112	43.37
69	2	21.00	44.50 x 51	44.62	44.00 x 58	45.12	42.62 x 54	43.00
72	2	22.50	44.62 x 58	45.50	44.25 x 76	44.75	42.75 x 97	43.12
77	1	24.00	42.00 x 82	43.37	41.50 x 50	43.25	39.20 x 76	42.75
80	2	22.00	40.37 x 66	42.62	42.62 x 190	45.50	40.62 x 115	44.00
70	1	24.50	42.87 x 140	43.37	42.00 x 115	43.00	41.00 x 109	41.62
63	2	21.50	43.00 x 71	44.25	41.87 x 113	43.37	39.50 x 115	42.25
70	2	22.50	41.75 x 35	42.62	41.00 x 70	42.00	39.00 x 79	37.75
68	2	20.50	44.12 x 163	45.57	44.12 x 168	45.62	42.25 x 155	44.12
52	2	24.00	42.32 x 145	43.75	41.62 x 150	43.00	40.12 x 155	41.87
69	2	24.00	43.00 x 83	44.12	43.50 x 70	44.45	41.75 x 97	43.00

55	1	22.50	41.12 x 75	44.75	40.50 x 67	44.25	39.00 x 79	42.50
98	1	23.00	43.37 x 97	45.62	43.75 x 155	44.37	41.62 x 120	43.50
60	1	22.50	45.25 x 91	46.50	45.95 x 21	46.00	44.25 x 71	44.75
87	2	20.00	41.75 x 71	43.25	41.50 x 154	42.87	39.00 x 120	41.00
75	1	21.00	43.75 x 75	45.00	42.00 x 71	44.75	41.12 x 103	42.43
72	1	19.50	39.25 x 110	42.25	38.50 x 93	41.75	37.00 x 115	39.50
67	1	18.50	42.25 x 94	44.62	41.25 x 110	44.00	39.37 x 115	42.50
87	2	21.50	42.25 x 64	43.12	41.75 x 71	42.75	40.00 x 79	40.12
35	1	19.00	43.25 x 93	46.00	43.50 x 114	45.37	41.25 x 145	43.78
82	1	17.00	44.37 x 30	44.75	43.87 x 166	44.25	41.75 x 145	43.00
56	1	28.00	45.50 x 76	46.37	45.10 x 76	40.00	43.87 x 76	44.25
60	2	21.50	42.87 x 76	45.75	43.12 x 88	45.25	41.12 x 79	43.50
80	2	21.50	44.37 x 36	45.00	44.00 x 37	44.75	42.50 x 49	42. 50
84	1	20.50	38.25 x 137	39.00	37.75 x 116	39.87	35.25 x 105	38.00
79	1	20.00	40.12 x 74	40.87	39.50 x 70	40.50	38.12 x 71	39.12
67	2	21.00	44.25 x 54	45.12	45.12 x 48	45.75	43.00 x 66	43.50
62	2	21.50	43.37 x 29	44.12	42.12 x 173	43.12	40.75 x 155	42.12