ESTIMATION OF OCULAR AXIAL LENGTH USING MAGNETIC RESONANCE IMAGING TECHNIQUE AMONG ADULTS IN JOS METROPOLIS, NORTH-CENTRAL NIGERIA .

M.SC. DISSERTATION

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This work is dedicated to my dear wife Chika .B. Udeh and my kids-Prince Uchenna William (Bobo), Chijindu John(CJ) and Jesse Tochukwu (JT).

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Lastly, to my late dad who gave me the inspiration for this programme. May God grant you eternal rest, Amen.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The purposes of this study are to generate an indigenous normogram for ocular axial lengths in a Nigerian population, determine whether there are differences in axial lengths between the right and left eye and among different adult age groups. The study will also determine whether there are differences in axial lengths between males and females and possible racial differences between Nigerians and Caucasians. This prospective, cross sectional study involving one hundred (100) Nigerian adults was carried out at Radiology Department, Jos University Teaching Hospital (JUTH), Jos, Plateau State. Convenience sampling method was used to select the subjects. Pilot study was done to determine the intra-and inter rater reliability of MRI measurement of axial length. The equipment used is a Magnetom Concerto (Siemens) 0.2Tesla MRI machine manufactured in Germany in 2007.Head coils were used as standard practice for brain and ophthalmic scans. Subjects were placed in the supine position with the scan plane parallel to the coronal plane.T2-weighted axial scans were obtained. Axial lengths of both eyes as well as the age, sex and weight of the subjects were recorded. Axial length normogram was obtained as 2.46 ± 0.13cm. Measurements of axial length were reliable within and between radiographers ($p > 0.05$). There was no positive correlation with axial length of different age groups. There were no statistical significant difference with axial lengths of males and females($p=0.63$) and Nigerians and Caucasians ($p<0.05$) . Axial length normograms for a Nigerian population will be added advantage for radiologists and radiographers in Nigeria in their practice. Measurement of axial lengths outside the normal range will likely suggest any of the eye defects.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The human eye is the sense organ with which we view the world. We use our eyes in almost every activity we perform whether reading, working, watching television, writing a letter, driving a car and in countless other ways (Lauterbur, 2003). Most people probably would agree that sight is the sense they value more than all the rest. The eye allows us to see and interpret the shapes, colours and dimensions of objects in the world by processing the light they reflect or emit. The eye is able to detect bright or dim light but it cannot sense objects when light is absent.

The amount of light entering the eye is controlled by the pupil, which dilates and contracts accordingly. The cornea and lens, whose shape is adjusted by the ciliary body, focus the light on the retina, where receptors convert it into nerve signals that pass to the brain. A mesh of blood vessels, the choroid, supplies the retina with oxygen and sugar. Lacrimal glands (left) secrete tears that wash foreign bodies out of the eye and keep the cornea from drying out. Blinking compresses and releases the lacrimal sac, creating a suction that pulls excess moisture from the eyeĝs surface.

Axial length of the eye is an important parameter in ophthalmology (Akduman et al, 2008). The establishment of this parameter helps in the classification of eye defects and normal eye (Montgomery , 1998). Radiology has been shown to play a major role in the establishment of this parameter (Nacke et al,2011). Studies have been carried out in the assessment of axial length using ultrasound and computed tomography (Leiva et al, 2008) and the results compared to findings in ophthalmology .

However, magnetic resonance imaging (MRI) is a diagnostic tool which has been under-utilized in the assessment of this parameter (axial length). Magnetic Resonance Imaging is one of the latest technological innovations in the health sector and a medical diagnostic technique that combines strong magnetic fields, radio waves and computer technology to create images of the body using the principles of nuclear magnetic resonance (Mansfield, 2003). It is a technology for producing detailed inner views of the body without the need for potentially harmful X-rays or invasive exploratory surgery (Lauterbur, 2003). A versatile, powerful and sensitive tool, MRI can generate thin section computerized images of any part of the body including the heart, arteries and veins from any angle and direction (multiplanar imaging) in a relatively short period of time.

In current medical practice, MRI is preferred for diagnosing most soft tissue diseases because it gives excellent soft tissue contrast and superior anatomic detail (Abrikosov, 2000). It can distinguish soft tissue in both normal and diseased states. In using MRI, it is able to delineate the posterior aspects of the cornea and retina better than ultrasound and CT scan (Stone,2012). Since the lens of the eye is involved in axial length assessment, MRI is preferable to computed tomography (CT) because the former does not use ionizing radiation. No known risks have been recorded except for patients with cardiac pacemakers, patients who might have iron fillings next to their eyes (e.g. sheet metal workers), patients with inner ear transplants and patients with aneurysmal clips in their brains (Leggert et al, 1999). Although an MRI scan is relatively expensive, it may actually reduce costs to patients and hospitals by providing diagnostic evaluation to out patients and thereby frequently limiting more expensive hospitalization.

Axial length is defined as the distance from the back of the cornea to the back of the retina (Montogomery , 1998). Leiva et al (2008) defined axial length as the distance, through the visual axis from the posterior corneal surface to the posterior pole of the eye in axial view. The axial length of the eye at birth is approximately 17mm. It increases rapidly until age 10 and then increases slowly(Bradford,2012). It reaches approximately 24mm in adulthood. It is typically longer than 24mm in myopes and shorter than 24mm in hyperopes .The reason adduced was that myopes have longer eyeballs while hyperopes have shorter eyeball (Akduman, 2008).

According to Montogomery (1998), the average newbornơs eyeball is about 18mm in diameter from front to back (axial length). In an infant, the eye grows slightly to a length of approximately 19.5mm. The eye continues to grow, gradually to a length of about 24-25mm or about 1 inch in adulthood. A ping-pong ball is about one and half (1 ½) inch in diameter, which makes the average adult eyeball about two-third (2/3) the size of a ping-pong ball. The eyeball is set in a protective cone-shaped cavity in the skull called the ñorbitò or ñsocketò. This bony orbit also enlarges as the eye grows. The orbits are symmetrical and of normal size with normal development of the orbital cones. The orbital walls show a normal configuration with smooth, sharp margins with no evidence of bone destruction, no circumscribed expansion of the bony or soft tissue components of the orbital wall (Moeller et al, 2000). Eye defects like myopia and hypertropia could be diagnosed by establishing a normogram for axial lengths of the eye.

