ADENOID HYPERTROPHY: CORRELATION OF RADIOGRAPHIC PARAMETERS TO POSTOPERATIVE ADENOID VOLUME AMONG CHILDREN AT MOI TEACHING AND REFERRAL HOSPITAL,ELDORET.

BY

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ADENOID HYPERTROPHY: CORRELATION OF RADIOGRAPHIC PARAMETERS TO POSTOPERATIVE ADENOID VOLUME AMONG CHILDREN AT MOI TEACHING AND REFERRAL HOSPITAL, ELDORET.

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DEDICATION

I dedicate this work to my mother, Lucy Wanjiku, who is always in my corner regardless of the season of life and my nephew, Right Gathuru, who reminds me that in life it is the seemingly small things that truly matter. Above all to God Almighty, who gives me life and without whom none of this would have been possible.

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ABSTRACT

Background: Adenoid hypertrophy is a common clinical condition especially in the paediatric population. Postnasal space (PNS) x-rays are the imaging modality frequently used to assess the adenoids. Various objective parameters of assessing adenoid size on PNS x-ray have been proposed with no agreement on which is most suitable. In this study, the correlation of two radiographic parameters: adenoidal-nasopharyngeal ratio (ANR) and antroadenoid diameter (AA diameter) to the volume of adenoid tissues measured postoperatively will be compared, in order to determine which is more suitable in assessing the adenoids on postnasal space x-ray.

Objective: To determine and compare the correlation of ANR and AA diameter to postoperative adenoid volume in order to establish which of the two parameters of assessing adenoid size on postnasal space x-ray is more suitable.

Methods: This was a cross-sectional study carried out at the Moi Teaching and Referral Hospital (MTRH) between September 2017 and August 2018. 107 patients aged below 15 years diagnosed with adenoid hypertrophy and scheduled to undergo adenoidectomy were enrolled. All the x-rays were reviewed by the principal investigator and findings verified by two consultant radiologists. The postoperative volume of the adenoid tissues was measured by a trained research assistant. Data were analysed using STATA version 13E. Descriptive statistics were summarized using tables and graphs. Correlation of ANR and AA diameter to the postoperative adenoid volume was calculated using Pearson's correlation coefficient. Correlation was calculated controlling for the number of days between the x-ray and surgery which was a potential confounding factor. Comparison of the two correlation coefficients was carried out using Steiger's Z-test.

Results: The age of the participants ranged from 11 months to 11 years; mean of 3.4 years. The mean ANR was 0.70, mean AA diameter was 3.10mm while the mean postoperative adenoid volume was 2.83mL. Correlation of the ANR to the postoperative adenoid volume was 0.661($p<0.001$) while that of the AA diameter was -0.222 ($p=0.022$). Null hypothesis was tested using Steiger's Z-test and the difference between the two correlation coefficients found to be significant; the ANR was determined to have a stronger correlation to adenoid volume than the AA diameter.

Conclusions: The correlation of ANR to postoperative adenoid volume was moderately positive and statistically significant at 0.661 while that of AA diameter to postoperative adenoid volume was weak and negative but statistically significant at -0.222. Comparing the correlation of the two radiographic parameters, the ANR is determined to have a stronger correlation to the adenoid volume and the difference between the two is significant. Thus, the ANR is a better predictor of adenoid volume than the AA diameter.

Recommendation: Use of the ANR when reporting PNS x-rays at MTRH.

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LIST OF ABBREVIATIONS

AA diameter	Antroadenoid diameter
ANR	Adenoidal-nasopharyngeal ratio
CT	Computed Tomography
ENT	Ear, nose and throat
KNH	Kenyatta National Hospital
mL	milliliters
mm	millimeters
MRI	Magnetic Resonance Imaging
MTRH	Moi Teaching & Referral Hospital
PACS	Picture archiving and communications system
PNS	Postnasal space
SD	Standard deviation

OPERATIONAL DEFINITION OF TERMS

Adenoidal-nasopharyngeal ratio: radiographic parameter described by Fujioka, Young and Girdany in 1979 that measures the size of the adenoid relative to the nasopharynx. This measurement is illustrated in the appendices.

Antroadenoid diameter: radiographic parameter described by Hibbert and Whitehouse in 1978 that assesses the degree of narrowing of the nasopharyngeal airway as the narrowest distance between the adenoids and the posterior wall of the maxillary antrum. This measurement is illustrated in the appendices.

Postnasal space x-ray: lateral radiograph of the neck taken to assess tissues of the postnasal space including the adenoids.

Postoperative adenoid volume: the volume of the adenoid tissues measured after adenoidectomy.

Radiographic parameters: measurements on postnasal space x-ray to assess the size of the adenoids. The two parameters used in this study are adenoidal-nasopharyngeal ratio and antroadenoid diameter.

Strength of correlation: the strength of correlation coefficient between the variables is interpreted using values described by Schober, Boer and Schwarte (2018) (Schober, Boer, & Schwarte, 2018).

Table 1: Strength of correlation coefficient

Size of correlation	Interpretation
.90 to 1.00 (-0.90 to -1.00)	Very strong positive (negative) correlation
.70 to .89 (-.70 to -.89)	Strong positive (negative) correlation
.40 to .69 (-.40 to -.69)	Moderate positive (negative) correlation
.10 to .39 (-.10 to -.39)	Weak positive (negative) correlation
.00 to .09 (-.09 to .00)	Negligible positive (negative) correlation

CHAPTER ONE: INTRODUCTION

1.1 Background

Adenoid hypertrophy

The nasopharynx, also known as the postnasal space, is the most superior part of the pharynx located between the posterior choanae and the inferior margin of the soft palate. It continues anteriorly as the nasal cavity and inferiorly as the oropharynx (Ryan, McNicholas, & Eustace, 2004). The adenoid, also known as the nasopharyngeal tonsil, is a mass of submucosal lymphoid tissue located at the junction of the roof and posterior wall of the nasopharynx. Together with the tubal, palatine and lingual tonsils, the adenoids are part of mucosa associated lymphoid tissue (MALT) and are collectively known as the Waldeyer's ring. These tissues form a first line of defence against pathogens entering the body via ingestion or inhalation (Emaneini, Khoramrooz, Shahsavan, Dabiri, & Jabalameli, 2015).

Hypertrophy of the adenoids is a well-recognized clinical condition associated with obstruction of the nasopharyngeal airway common especially among children. Pereira et. al. (2017) carried out a meta-analysis on the prevalence of adenoid hypertrophy amongst children using data obtained from seventeen studies based in different countries and found the overall prevalence to be 49.70% (Pereira et al., 2017). Similar findings were obtained by DeRowe, Forer, Fishman, Cohen and Fliss (2002) in a study on 190 children at a paediatric ear, nose and throat (ENT) outpatient clinic, where adenoid hypertrophy was the most frequent finding at 30.1% (56 patients) (DeRowe, Forer, Fishman, Cohen, & Fliss, 2002). Adenoid hypertrophy leads to varying signs and symptoms such as snoring, mouth breathing, postnasal discharge and obstructive sleep apnea. Complications

that may arise secondary to untreated adenoid hypertrophy include cor pulmonale, otitis media (Wright, Pearl, & Manoukian, 1998) and in severe cases of chronic mouth breathing, rearrangement of the neuromuscular and soft tissues of the face may occur resulting in craniofacial distortion in what is termed "adenoid facies" (Elluru, 2005), thus the need for timely diagnosis and management.

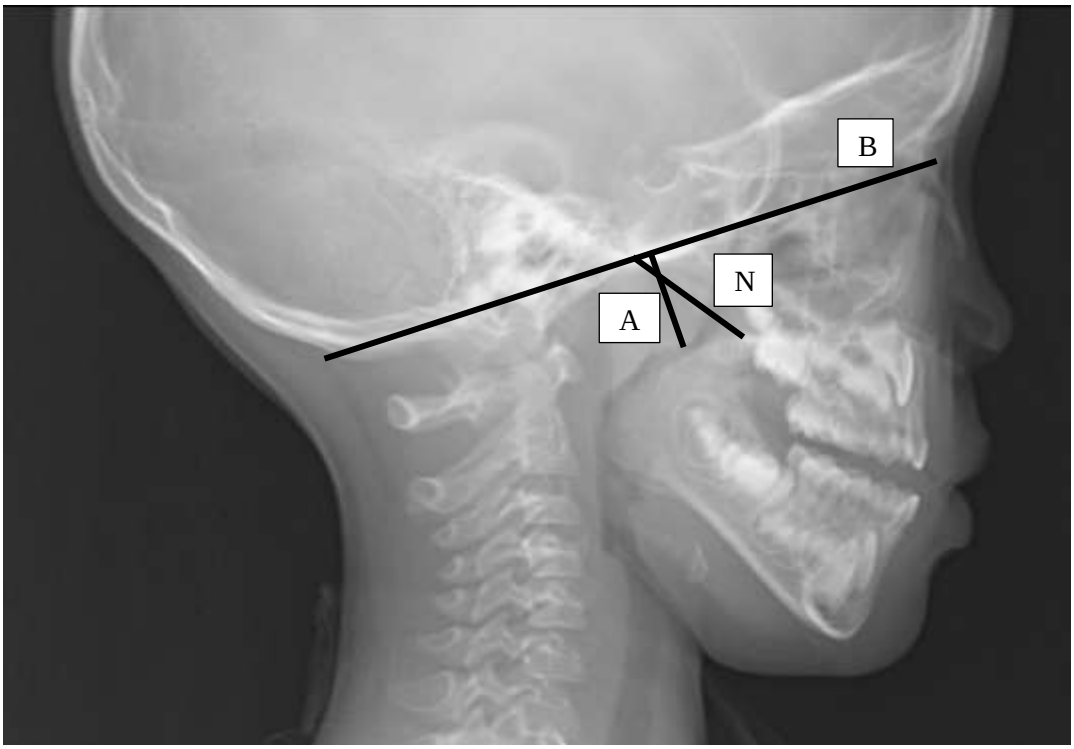
Management of adenoid hypertrophy can be either medical, involving the administration of medication such as steroids, or surgical with the removal of the adenoids, also known as adenoidectomy. Adenoidectomy is one of the most frequently performed paediatric ENT surgical procedures. T-Ping and Weckz (2008) in a study at public health facilities in three different municipalities in Brazil among patients under 17 years of age found adenotonsillectomy to be the most common surgical procedure at 22.1% (T-Ping & Weckx, 2008). These findings were echoed by Oburra and Idenya in 2001 in a study in Nairobi who found adenotonsillectomy to be the most common ENT/head and neck surgical operation with a frequency of 21.8% at a city public hospital and a rate of 48.2% and 74.6% at two private facilities (Oburra & Idenya, 2001).

Imaging of adenoid hypertrophy using postnasal space x-rays

Owing to their location in the postnasal space, it is difficult to visualize the adenoids clinically (Crepeau, Patriquin, Poliquin, & Tetreault, 1982) hence the need for imaging to assess the size of the adenoids. Postnasal space (PNS) x-rays are one such imaging modality and are taken with the patient lying in supine position with the lateral aspect of the head in contact with the detector. The x-rays are taken in true lateral position with the mouth closed to avoid elevation of the soft palate which may cause spurious results. PNS

x-rays are commonly used to image the adenoids especially in the developing world, as they are easily accessible and readily available (Kolo, Ahmed, Kazeem, & Nwaorgu, 2011). In addition, PNS x-rays are non-invasive and have been shown to be of value in the diagnosis of adenoid hypertrophy (Kurien, Lepcha, Mathew, Ali, & Jeyaseelan, 2005). There is, however, no agreement as to how the adenoids should be measured on postnasal space x-ray (Major, Flores-Mir, & Major, 2006). Subjective assessment is commonly used by many radiologists; however, this has been shown to be less accurate than objective measurement (Araújo Neto, Queiroz, Baracat, & Pereira, 2004). Moreover, subjective assessment correlates poorly with the size of the adenoids on intraoperative examination (Lertsburapa, Schroeder, & Sullivan, 2010) and is not reproducible, having low inter-observer agreement (Maw, Jeans, & Fernando, 1981)

Various objective measurements of adenoid size on postnasal space x-ray have been proposed with no consensus on which method is most suitable (Major et al., 2006). The adenoidal-nasopharyngeal ratio (ANR) described by Fujioka, Young and Girdany (1979) is the most commonly used method (M. F. N. Feres, Hermann, Cappellette, & Pignatari, 2011). Using the ANR, a straight line (B) is drawn along the anterior margin of the basiocciput along the base of the skull. A line (A), is measured from the point of maximal convexity of the adenoid perpendicular to the line (B) to represent the size of the adenoids. The size of the nasopharynx (N) is then determined by drawing a line from the posterosuperior aspect of the hard palate to the anteroinferior margin of the spheno-occipital synchondrosis. The final value of ANR is then determined by dividing the size of the adenoids (A) by the size of the nasopharynx (N). This is illustrated in the image below:



A number of authors advocate for measuring the ANR when assessing the size of the adenoids on x-ray. Kemaloglu, Inal, Goksu and Akyildiz in 1999 determined that the adenoidal-nasopharyngeal ratio was of more importance in deciding whether enlarged adenoids were clinically significant when compared to the absolute size of the adenoid or the nasopharynx (Kemaloglu, Inal, Goksu, & Akyildiz, 1999). This finding was supported by KS, Rajeshwari and Jain in 2012 in a study on 100 children to determine the significance of using the ANR to evaluate adenoid hypertrophy in children (KS, Rajeshwari, & Jain, 2012).