1.2 Statement of Problem

There have been studies in Europe (Akduman, 2008; Nacke et al, 2009) which have assessed the axial lengths of the adult eye using magnetic resonance imaging. Due to possible racial differences in axial lengths of the eye, there is need to embark on similar study in our locality since no literature exists for any Nigerian adult population.

1.3 Objective of the Study

The purpose of this study is to evaluate the axial lengths of the eye in healthy Nigerian adult population using MRI.

The specific objectives of the study are:

1. To establish normogram of the axial lengths of the eye in a healthy Nigerian adult population using MRI.
2. To determine if there is any significant difference in the mean axial length measurement of the right and left eye.

   The following hypotheses were tested:

   i) Null hypothesis (H_o): There is no significant difference between the mean axial lengths of the right and left eye.

   ii) Alternative hypothesis (H_1): There is a significant difference in the mean axial lengths of the right and left eye.
3. To compare the findings in this study with what is found in the literature amongst Caucasians.
4. To compare mean axial lengths in different age groups.
5. To compare mean axial lengths in males and females.

1.4 Significance of the Study

1. Magnetic resonance imaging evaluation of axial lengths of the eye will set a benchmark for normal value in an adult Nigerian population.
2. Magnetic resonance imaging evaluation of axial lengths of the eye will be a useful tool in diagnosing eye defects such as myopia and hypermetropia in radiology.
3. Magnetic resonance imaging evaluation of axial lengths of the eye will form a background for further ocular studies in Nigeria and Africa in general.

1.5. Scope of the Study

The study was limited to the residents of Jos, Plateau State ,Nigeria and was carried out at Radiology department, Jos University Teaching Hospital (JUTH), Jos, Nigeria.

1.6 Definition of Terms

a) Axial Length: This is the distance through the visual axis from the posterior corneal surface to the posterior aspect of the retina (Leiva et al,2008).

b) Emmetropes : These are individuals considered to have axial lengths within the normal range(23-26.5mm) (Bottomley, 2007).

c) Hypermetropia : This is the eye defect where the eyeball is shorter than the normal range (23.4-26.8mm),hence images fall behind the retina (Sobering et al, 2005).

d) Myopia : This is the eye defect where the eyeball is longer than the normal range, hence images fall in front of the retina (Sobering et al, 2005).

e) Supine Position : Imaging position with the patient lying on his/her back as opposed to prone position (Gutteridge et al, 2006).

f) t-test : Statistical test used in medical research to compare the differences in the mean values of two groups of data. An appropriate level of significance must be used (Everitt, 2003).

g) T1-weighted : A sequence where signal contrast in the image is determined predominantly by differences in T1 relaxation times. A short TE to minimize T2-weighting and a short TR is used (McAtamney, 2009).

h) T2-weighted : Image in which the signal contrast is determined predominantly by differences in T2 relaxation times. It uses a long TR to minimize T1-weighting and long TE (McAtamney, 2009).

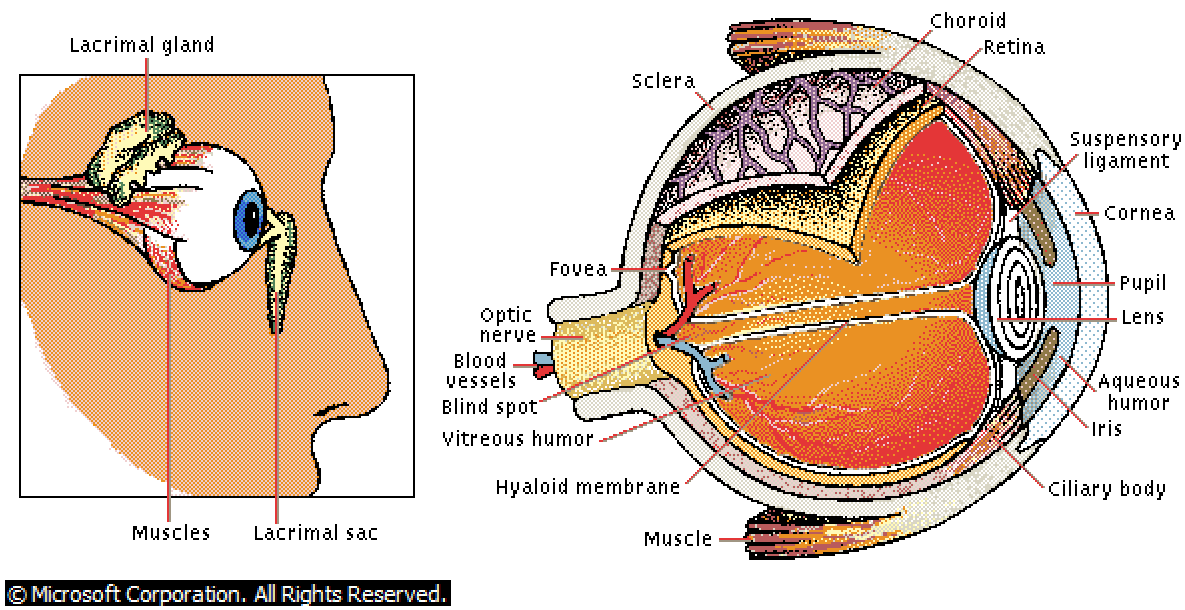
i) Myopes : These are individuals with the eye defect myopia(Elster et al, 2000).

j) Hyperopes : These are individuals with the eye defect hypermetropia (Elster et al, 2000).