Use of the ANR has, nevertheless, been criticized as involving cumbersome calculations since two measurements are made then a ratio computed which is likely to increase interobserver variability (Jeans, Fernando, & Maw, 1981).

A second objective measurement of evaluating the size of the adenoids on x-ray is the antroadenoid diameter (AA diameter). This technique was developed by Hibbert and Whitehouse in 1978 and assesses the degree of narrowing of the nasopharyngeal airway as the narrowest distance between the posterior wall of the maxillary antrum to the anterior aspect of the adenoids. This is illustrated using the red line in the image below:

Measurement of the nasopharyngeal airway has been supported in different studies. Hibbert and Stell in 1979 found the antroadenoid diameter to be significantly different between children scheduled to undergo adenoidectomy and normal controls when compared to the absolute size of the adenoids. (Hibbert & Stell, 1979). Crepeau, Patriquin, Poliquin and Tetreault backed these findings in a study in 1982 where the antroadenoid diameter was determined to have a stronger correlation to a symptomatology score for adenoid hypertrophy ($r=-0.34$, $p<0.005$) when compared to the diameter of the adenoids ($r=0.27$, $p<0.02$) (Crepeau et al., 1982).

The antroadenoid diameter has, however, been found to be less sensitive in evaluating the size of the adenoid tissues in a number of studies. Jeans, Fernando and Maw in 1981 carried out a study correlating several measurements of the adenoid size on PNS x-ray to the volume of adenoid tissues postoperatively, where the correlation of the antroadenoid diameter was 0.28($p<0.1$) while that of the ANR was 0.51 ($p<0.01$) (Jeans, Fernando, & Maw, 1981). In addition, some authors have cautioned against measurement of the nasopharyngeal airway on x-ray arguing that the nasopharyngeal airway is a more complex three-dimensional structure than the adenoid, thus loses more information when compressed to a two-dimensional image (Major et al., 2006).

There is, therefore, need to determine which method of assessing the size of the adenoids on postnasal space x-ray is more accurate. This study aims to achieve that by comparing the correlation of the ANR and AA diameter to the volume of the adenoid tissues measured postoperatively.

1.2 Problem Statement

Postnasal space x-rays are commonly used to assess the size of the adenoids especially in resource-limited settings as they are easily accessible and readily available. However, despite their frequent use, there is no agreement on how the adenoids should be measured on x-ray (Major et al., 2006). On the one hand, some authors advocate for measurement of the adenoidal-nasopharyngeal ratio in which the size of the adenoids is measured relative to the size of the nasopharynx arguing that it is more sensitive in evaluating hypertrophy of the adenoids when compared to measuring the absolute size of the adenoid tissues or the depth of the nasopharyngeal airway (Kemaloglu et al., 1999) (KS

et al., 2012). On the other hand, measurement of the degree of narrowing of the nasopharyngeal airway using the antroadenoid diameter has been found to be more accurate correlating significantly with clinical symptoms of adenoid hypertrophy (Crepeau et al., 1982).

In this study, the correlation of the ANR and the AA diameter to the volume of the adenoid tissues post-operatively will be compared with an aim to determine which of the two parameters is more accurate in assessing adenoid size on postnasal space x-ray.

1.3 Justification

Adenoid hypertrophy is a common clinical condition particularly among children with adenoidectomy being one of the most frequent ENT surgical procedures. This is evidenced by data from a meta-analysis on seventeen studies from various countries by Pereira et. al. (2017) where the overall prevalence of adenoid hypertrophy was determined to be 49.70% (Pereira et al., 2017) . Locally at Moi Teaching and Referral Hospital (MTRH) in the year 2016, adenoidectomy was the most common ENT surgical procedure at 22.3% (148 of 663 cases). Untreated, adenoid hypertrophy can lead to various complications including cor pulmonale, otitis media (Wright et al., 1998) and in severe cases of chronic mouth-breathing, craniofacial distortion in what is termed as “adenoid facies” (Elluru, 2005), hence the need for accurate timely diagnosis and management.

Postnasal space x-rays are the imaging modality commonly employed in the diagnosis of adenoid hypertrophy especially in resource-limited settings due to availability and easy accessibility. There has, however, been no consensus on how the adenoids should be

evaluated on x-ray (Major et al., 2006)**.** In addition, despite the regular use of PNS x-rays to assess adenoid size in our settings, there is paucity of data on the same and no standardized protocol for reporting the x-rays. This study aims to compare the correlation of two radiographic parameters of adenoid size: ANR and AA diameter, to the postoperative volume of the adenoid tissues with a goal to determine which of the two measurements is more accurate. This will help to inform a protocol for reporting PNS x-rays at MTRH and be of great value in the management of patients with the disease.

1.4 Research Question

What is the correlation of radiographic parameters to postoperative adenoid volume among children with adenoid hypertrophy at MTRH?

1.5 Objectives

1.5.1 Broad objective

To determine the correlation of radiographic parameters to postoperative adenoid volume among children with adenoid hypertrophy at MTRH.

1.5.2 Specific objectives

1. To determine the correlation of adenoidal-nasopharyngeal ratio to postoperative adenoid volume among children with adenoid hypertrophy at MTRH.
2. To determine the correlation of antroadenoid diameter to postoperative adenoid volume among children with adenoid hypertrophy at MTRH.
3. To compare the correlation of adenoidal-nasopharyngeal ratio to postoperative adenoid volume and antroadenoid diameter to postoperative adenoid volume among children with adenoid hypertrophy at MTRH.

1.6 Hypothesis

The null hypothesis is that there is no difference between the correlation coefficient of adenoidal-nasopharyngeal ratio to postoperative adenoid volume (r_1) and the correlation coefficient of antroadenoid diameter to postoperative adenoid volume (r_2).

$$r_1 = r_2$$

The alternative hypothesis is that there is a difference in the correlation coefficient of adenoidal-nasopharyngeal ratio to postoperative adenoid volume (r_1) and antroadenoid diameter to postoperative adenoid volume (r_2)

$$r_1 \neq r_2$$

CHAPTER TWO: LITERATURE REVIEW

2.1 Anatomy of the nasopharynx and the adenoid

The nasopharynx, also known as the postnasal space, is the most superior part of the pharynx located between the posterior choanae and the inferior margin of the soft palate. It continues anteriorly as the nasal cavity and inferiorly as the oropharynx. The muscular layer surrounding the nasopharynx is the superior pharyngeal constrictor. Other muscles contained within the nasopharynx are the levator veli palatini and the tensor veli palatini which act to elevate the soft palate during swallowing hence separating the nasopharynx from the oropharynx. Located on the lateral wall of the nasopharynx is the eustachian tube, posterior to which is the torus tubarius, a mucosal elevation formed by the cartilaginous end of the eustachian tube. (Ryan et al., 2004)

The adenoid is a mass of lymphoid tissue located in the nasopharynx at the junction of the roof and posterior wall. The adenoids, together with the palatine, lingual and tubal tonsils form the Waldeyer's ring, which is a group of mucosa-associated lymphoid tissue (MALT) that forms a first line of defense against pathogens entering the body via ingestion or inhalation (Emaneini et al., 2015). The adenoids have been shown to be present in the nasopharynx from six months of age (Capitanio & Kirkpatrick, 1970), enlarge rapidly between the ages of three to five (Jeans, Fernando, Maw, & Leighton, 1981), then regress significantly in size from the age of fifteen years (Jaw, Sheu, Liu, & Lin, 1999).

2.2 Epidemiology of adenoid hypertrophy

A number of studies have been done to estimate the prevalence of adenoid hypertrophy. Globally, in a meta-analysis on studies from seventeen different countries, Pereira et al. (2017) found an overall prevalence of 49.7 %. The data in the meta-analysis was obtained from paediatric ENT outpatient clinics and involved a total of 5,248 children (Pereira et al., 2017). Aydin et al. (2008) carried out a study in Istanbul, Turkey to establish the prevalence of adenoid hypertrophy and nocturnal enuresis among school-going children; study participants were divided into sub-groups according to age with Group I (n=232) being children aged 5-7, Group II (n=506) aged 8-10 and Group III (n=394) aged 11-14. The prevalence of adenoid hypertrophy was found to be 58 (27%) in Group I, 94 (19.5%) in Group II and 78 (19.9%) in Group III. The study was carried out in four primary schools that had been selected randomly. In a study on the prevalence of ENT disorders at the paediatric outpatient clinic at a tertiary health facility in the United Arab Emirates, Suman (2015) found adenoid hypertrophy to be the second most common nasal disorder at 51 patients, forming 8.2% of the 625 patients that were included in the study. In this study, ENT disorders were ranked as either primarily ear, nose or throat disorders and using this categorization, the study participants with adenoid hypertrophy formed 30% of those with diseases of the nose (Suman, 2015).

Chinawa, Akpeh and Chinawa (2015) found the prevalence of adenoid hypertrophy among children attending a private hospital in Enugu, south east Nigeria, to be 1.3% (n=2010). (Chinawa, Akpeh, & Chinawa, 2015). This is in contrast to a study by Eziyi, Amusa and Nwawolo (2014) among primary school children in Ife Ife, south west Nigeria, where the prevalence of adenoid hypertrophy was determined to be 7.7%

(n=600) (Eziyi J.A, 2014). The possible reason for the variation in the prevalence calculated in the two studies could be the difference in sample sizes, where Eziyi et al. (2014) calculated the prevalence of adenoid hypertrophy based on a smaller sample size (n=600) than Chinawa et al. (2015) (n=2010). Chinawa et al. (2015) made a diagnosis of adenoid hypertrophy on the basis of clinical evaluation and confirmed using postnasal space radiographs while Eziyi et al. (2014) based the diagnosis on clinical symptomatology.

Adenoidectomy has been shown to be one of the most frequent paediatric ENT surgical procedures in various studies. T-Ping and Weckx (2008) carried out a prospective study among children below the age of seventeen years attending public health facilities in three different municipalities in Brazil and found adenoidectomy and/or tonsillectomy to be the most common ENT surgical procedure at 22.14% (257 of 1161 patients seen) (T-Ping & Weckx, 2008). In addition, in a study by Oburra and Idenya (2001) in Nairobi on two private health facilities and one public hospital, adenoidectomy was reported to be the most frequent ENT surgical procedure at 74.6%. 48.2% and 21.8% at the two private and public hospitals respectively (Oburra & Idenya, 2001). These findings are supported by unpublished data from Kenyatta National Hospital (KNH), Nairobi, which showed an increase in the number of adenotonsillectomies from 2012 at 301 adenotonsillectomies were performed to the year 2014 when 492 surgeries were performed (Sempele, 2016).

2.3 Use of Postnasal Space X-rays in the Diagnosis of Adenoid Hypertrophy

Due to their location in the postnasal space, it is difficult to assess the adenoids clinically hence the need for imaging. Postnasal space x-rays are the most frequently used diagnostic test in the evaluation of the adenoids among children suspected to have

adenoid hypertrophy (Major et al., 2006). This is evidenced by data from a study by T-Ping and Weckx in 2008 among children attending various health facilities in three different municipalities in Brazil, where postnasal space x-rays were found to be the most regularly requested tests at 24.98% (290 of 1161 patients seen). (T-Ping & Weckx, 2008). Some of the advantages of PNS x-rays include ready availability, affordability and the ease of interpretation (Kolo et al., 2011) as well as the fact that x-rays are non-invasive (Kurien et al., 2005). Moreover, the use of PNS x-rays in diagnosis of adenoid hypertrophy has been found to be of value in several studies. Singla (2013) in a study conducted at the ENT department of a health facility in Amritsar, India, found x-rays to be of value in the diagnosis of adenoid hypertrophy in relation to endoscopy (Singla, 2013). Kurien et al. (2005) found similar results when they calculated a moderate agreement that was statistically significant between x-rays and nasoendoscopy (weighted kappa of 0.51, $p<0.01$). In 2011, Saedi, Sadeghi, Mojitahed and Mahboubi conducted a study at the ENT ward of a tertiary referral health facility in Iran where they compared the relationship between adenoid size on PNS x-ray and grading of adenoid size using nasoendoscopy to a clinical symptom score and determined the relationship to be significant only for measurement of adenoid size using x-ray and not endoscopy (Saedi, Sadeghi, Mojtahed, & Mahboubi, 2011).

Further evidence of the usefulness of postnasal space x-rays in the evaluation of the adenoids is illustrated in a study by Maw, Jeans and Fernando (1981) in Bristol, England, where findings on x-ray (including a combined radiological score determined by subjective assessment as well as objective measurements of the adenoid on x-ray) were correlated to a clinical score and the volume of the adenoid tissues measured post-

operatively. The results of this study indicated significant correlation between the radiological score and clinical score ($r=0.69, p<0.001$), radiological score and adenoid volume ($r=0.66, p<0.001$), objective measurement of the airway and clinical score ($r=-0.55$, $p<0.001$) and measurement of the airway and adenoid volume ($r=0.67, p<0.001$). (Maw et al., 1981). Sempele (2016) in Nairobi found similar results in a study on the correlation of two radiographic parameters to a clinical score ($r=-0.625, p<0.001$ and $r=0.629, p<0.001$) and determined x-rays to be a reliable screening tool in the assessment of the adenoids.(Sempele, 2016).

2.4 Correlation of Adenoidal-Nasopharyngeal Ratio to Adenoid Volume

The adenoidal-nasopharyngeal ratio is a method of assessing the size of adenoid tissue on postnasal space x-ray that was initially described by Fujioka et al. (1979). Using this method, the size of the adenoid is measured in relation to the size of the nasopharynx. A line, B, is drawn along the straight portion of the anterior margin of the basiocciput. A second line, A, is then drawn from the point of maximal convexity of the adenoid tissues perpendicular to the line B. This represents the size of the adenoid tissue. The size of the nasopharynx is then measured by drawing a line, N, from the postero-superior edge of the hard palate to the antero-inferior border of the spheno-basioccipital synchondrosis. In situations where the spheno-basioccipital synchondrosis cannot be identified, the line, N is drawn from the hard palate to the point where the lateral pterygoid plates intersect the base of the skull. The AN ratio is then obtained by dividing the measurement A by N. (Fujioka, Young, & Girdany, 1979). This measurement is illustrated in the appendices.

The adenoidal-nasopharyngeal ratio is the most frequently studied parameter of assessing adenoid size on x-ray (M. F. N. Feres et al., 2011; Mlynarek et al., 2004**).** In a study by

Jeans et al. (1981) at a university teaching hospital in Bristol, England, comparing various radiological measurements to the volume of adenoid tissues postoperatively, the adenoidal-nasopharyngeal ratio had a moderate positive correlation that was statistically significant ($r=0.51$, $p<0.01$). Elwany (1987) in Saudi Arabia, carried out a study where he correlated ANR, a subjective radiological assessment of the adenoids and a clinical assessment score to the weight of the adenoid tissue measured after adenoidectomy. ANR was found to have a moderate positive and statistically significant correlation to the weight of the adenoids ($r=0.66$, $p<0.001$). In addition, Elwany found that there was a higher interobserver agreement for ANR when compared to subjective grading of adenoid size on x-ray (Elwany, 1987).

In 2009, Caylakli, Hizral, Yilmaz and Yilmazer at a teaching hospital in Ankara, Turkey, found a moderate positive correlation between ANR and the percentage obstruction of the choanae as determined using flexible endoscopy ($r=0.511$, $p<0.0001$). They concluded that ANR may be used to assess the size of the adenoid tissues in cases where endoscopy was not plausible or the findings after endoscopy were not adequate. The ANR was also beneficial as it was not affected by changes in the position of the patient unlike other methods of measuring adenoid size on postnasal space x-ray. (Caylakli, Hizral, Yilmaz, & Yilmazer, 2009).

In a study by Kemaloglu et al. (1999) in Turkey on the predictive reliability of ANR, the ANR was found to be a reliable method of determining whether adenoid hyperplasia was clinically significant or not, rather than measuring the size of the adenoid or nasopharynx. In this study, the ANR was measured using three different techniques and correlated to a clinical score. Study participants were categorized in two ways: 1) based on findings on

clinical evaluation as either candidates likely to undergo adenoidectomy and normal controls 2) according to age in three main groups: 48-71 months, 72-95 months and 96-120 months (Kemaloglu et al., 1999). Sempele (2016), also carried out a study at KNH in Nairobi, Kenya, correlating two measurements of adenoid size n x-ray to a clinical symptomatology score and found a moderate positive and statistically significant correlation of ANR to the clinical score($r=0.629$, $p<0.001$) (Sempele, 2016). Similar moderately positive correlation of the ANR to a standardized clinical score of $r=0.419$ ($p<0.001$) was obtained in a study in Lahore, Pakistan by Manzoor, Afridi and Malik (2017) (Manzoor, Afridi, & Malik, 2017)

Use of the ANR in the evaluation of the adenoids in patients with adenoid hypertrophy has however been critiqued in various studies. Jeans et al. (1981) determined the ANR to have a lower interobserver correlation when compared to other radiographic measurements of adenoid size and attributed this to the fact that calculation of the ANR involved two measurements and thus increasing the likelihood of differing observations (Jeans, Fernando, & Maw, 1981). Wormald and Prescott (1992) carried out a study in Cape Town, South Africa, correlating various radiographic parameters of the adenoid size on PNS x-ray to the percentage obstruction of the airway using nasoendoscopy and determined the ANR to have a weak non-significant correlation of $0.11(p>0.5)$. The ANR was, however, determined in the study to high specificity and positive predictive value of 95% and 94% respectively in relation to the findings on endoscopy (Wormald & Prescott, 1992).

Cut off values for grading of adenoid hypertrophy using the ANR are derived from values described by Malik, Malik and Anwar (2013) as illustrated below (Malik, Malik, & Anwar, 2013):

Table 2: Grading of adenoid hypertrophy

Degree of adenoid hypertrophy	**Adenoidal-nasopharyngeal ratio**
Mild	<0.25
Moderate	0.25 - <0.50
Moderately severe	0.50 - <0.75
Severe	0.75

2.5 Correlation of Antroadenoid Diameter to Adenoid Volume

The AA diameter was initially described by Hibbert & Whitehouse (1978). Using this measurement, the nasopharyngeal airway is assessed by measuring the shortest width between the adenoid tissues and the posterior wall of the maxillary antrum. (Hibbert & Whitehouse, 1978).

Use of the AA diameter when assessing the size of the adenoid tissues on PNS x-ray has been supported by various authors. Crepeau et al. in 1982 conducted a study at a teaching hospital in Quebec, Canada, correlating the AA diameter and the absolute size of the adenoid tissues to a symptomatology score and found a higher correlation for the AA diameter ($r=-0.34, p<005$) when compared to that of the size of the adenoids ($r=0.27$, $p< 0.02$) (Crepeau et al., 1982). Sorensen, Solow and Greve (1980) in Copenhagen, Denmark, found significant correlation coefficients for the AA diameter to rhinomanometry and snoring as a clinical symptom at 0.52 ($p<0.05$) and 0.42 ($p<0.05$) respectively (Sørensen, Solow, & Greve, 1980). This was further supported by Hibbert

and Whitehouse (1978) in Liverpool, England, who determined that the AA diameter had a strong negative but statistically significant correlation to the postoperative volume of the adenoids at $r=-0.78$ ($p<0.001$) (Hibbert & Whitehouse, 1978). In a study on the inter-observer variation of clinical and radiological evaluation of the size of the adenoids, Maw et. al. concluded that the AA diameter had a weak negative but statistically significant correlation to the volume of the adenoids measured postoperatively at -0.28 ($p=0.049$). Maw et. al. also correlated the AA diameter to a clinical score and radiological score determined by subjective assessment of PNS x-rays and found statistically significant correlation values at -0.28 ($p=0.046$) and -0.57 ($p<0.001$) respectively (Maw et al., 1981). In a study in Liverpool, England by Hibbert and Stell in 1979 the values of the absolute size of the adenoid and the AA diameter were compared in a group of children who were scheduled to undergo adenoidectomy to those of another group of children that had a history of head injury and that were considered as normal controls. Results from this study indicated that the absolute size of the adenoids did not differ between the children scheduled to undergo adenoidectomy and the normal controls ($t=0.07$. 58 d.f.). However, there was a significant difference in the size of the antroadenoid diameter between the two groups ($t=2.8$, 58 d.f., $p<0.01$). (Hibbert & Stell, 1979)..

Measurement of the antroadenoid diameter when assessing the size of the adenoids has, however, been criticized by some authors. Jeans et. al. (1981) found a weak correlation ($r=0.28$, $p<0.1$) of the antroadenoid diameter to the volume of the adenoid tissues obtained post-operatively (Jeans, Fernando, & Maw, 1981). In a study by Wormald and Prescott (1992) in Cape Town, South Africa correlating four different radiographic parameters and a symptomatology score to the percentage obstruction of the

nasopharyngeal space as measured using nasoendoscopy, the antroadenoid diameter was determined to have a weak correlation of 0.22 ($p<0.05$). It was, however, determined in this study that the AA diameter had a high positive predictive value at 83% for the evaluation of the adenoids in relation to endoscopy (Wormald & Prescott, 1992). Similar high positive predictive value for AA diameter was determined in a study by Feres, Hermann, Sallum and Pignatari (2014) at a public referral facility for paediatric ENT in Brazil at 77% in relation to percentage obstruction using endoscopy, for children who were candidates for adenoidectomy. In this study, however, lower values for sensitivity and negative predictive value at 68.1% and 65% respectively, were found for children who were deemed as patients with adenoids that were pathologically enlarged who had a threshold of 66.67% obstruction of the nasopharyngeal airway on endoscopy. The children who were candidates for adenoidectomy had a cut-off point of 75% obstruction of the airway on endoscopy. (M. F. Feres, Hermann, Sallum, & Pignatari, 2014).

Cut-off values for enlarged adenoids when using the AA diameter to assess the adenoids are derived from the study by Hibbert and Stell in 1979 as 2 mm in children younger than 70 months and 3 mm in older children. Children in whom the AA diameters are equal to or lower than the cut-off values are considered to have enlarged adenoids (Hibbert & Stell, 1979)

2.6 Comparison of Correlation of Adenoidal-Nasopharyngeal Ratio to Adenoid Volume and Correlation of Antroadenoid Diameter to Adenoid Volume

In the present study, the correlation of the ANR to the postoperative adenoid volume is compared to that of the AA diameter in a bid to determine which of the two parameters is more accurate. A similar study was carried out by Jeans et al. in 1981 at a university

teaching hospital in Bristol, England where the correlation of various radiographic parameters was calculated in relation to the volume of the adenoid tissues measured postoperatively. The results of this study indicated that the ANR had a stronger correlation ($r=0.51$, $p<0.01$) when compared to that of the AA diameter ($r=0.28$, $p<0.1$) (Jeans, Fernando, & Maw, 1981).

In a study on 40 children at a hospital in Seoul, South Korea, Cho et al. (1999) found the ANR to have a stronger correlation ($r=0.604$, $p<0.005$) to the size of the adenoids as measured using acoustic rhinometry when compared to that of the antroadenoid diameter ($r=0.286$, $p=0.126$). In addition, the antroadenoid diameter was not found to differ between the children who had adenoid hypertrophy and were scheduled to undergo adenoidectomy and a control group who had no symptoms of adenoid hypertrophy (Cho et al., 1999).

Feres et al. (2014) in a study in Sao Paulo, Brazil, on the accuracy of various radiographic parameters in relation to the percentage obstruction of the airway on endoscopy found higher values for the ANR in children who had enlarged adenoids when compared to AA diameter. In this study, study participants were categorized using endoscopy as either having adenoids that were pathologically enlarged (66.67% obstruction) or as children who were likely to undergo adenoidectomy (75% obstruction). Sensitivity and negative predictive values for ANR were 77.2% and 72.4% respectively when compared to those of AA diameter at 68.1% and 65% for the children who had 66.67% obstruction of the airway on endoscopy (that is, those who were considered to have pathologically enlarged adenoids). The values were, however, different in those who were possible candidates for adenoidectomy where the specificity and positive predictive

values for the AA diameter were higher than those of the ANR at 77.7% and 69.2% respectively for the AA diameter and 75% and 66% for the ANR (M. F. Feres et al., 2014).

In 1992 at a public hospital in Cape Town, South Africa, Wormald and Prescott carried out a study correlating four different radiological measurements on postnasal space x-ray including the adenoidal-nasopharyngeal ratio and antroadenoid diameter to the degree of obstruction of the choanae assessed using endoscopy. The findings obtained by Wormald and Prescott differed from those of the afore-mentioned studies, as the ANR had a lower correlation ($r=0.11$, $p>0.5$) compared to that of the antroadenoid diameter ($r=0.22$, $p<0.05$) (Wormald & Prescott, 1992).

Similar findings were obtained by Waters et al. (2013) in Australia where number of parameters of adenoid size on PNS x-ray were correlated to measures of various variables of sleep apnea using polysomnography and determined the AA diameter to have a higher correlation than the ANR. Full overnight polysomnography was done for all 72 participants in this study and the measurements of sleep apnea that were studied include indices for apnea-hypopnea and obstructive apnea-hypopnea (AHI and OAHI respectively) as well as oxygen saturation. (Waters et al., 2013)

CHAPTER THREE: MATERIALS AND METHODS

3.1 Study Design

This was a cross-sectional study.