CHAPTER TWO

LITERATURE REVIEW

Light waves from an object (such as a tree) enter the eye first through the cornea which is the clear dome at the front of the eye. The light then progresses through the pupil, the circular opening in the center of the colored iris (Akduman et al, 2008). Several structures compose the human eye. Among the most important anatomical components are the conjunctiva, cornea, iris, crystalline lens, vitreous humor, retina, macula, optic nerve and extraocular muscles (Moeller et al, 2000). If the eye is considered to be a type of camera, the retina is equivalent to the film inside of the camera, registering the tiny photons of light interacting with it (Paul, 2003).



Adapted from Human Atlas and Anatomy

Figure 1: Anatomy of the Human Eye.

The need for ocular axial length

Considering the importance of the human eye, the need to study the axial length as an important parameter **is useful. Axial length is considered one of the cardinal parameters in detecting short or long sightedness (Leiva et al, 2008).**

The average newbornôs eyeball is about 16 millimeters in diameter, from front to back (axial length). In an infant, the eye grows slightly to a length of approximately 19½ millimeters. The eye continues to grow, gradually, to the length of about 24-25 millimeters (Goldschmidt, 2009).In the adult, axial length remains practically unaltered. A slight but steady change towards hyperopia is the rule ,especially after the age of 40. The human eye grows extensively after birth. The full term newborn eye has a mean axial length of 16-18 mm & mean anterior chamber depth 1.5-2.9 mm. The mean adult values for axial length are 22-25 mm and mean refractive power -25.0 -+1.0 D. The mean depth of the anterior chamber in an adult emmetropic eye is 3-4 mm. Evidence from human studies point out that both heredity and the environment contribute to the refractive power of the eye (Hurst et al,2010). Since myopia often presents and progresses throughout the school years, it has been hypothesised that high levels of near work may contribute to its development. A number of studies have reported significant associations between near work and myopia development (Curtin, 2005). Because of its high prevalence in the developed world, myopia has been widely studied from different approaches. The motivation for these studies is the search for optimal alternatives to correct for the optical degradation induced by this condition and the understanding of the mechanisms of emmetropization and the factors that may lead the eye to become myopic. Hyperopia, however, has been less studied than myopia because of its lower prevalence in developed countries, relative stability, and difficulties in measuring its magnitude accurately in young subjects(Strang et al,2008).

The main structural difference between hyperopic and myopic eyes is the axial length, which is higher for myopic eyes (Carney, 2007). Cheng et al (1992), used magnetic resonance for a small sample of eyes and showed that myopic eyes are larger in all three dimensions (i.e., equatorial, antero-posterior, and vertical axes). Axial length and anterior chamber depth play an important role in refractive status of the eye in different age groups.

Methods of assessing ocular axial length:

Various techniques have been so far described to establish the normal globe length of the eye. Akduman et al (2008) assessed axial length measurements taken with MRI and then compared with those he obtained from A-scan ultrasonography. That study was a double-blinded prospective comparison study of axial length measurements made by MRI and A-scan ultrasonography. Magnetic resonance imaging scans of 20 patients undergoing MRI were reviewed to determine axial length of the eye. Standard A-scan measurements of axial length were also obtained. Axial length measurements by MRI were compared to A-scan ultrasonography measurements. In 36 eyes, an MRI scan was obtained in the correct plane to measure the axial length. The axial length measured by MRI was on average 0.18 ± 0.29 mm longer (range ï 0.41 to +0.7 mm) than the axial length measured by A-scan, for a refractive error average of +0.28 ± 0.58 D (SD), and a range of ï 1.06 to +1.52D. Axial length measurements with MRI matched reliably with axial lengths measured by A-scan ultrasonography. Nacke (2009) stated that in ophthalmology, it is very often necessary to determine the axial eye length. When standard measuring techniques fail, B-scan sonography may be used. However, coupling problems inhibit exact measurement in the latter. The aim of his study was to counter these problems.

Correction values were created for the ultrasonic devices Master-Vu (Sonomed), CineScan (Quantel Medical) and System-ABD (Innovative Imaging), including the position of the coupling layer of the hand pieces and the lid thickness. For evaluation of the method, the axial eye lengths of 35 eyes were measured transpalpebrally. These data were compared to those from the (4) IOL Master (Carl Zeiss Meditec). The usefulness of the developed method was shown by two patients. The correction values were (1) 3.0 mm, (2) 1.5 mm, and (3) 1.5 mm. The medial aberrations to (4) were (1) 0.4+/-0.5 mm, (2) 0.9+/-0.7 mm, and (3) 0.2+/-0.7 mm. The introduced method enables transpalpebral eye length measurement and is also applicable in cases of missing retinal compliace or in eyes with an obfuscated optical medium .

Other techniques were old-fashioned and include the indirect method (Duke,1980), radiographic method (Duke, 1980), ultrasonic method (Gray et al, 1999), angiographic method (Dichiro, 1996) and photographic method (Perkin et al, 2000). The axial length of the human eye as determined by the above methods averages between 22-27mm. Dichiro (1996) described the angiographic method of determining the actual length of the eye and obtained an average measurement of 27mm. Gray, et al (1999) compared the photographic method with the ultrasonic method and concluded that the photographic measurements were consistently larger than the ultrasonic measurement by 3.5mm. The photographic method measured the radius of rotation of the corneal apex about the centre of rotation of the posterior sclera segment. The calculation assumed that the apex of the cornea lies on the circumference of the circle described by the posterior sclera and the centre of rotation of the globe is midway between the corneal apex and the posterior pole. These assumptions were later found to be wrong. Also, accommodation during ultrasonic and photographic procedures may also account for differences in axial length measurements, as measured by these two techniques (Gray et al, 1999). It was concluded that a combination of various methods may be employed to determine the accuracy of the ocular axial length (Gray et al, 1999).

Kadir et al (2007) made a comparison of geometrical properties (axial length, corneal apical radius of curvature, and corneal asphericity) and optical aberrations (total, corneal, and internal) between a group of myopic and hyperopic eyes, with age and absolute refraction matched between both groups. The aim was to understand the optical and geometrical properties of the ocular components associated with myopia and hyperopia, and whether there are differences in the physical properties of the ocular components of myopic and hyperopic eyes that may cause differences in the aberration pattern. Twenty-four(24) myopic and 22 hyperopic eyes were measured. These eyes did not show any ocular disease or condition apart from the corresponding ametropia. Both groups were age-matched: mean ± STD was 30.5 ± 3.8 years (range, 26ï 39 years) for the myopic and 30.3 ±5.2 years (range, 23ï 40 years) for the hyperopic group. The spherical equivalent refractive error ranged from ī 0.8 to ī 7.6 D (ī 3.3 ± 2.0 D) for the myopic group and from +0.5 to +7.4 D (3.0 ± 2.0 D) for the hyperopic group. Astigmatism was less than 2.5 D for all of subjects. The axial length (AL) of hyperopic eyes (22.62 ± 0.76 mm) was significantly lower (p<.001) than the axial length of myopic eyes (25.16 ± 1.23 mm). Myopic eyes showed a statistically significant linear correlation of axial length with absolute spherical equivalent refractive error (p=.001, r= 0.57, slope =0.38 mm/D, intercept at 0 D=24.2 mm). Hypermetropic eyes tended to shorten with increasing spherical equivalent but the correlation was not statistically significant within the sampled spherical equivalent refractive error (p=.25, r=ī 0.26, slope=ī 0.10 mm/D, intercept at 0 D=22.9 mm).

Recently the development of computed tomography (CT) has made invivo measurements of oculo-orbital structures possible and this has been taken advantage of in obtaining the ocular axial length (Kadir et al, 2007). In order to eliminate any possible distortion of the images on the CT video screen, Crow et al (2002) first obtained photographic transparencies of the images. These transparencies were projected onto a screen, such that the projected image was of actual size. Axial length of the eye was obtained from the projected image. Misra et al (2011), however employed a new CT technique for obtaining the invivo global length directly by utilizing the computerized distance measurement techniques.

Estimation of the axial length of the eye is needed to establish axial emmetropic stages, glaucomatous global enlargement, locating intraocular foreign bodies and intraocular tumours and for the diagnosis of shallow retinal detachment (Crow et al ,2002). Magnetic Resonance Imaging technique has many advantages because it is more convenient, non-invasive, painless and patient needs no hospitalization (Momose et al, 2006). The projectile effect of a metal object exposed to the field can seriously compromise the safety of anyone sited between the object and the magnet system. The potential harm cannot be over emphasized. Even small objects, such as paper clips and hair pins, have a terminal velocity of 40 mph when pulled into a 1.5T magnet, and therefore pose a serious risk to the patient and anyone else present in the scan room. Some techniques (radiographic/photographic) did not include choroido-scleral thickness (1.5mm approx) and hence the axial length of the eye was under-estimated. Magnetic resonance imaging modality, however, identifies this structure; gaze fixation is not required for obtaining MRI biometry (Momose et al, 2006). In patients with axial length [of at least] 26 mm, the mean deviation of the final from predicted refraction was ï 1.23 D (SD 0.67) in the MRI group and ï 2.3 D (SD 2.02) in the A-scan group. The difference between these two groups was statistically significant (P = .02).

When examining patients with axial length less than 26 mm, however, the two measurement devices were "comparably accurateò. The mean deviation of final from predicted refraction for patients with axial length less than 26 mm was ï 0.12 D (SD 1.29) in the MRI group and ï 0.33 D (SD 1.39) in the A-Scan group. The prospective, randomized study examined 70 patients divided into two groups, one measuring MRI results (33 patients) and the other measuring A-scan results (37 patients), hence Momose (2006) concluded that eyes filled with silicone oil had more accurate axial length measurement results with MRI biometry than with A-scan echography when axial lengths measured 26 mm or more.

Previously estimated axial length of the eye was affected by image magnification of the camera, corneal curvature and the degree of image separation on the corneal surface, the convergence of rays of each interface and the effect of accommodation. Such errors have been completely eliminated in magnetic resonance imaging technology (Crow et al, 2002). As both orbits are simultaneously displayed, uniocular emmetropic states and subnormal anatomies can be detected.

Summary:

This study will afford radiologists, radiographers, ophthalmologists and optometrists the opportunity to carry out magnetic resonance evaluation of axial lengths of the eye in routine brain scans and will set a benchmark for normal value. Trauma patients will also have their axial lengths assessed with a view to diagnosing pathological conditions. Its evaluation will be a useful tool in diagnosing eye defects such as myopia and hypermetropia . Eye defects like myopia and hypermetropia could be diagnosed by establishing a normogram for axial lengths of the eye.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Research Design

This is a clinic-based cross sectional study.

3.2 Duration

The study was carried out between February, 2014 and October, 2015.

3.3 Study Population

A sample of Nigerian adults from the age of 18 years and above was selected for the study. These volunteers were recruited from Jos University Teaching Hospital, (JUTH) Jos as well as from residents of Jos.

3.4 Sampling Techniques

A convenience sampling method was adopted in selecting the desired sample for this study.

3.5 Sample Size

A sample of 100 subjects who met the subject selection criteria were enlisted. Lwanga and Tyre (1986) advocate a larger sample size to compensate for possible attrition in the sample. This minimum sample size n, according to Lwanga and Tyre, was arrived at using the formula as follows:

$$n = \frac{2\,(Z^2 S^2)}{D^2} \qquad \text{(for a finite population)}$$

Where:

Z= score corresponding to a 5% level of significance with a critical value of 1.96

S= Standard deviation=0.18

D= Tolerable error= 0.05

If S= 0.18 is substituted in the above formula, then

$$n = \frac{2 (1.96)^2 \times (0.18)^2}{(0.05)^2} = 99.57$$

Therefore n= 100

3.6 Subject Selection Criteria

Subjects for this study were checked for any eye defects by the ophthalmologist/optometrists because it will influence the outcome of the results. Such exclusion criteria are subjects with:

a. myopia

b. hypermetropia

c. eye lid swelling

d. eye ball injury

These pathologies could cause deformity in eyeball contour (Akduman , 2008).