3.2 Study Site

The study was conducted at the x-ray reporting room at the department of Radiology and Imaging, Moi Teaching and Referral Hospital (MTRH) as well as the paediatric surgical ward and ENT operating theatres at MTRH. The hospital is a level 6 health facility located in Eldoret town, Uasin Gishu County, 310 kilometers north-west of Nairobi and serves as a teaching hospital for Moi University School of Medicine, Nursing, Public Health and Dentistry. Other institutions that use this facility include Kenya Medical Training College (KMTC), Eldoret and University of Eastern Africa, Baraton School of Nursing. MTRH is also a training centre for medical, clinical and nursing officer interns. It serves as the main referral hospital for the Western and Rift Valley regions of Kenya and also receives patients from parts of Eastern Uganda and Southern Sudan. The catchment population of the hospital is approximately 24 million people. Apart from Radiology and Imaging, the facility has several other departments including Internal Medicine, Surgery, Paediatrics, Obstetrics and Gynaecology, Psychiatry among others.

3.3 Study Population

The study population was patients aged 15 years and below with adenoid hypertrophy who were scheduled to undergo adenoidectomy at MTRH during the study duration.

3.4 Eligibility Criteria

3.4.1 Inclusion criteria

1. Patients aged 15 years and below with adenoid hypertrophy and scheduled to undergo adenoidectomy.

Cut-off age of 15 years for patients to be included in the study was chosen due to data which shows that the size of the adenoid tissues decreases significantly after the age of 15 (Jaw et al., 1999).

2. Written informed consent and assent.

3.4.2 Exclusion criteria

1. Patients with craniofacial anomalies that alter the morphology of the nasopharynx including Down's syndrome and cleft palate.

2. Patients with history of surgery for cleft palate.

3. Patients with history of previous adenoidectomy.

3.5 Sampling Procedure

3.5.1 Sample Size

Sample size is calculated using the formula described by Hulley, Cummings, Browner, Grady and Newman (2013) for studies involving difference between two correlation coefficients, which is:

$$n = [(z_{\alpha} + z_{\beta}) / (c_1 - c_2)]^2 + 3$$

$$\text{where, } c_1 = 0.5 * \ln[(1+r_1) / (1-r_1)]$$

$$c_2 = 0.5 * \ln[(1+r_2) / (1-r_2)]$$

r_1 is the expected correlation co-efficient of adenoidal-nasopharyngeal ratio to postoperative adenoid volume, r_2 is the expected correlation coefficient of antroadenoid

diameter to postoperative adenoid volume, z_α is the z-score at the chosen value of α (type I error) and z_β is the z-score at the chosen value of β (type II error). (Hulley, Cummings, Browner, Grady, & Newman, 2013)

Using α of 5% (level of confidence of 95%), β of 20% (power of 80%), and correlation coefficients from a study by Jeans et al. of r_1 of 0.51 and r_2 of 0.28 (Jeans, Fernando, & Maw, 1981), the calculated sample size (n) was:

$$c_1 = 0.5 * \ln [(1+0.51) / (1-0.51)]$$
$$= 0.5627$$
$$c_2 = 0.5 * \ln [(1+0.28) / (1-0.28)]$$
$$= 0.2877$$
$$n = (2.8 / 0.275)^2 + 3$$
$$= 107$$

3.5.2 Sampling Technique

Consecutive sampling was used where the patient and/or guardian of every child diagnosed with adenoid hypertrophy and who was scheduled to undergo adenoidectomy was approached and written informed consent sought. Assent was sought from children above 7 years of age.

3.6 Study Procedure

Children presenting for postnasal space x-ray were identified at the x-ray room at the department of Radiology. Postnasal space x-rays were done by trained radiographers and the x-rays reported by the principal investigator and verified by two consultant radiologists and the diagnosis of adenoid hypertrophy made. Thereafter, the patients were followed up at the ENT clinic where potential study participants (those booked for adenoidectomy) were then identified from records at the ENT clinic and the date for

surgery noted. On the day of admission for surgery, which was the day before surgery, study participants were identified and recruited at the paediatric surgical ward by the principal investigator where written informed consent was obtained from the parents/guardians and assent from children above 7 years of age for those meeting eligibility criteria. The x-ray findings were retrieved from the picture archiving and communication system (PACS) at x-ray reporting workstations. The patients were then followed up post-operatively where the volume of the adenoid tissues removed during adenoidectomy was measured using the method described by Mason, Hehar, Holden and Jones in 1995 using a 20ml syringe. The volume of the adenoid tissues was measured by a trained research assistant to avoid bias.

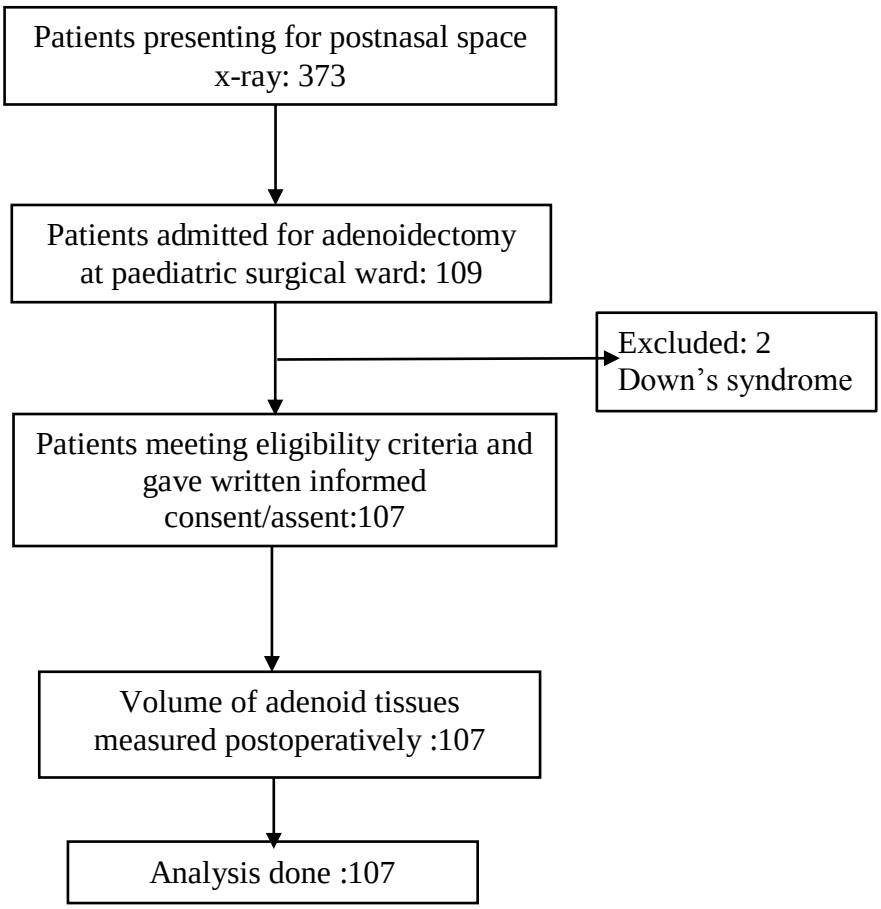


Figure 1: Enrolment flow chart

3.7 Measurement of adenoid volume

The volume of the adenoids was measured immediately after adenoidectomy. The adenoids were first placed in a kidney dish containing normal saline to remove any residual blood and blood clots. The volume of the adenoid tissues was then measured using the method of fluid displacement using a 20mL syringe described by Mason et. al. in 1995. Normal saline was placed in the syringe to a level of 'n.0' ml which was recorded, and the nozzle of the syringe capped off using a finger. The plunger of the syringe was then removed. The adenoid tissues were subsequently completely immersed in the normal saline and the level to which the normal saline was displaced was recorded. The volume of the adenoid tissues was then determined by subtracting the original volume of normal saline in the syringe from the volume after immersing the adenoid tissues (Mason, Hehar, Holden, & Jones, 1995). Postoperative adenoid volumes were measured by a trained research assistant, who was a theatre nurse. The research assistant was blinded to the findings on x-ray to avoid bias.

Adenoidectomies were performed by ENT surgeons using the same technique of curettage adenoidectomy which involves first directly visualizing the adenoids through the mouth followed by curettage using an adenoid curette followed by digital palpation to ensure no residual adenoid tissue is left.

3.8 Postnasal Space X-ray Imaging Protocol

All PNS x-rays were taken at the radiology department, MTRH using a GE Definium 6000 digital x-ray machine. PNS x-rays were taken with the child lying in supine position on a couch, neck slightly extended with lateral aspect of head in contact with Bucky grid. The jaw was raised slightly so that the angles of the mandible were separated from the

bodies of the upper cervical spine. The head was adjusted so that the median sagittal plane is parallel to the Bucky in true lateral position. Images were taken with the mouth closed. X-ray beam was centred to the external auditory meatus and collimated to include the maxillary sinus, posterior pharynx and the cervical vertebrae. Exposure factors used were 70 kilovolts and 3.2 milliampere-seconds with a source to image distance of 140cm. Digital images were used to avoid errors due to magnification. Images stored on the picture archiving and communication system (PACS) workstations were saved on compact disks.

3.9 Reporting of Postnasal Space X-rays

The size of the adenoids was measured using two methods: adenoidal-nasopharyngeal ratio described by Fujioka et. al. (1979) and antroadenoid diameter described by Hibbert and Whitehouse (1978). Both measurements are illustrated in the appendices.

3.10 Data Collection

Data was collected from September 2017 to August 2018. Entry was made in the questionnaires and later transferred to a computer database using double entry to ensure accuracy. Serial numbers were used to protect the patients' identity. The filled-in questionnaires were kept in a cabinet under lock and key by the principal investigator. The study images were stored directly as DICOM files in a computer and in compact discs. All images were deidentified and coded to protect the patients' identity. The images were kept under lock and key by the principal investigator. All patient details were kept confidential. The computers used were password-protected and access was only allowed for the principal investigator and supervisors.

3.11 Data Management and Analysis

Data was analysed using STATA version 13E. The demographic and clinical characteristics of the study participants were summarised using frequencies and percentages and presented using charts and tables. Continuous variables including age as well as values of ANR, AA diameter and postoperative adenoid volume were presented using tables and graphs and analysed using mean and standard deviation(SD). Correlation of adenoidal-nasopharyngeal ratio to postoperative adenoid volume and antroadenoid diameter to postoperative adenoid volume was analysed using Pearson's correlation. The correlation was calculated controlling for the number of days between x-ray and adenoidectomy which was a potential confounding factor. The results were presented using charts. The null hypothesis was tested using Steiger's Z-test. In all the analyses, a level of significance(α) of 0.05 was used thus a p-value of less than 0.05 was considered statistically significant.

3.12 Study limitations

1. Adenoidectomy was performed by more than one ENT surgeon. The effect of this was minimized as adenoidectomy was performed using the same technique of curettage adenoidectomy.

3.13 Ethical Considerations

Approval to carry out the study was sought from the Institutional Research and Ethics Committee (IREC). Permission to conduct the study was obtained from the CEO, Moi Teaching and Referral Hospital. Parents/guardians were informed about the procedures involved in the study and that their children would receive medical attention as necessary regardless of their willingness/unwillingness to participate in the study. Assent was

obtained from children above 7 years of age. All patients received medical attention regardless of whether they did or did not consent to take part in the study. No incentives or inducements were used to convince patients to participate in the study. Confidentiality was maintained throughout the study. The questionnaires used did not contain the names of the patients nor their hospital numbers. The materials used to collect the data including the questionnaires and the compact discs used to store the images were kept in a locked cabinet by the principal investigator during the study period.

CHAPTER FOUR: RESULTS

4.1 Introduction

The findings here are based on 107 children who presented with adenoid hypertrophy and underwent adenoidectomy at Moi Teaching and Referral Hospital during the study period.

4.2 Demographic Characteristics

A total of 107 participants were enrolled into the study. Seventy-nine percent (n=85) were residents of Uasin Gishu, seven percent (n=8) came from Elgeyo-Marakwet, six percent (n=6) from Bungoma and five percent (n=5) from Nandi. The remaining three study participants came from Trans-Nzoia (n=2) and Kakamega (n=1). This is illustrated in **figure 2** below.

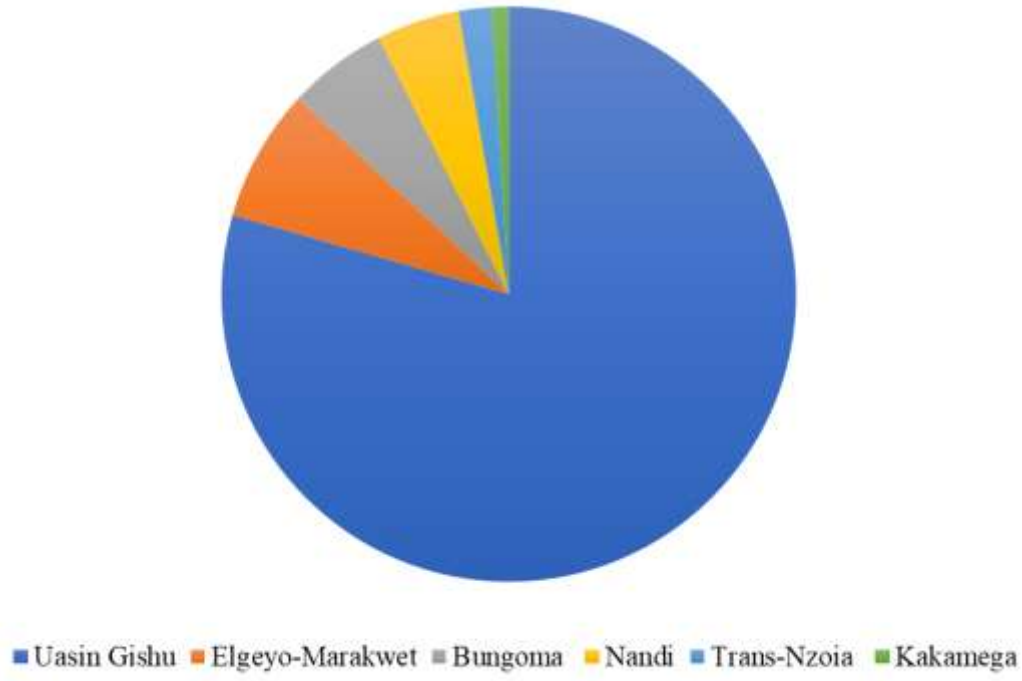


Figure 2: Residence of study participants

The age of the study participants ranged between 11 months and 11 years with a mean age of 3.4 (SD 2.0). Male children were the majority at 72 (67.3%) giving a male to female ratio of 2.1:1. As seen in **figure 3** below, majority of the patients were aged between 1 year and 5 years. The mean age of female was 3.3 (SD 1.8) years compared to those of males which was 3.4 (SD 2.1) years. The difference in mean age between male and female was not statistically significant (p=0.749).

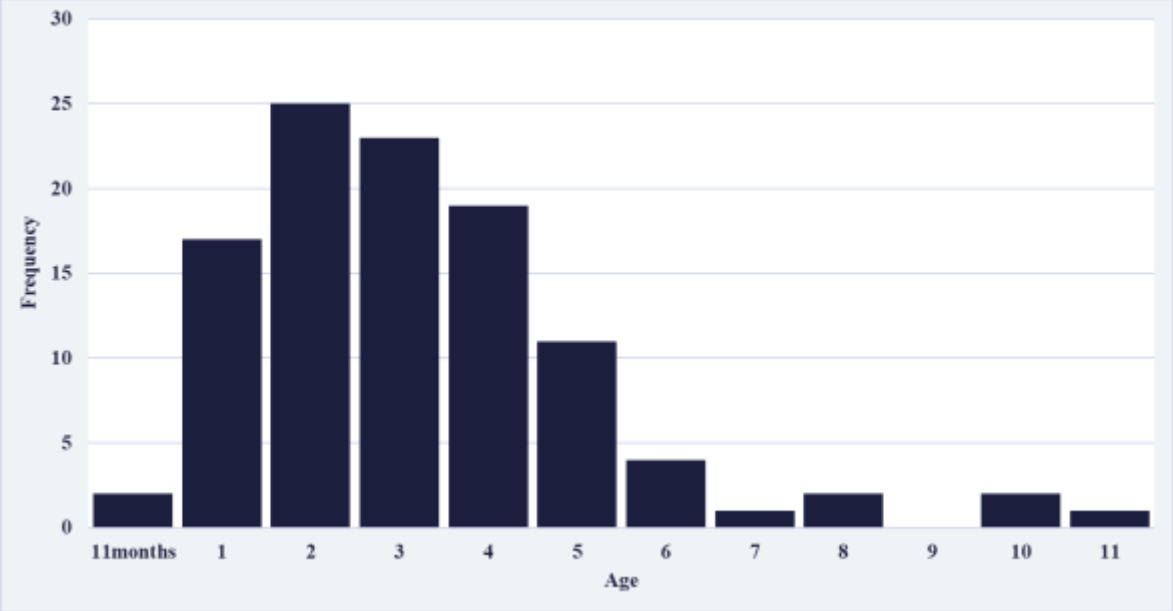


Figure 3: Age distribution

4.3 Findings on Postnasal Space x-ray and Postoperative Adenoid Volume

The findings on the radiographic parameters including ANR and AA diameter as well the postoperative volume of the adenoids are as summarized in **table 3** below:

Table 3: Findings on postnasal space x-ray and postoperative adenoid volume

Variable	Category	Mean (SD)	Min-Max
X-ray	ANR	0.70 (0.16)	0.34-0.97
	AA diameter	3.10 (1.82)	0.20-8.40
Surgical	Adenoid volume	2.83 (1.20)	1.00-7.00

4.4: Correlation of Adenoidal-Nasopharyngeal Ratio to Postoperative Adenoid Volume

Controlling for the number of days between x-ray and adenoidectomy, the correlation of the adenoidal-nasopharyngeal ratio to adenoid volume was positive at 0.661. This was statistically significant with a p-value of <0.001.

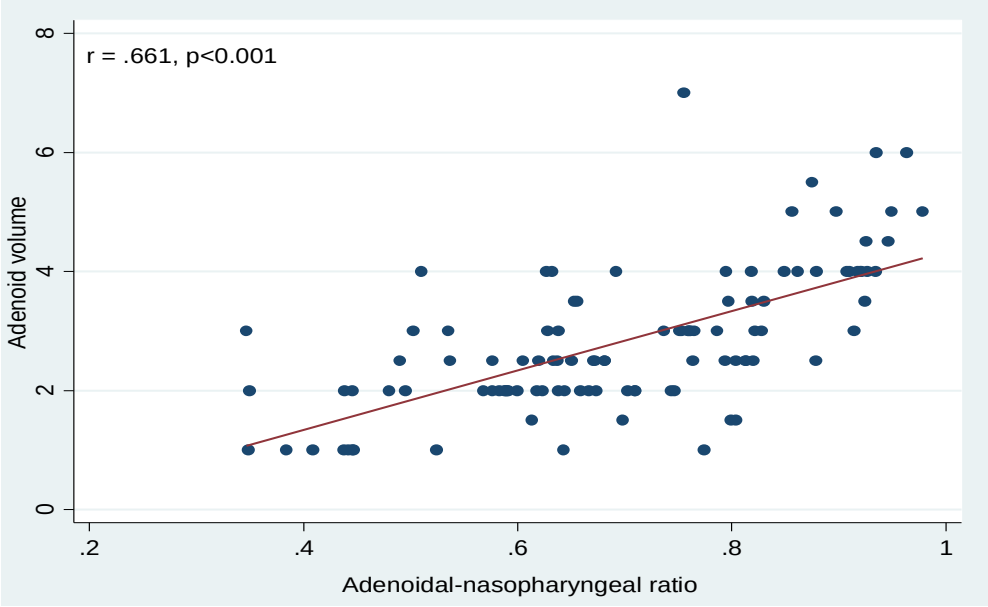


Figure 4: Correlation of adenoidal-nasopharyngeal ratio to postoperative adenoid volume

4.5 Correlation of Antroadenoid Diameter to Postoperative Adenoid Volume

The correlation of antroadenoid diameter to adenoid volume, controlling for the number of days between x-ray and adenoidectomy was negative and statistically significant (r=-0.222, p=0.022).

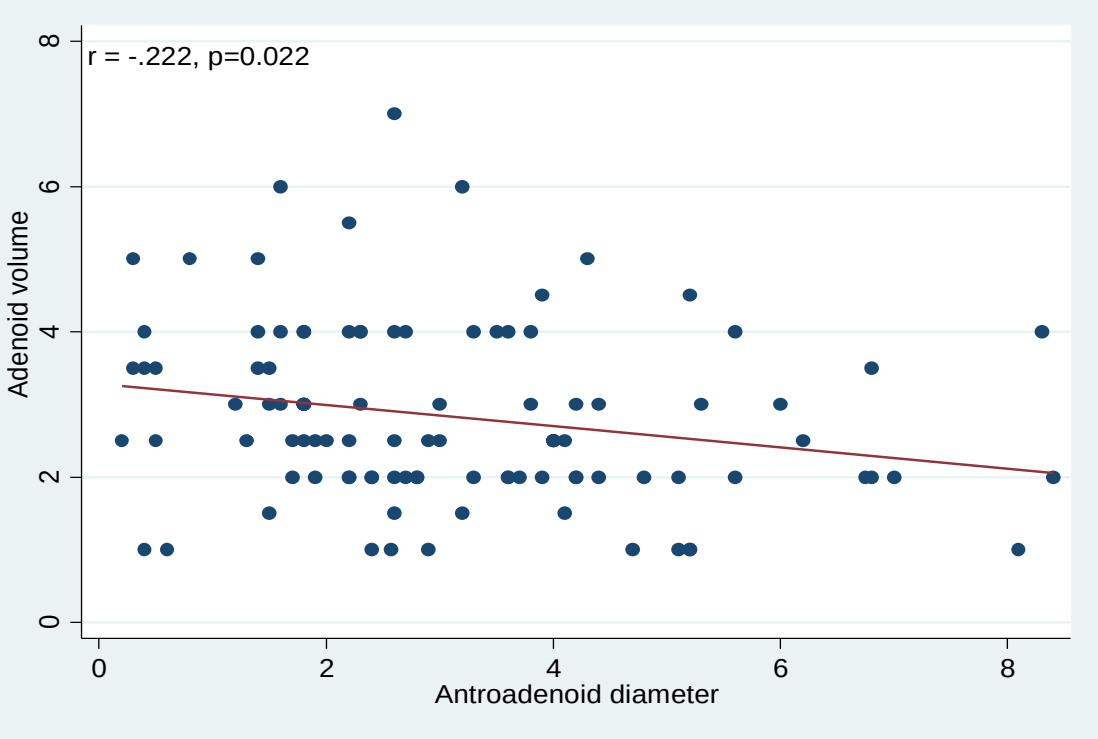


Figure 5: Correlation of antroadenoid diameter to postoperative adenoid volume

4.6 Comparison of Correlation of Adenoidal-Nasopharyngeal Ratio to Postoperative Adenoid Volume and Antroadenoid Diameter to Postoperative Adenoid Volume

Comparing the absolute size of the two correlation coefficients |r|, that is 0.661 for the correlation of adenoidal-nasopharyngeal ratio to postoperative adenoid volume and 0.222 for the correlation of antroadenoid diameter, the adenoidal-nasopharyngeal ratio has a stronger correlation than the antroadenoid diameter.

To test the null hypothesis that there is no difference in the correlation of adenoidal-nasopharyngeal ratio to postoperative adenoid volume and the correlation of antroadenoid diameter to postoperative adenoid volume, Steiger's Z-test for correlated correlations was used as the two correlations share a common variable: postoperative adenoid volume. The absolute values of the correlation are used to calculate the Z-statistic using Steiger's test instead of the signed values, because we are interested in the strength of correlation that is, which of the two (adenoidal-nasopharyngeal ratio or antroadenoid diameter) is a significantly better predictor of adenoid volume. Thus 0.661 is used as the correlation coefficient of adenoidal-nasopharyngeal ratio to postoperative adenoid volume and 0.222 is used as the correlation coefficient of antroadenoid diameter to postoperative adenoid volume (instead of -0.222). Using the Steiger's Z-test, a Z-statistic is calculated using the formula:

$$Z = Z_{12} - Z_{13} * \frac{\sqrt{(n-3)}}{\sqrt{2*[1-r_{23}]} * h}$$

$$h = \frac{1-[f*rm^2]}{1-rm^2}, \quad f = \frac{1-r_{23}}{2*[1-rm^2]}, \quad rm^2 = \frac{r_{12}^2 + r_{13}^2}{2}$$

where, r_{12} is the correlation of ANR to postoperative adenoid volume= 0.661

r_{13} is the correlation of AA diameter to postoperative adenoid volume=0.222

r_{23} is the correlation of ANR to AA diameter=0.28

Z_{12} is the Z transformation of r_{12}

and Z_{13} is the Z transformation of r_{13}

The Z-statistic calculated was Z=4.555, p<.05. This is larger than the Z-critical of 1.96 using a two-tailed test at a level of significance of 0.05. The null hypothesis is thus rejected, and it is determined that there is a significant difference between the correlation of adenoidal-nasopharyngeal ratio to postoperative adenoid volume and the correlation of antroadenoid diameter to postoperative adenoid volume.

It is thus concluded that the adenoidal-nasopharyngeal ratio is a better predictor of adenoid volume and the difference between the two correlation coefficients is significant.

Sample Images

Figure 6: Case of an eight-year-old male with a three-year history of snoring, mouth breathing, interrupted breathing while sleeping and nasal blockage. Adenoidal-nasopharyngeal ratio of 0.83 and antroadenoid diameter of 1.5mm. The volume of the adenoids post-operatively was 3mL.

Figure 7: Case of a four-year-old female with a three-year history of snoring, mouth breathing, discharge from the ears and nasal blockage. Adenoidal-nasopharyngeal ratio of 0.96 and antroadenoid diameter of 3.2 mm. The volume of the adenoids post-adenoidectomy was 6mL.

Figure 8: Case of a three-year-old male with a one-year history of snoring, mouth breathing and nasal blockage. Adenoidal-nasopharyngeal ratio of 0.73 and antroadenoid diameter of 1.2mm. The volume of the adenoids measured postoperatively was 3 mL.