Other exclusion criteria are:

a. metallic implants

b. bullet or shrapnel injury

c. cardiac pacemakers

3.7 Ethical Clearance

Ethical clearance for the study was obtained from the ethical clearance committee of Jos University Teaching Hospital (JUTH), Jos, Plateau State.

3.8 Equipment

All scans for this study were carried out with the Magnetom Concerto (Siemens) Tesla (0.2T) MRI machine manufactured in Germany in the year 2007.It is a resistive, open magnet with low-field strength. Head coils (transceiver) were employed in the measurement. All measurements were done with the on-screen electronic calipers of the MRI units.

3.9 Scanning Technique

The orbits were demonstrated in the T2-weighted axial planes. Axial lengths of the orbits were also measured in the axial planes. These are positions advocated by Moeller(2000). Scans were done with the subjects in the supine position. Patients were placed in the supine position, with the scan plane parallel to the plane containing the lines interconnecting the outer external meatus and the lateral eye corner on each side of the head (Momose et al, 2006). Prior to scanning, the age, weight, sex of each subject was recorded. For the pilot study for intra- and inter-rater reliability, two radiographers each took turns to measure the axial lengths of ten (10) participants and the average for each was obtained and compared for reliability.

Landmarks:

Position- supine

Scan plane- parallel to the plane containing the lines interconnecting the outer external meatus and the lateral eye corner on each side of the head.

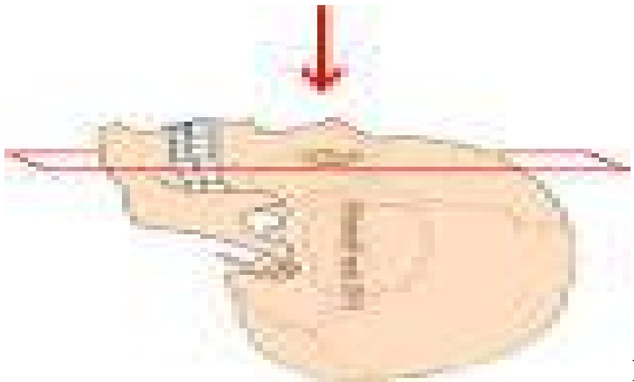


Fig 2:Anatomic Landmark

Field of View- 350cm

Phase oversampling- 75-100% ; Average- 2

Slice Thickness- 4mm

Phase Encoding Direction: Right to left.

Weighting- T2-weighted axial images.

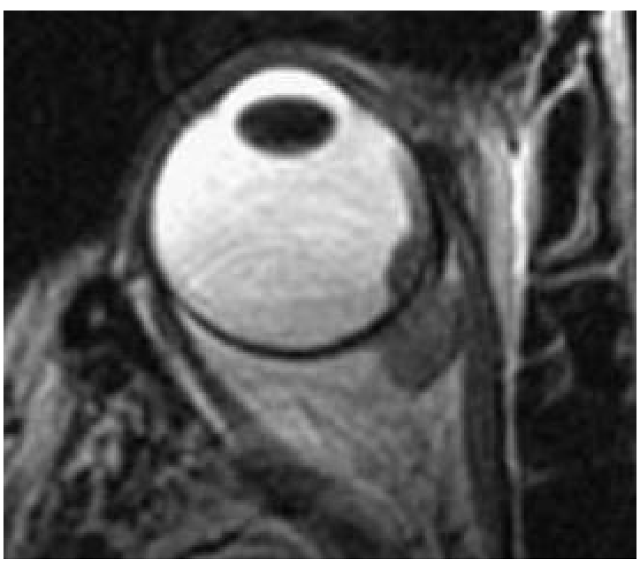


Figure 3 MRI image of axial length (Adapted from MRI Techniques and Protocols).

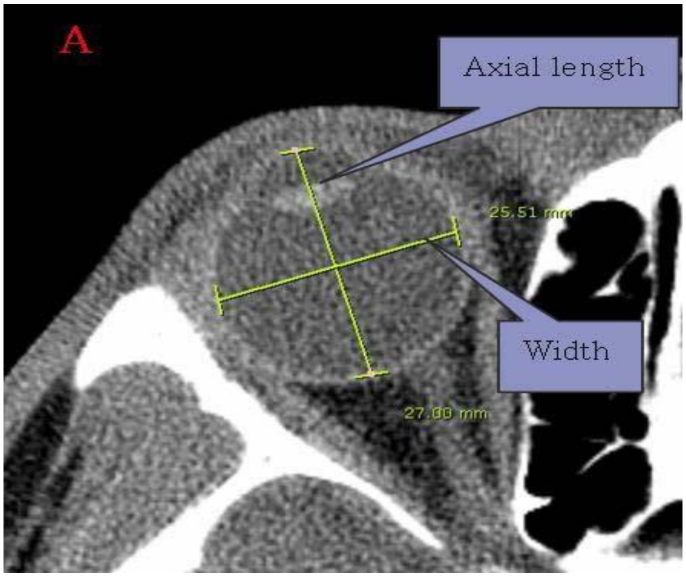


Figure 4: CT image of axial length.

Adapted form MRI Techniques and Protocols.

Statistical Analysis

Descriptive and inferential statistics were used in data analysis. Data was analyzed using SPSS Version 19. Measures of central tendency namely: arithmetic mean, median and mode were calculated for the values. Using measures of dispersion (Range, standard deviation (SD), standard error (SE), disparities of mean values were calculated and confidence interval was established.

i. t-test was used in comparing the mean measurement of axial lengths of right and left eye. This test statistic is suitable in this case because the population is large, normally distributed and their standard deviation known (Nwabuokei, 2001). Critical value (CV) of t at 5% level of significance for a two-tailed test (a/2) is 1.96 (Nwabuokei, 2001). At a significance level of 5% stated above, a two-tailed t-test shall be used to determine if the mean measurement of the axial lengths of the right and left eye are equal.

The following hypotheses were tested:

Null hypothesis (H_o): There is no significant difference between the mean axial lengths of the right and left eye.

Alternative hypothesis (H_1): There is a significant difference in the mean axial lengths of the right and left eye.

ii) To compare the findings in this study with what is found in the literature amongst Caucasians, Pearsonôs correlation coefficient for paired samples was used.

iii.) To compare the mean axial lengths obtained for the different age groups, regression analysis was used.

iv.) To compare mean axial lengths between males and females t-test was used.

CHAPTER FOUR

RESULTS

4.0. Data Analysis and Presentation

Measurements of the axial lengths of the eye obtained were grouped into right and left eyes and the lengths were further classified according to age and sex. The unit of measurement of the axial length is in millimeter (mm). In this study, a sample of 100 Nigerian adults resident in Jos from 18 years and above that met the subject selection criteria were analyzed. Sixty four percent (64%) of the participants were males while thirty six percent (36%) were females. The normal values of the axial lengths of the eye are important parameters during brain/ophthalmic MRI scans. Since experience has influence in the accuracy of this measurement, the measurements were carried out under the close supervision of a consultant radiologist with more than seven(7) years MRI experience.

In this study, axial length was analyzed in terms of length which is a simple, reproducible, reliable and objective measurement. Measurement axial length was reliable within and between radiographers as shown by high intra-and inter rater reliability in this study.

Table 1: Intra- and Inter rater reliability of MRI Axial Length (AL) Measurement.

Observer	Intra-and Inter rater reliability
Intra Observer Radiographer 1	Intra rater reliability AL= ICC (1,1) = 0.95
Intra Observer Radiographer 2	Intra rater reliability AL = 1CC (1,1) = 0.86
Inter Observer Both Radiographers	Inter rater reliability AL = ICC (1,1) = 0.9

Note : ICC =Intra Class Coefficient; ICC (1,1) = Intra Class Correlation Coefficient for the measurement obtained by each radiographer (intra observer) and between the measurements obtained by both radiographers (inter observer).

From Table 1, it can be deduced that axial length measurement reliability for intra observer for radiographer 1 and 2 is 0.95 and 0.86 respectively while the inter rater reliability for both radiographers is 0.9.Hence, axial length measurement is reliable and reproducible within and between radiographers.

Table 2: Mean axial length according to age groups.

	Age Group (year)			
Statistics	20-29	30-39	40-49	50-59
Frequency	16	32	32	20
Mean(AL)mm	24.5	24.7	24.4	25
Range	23.6-26.2	23-25.2	23.7-24.8	23.9-26.5
SD	0.77	0.70	0.57	0.58

The mean axial length was 24.7±0.7mm. Analysis of Variance performed on the mean difference in axial length across the age group was not statistically significant (F=2.06, df=3, 96, p=11).

The regression analysis performed on AL and age shows no statistical significance (r=0.08), p =0.43.The model was represented by the equation AL =23.33+ 0.004AGE