Figure 9: Case of a five-year-old male with a two-year history of snoring, mouth breathing and nasal blockage. Adenoidal-nasopharyngeal ratio of 0.71 and antroadenoid diameter of 4.2mm. The volume of the adenoid tissues measured postoperatively was 2 mL

Figure 10: Case of a four-year-old male with a one-year history of snoring and mouth breathing. Adenoidal-nasopharyngeal ratio of 0.67 and antroadenoid diameter of 2.2 mm. The volume of the adenoids measured postoperatively was 2 mL.

CHAPTER FIVE: DISCUSSION

5.1 Demographics and Clinical Characteristics

The majority of the patients in this study were male at 67.3% (72 patients) with a male to female ratio of 2.1:1. Similar findings were obtained in a study by Sempele (2016) at KNH, Nairobi, on the correlation of findings on PNS x-ray to a clinical score where the number of study participants who were male formed the majority at 67% (37 patients) with a male to female ratio of 2:1. (Sempele, 2016). Kolo et. al. (2011) in a study at a teaching hospital in Northern Nigeria found comparable results where 22 (64.7%) of the 34 patients studied were male (Kolo et al., 2011). These findings were further supported by Manzoor et. al. (2017) in a study at the ENT outpatient department of a hospital in Pakistan where 115 of the 150 patients (76.67%) included in the study were male (Manzoor et al., 2017).

The reason for male predominance among children diagnosed with adenoid hypertrophy is unclear, however, we postulate that this could be explained by the fact that females have been shown to attain maximum depth and area of the nasopharynx at an earlier age than males with a larger increase in the size of the nasopharynx per year (Handelman & Osborne, 1976), thus have a lower likelihood of developing obstructive symptoms in cases of enlargement of the adenoids.

The ages of the participants in this current study ranged between 11 months and 11 years with a mean age of 3.4 years. These findings concur with conclusions from various studies in which the adenoids were shown to be evident on x-ray from six months of age (Capitanio & Kirkpatrick, 1970), increase rapidly in size from three to five years (Jeans,

Fernando, Maw, et al., 1981), with subsequent significant decrease in dimensions after the age of fifteen (Jaw et al., 1999).

Snoring, mouth-breathing and nasal obstruction were the most frequently reported symptoms at 107 (100%), 104 (97.2%) and 103 (96.26%) patients respectively. Sempele (2016) in KNH, Nairobi, described similar findings with a history of snoring and difficulty breathing being reported in all 55 children who had been recruited into the study (Sempele, 2016). In a study at the ENT clinic of a teaching hospital in Northern Nigeria, Kolo et. al. (2011) found snoring to be the most common symptom reported in 38.5% of the children recruited into the study, followed by mouth-breathing at 35.9%. The study was on the correlation of the ANR to a symptomatology score with a focus on four main symptoms of adenoid hypertrophy including snoring, mouth-breathing, sleep apnea and nasal blockage. None of the study participants was reported as having all four of the symptoms studied (Kolo et al., 2011). The high occurrence of snoring and mouth-breathing in patients with adenoid hypertrophy is as a result of obstruction of airflow via the nasal cavity and nasopharyngeal airway due to the enlarged adenoids. KS et.al. (2012) in their study in India on the correlation of the size of the adenoid tissue measured using the ANR to clinical symptomatology found a significant increase in the size of the adenoids in children who had snoring and mouth breathing (KS et al., 2012). These symptoms have been shown to resolve significantly after adenoidectomy (D. Wang, Clement, Kaufman, & Derde, 1995).

Discharge from the ears was only reported in 3 of the 107 patients enrolled in this current study. These findings are in congruence with results from Wang, Bernheim, Kaufman and Clement (1997) on the relationship between the size of the adenoids on endoscopy

and findings on tympanometry where it was concluded that the causes of otitis media are multi-factorial and hypertrophy of the adenoids could only partially account for its etiology (Wang, Bernheim, Kaufman, & Clement, 1997).

5.2 Findings on PNS X-ray and Postoperative Adenoid Volume

The mean ANR in this study was 0.70 ± 0.16. The values of the ANR ranged from a minimum of 0.34 to a maximum of 0.97. This compares well with findings from various authors. In a study in 1981 at a university teaching hospital in Bristol, England, on the correlation of various parameters of adenoid size on PNS x-ray to the volume of the adenoids measured postoperatively, Jeans et. al. found a mean ANR of 0.71 ± 0.16 while the minimum ANR was 0.31 and the maximum value was 1.0 (Jeans, Fernando, & Maw, 1981). Elwany in Saudi Arabia in 1987, in a study on the validity of using the ANR when deciding whether patients with adenoid hypertrophy should undergo adenoidectomy, found similar results where the mean ANR was 0.71± 0.105 (Elwany, 1987). Orji and Ezeanolue (2008) in their study on the correlation of clinical symptoms to a radiological score in southeastern Nigeria also found comparable results where the mean ANR was 0.718 (Orji & Ezeanolue, 2008).

The findings of the ANR in this study, however, vary from those by Feng et. al. (2015) in a retrospective study in China where the value of the mean ANR was lower at 0.49 (Feng et al., 2015). This could be explained by the difference in methodology, where in the study by Feng et. al. the measurement of the ANR was repeated on ten of the study participants by two different observers, thus increasing variation in the results obtained.

The mean value of the AA diameter was 3.10 ± 1.82 mm with the AA diameter ranging from a minimum of 0.20 mm to a maximum of 8.40 mm. Cho et. al. (1999) in South

Korea obtained similar values for the AA diameter with a mean of 3.39 ± 1.02mm (Cho et al., 1999). The results are, however, lower than those from a study by Feres et. al. (2014) at a university teaching hospital in Brazil, where the AA diameter had a mean of 7.03 ± 2.84mm (M. F. Feres et al., 2014). The difference in the ages of the study participants included in the two studies could account for the variation in results, where Feres et. al. enrolled children of an older age group of four to fourteen years with a mean age of 9.45 years while in the current study, the ages of the participants ranged from 11 months to 11 years with a mean of 3.4 years. The adenoids have been shown to increase rapidly in size from three to five years of age (Jeans, Fernando, Maw, et al., 1981), hence older children are likely to have smaller adenoids with subsequent higher values of the AA diameter.

The volume of the adenoid tissues measured postoperatively had a mean of 2.83 ± 1.21 mL. The minimum value for the postoperative adenoid volume was 1 mL while the maximum was 7 mL. Jeans et al. in 1981 found higher values with a mean of 3.59 ± 1.49 mL (Jeans, Fernando, & Maw, 1981). The variation in these results could be explained by the difference in the sample sizes of the two studies , where Jeans et al. enrolled fewer patients (n=38) whereas in our study one hundred and seven patients were included.

5.3 Correlation of Adenoidal-Nasopharyngeal Ratio to Postoperative Adenoid Volume

Controlling for the number of days between the time the PNS x-ray was taken to the time of adenoidectomy, the correlation of the adenoidal-nasopharyngeal ratio to the adenoid volume was 0.661, which was statistically significant with a p-value of <0.001.

This represents a moderate positive and statistically significant relationship between the adenoidal nasopharyngeal ratio and the postoperative volume of the adenoids.

These results are similar to findings from different authors. Jeans et al. (1981) in Bristol, England carried out a study on the correlation of various radiographic parameters to the volume of the adenoids measured postoperatively and found a moderately positive and significant correlation at 0.51 ($p<0.01$) for the adenoidal-nasopharyngeal ratio. Lertsburapa et al. (2010) in a study at a children's hospital in Chicago, America, correlating the ANR to the size of the adenoids as determined using intraoperative mirror examination on a cohort of 61 children determined the correlation to be 0.64 ($p<0.0001$) (Lertsburapa et al., 2010). In a study on a hundred children to assess the value of the ANR in choosing patients for adenoidectomy and its reproducibility among observers, Elwany (1987) in Saudi Arabia determined the correlation of the ANR to the weight of the adenoids measured postoperatively to be 0.66 ($p<0.001$) (Elwany, 1987). Kemaloglu et al. in Turkey found a similar correlation coefficient of 0.68 ($p<0.0001$) to a clinical nasal obstruction score among children who were possible adenoidectomy candidates. (Kemaloglu et al., 1999). These findings were further corroborated by Sempele (2016) in a study at KNH, Nairobi on the correlation of radiological findings to a clinical score where the correlation for the ANR was 0.629 ($p<0.001$). The clinical symptoms that were assessed in this study include difficulty in breathing and snoring, which were graded based on severity, and sleep apnea which was scored as either being absent or present (Sempele, 2016).

The findings in the present study, however, differ from those of a number of authors. Wormald and Prescott (1992) in a study on 48 children in Cape Town, South Africa

found the correlation for the ANR to be weak and non-significant at 0.11 ($p>0.5$). The discrepancy in findings could be explained by the fact that in the study by Wormald and Prescott, the ANR was correlated to the percentage obstruction of the nasopharyngeal airway as determined by endoscopy while in this current study correlation was made to the volume of adenoid tissues postoperatively. In addition, there was double evaluation of 26 of the 48 patients before and after surgery in the study by Wormald and Prescott and the endoscopies were done by two observers, which may have contributed to variation in the results obtained (Wormald & Prescott, 1992).

The correlation of ANR in this present study also contrast findings by Kolo et al. (2011), where the ANR was determined to have a weak and non-significant correlation of 0.168 ($p=0.375$) to a symptomatology score (Kolo et al., 2011). Difference in study design, where Kolo et al. (2011) carried out a retrospective study, obtaining data on clinical findings from the patients' notes on hospital files could account for the variation in results. In addition, the ANR was measured on analog images using a transparent ruler, which may have contributed to lack of precision in the findings due to likelihood of differences in magnification on the images, compared to digital images used in this current study.

5.4 Correlation of Antroadenoid Diameter to Postoperative Adenoid Volume

Controlling for the number of days between the time PNS x-rays were taken to the time of surgery, the correlation of the antroadenoid diameter to the volume of the adenoid tissues was -0.222 ($p=0.022$). This represents a weak but statistically significant negative relationship between the antroadenoid diameter and the volume of adenoid tissues

measured postoperatively. As the values of the antroadenoid diameter increased, there was a reduction in the postoperative volume of the adenoids.

These findings are comparable to results from a study by Maw et. al. (1981) on a cohort of forty-six children in Bristol, England, where the AA diameter had a weak negative but statistically significant correlation to postoperative adenoid volume at -0.28 ($p=0.049$) (Maw et al., 1981). These findings were echoed by Crepeau et. al. (1982) in a study on the correlation of parameters of adenoid size on postnasal space x-ray to a symptomatology score, where the correlation of the AA diameter was -0.34 ($p<0.005$). One hundred and fifteen children below fifteen years of age were enrolled into the study, which was carried out at a university teaching hospital in Quebec, Canada (Crepeau et al., 1982). Wormald and Prescott (1992) also found similar results in a study on the correlation of various radiographic parameters to findings on endoscopy, where the AA diameter had a weak but significant correlation ($r=0.22$, $p<0.05$) (Wormald & Prescott, 1992). The disparity in the direction of the correlation with the correlation coefficient in the study by Wormald and Prescott being positive ($r=0.22$) compared to the negative correlation ($r=-0.222$) obtained in this current study can be attributed to variation in the method of comparison used where Wormald and Prescott compared the AA diameter to the degree of obstruction of the postnasal space while in this current study comparison was made to the volume of the adenoid tissues measured postoperatively.

The value of the correlation of the antroadenoid diameter to postoperative adenoid volume in this study differs from that in a study by Hibbert and Whitehouse (1978) in Liverpool, England, where the correlation was determined to be -0.78, $p<0.001$. This difference in results could be rationalized by the difference in method of comparison used

and difference in analysis, where Hibbert and Whitehouse correlated the logarithm to base 10($\log_{10}$) of the antroadenoid diameter to $\log_{10}$ of the adenoid weight (Hibbert & Whitehouse, 1978).

Sorensen et al. (1980) carried out a study in Copenhagen, Denmark, comparing the antroadenoid diameter and other measurements of adenoid size on PNS x-ray to symptomatology and nasal respiratory resistance as measured using rhinomanometry and found the antroadenoid diameter to have the highest correlation ($r=-0.52$, $p<0.05$) to the nasal respiratory resistance and a correlation of -0.42 ($p<0.05$) to the symptom snoring (Sørensen et al., 1980). The variance in results obtained with this present study could be due to the difference in methodology where Sorensen et. al. correlated nasal respiratory resistance and symptomatology to the antroadenoid diameter whereas in this study correlation to the volume of adenoid tissues measured postoperatively was made.

Various studies have been set up to evaluate the cut-off point for normal when using the antroadenoid diameter to assess the adenoids on PNS x-ray. Hibbert and Stell in 1979 determined the normal limit of the antroadenoid diameter to be 2mm in children younger than 70 months and 3 mm in older children. (Hibbert & Stell, 1979)

5.5 Comparison of Correlation of Adenoidal-Nasopharyngeal Ratio to Postoperative Adenoid Volume and Antroadenoid Diameter to Postoperative Adenoid Volume

The null hypothesis that there is no difference between the correlation of ANR to postoperative adenoid volume and the correlation of the AA diameter to postoperative adenoid volume is rejected. It is, therefore, determined that the ANR is a better predictor of adenoid volume and the difference between the two correlation coefficients is significant.

In 1999, Cho et al. in Seoul, South Korea, also obtained similar results when they carried out a study on a sample of 40 children, comparing the ANR and the AA diameter to the size of the adenoids as measured using acoustic rhinometry. The ANR had a moderate positive statistically significant correlation ($r=0.604$, $p<0.005$) while the correlation of AA diameter was weak and non-significant ($r=0.286$, $p=0.126$). In addition, the value of the antroadenoid diameter did not differ between the children who were scheduled to undergo adenoidectomy and a control group comprised of children who had no symptoms of adenoid hypertrophy (Cho et al., 1999).

The findings in this study agree with findings of a systematic review by Major et al. (2006) in Brazil who opined that measuring the degree of nasopharyngeal airway narrowing on x-ray is to be interpreted with caution as the nasopharynx is a more complex three-dimensional structure than the adenoid, thus tends to lose more information on a two dimensional image such as an x-ray (Major et al., 2006). Mahboubi, Marsh, Potsic and Pasquariello (1985) in a study at a children's hospital in Philadelphia, United States of America, found variation in interpretation of the degree of narrowing of the airway between supine and erect radiographs of the same patient by observers, as the apparent dimensions of the airway changed depending on difference in the degree of extension of the neck and the position of the midline in relation to the plane of the film. In this study, measurement of the ANR did not differ between supine and erect positions (Mahboubi, Marsh, Potsic, & Pasquariello, 1985).

Orji and Ezeanolue (2008) in Enugu, Nigeria, also advocated for use of the ANR when assessing the adenoids on PNS x-ray arguing that both the size of the airway and the size of the nasopharynx are taken into account when measuring the ANR (Orji & Ezeanolue,

2008). Caylakli et. al. further supported these findings in their study in 2009 at a university teaching hospital in Ankara, Turkey, where they determined the ANR to be a useful measurement of adenoid size on x-ray, as well as a reliable parameter stating that it is reliant mainly on bony structures, thus unlikely to be affected by changes in position when taking the x-ray or superimposition of tissues (Caylakli et al., 2009). The ANR was also found to be a reliable measurement with high intraobsever and interobserver correlation coefficients of 0.91 and 0.96 respectively according to a study by Feng et. al. (2015) in Dalian, China (Feng et al., 2015).

Wormald and Prescott (1992), however, found differing results where the antroadenoid diameter was found to have a higher correlation ($r=0.22$, $p<0.05$) when compared to the adenoidal-nasopharyngeal ratio ($r=0.11$, $p>0.5$). The disparity in the results from this present study may be attributed to the difference in the methodology where Wormald and Prescott correlated the measurements on x-ray to the degree of obstruction of the choanae evaluated using endoscopy compared to the volume of the adenoid tissues measured postoperatively in this study. In addition, there was double evaluation of some of the patients before and after surgery. (Wormald & Prescott, 1992).

In a study on 72 children aged below 11 years of age in Westmead, Australia, Waters et. al. (2013) found the ANR to have a lower correlation than the AA diameter. Differences in the method of comparison, where Waters et al. correlated the ANR and AA diameter to measurement of sleep variables using overnight polysomnography whereas in the present study the radiographic parameters were correlated to measurement of the volume of the adenoids postoperatively, could account for the variation in the results of the two studies. In addition, the measurements on x-ray in the study by Waters et. al. were taken by five

observers of differing training including a sleep physician, ENT surgeon and registrar, a radiologist and a research officer, which may have contributed to discrepancy in the measurements obtained. (Waters et al., 2013).

Cut-off values for grading of adenoid hypertrophy using the ANR are derived from values described by Malik et. al. (2013) as illustrated in the table below (Malik et al., 2013)

Table 4: Grading of adenoid hypertrophy using adenoidal-nasopharyngeal ratio

Degree of adenoid hypertrophy	**Adenoidal-nasopharyngeal ratio**
Mild	<0.25
Moderate	0.25 - <0.50
Moderately severe	0.50 - <0.75
Severe	≥0.75

The correlation coefficients of both the radiographic parameters: ANR & AA diameter to the postoperative volume of the adenoid tissues in this present study are statistically significant at $r=0.661$ ($p<0.001$) and $r=-0.222$ ($p=0.022$) respectively, which is indicative of the fact that x-rays are of value in assessing the adenoids in patients with adenoid hypertrophy.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

1. The adenoidal-nasopharyngeal ratio has a moderately positive and statistically significant correlation to the volume of the adenoid tissues measured postoperatively.
2. The antroadenoid diameter has a weak negative and statistically significant correlation to the volume of the adenoid tissues measured postoperatively.
3. The null hypothesis is rejected; there is a statistically significant difference between the correlation of the adenoidal-nasopharyngeal ratio to the postoperative adenoid volume and the correlation of the antroadenoid diameter to the postoperative adenoid volume.

The adenoidal-nasopharyngeal ratio is determined to be a better predictor of adenoid volume than the antroadenoid diameter when assessing postnasal space radiographs for adenoid hypertrophy.

6.2 Recommendations

Use of the ANR when reporting postnasal space radiographs in cases of suspected adenoid hypertrophy at MTRH.

A proposed template for reporting postnasal space radiographs is illustrated below:

PNS X-RAY

Patient name:…….

Date of birth: ……

Sex(M/F):……

Hospital no: ……

Date: ……..

Indication:……..

Findings

There is (no) enlargement of the adenoid tissues.

The adenoidal-nasopharyngeal ratio (ANR) is: …….

This corresponds to mild/moderate/severe adenoid hypertrophy.

The visualized bony structures and surrounding soft tissues are (not) normal.

Impression: Mild/moderate/severe adenoid hypertrophy

Figure 11: Proposed sample template for reporting postnasal space radiographs

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APPENDICES

Appendix 1: Consent Form

Investigator: My name is Dr Gathuru L. Muthoni. I am a qualified doctor, registered with the Kenya Medical Practitioners and Dentists Board. I am currently pursuing a master's degree in Radiology and Imaging at Moi University. I would like to recruit your child into my research which is to study the correlation of measurements of adenoid size on postnasal space x-ray to postoperative adenoid volume among children with adenoid hypertrophy at Moi Teaching and Referral Hospital.

Purpose: This study will seek to determine the correlation of measurements of adenoid size on postnasal space x-ray to the volume of the adenoids obtained post-operatively.

Procedure: Children scheduled to undergo adenoidectomy will be identified and recruited into the study after written informed consent is sought from the parents and/or guardians and assent from children above 7 years of age. Data on demographic characteristics will be obtained. The findings on postnasal space x-rays will be retrieved. The patients will then be followed up for the findings on adenoidectomy. Adenoid volume will be measured. Clinical, radiologic and surgical findings will be collected on data collection forms. Data collecting material will be kept in a locked cabinet during the study period.

Benefits: There will be no direct benefits of participating in this study. Study subjects will be accorded same quality of management as non-study subjects.

Risks: There are no anticipated risks to the participants attributable to this study.

Confidentiality: All information obtained in this study will be treated with utmost confidentiality and shall not be divulged to any unauthorized person

Rights to Refuse: Participation in this study is voluntary; there is freedom to refuse to take part or withdraw at any time. This study has been approved by the Institutional Research and Ethics Committee (IREC) of Moi University/Moi Teaching and Referral Hospital.

Sign or make a mark if you agree to take part in the study

Parent/Guardian: …… Investigator:……. Date: ……

Kiswahili version

Mpelelezi: Jina langu ni Dkt. Gathuru L. Muthoni. Mimi ni daktari aliyehitimu na kusajiliwa na bodi ya Kenya ya Madaktari na Madaktari wa meno. Kwa sasa natafuta shahada ya uzamili katika Radiologia na Imaging katika Chuo Kikuu cha Moi. Ningependa kusajili mtoto wako katika utafiti wangu ambao ni wa kujifunza uwiano kati ya ukubwa wa adenoid kwenye x-ray na kiasi cha adenoid baada ya upasuaji miongoni mwa watoto walio na adenoid hypertrophy katika hospitali ya mafundisho na rufaa ya Moi.

Kusudi: Utafiti huu utachunguza uwiano kati ya ukubwa wa adenoid kwenye x-ray na kiasi cha adenoid baada ya upasuaji.

Utaratibu: Watoto walio na adenoid hypertrophy na wanaotarajiwa kufanyiwa upasuaji watasajiliwa katika utafiti huu ikiwa wazazi na/au walezi wao watakubali baada ya kuelezwa juu ya utafiti. Matokeo ya ukubwa wa adenoid kwenye x-ray yatapatikana kutoka kwenye vituo vya kazi vya x-ray. Kiasi cha adenoid baada ya upasuaji kitapimwa na kurekodiwa. Data zitakusanywa kwenye fomu za ukusanyaji data. Hifadhi zitakazotumika katika ukusanyaji wa data zitawekwa katika kabati iliyofungwa na mpelelezi mkuu katika kipindi cha utafiti.

Faida: Hakutakuwa na faida ya moja kwa moja ya kushiriki katika utafiti huu. Wanaofanyiwa utafiti watakuwa na haki na kupewa matibabu sawa na wale ambao hawatahusishwa na utafiti huu

Hatari: Hakuna hatari inayotarajiwa kwa washiriki kutokana na utafiti huu.

Usiri: Habari zote zitakazopatikana katika utafiti huu zitawekwa kwa usiri mkubwa na wala hazitatolewa kwa mtu yeyote asiyehusika na utafiti.

Haki ya kukataa: Kushiriki katika utafiti huu ni kwa hiari yako; kuna uhuru wa kukataa kusajiliwa au kutoka wakati wowote. Utafiti huu umepitishwa na Utafiti wa Taasisi na Kamati ya Maadili (IREC) ya Chuo Kikuu cha kufundishia Moi na Hospitali ya Rufaa.

Tia sahihi au kufanya alama kama unakubali kushiriki katika utafiti

Mgonjwa: ..... Mpelelezi: .....

Tarehe: .....

APPENDIX II: ASSENT FORM
English version

Information

This informed assent form is for children above 7 years of age who have adenoid hypertrophy and are scheduled to undergo surgery.

What is medical research?

Medical research is when doctors collect information to get new knowledge about disease or illness. This helps doctors find better ways of treating diseases and helping children or people who are sick.

What is this research study about?

This research study on children with large adenoids. The adenoids are tissues at the back of the nose, which when larger than normal cause snoring, breathing through the mouth and blockage of the nose. X-rays are used by doctors to see how big the adenoid tissues are in children with these symptoms. In this study, the size of the adenoids on x-ray will be compared to the adenoid removed during surgery to decide which method of measuring the adenoids on x-ray is better. This will be of help for children with large adenoids.

Who is doing this research?

My name is Dr Gathuru M. Lynne and I'm a medical doctor. I'm currently studying for my second degree (Masters in Medicine) in Radiology & Imaging at Moi University.

What will happen to me in this study?

I will invite you to be part of this study. If you agree to participate in this study, your x-rays will be reviewed, and the size of the adenoid tissue recorded. You will then be followed up and the volume of the adenoid removed during surgery measured.

There are no risks or benefits of participating in this study and you will be given the same medical care as the children who are not in the study. You can choose whether or not you would like to participate in the study. I have discussed this with your parent(s)/ guardian(s) and they know we are asking for your permission to be part of the study. In case you refuse to be part of the study you will not be forced to even if your parents agreed for you to participate.

In case of any questions, feel free to ask, I will be happy to assist.

Certificate of assent

Do you understand this research study and are willing to take part in it?

Yes: …….. No: ……..

Has the researcher answered all your questions?

Yes: ……... No: ……..

Do you understand that you can pull out of the study at any time?

Yes: ……. No: …….

I agree to take part in the study _____

OR

I do not wish to take part in the study, and I have not signed the assent below_____.

Only if child assents:

Name of child _____

Child's thumb print:

Date: _____

Kiswahili version

Fomu hii ya idhini ni ya watoto walio umri wa zaidi ya miaka saba ambao walio na adenoid hypertrophy na ambao wanatarajiwa kufanyiwa upasuaji.

Utafiti wa matibabu ni nini?

Utafiti wa matibabu ni wakati madaktari wanapopata taarifa ili kupata ujuzi mpya kuhusu magonjwa. Hii husaidia madaktari kupata njia bora za kutibu magonjwa na kusaidia watoto au watu ambao ni wagonjwa.

Utafiti huu unahusu nini?

Utafiti huu unahusisha watoto walio na adenoids kubwa. Adenoids ni tishu inayopatikana nyuma ya pua. Ukubwa wa adenoids ikiwa zaidi ya kawaida inaweza kusababisha dalili kama kukoroma, kupumua kwa njia ya kinywa na kuziba pua. X-rays hutumiwa na madaktari kuona ukubwa wa tishu ya adenoids kwa watoto wenye dalili hizi. Katika utafiti huu, ukubwa wa adenoids kwenye x-ray utafananishwa na kiasi cha adenoid itakayopimwa baada upasuaji ili kuamua njia gani ya kupima adenoids kwenye x-ray ni bora. Hii itakuwa ya manufaa kwa watoto wenye adenoids kubwa.