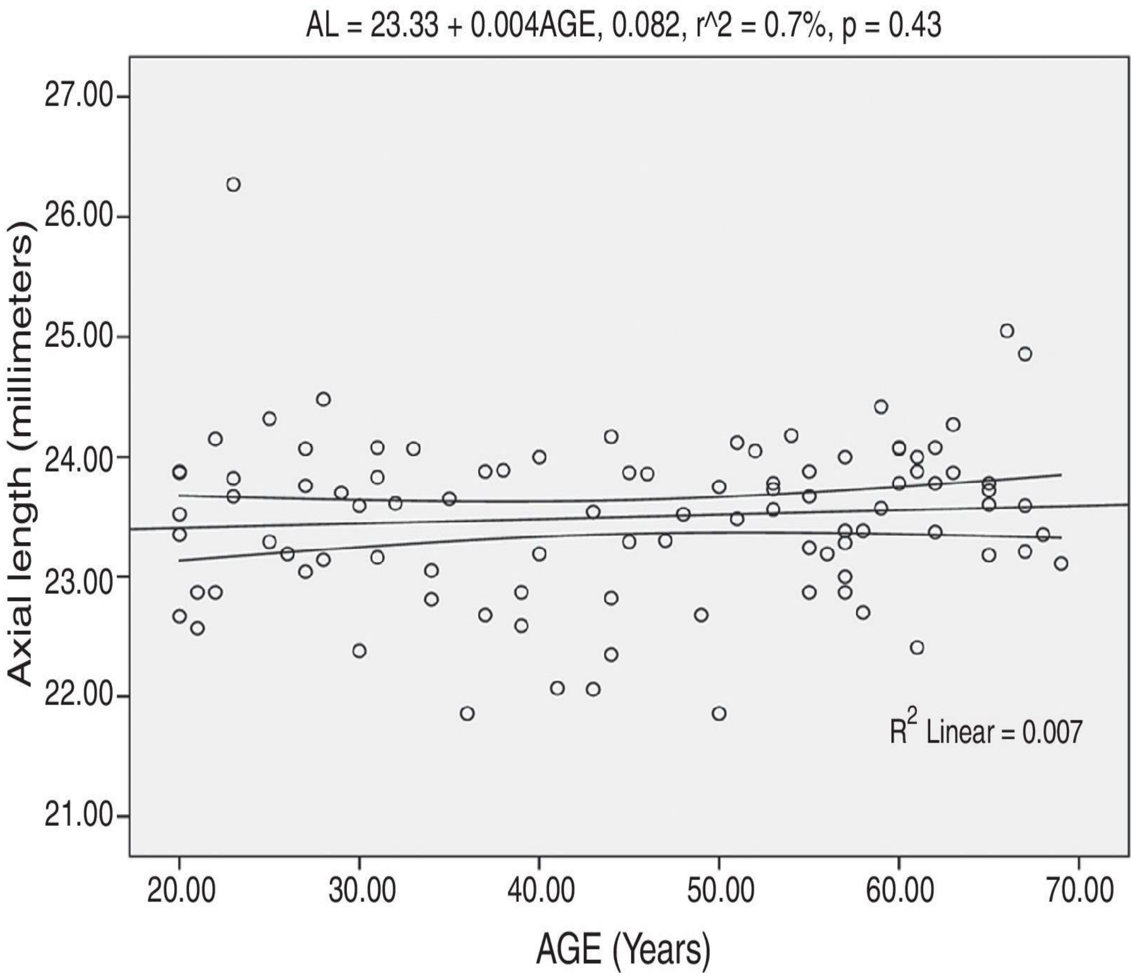


Fig 5: Regression Analysis of Axial Length with the various Age groups

Figure 5 shows the correlation of AL and age with the 95% confidence interval of the linear regression line.

No statistical difference was observed in the mean axial lengths of the different age groups.

TABLE 3: Age and Gender Distribution of subjects

Age (years)	male	female	Percentage%
20-29	8	8	16
30-39	16	16	32
40-49	28	4	32
50-59	12	8	20
Total	64	36	100

Forty eight percent (48%) of subjects were within the age range of 20 and 39 years while fifty two percent (52%) were within the age range of 40-59 years.

Sixty four percent (64%) of subjects were males and thirty six percent (36%) were females.

Table 4: Comparison of axial length in male and female

	Male (mean±SD)	Female (mean±SD)	t	P value
Axial length(cm)	2.46±0.11	2.45±0.12	-0.5	0.63
Number	64	36		
Range	2.4-2.8	2.4-2.7		

Table 4 shows that no statistically significant differences were found in the axial length dimensions between males and females.

Table 5 : Comparison of Mean axial length of the right and left eyes.

Statistics	Rt.AL	Lt.AL	t	p
Count	100	100	1.654	P<0.05
Mean AL	2.49	2.48		
Range	2.47-2.56	2.46-2.53		
SD	0.43	0.45		
Std.Error	0.07	0.08		

The table shows the t-test comparison of mean axial lengths of the right and left eye. The calculated value of $t = 1.654$ which is less than the critical value of $Z = 1.96$; $P < 0.05$.

HYPOTHESES

Ho: There is no significant difference in mean axial length measurement between the right and left eye.

H_1: There is significant difference in mean axial length measurement between the right and left eye.

Decision Rule: if calculated t Ò1.96 at a a/2 accept Ho, otherwise reject Ho.

Conclusion: Hence, there is no significant difference in the mean measurement of the axial length of the right and left eye.

CHAPTER FIVE

Discussion and Conclusion

5.0. Discussion

In this study, axial length was analyzed in terms of length which is a simple, reproducible, reliable and objective measurement. Measurement axial length was reliable within and between radiographers as shown by high intra-and inter rater reliability in this study.

5.1: Relationship between Axial Lengths and Age of Subjects.

Akduman (2008) and Montgomery (1998) observed that axial lengths of humans stops growing at 18 years of age and such axial lengths under normal circumstances are maintained up till the age of about sixty years (60) before diminishing in size.

In present study, no obvious direct relationship was observed between axial length dimensions and the age of the participants. With average p values at 0.13 and 0.14, it was established that at adulthood axial lengths show no significant growth in size with increasing age. This finding was consistent with the claim of Shufelt et al (2005) that there were no age-related differences in axial length ($p>0.05$). However, this was not consistent with the study of Wong et al (2010) who reported shorter axial length in older persons which was attributed to cohort effect. However, a model was developed from the regression analysis for axial lengths estimation for enmmetropes i.e $AL= 23.33 +0.004AGE$.This model is consistent for adults between the ages of 18-65 years. This regression equation will assist in the possible estimation of axial lengths for enmetropes between the ages of 18-65 years of age.

5.2 Relationship between Axial Lengths of the Right and Left Eye.

The t-test comparison of mean axial lengths of right and left eye showed the calculated z = 1.654.The mean axial length for the right and left eye is 2.49 ± 0.43cm and 2.48 ± 0.45cm respectively. This agrees with the studies done by Goldschmidt (2009) and Liney (2009).Quinn et al (2003) opines in their work that no two axial lengths i.e right and left eye are the same , however, the difference between them is not significant with a z value of 1.61, $p < 0.05$. Dunne et al (2006) conducted a study pertaining the mean difference in axial length for right and left eyes in 152 adult Saudis from 16 to 50 years and found that there was no statistically significant difference between them with a z=1.7. However, it contradicts the findings of Deller et al (2003) with a t value of 1.99 suggesting that there is statistically significant difference between the mean axial lengths of the right and left eye.

Weiss et al (2013) concluded that significant differences could be noticed in mean axial length of the right and left eye in congenital orbital abnormalities. They attributed this to refractive errors which tends to have deeper anterior chambers.

5.3: Comparison of mean axial length of male and female

This study revealed that there is no statistical difference in the mean axial lengths of males and females. Males (2.46 ± 0.11cm) and females (2.45 ± 0.12cm).

This is in line with studies done in a normal adult Turkish population by Hertel (2013) with values, males(2.43 ± 0.13cm) and females (2.41 ± 0.12cm).Other studies done by other researchers Holt et al (2010) showed males(2.39 ± 0.2cm),female (2.4 ± 0.1cm); Feldon et al (2008) males(2.42 ± 0.11cm), female(2.4 ± 0.1cm) and Hudson et al (2009); males(2.44 ± 0.14cm), females(2.4 ± 0.12cm) . They opined that the reason could be as a result of similar orbital shapes and sizes of males and females. There was no statistical differences in the mean axial lengths with respect to sex ($p>0.05$).Therefore, sex certainly is not a determining factor for orbital axial length dimension in adults in this population. This suggests that special tables based on gender are not necessary.

5.4: Comparison of results obtained with that of Caucasians

The mean axial length from this study is 2.46 ± 0.13cm while that for Caucasians(Woodrow, 2012) was 2.48 ± 0.12cm.The mean difference is 0.02. Studies done by Gutteridge et al (2006) on adult Austrians found Caucasian axial lengths as 2.48 ± 0.13cm while that done recently by Nacke et al (2012) on adult Belgians had 2.46 ± 0.13cm as its finding . These results agree with the finding from this study stating that there is no statistical significant difference between axial lengths in this population and that of Caucasian populations compared with it, hence ruling out racial differences with respect to axial lengths of the eye.

5.5: Conclusion

The dimensions of axial lengths of the eye among Nigerian adults in Jos especially among emmetropes were estimated. No direct correlation was observed concerning the sex and axial lengths of the participants. Magnetic resonance imaging has proven to be a reliable imaging tool for assessing axial lengths and its advantages measuring axial lengths of eye include its independence from parameter assumptions such as refractive index, the ability to image the eye through any desired meridian, absence of ionizing radiation and the relatively good image resolution. This study has established that there are no statiscal significant difference between the axial lengths of the right and left eye for enmetropes. It has also demonstrated that there are no statistical significant differences in axial lengths of males and females as well as between population used in this study and that of Caucasians.

5.6: Recommendations

1) Orbital axial lengths using MRI should be routinely done in brain and ophthalmic scans to rule out eye defects.

2) In view of the study, well trained and experienced radiologists and radiographers should do the measurements.

3) The model developed for orbital axial length estimation for normal values can also be used by ophthalmologists and optometrists in their practice.

5.7: Limitations of the Study :

1) The use of low-Tesla (0.2T) MRI equipment may have denied the work the precision and accuracy needed in detailed measurements.

2) The sample of Nigerian adults used in this study is rather small for a country as densely populated as Nigeria. The sample could have been increased to effectively represent the population.

5.8 Areas for Further Research

1.) Axial length assessment in myopes and hypermetropes.

2.) Effects of Ocular shapes on Axial Length Estimation.

3) Orbital axial length estimation using computed tomography scans.

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APPENDICES

Appendix I: Ethical clearance copy obtained from the Ethical Clearance Committee of the Jos University Teaching Hospital, Jos, Plateau State.

Appendix II : List of Tables / List of Figures.

Appendix III : Raw Data.

APPENDIX III:

RAW DATA OF 100 PARTICIPANTS

S/N	RTAXIAL LENGTH (C M)	LTAXIAL LENGTH (C M)	AGE (yrs)	SEX
1	2.48	2.44	42	M
2	2.55	2.50	49	M
3	2.44	2.46	23	F
4	2.44	2.46	28	M
5	2.42	2.43	30	F
6	2.43	2.44	36	F
7	2.52	2.88	46	M
8	2.53	2.5	50	F
9	2.48	2.43	53	M
10	2.49	2.46	38	M
11	2.46	2.44	50	F
12	2.5	2.5	45	M
13	2.42	2.40	46	M
14	2.48	2.5	38	F
15	2.5	2.51	39	M
16	2.4	2.5	29	F
17	2.5	2.4	28	M
18	2.5	2..5	32	M
19	2.5	2.4	32	M
20	2.4	2.4	45	M
21	2.5	2.6	45	F
22	2..4	2.4	48	M
23	2.4	2.4	50	M
24	2.5	2.5	38	F
26	2.5	2.4	57	M
27	2.48	2.44	42	M
28	2.55	2.50	49	M
29	2.44	2.46	23	F
30	2.44	2.46	28	M
31	2.42	2.43	30	F
32	2.43	2.44	36	F
33	2.52	2.88	46	M
34	2.53	2.5	50	F
35	2.48	2.43	53	M
36	2.49	2.46	38	M
37	2.46	2.44	50	F
38	2.5	2.5	45	M
39	2.42	2.40	46	M
40	2.48	2.5	38	F

41	2.5	2.51	39	M
42	2.4	2.5	29	F
43	2.5	2.4	28	M
44	2.5	2.5	32	M
45	2.5	2.4	32	M
46	2.4	2.4	45	M
47	2.5	2.6	45	F
48	2.4	2.4	48	M
49	2.4	2.4	50	M
50	2.5	2.5	38	F
51	2.5	2.4	57	M
52	2.48	2.44	42	M
53	2.55	2.50	49	M
54	2.44	2.46	23	F
55	2.44	2.46	28	M
56	2.42	2.43	30	F
57	2.43	2.44	36	F
58	2.52	2.88	46	M
59	2.53	2.5	50	F
60	2.48	2.43	53	M
61	2.49	2.46	38	M
62	2.46	2.44	50	F
63	2.5	2.5	45	M
64	2.42	2.40	46	M
65	2.48	2.5	38	F
66	2.5	2.51	39	M
67	2.4	2.5	29	F
68	2.5	2.4	28	M
69	2.5	2.5	32	M
70	2.5	2.4	32	M
71	2.4	2.4	45	M
72	2.5	2.6	45	F
73	2.4	2.4	48	M
74	2.4	2.4	50	M
75	2.5	2.5	38	F
76	2.5	2.4	57	M
77	2.48	2.44	42	M
78	2.55	2.50	49	M
79	2.44	2.46	23	F
80	2.44	2.46	28	M
81	2.42	2.43	30	F
82	2.43	2.44	36	F
83	2.52	2.88	46	M
84	2.53	2.5	50	F
85	2.48	2.43	53	M
86	2.49	2.46	38	M

87	2.46	2.44	50	F
88	2.5	2.5	45	M
89	2.42	2.40	46	M
90	2.48	2.5	38	F
91	2.5	2.51	39	M
92	2.4	2.5	29	F
93	2.5	2.4	28	M
94	2.5	2.5	32	M
95	2.5	2.4	32	M
96	2.4	2.4	45	M
97	2.5	2.6	45	F
98	2.4	2.4	48	M
99	2.4	2.4	50	M
100	2.5	2.5	38	F