Nani anafanya utafiti huu?

Jina langu ni Dkt. Gathuru M. Lynne na mimi ni daktari aliyehitimu. Kwa sasa ninajifunza kwa shahada yangu ya pili (Masters in Medicine) katika Radiologia & Imaging katika Chuo Kikuu cha Moi.

Nini kitatokea kwangu katika utafiti huu?

Nitakualika kushiriki katika utafiti huu. Iwapo utakubali, matokeo yako ya x-ray yataangaliwa tena na kiwango cha adenoids kurekodiwa. Baada ya upasuaji, kiwango cha adenoid kilichotolewa wakati wa upasuaji kitapimwa na kurekodiwa.

Hakuna hatari au faida za kushiriki katika utafiti huu na utapewa huduma sawa ya matibabu kama watoto ambao hawatashiriki kwenye utafiti. Unaweza kuchagua kama ungependa kushiriki katika utafiti huu. Nimezungumza na mzazi na/au mlezi wako na anajua tunaomba ruhusa yako kushiriki katika utafiti. Ikiwa unakataa kuwa sehemu ya utafiti huwezi kulazimishwa hata kama wazazi wako walikubali kushiriki.

Ikiwa kuna maswali yoyote, jisikie huru kuuliza, nitafurahia kusaidia.

Hati ya kukubali

Je unaelewa utafiti huu na uko tayari kushiriki?

Ndio: ..... La: .....

Je, mtafiti alijibu maswali yako yote?

Ndio: ..... La: .....

Je unaelewa kwamba unaweza kuondoka kwa utafiti huu wakati wowote?

Ndio: ……. La: ……

Nakubali kushiriki katika utafiti huu _____

AU

Sitaki kushiriki katika utafiti huu na sijasaini idhini hii _____

Ikiwa tu mtoto ataidhinisha:

Jina la mtoto: ……..

Alama ya kidole cha mtoto:

Tarehe: ……

APPENDIX III: DATA COLLECTION FORM

Instructions

1. All sections to be filled accordingly.
2. Writings should be clear and legible.
3. To be filled in by the principal investigator or assistant once the patient's parent or guardian has given consent for their child to be involved in the study and assent obtained for children above 7 years of age.

Serial No: ……..

Date: ……..

BIODATA

DOB/Age: …….

Gender: …….

Residence: ……

Contact No: ……...

CLINICAL HISTORY

Does your child have any of the following symptoms?

Snoring	Yes: ……	No: …….
Mouth-breathing	Yes: ……	No: …….
Interruption in breathing when sleeping	Yes: ……...	No: …….
Discharge from the ears	Yes: ……...	No: …….
Nasal blockage	Yes: ……...	No: …….

Does your child have any other symptoms?

Yes: ……. (specify): ……

No: …….

For how long has your child been experiencing these symptoms? ……

PHYSICAL EXAMINATION

General:

Respiratory rate: ……

SpO_2: ……

Mouth breathing:

Present: …….. Absent: ……

Features of adenoid facies:

High-arched palate	Yes: …….**.....**	No: …….
Prominent crowded upper teeth	Yes: ……..	No: ……**.**
Elongated face	Yes: ……..	No: …….

External ear

Symmetry: Yes: ……

No: ……

Lesions: Yes: ……..... (specify): ……

No: ……..…..

Discharge from the external auditory meatus

Yes: …….. (describe): …….

No: ……

Findings on PNS x-ray

Adenoidal measurement: ……

Measurement of nasopharyngeal space: …….

Adenoidal-nasopharyngeal ratio: ……

Antroadenoid diameter: …….

SURGICAL FINDINGS

Postoperative adenoid volume: …….

INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

MOI TEACHING AND REFERRAL HOSPITAL
P.O. BOX 3
ELDORET
Tel: 33471/2/3

MOI UNIVERSITY
SCHOOL OF MEDICINE
P.O. BOX 4606
ELDORET

Reference: IREC/2016/117
Approval Number: 0001749

26th September, 2016

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
26 SEP 2016
APPROVED
P. O. Box 4606-30100 ELDORET

Dr. Gathuru Lynne Muthoni,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
ELDORET-KENYA.

Dear Dr. Gathuru,

RE: FORMAL APPROVAL

The Institutional Research and Ethics Committee has reviewed your research proposal titled:-

"Correlation between Adenoid Size on Postnasal Space X-ray and Adenoid Volume among Children with Adenoid Hypertrophy at MTRH".

Your proposal has been granted a Formal Approval Number: ***FAN: IREC 1749*** on 26th September, 2016. You are therefore permitted to begin your investigations.

Note that this approval is for 1 year; it will thus expire on 25th September, 2017. If it is necessary to continue with this research beyond the expiry date, a request for continuation should be made in writing to IREC Secretariat two months prior to the expiry date.

You are required to submit progress report(s) regularly as dictated by your proposal. Furthermore, you must notify the Committee of any proposal change (s) or amendment (s), serious or unexpected outcomes related to the conduct of the study, or study termination for any reason. The Committee expects to receive a final report at the end of the study.

Sincerely,

For

PROF. E. WERE
CHAIRMAN
INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE

cc CEO - MTRH Dean - SOP Dean - SOM
Principal - CHS Dean - SON Dean - SOD

INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

MOI TEACHING AND REFERRAL HOSPITAL
P.O. BOX 3
ELDORET
Tel: 33471/2/3

MOI UNIVERSITY
SCHOOL OF MEDICINE
P.O. BOX 4606
ELDORET
Tel: 33471/2/3

Reference IREC/2016/117
Approval Number: 0001749

19th September, 2017

Dr. Gathuru Lynne Muthoni,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
ELDORET-KENYA.

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
19 SEP 2017
APPROVED
P. O. Box 4606-30100 ELDORET

Dear Dr. Gathuru,

RE: APPROVAL OF AMENDMENT

The Institutional Research and Ethics Committee has reviewed the amendment made to your proposal titled:-

"Correlation between Adenoid Size on Postnatal Space X-ray and Adenoid Volume among Children with Adenoid Hypertrophy at MTRH".

We note that you are seeking to make an amendment as follows:-

1. To change specific objectives, sample size and sampling technique.

The amendment has been approved on 19th September, 2017 according to SOP's of IREC. You are therefore permitted to continue with your research.

You are required to submit progress(s) regularly as dictated by your proposal. Furthermore, you must notify the Committee of any proposal change(s) or amendment(s), serious or unexpected outcomes related to the conduct of the study, or study termination for any reason. The Committee expects to receive a final report at the end of the study.

Sincerely,

DR. S. NYABERA
DEPUTY-CHAIRMAN
INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE

cc: CEO - MTRH Dean - SPH Dean - SOM
Principal - CHS Dean - SOD Dean - SON

INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

MOI TEACHING AND REFERRAL HOSPITAL
P.O. BOX 3
ELDORET
Tel: 33471/2/3

MOI UNIVERSITY
COLLEGE OF HEALTH SCIENCES
P.O. BOX 4606
ELDORET
Tel: 33471/2/3

Reference IREC/2016/177
Approval Number: 0001749

11th December, 2018

Dr. Gathuru Lynne Muthoni,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
ELDORET-KENYA.

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
11 DEC 2018
APPROVED
P.O. Box 4606-30100 ELDORET

Dear Dr. Gathuru,

RE: APPROVAL OF AMENDMENT

The Institutional Research and Ethics Committee has reviewed the amendment made to your proposal titled:-

"Adenoid Hypertrophy: Correlation of Radiographic Parameters to Postoperative Adenoid Volume among Children at Moi Teaching and Referral Hospital, Eldoret".

We note that you are seeking to make an amendment as follows:-

- To change the title to above from ***"Correlation between Adenoid Size Postnasal Space X-Ray and Adenoid Volume among Children with Adenoid Hypertrophy at MTRH".***

The amendment has been approved on 11th December, 2018 according to SOP's of IREC. You are therefore permitted to continue with your research.

You are required to submit progress(s) regularly as dictated by your proposal. Furthermore, you must notify the Committee of any proposal change(s) or amendment(s), serious or unexpected outcomes related to the conduct of the study, or study termination for any reason. The Committee expects to receive a final report at the end of the study.

Sincerely,

PROF. E. WERE
CHAIRMAN
INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE

cc: CEO - MTRH Dean - SPH Dean - SOM
Principal - CHS Dean - SOD Dean - SON

MOI TEACHING AND REFERRAL HOSPITAL

Telephone: 2033471/2/3/4
Fax: 61749
Email: director@mtrh.or.ke
Ref: ELD/MTRH/R.6/VOL.II/2008

P. O. Box 3
ELDORET

30th September, 2016

Dr. Gathuru Lynne Muthoni,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
ELDORET-KENYA.

RE: APPROVAL TO CONDUCT RESEARCH AT MTRH

Upon obtaining approval from the Institutional Research and Ethics Committee (IREC) to conduct your research proposal titled:-

"Correlation between Adenoid Size on Postnasal Space X-ray and Adenoid Volume among Children with Adenoid Hypertrophy at MTRH".

You are hereby permitted to commence your investigation at Moi Teaching and Referral Hospital.

30/09/2016

DR. WILSON ARUASA
CHIEF EXECUTIVE OFFICER
MOI TEACHING AND REFERRAL HOSPITAL

CC - Deputy Director (CS)
- Chief Nurse
- HOD, HRISM

APPENDIX IV: ADENOIDAL-NASOPHARYNGEAL RATIO

This method of measuring adenoid size was initially described by Fujioka et al. (1979), where the size of the adenoid is measured relative to the size of the nasopharynx. In this method, a straight line, B, is drawn along the anterior margin of the basiocciput. The adenoidal measurement is then made from the point of maximal convexity of the shadow of the adenoid along a line perpendicular to B. This measurement is termed A. The nasopharyngeal space, N, is then measured from the posterior tip of the hard palate to the anterior edge of the spheno-basioccipital synchndrosis. The adenoidal measurement is then divided by the measurement of the nasopharyngeal space to calculate the adenoidal-nasopharyngeal (AN)ratio. (Fujioka et al., 1979).

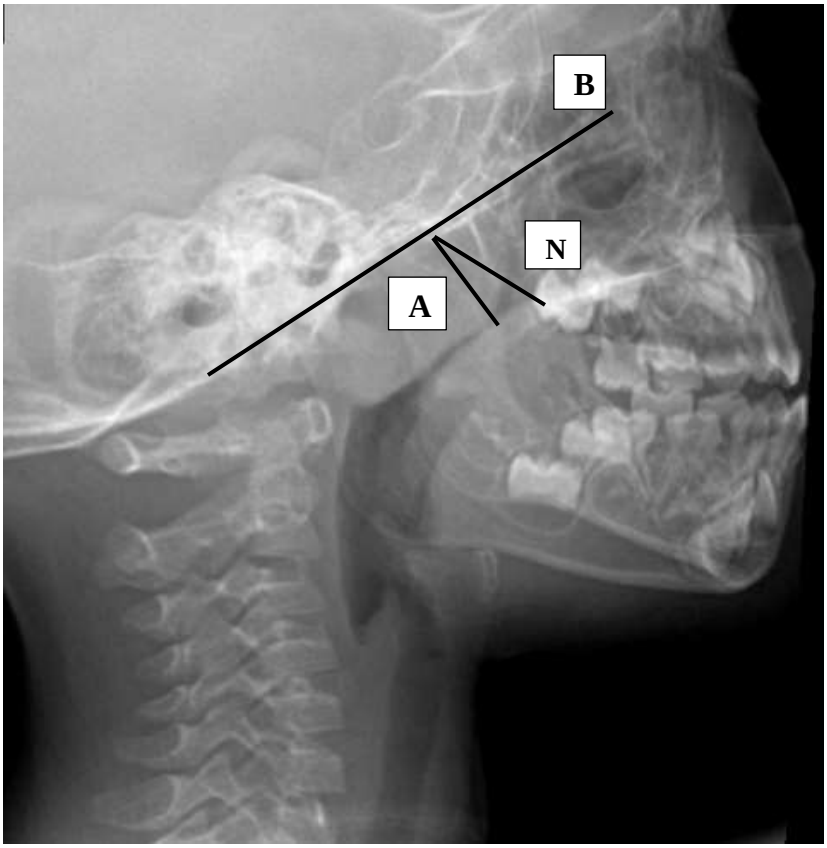

Figure 12: Adenoidal-nasopharyngeal ratio

APPENDIX V: ANTROADENOID DIAMETER

This method of measuring adenoid size assesses the degree of narrowing of the airway and was described initially by Hibbert and Whitehouse (1978). The measurement is taken along a line drawn from the prominence of the shadow of the adenoid tissues to the posterior wall of the maxillary antrum. The posterior wall of the maxillary antrum is on the same level as the posterior choanae on postnasal space x-ray (Hibbert & Whitehouse, 1978). This is illustrated below:

Figure 13: Antroadenoid diameter